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Gastrointestinal Nematodes, Including Three New Species, from Australian and Papua New Guinean Pythons

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ABSTRACT: Three new nematodes are described (*Kalicephalus australiensis, Spinicauda moretonis,* and *Abbreviata hastaspicula*), and another eight species recorded from pythons from Queensland, Australia, and from Papua New Guinea. The distribution of five of the most frequently recorded species of nematodes is predominantly or exclusively confined to the tropical coastal northeast region of the state, and the probable reasons for this distribution are briefly discussed.

Although a considerable amount of work has been done on the ascaridoid nematodes of Australian pythons (Sprent, 1963, 1969a, b, 1970; Sprent and Mines, 1960), and other nematodes have been recorded or described in the papers of Johnston and Mawson (1942a, 1951), Baylis (1931), and others, there has been no systematic survey of the gastrointestinal parasites of this most conspicuous and best-known group of Australian snakes. This study was, therefore, undertaken to clarify the species of nematodes which occur in these snakes, and their prevalence and distribution within this northeastern sector of Australia.

The following nematode species were recovered: *Capillaria longispicula, Kalicephalus australiensis* sp. n., *Kalicephalus giganteus, Herpetostrongylus pythonis, Moaciria* sp., *Ophidascaris moreliae, Amplicaecum robertsi, Polydelphis anoura, Spinicauda moretonis* sp. n., *Abbreviata hastaspicula* sp. n., and *Abbreviata confusa.* Table 1 shows the numbers collected and their locality.

Materials and Methods

Forty-nine pythons (one from New Ireland [Papua New Guinea] and 48 from Queensland, Australia) preserved in the Queensland Museum, Brisbane, were dissected and the gastrointestinal nematodes were recovered. The pythons studied were: *Aspidites melanocephalus* (8), *Aspidites ramsayi* (5), *Liasis childreni* (10), *Liasis amethystinus* (8), *Liasis fuscus* (1), and *Morelia spilotes* (17). They were chosen from as wide a geographical range as possible, though few were available from western areas of the state. All specimens, after recovery from the hosts, were cleaned and examined in chlorolactophenol and stored in 70% alcohol with 5% glycerine. Drawings were made using a drawing tube attached to a Leitz Wetzlar Dialux microscope. All specimens have been deposited in the Queensland Museum, Brisbane, Australia. All measurements are given in μm unless otherwise stated. An asterisk (*) is used after certain features to indicate that the measurement is the distance from the anterior end of the worm.

Results

Subclass Adenophorea
Order Enoplida
Superfamily Trichuroidea
Capillaria longispicula (Sonsino, 1889)

Five of the eight *Liasis amethystinus* examined were infected with between 1 and more than 100 *Capillaria longispicula,* all from tropical northeast coastal

Queensland, and one of the three *Morelia spilotes* from this area was infected; there were no infections in this latter python from southeast or west Queensland. This species was described from *Python molurus* from India, and these are new host records, and the first recorded from Australia (QM G11698–G11703).

Subclass Secernentea
Order Strongylida
Superfamily Diaphanocephaloidea
Kalicephalus australiensis sp. n.

TYPE HOST: *Liasis amethystinus*.

OTHER HOST: *Morelia spilotes*.

HABITAT: Intestine.

TYPE LOCALITY: Innisfail, Northeast Queensland.

TYPE SPECIMENS: Holotype (male) QM G11704; allotype QM G11705; paratypes QM G11706–G11715.

DESCRIPTION (Fig. 1A–D): Worms short and stout. Maximum width at about one-third of length, tapering gradually posteriorly. Males usually more coiled than females. Most specimens contained large amounts of blood in the upper intestine. Face not appreciably tilted, slightly rounded, with inflated cuticle. Head diameter proportionately less in males than in females. No cervical cuticular inflation, corona radiata, or buccal teeth. Anterior chitinoid ridge slightly rounded, medium width. Posterior ventral chitinoid piece rounded, almost hemispherical in outline, posterior dorsal chitinoid piece angular. Long dorsal gutter. Esophagus short and heavily bulbed. Excretory pore variable, but always anterior to maximum bulb diameter. Nerve ring at narrowest portion of esophagus. Cervical papillae not seen.

MALE (14 specimens): Length 3.90–5.40 (mean, 4.50), maximum width 0.17–0.24 (0.20), head diameter 0.17–0.21 (0.20), buccal capsule depth 0.18–0.22 (0.21), esophagus length 0.34–0.41 (0.38), esophagus bulb width 0.16–0.20 (0.18), nerve ring* 0.24–0.30 (0.27), excretory pore* 0.31–0.44. Spicules short (250–310 μm), alate, equal, wide for the first one-quarter of their length, thereafter thin, and with fine nonspatulate pointed tip. A consistent sinuous portion of both spicules at about ⅔ of their length in all specimens. Gubernaculum long and thin, also slightly wavy. Genital cone short, with a small cone-shaped projection at either side of the genital aperture. Bursa with ventral rays long and thin, apposed for their whole lengths except at the tips. Lateral rays robust; externolateral shortest, directed away from the other two. Terminal branches of dorsal rays of pattern 1V (Schad, 1962). A single sessile medial ventral papilla anterior to the copulatory bursa.

FEMALE (13 specimens): Length 4.87–6.15 (mean, 5.53), maximum width 0.23–0.32 (0.27), head diameter 0.24–0.31 (0.27), buccal capsule depth 0.21–0.27 (0.24), esophagus length 0.40–0.48 (0.44), esophagus bulb width 0.20–0.27 (0.23), nerve ring* 0.30–0.37 (0.35), excretory pore* 0.40–0.53 (0.47). Tail short (0.13–0.17), tapering rapidly to a point, ventral surface often concave. Vulva on a protrusible peduncle, 60–66% from anterior end. Amphidelphic. Eggs 64 × 39 μm.

DIAGNOSIS: Diaphanocephalidae. Small size, face slightly rounded with inflated cuticle, protrusible vulva, dorsal ray pattern 1V, prebursal ventral medial papilla, spicules nonspatulate with consistent bend at ⅔ length, female tail short.

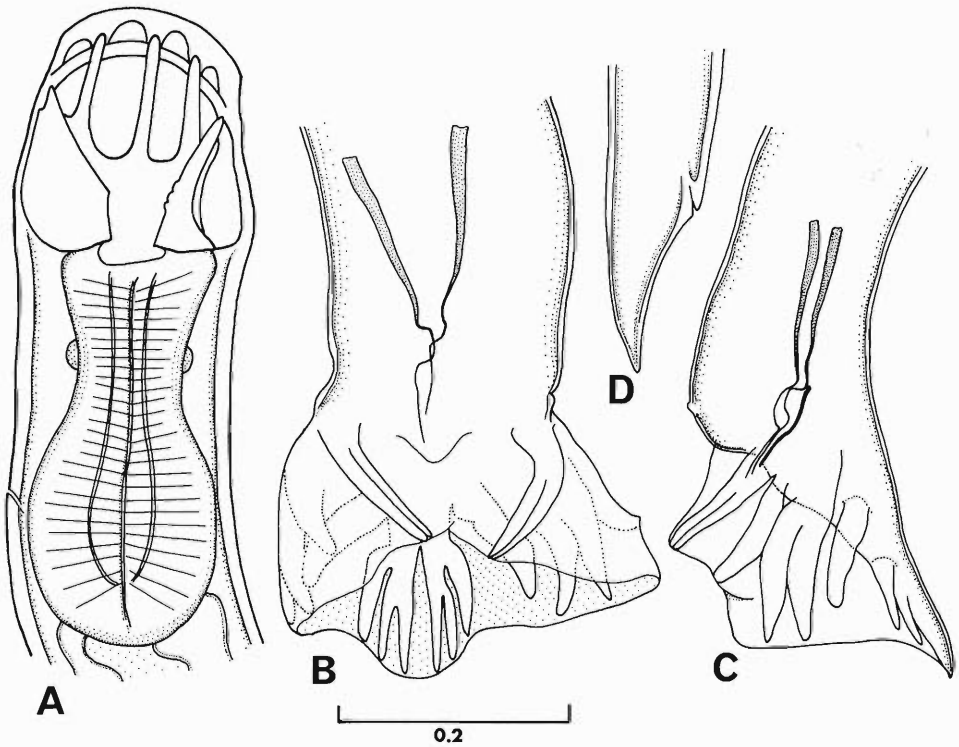

Figure 1. ***Kalicephalus australiensis.*** **A, male holotype, anterior end, lateral; B, male paratype, posterior end, ventral; C, male paratype, posterior end, lateral; D, female paratype, tail, lateral. (Same scale.)**

Discussion

The amphidelphic condition, absence of buccal teeth, cervical inflation or corona radiata, short equal spicules, pattern of the terminal branches of the dorsal ray, abundant males, and geographical region place this species in the *variabilis* group (Schad, 1962). It differs from the other species in the group in the combination of small size, stout esophagus, short female tail, protrusible vulva, and wavy pointed spicules. The species closest to it is *K. sinensis* (Hsü, 1934) (only recorded from *Elaphe* spp. snakes in China) from which it differs in the protrusible vulva, less curved face, consistently further anterior excretory pore, absence of conspicuous excretory gland, and pointed tips to the spicules. No other species from this group have been recorded from Boidae, or from any other Australian hosts.

The other amphidelphic *Kalicephalus* spp. in the Oriental and Australian region, from which it must be differentiated, are *K. bungari* and *K. brachycephalus* (different dorsal ray patterns), *K. longispicularis* (very long spicules), *K. willeyi* (males very rare, larger size, straight spicules), and *K. enygri* (flatter face, weak esophageal bulb, higher vulva ratio, vulva flush with body wall, larger size).

The other *Kalicephalus* species from which it must be distinguished in Australia is *K. costatus indicus* (prodelphic, distinctive spiked female tail, usually larger size, dorsal ray pattern 111), and in Papua New Guinea from *K. enygri, K. novaebritanniae* (larger size, angular posterior chitinoid plates, prodelphic, higher vulva

ratio, and inflated cervical cuticle), and *K. giganteus* (relatively massive size, posterior chitinoid plates angular, corona radiata, inflated cervical cuticle, and buccal teeth).

This species was found in the single *Liasis amethystinus* from New Ireland (Papua New Guinea), in six of the seven *L. amethystinus* from tropical northeast Queensland in numbers ranging from one to more than 100, and in all three of the *Morelia spilotes* from this area in numbers ranging to 165, but in none of this species of snake from other areas of the state.

Kalicephalus giganteus Schad, 1962

This species was described from *Liasis papuanus* which had died in the London Zoo, and whose provenance was assumed to be Papua New Guinea. This is the only other record of the species, collected in New Ireland; its absence from seven *L. amethystinus* from Queensland suggests that it probably does not occur in Australia (QM G11716).

Superfamily Trichostrongyloidea

Herpetostrongylus pythonis Baylis, 1931

This species was described from near Townsville, north Queensland. It was present in small numbers in the intestines of three of the seven *Liasis amethystinus* from the tropical northeast of the state, and in one of the three *Morelia spilotes* collected from this area, but was not found in any of this species of snake collected from other areas of the state. Most specimens recovered were tightly coiled in a corkscrew as in the original description (QM G11717–G11720).

Order Ascaridida
Superfamily Heterakoidea

Moaciria sp. Jones (In Press)

Specimens were collected from the recta of two of the eight *Liasis childreni,* but from none of the other snakes of this species (QM G11721 [holotype], G11722 [allotype], and G11723 and G11724 [paratypes]).

Spinicauda moretonis sp. n.

TYPE HOST: *Morelia spilotes.*

HABITAT: Stomach.

TYPE LOCALITY: Cape Moreton, Moreton Island, SE Queensland, Australia.

TYPE SPECIMENS: Holotype QM G11725; allotype QM G11726; paratypes QM G11727.

DESCRIPTION (Fig. 2A–E): Small cylindrical worms in poor to fair condition, with fine transverse striations throughout their length. Narrow lateral alae extend from about the level of the nerve ring to the level of the anus in the female, and to the level of the precloacal sucker in the male. Worms taper markedly towards either end. Three small lips each bearing a small apical tooth; lip papillae not visible. Lips slightly offset from body, retractable, leading into a short pharynx and a long narrow esophagus terminating in a large valved globular bulb preceded by a slight constriction. Lateral line cells prominent in many specimens. Nerve ring surrounds esophagus at about ⅓ its length, and excretory ducts lead ante-

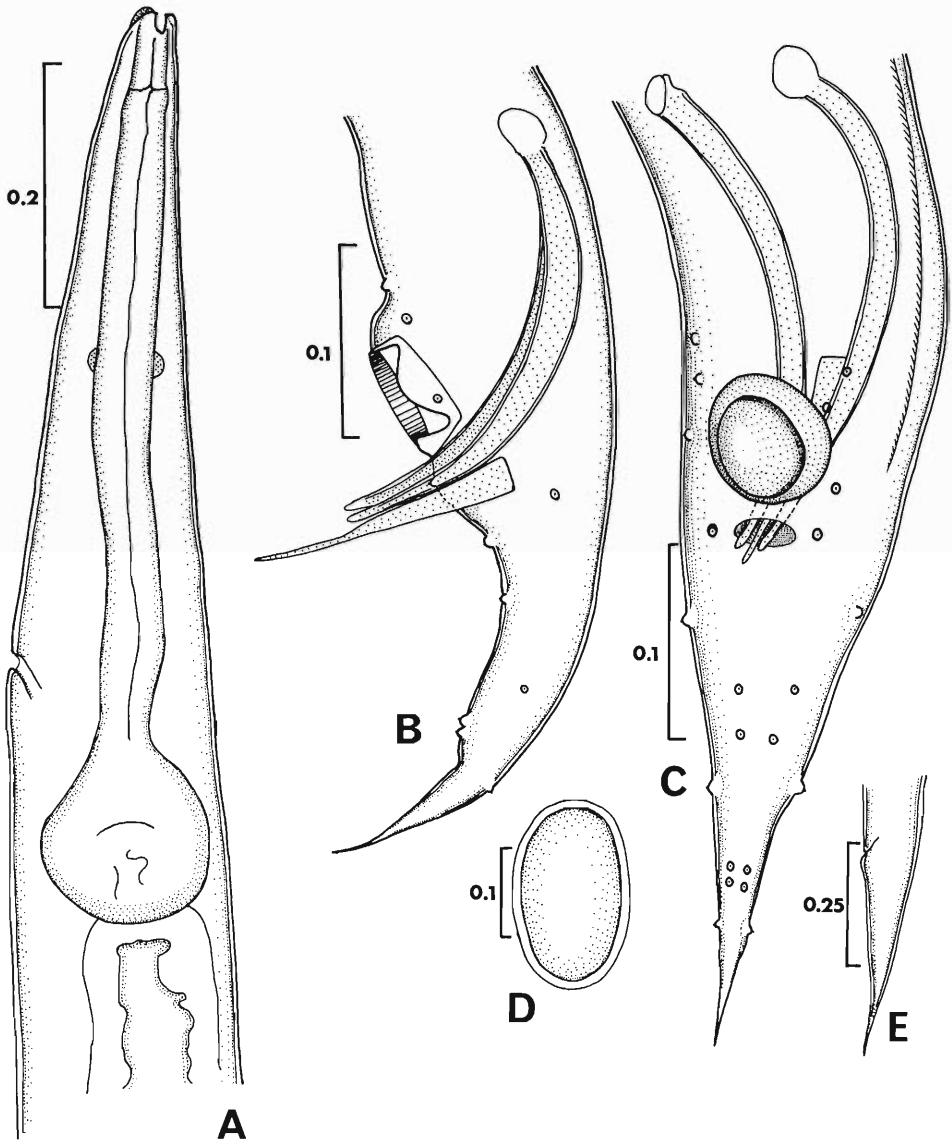

Figure 2. ***Spinicauda moretonis*****. A, female paratype, anterior end, lateral; B, male holotype, posterior end, lateral; C, male holotype, posterior end, ventral; D, egg; E, female paratype, tail, lateral.**

riorly to excretory pore at a short distance anterior to the esophageal bulb. Cervical papillae not visible.

MALE (4 specimens): Length 4.12–4.50, maximum width 0.17, esophagus length 0.42–0.47, esophagus width (excluding bulb) 0.04, esophagus bulb length 0.09–0.11, esophageal bulb width 0.11, pharynx length 0.04, excretory pore* 0.39. Shorter and more slender than females. Shallow circular precloacal sucker, 0.06 diameter, with a well-chitinized rim. Tail long, 0.24–0.28, tapering evenly to a fine point. A number of fairly large sessile papillae are arranged in the following manner (any smaller papillae which may have been present were not visible owing

Table 1. Nematodes recorded.

Host species	QM	Date collected	Locality	*Capillaria longispicula*	*Kalicephalus australiensis*	*Kalicephalus giganteus*	*Herpetostrongylus pythonis*	*Moaciria* sp.	*Spinicauda moretonis*	*Amplicaecum robertsi*	*Ophidascaris moreliae*	*Polydelphis anoura*	*Abbreviata hastaspicula*	*Abbreviata confusa*
Aspidites melanocephalus	6173	5-37	Beresford Stn. Clermont											1
Aspidites melanocephalus	8125	7-51	Wenlock, Cape York							2				27
Aspidites melanocephalus	8721	8-54	Charters Towers											
Aspidites melanocephalus	10036	9-58	Stuart, Townsville											
Aspidites melanocephalus	10308	6-59	Windorah, S.W.Q.											
Aspidites melanocephalus	13449	8-65	Rolingstone, Townsville									10 ads, 55 L		
Aspidites melanocephalus	17562	9-69	25 km S of Cooktown							1 ad, +L				
Aspidites melanocephalus	24015	2-74	5 km S of Emerald										208 ads, +L	1
Aspidites ramsayi	2260	2-15	Yuleba, W.Q.											9 ads, +L
Aspidites ramsayi	9655	6-51	Birdsville, S.W.Q.									1		
Aspidites ramsayi	10331	-55	Birdsville, S.W.Q.											
Aspidites ramsayi	10445	4-60	Birdsville, S.W.Q.							3				
Aspidites ramsayi	30171	-77	Durrie Stn., Birdsville									4		
Liasis childreni	4752	5-28	Normanton, N.Q.											
Liasis childreni	7516	7-49	Pullenvale, S.E.Q.											
Liasis childreni	8836	1-55	Eumundi											
Liasis childreni	14231	1-67	Gympie					3 .						

Table 1. Continued.

Host species	QM	Date collected	Locality	*Capillaria longi-spicula*	*Kali-cephalus australi-ensis*	*Kali-cephalus giganteus*	*Herpeto-strongylus pythonis*	*Moaciria* sp.	*Spini-cauda moretonis*	*Ampli-caecum robertsi*	*Ophid-ascaris moreliae*	*Poly-delphis anoura*	*Abbrev-iata hastaspicula*	*Abbrev-iata confusa*
Liasis childreni	14277	3-67	Rosewood nr. Ipswich											
Liasis childreni	14488	9-67	Waringa, Hivesville											
Liasis childreni	19705	2-70	20 km W of Rockhampton											
Liasis childreni	23764	11-73	Longreach											
Liasis childreni	26067	7-75	Mt. Etna nr. Batsville					13						
Liasis childreni	28440	5-77	Foot of Bunya Mtns., S.E.Q.											
Liasis fuscus	13450	8-65	Aitkenvale, Townsville											
Liasis amethystinus	4094	6-24	New Ireland, Papua New Guinea		ca. 8	7								
Liasis amethystinus	8640	9-48	Mt. Finigan, S of Cooktown	100+	1		8			ca. 40				
Liasis amethystinus	10446	1-60	El Arish, nr. Tully	7	ca. 10		ca. 35			ca. 15	ca. 15			
Liasis amethystinus	14322	10-65	17 km N of Innisfail	ca. 25	96					ca. 30				
Liasis amethystinus	14325	10-65	Nr. Innisfail	1	22					ca.15	4			
Liasis amethystinus	17563	8-69	Rainforest, 12 km W of Cairns		3					3				
Liasis amethystinus	17161	11-69	Nr. Cairns	1			1					1		
Liasis amethystinus	24564	-77	Mulgrave River, N.Q.		ca. 110					ca. 75				
Morelia spilotes	1129	5-13	Rosewood nr. Ipswich											
Morelia spilotes	7943	1-51	Mitchelton, Brisbane							1				

Table 1. Continued.

Host species	QM	Date collected	Locality	*Capillaria longi-spicula*	*Kali-cephalus australi-ensis*	*Kali-cephalus giganteus*	*Herpeto-strongylus pythonis*	*Moaciria* sp.	*Spini-cauda moretonis*	*Ampli-caecum robertsi*	*Ophid-ascaris moreliae*	*Poly-delphis anoura*	*Abbrev-iata hastaspicula*	*Abbrev-iata confusa*
Morelia spilotes	8886	1-55	Winton Sta. nr. Goondiwindi											
Morelia spilotes	9736	9-57	Birdsville, S.W.Q.											
Morelia spilotes	10355	1-60	Hunckley via Palmwood							1				
Morelia spilotes	11414	11-62	30 km N of Oakey											
Morelia spilotes	13332	5-65	Oonoonba, N.E.Q.									7		
Morelia spilotes	14328	10-65	Mt. Glorious, S.E.Q.							15				
Morelia spilotes	14324	10-65	17 km N of Innis-fail	1	165		5			2				
Morelia spilotes	14326	2-66	13 km N of Innis-fail		31						1			
Morelia spilotes	14329	2-66	Nr. Innisfail		ca. 90					4	2			
Morelia spilotes	22980	3-73	Toowoomba							ca. 20	ca. 20	1		
Morelia spilotes	24355	5-74	Cape Moreton, Moreton Is.						68					
Morelia spilotes	26057	6-75	Mt. Nebo, S.E.Q.							10		3		
Morelia spilotes	28476	7-77	Mt. Glorious, S.E.Q.							ca. 30				
Morelia spilotes	29851	3-77	Bulloo R. Thargaminda, S.W.Q.											2

to the condition of the males): 1 pair anterior to sucker, 2 pairs at level of sucker, 1 pair adanal; 7 pairs on the tail, of which 2 pairs are lateral, 4 pairs are ventral, and the most caudal pair is dorsolateral. No caudal alae. Spicules equal (270–310 μm), similar, well-chitinized, fairly thick, strongly bowed ventrally with blunt, poorly chitinized tips. Gubernaculum ½ length of spicules (0.13–0.15), straight, anterior end flat and wide, tapering gradually to a fine pointed tip which projects from the cloaca in all specimens.

FEMALE (4 specimens): Length 6.3–6.6, maximum width (at about ⅔ length), 0.26–0.28, esophagus length 0.75–0.77, esophagus width (excluding bulb) 0.04–0.05, esophagus bulb length 0.15–0.16, esophagus bulb width 0.15–0.16, pharynx length 0.05–0.06, nerve ring* 0.28–0.30, excretory pore* 0.50–0.56, tail long and pointed, 0.38–0.42, vulva* 2.77–3.15 (about midlength of worms), with wide projecting lips. Vagina turns posteriorly. All specimens were full of eggs, which were large and elongated (95–106 × 62 μm), with smooth, thick shells, unembryonated.

DIAGNOSIS: Spinicaudinae; spicules equal, gubernaculum straight and pointed, ½ length of spicules, at least 11 pairs of caudal papillae in male, 1 pair in front of sucker. Eggs large.

Discussion

Spinicauda moretonis sp. n. must be distinguished from the following species: *S. australiensis* Baylis 1930 from *Tiliqua scincoides* is the only other species so far described from Australia, and differs from the present species, and from all others in the genus, in possessing unusually long spicules. *Spinicauda spinicauda* (Rudolphi, 1819), from which neither *S. amarali* Pereira, 1935 nor *S. campanulata* (Linstow, 1899) can be distinguished (Inglis, 1957), is found in South American skinks and other lizards, and has larger spicules and a wider sucker, and the male tail narrows suddenly to the pointed tip. *Spinicauda sonsinoi* (Linstow, 1894) (from which *S. grimmae* Belle, 1957 cannot be separated; Inglis, 1957) is similar to *S. moretonis* but has longer spicules, longer tail in both sexes and longer esophagus, and the gubernaculum is curved at the anterior end. The size of the eggs in *S. sonsinoi* is not stated, but in *S. grimmae* they are said to be spherical. *Spinicauda eryxi* Agrawal, 1966 is the only other species so far described from a snake, also a boid, but differs in possessing a row of six ventral preanal papillae, which are lacking in this species. *Spinicauda inglisi* Chabaud and Brygoo, 1960 from chameleons in Madagascar differs from *S. moretonis* in having a very small, deeply retracted head, larger spicules, which are about three times the length of the gubernaculum, and more developed lateral alae. In addition, *S. moretonis* possesses larger eggs than any of the described species.

Members of this subfamily are usually found in the large intestine or rectum of their host, and the finding of these worms in rather poor condition in their host's stomach suggests that the infection may have been a spurious one, although there were no food residues in this snake's intestinal tract.

Superfamily Ascaridoidea
Amplicaecum robertsi Sprent and Mines, 1960

Specimens were recovered in fairly large numbers from the stomachs of six of the seven *Liasis amethystinus* from tropical northeast Queensland, and in eight of the 17 *Morelia spilotes* examined, heaviest infection again being from the

specimens collected in tropical and rain forest areas, and from one *Aspidites ramsayi* and from two *A. melanocephalus* (QM G11738–G11752, and G11758).

Ophidascaris moreliae Sprent, 1969

Specimens were recovered in small numbers from the stomach of two *Liasis amethystinus* and three *Morelia spilotes*, all but one of which were from the tropical northeast region (QM G11753–G11757).

Polydelphis anoura Dujardin, 1845

This widely distributed species (Sprent, 1969a) was recovered in low numbers from the upper intestinal tract of seven pythons (*Aspidites ramsayi, A. melanocephalus, Liasis amethystinus,* and *Morelia spilotes*) collected from areas ranging from the high rainfall coastal regions to the dry far inland areas. *Aspidites melanocephalus* is a new host record (QM G11759–G11765).

Order Spirurida
Superfamily Physalopteroidea
Abbreviata hastaspicula sp. n.

TYPE HOST: *Aspidites melanocephalus*.

HABITAT: Stomach.

TYPE LOCALITY: Emerald, Central Queensland.

TYPE SPECIMENS: Holotype QM G11728; allotype QM G11729; paratypes (94 males, 112 females) QM G11730–G11732.

DESCRIPTION (Fig. 3A–H): White cylindrical worms with cervical collarette. Females stout relative to their length, slightly more numerous than males. Mouth bordered by 2 lips, each bearing a large external apical tooth. Medial to this the internal apical tooth is variable in structure, being bifid to the base in some specimens, in others single and pointed, with many intermediate forms. Each lip slopes backwards from apex, each bearing on an eminence a bifid ventral and dorsal tooth. In some specimens 3 or 4 very small mouth corner denticles are present, but in others they are not visible. Two sessile papillae and an amphid on the external surface of each lip. Muscular esophagus relatively long, followed by a wider glandular esophagus about six times as long. Nerve ring surrounds muscular esophagus just before its posterior end; cervical papillae small and pointed, posterior to commencement of glandular esophagus, and excretory pore a short distance posterior to this, with excretory duct leading anteriorly from it.

MALE (10 specimens): Length 11.17–12.37 (mean, 11.78), maximum width 0.40–0.67 (0.53), muscular esophagus length 0.26–0.41 (0.34), muscular esophagus width 0.10–0.14 (0.12), glandular esophagus length 1.75–2.84 (2.24), glandular esophagus width 0.20–0.24 (0.22), nerve ring* 0.23–0.38 (0.30), excretory pore* 0.50–0.77 (0.62), cervical papillae* 0.43–0.61 (0.52). Copulatory bursa extending to tip of tail, supported by 7 pairs of pedunculated papillae, of which 4 long pairs are pericloacal, and 3 shorter pairs are further posterior, the first 2 of which are close together with a conspicuous phasmid between them. Four sessile papillae postcloacally and 3 precloacally. Ventral surface of bursa lined by rows of tuberculations extending onto the medial surface of the alae, and terminating in a concave arc at the level of the posteriormost papillae. Left spicule weakly chi-

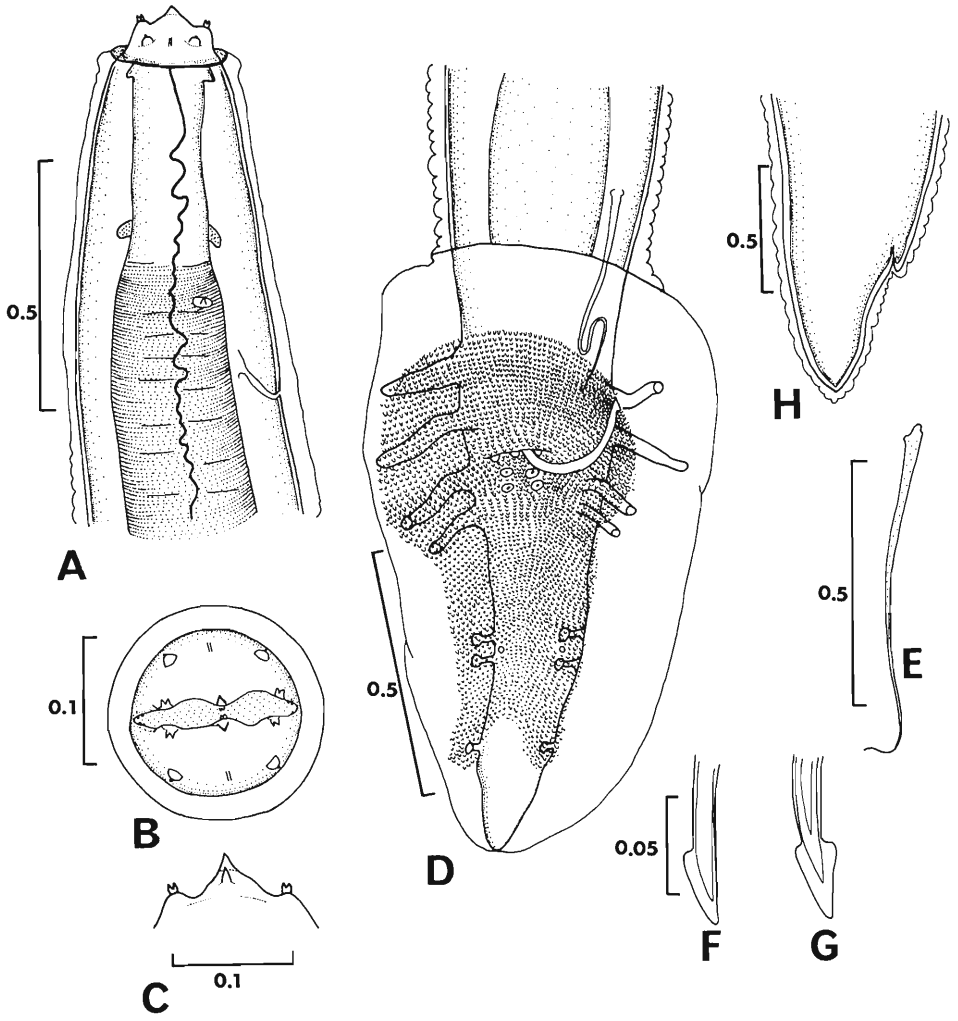

Figure 3. *Abbreviata hastaspicula.* **A, allotype, anterior end, lateral; B, female paratype, *en face*; C, female paratype, internal surface of lip; D, male paratype, posterior end, ventral; E, left spicule; F, tip of right spicule, lateral; G, tip of right spicule, dorsal; H, female paratype, tail, lateral.**

tinized, 620–700 μm, thin, terminating in a very fine point. Distal portion bent ventrally, and curved or looped back in many specimens. Right spicule only a little shorter than the left (590–670 μm), thick, well chitinized, curved ventrally, especially in the distal portion, with a conspicuous pointed enlargement at the tip in the shape of a spearhead, protruding from the cloaca in every specimen.

FEMALE (7 specimens): Length 17.62–30.75 (mean, 25.8), maximum width 0.66–1.10 (0.88), muscular esophagus length 0.37–0.44 (0.40), muscular esophagus width 0.14–0.19 (0.16), glandular esophagus length 2.22–3.61 (3.11), glandular esophagus width 0.27–0.32 (0.29), nerve ring* 0.36–0.43 (0.39), excretory pore* 0.64–0.80 (0.75), cervical papillae* 0.56–0.70 (0.62). Tail short (0.28–0.43), conical, blunt, vulva situated on a slight elevation at between 1/5 and ¼ of the distance from the anterior end (3.82–7.50)*, 1.22–2.01 behind esophago-intestinal

junction. Reservoir branches twice to give 4 uterine branches. Coils of uterus extend anterior to the vulva in almost all specimens, as far as the posterior portion of the glandular esophagus. Eggs relatively small, 42 × 31 to 39 × 31 μm, slightly elongated, with thin, smooth shells, embryonated.

DIAGNOSIS: *Abbreviata* with internal apical tooth single or bifid, and mouth corner denticles inconstant. Males with weakly chitinized left spicule, only slightly longer than the right. Right spicule stout with pointed enlargement at the tip. Females stout, vulva 1/5 to 1/4 of distance from anterior end.

ETYMOLOGY: From *hasta,* Latin for a spear.

Discussion

This species is distinguished from all other reptilian *Abbreviata* species in the Australian and Papua New Guinean region by the presence of the spearheadlike enlargement at the tip of the right spicule. In addition, the difference in the lengths of the spicules is less than in any other recorded species in this genus in the region, and the left spicule is unusually weak. An unusual feature is the variability in the mouth corner denticles; when present they are smaller than in the more slender *A. confusa,* with which they were associated.

Abbreviata confusa Johnston and Mawson, 1942

This species was recovered in low numbers from three *Aspidites melanocephalus,* one *A. ramsayi,* both of which are now host records, and from one *Morelia spilotes*. All records were from drier inland areas (QM G11733–G11737).

Discussion

Pythons are predominantly snakes of moist tropical regions, though some have adapted to other environments. This distribution is reflected in the distribution of many of their nematode parasites in Queensland. Three of the species, *Kalicephalus australiensis, Herpetostrongylus pythonis,* and *Capillaria longispicula* appear to be confined to *M. spilotes* and *Liasis amethystinus* in the heavy rainfall areas of northeast coastal Queensland, where a high proportion of these snakes are infected. The few life cycles that are known from the trichostrongyle nematodes and from the genera *Kalicephalus* and *Capillaria* suggest that these species probably have direct life cycles, and their confined distribution is probably related to the susceptibility of their eggs to desiccation, the ambient temperature required for their embryonation, and to the greater density of pythons in those areas. In addition, two other species, *Amplicaecum robertsi* and *Ophidascaris moreliae,* are commonest in these areas, although they also occur in rain forest areas down to the southeast of the state and, in the case of *A. robertsi,* in small numbers in other areas. Both these species require small mammals as intermediate hosts (Sprent, 1963, 1969), and their predominance in the tropical more humid areas is probably related to the composition or density of these intermediate hosts, or to the susceptibility of their eggs to desiccation. The third ascaridoid species *Polydelphis anoura,* on the other hand, occurs in drier parts of the country also.

In contrast to these, *Abbreviata confusa*, which has a fairly wide host range (Johnston and Mawson, 1942a, b, 1947, 1951), is absent from these coastal tropical regions; the five records in this study are all from drier areas away from the coastal strip, and the two records from Queensland for which an exact locality

is given by Johnston and Mawson (1947, 1951) are also away from the coast, at Eidsvold and Dalby, although they do report the species from coastal areas in more southerly areas of Australia. It is probable that their distribution is limited by the distribution of the suitable arthropod intermediate host.

Acknowledgments

I would like to thank Ms. Jeanette Covacevitch, Curator of Reptiles at the Queensland Museum, for allowing me access to the snakes and for the provision of facilities for their examination.

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Postscript

Spinicauda moretonis also differs from the male *S. komodoensis* (Pinnell and Schmidt, 1977) in having a longer tail, a shallow sucker, shorter spicules (270–310 μm compared with 457 μm) and gubernaculum (130–150 μm compared with 295 μm), and in the absence of papillae over the body surface of the worm.

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OBITUARY NOTICES

Reinhard Harkema
Nov. 23, 1910–Oct. 1, 1978
Member since 1961

Harry Mathias Martin
Mar. 28, 1892–Oct. 19, 1978
Member since 1949

Proc. Helminthol. Soc. Wash.
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Differentiation of Fourth and Early Fifth Stages of *Parascaris equorum* (Goeze, 1782) Nematoda: Ascaridoidea

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ABSTRACT: The morphology of *Parascaris equorum* of horses was studied; light and scanning electron microscopy were used. Late fourth-stage larvae have narrow, rectangular lips bearing few, large, triangular, irregularly spaced denticles and the lips are not markedly set off from the body. The cuticle of the late fourth stage is completely transversely striated, with incomplete longitudinal ridges creating a brickwork pattern; longitudinal alae are present. Total body lengths of fourth-stage larvae range from 10 to 32 mm. A single molting fourth-stage male was found to be 33 mm long. Early fifth-stage nematodes have wide, trilobate lips with a deep transverse groove on their medial surface; the lips bear many small regularly spaced denticles and are set off from the body by a deep postlabial constriction. The fifth-stage cuticle is finely striated, without markings; longitudinal alae are lacking. Early fifth stages are 33.3 to 85.0 mm long.

The recent increase in the number of horses has been followed by a resurgence of interest in controlling their helminth parasites. Testing the efficacy of anthelmintics requires that helminths be identified to taxon and to stage of development. Although newly developed keys are available for adult helminths (Lichtenfels, 1975), identification standards for their larvae are lacking. This report describes anatomical characters that can be used to differentiate fourth-stage larvae and adults of *Parascaris equorum* (Goeze, 1782), the large intestinal roundworm of horses.

Apparently, the morphology and morphometrics of late fourth-stage larvae and early fifth stages of *P. equorum* have not been studied. More data have been published on the larval development of *Ascaris suum* Goeze, 1782 of swine (Roberts, 1934; Douvres et al., 1969), but reliable morphometrics of the late developmental stages of this nematode are also lacking (F. G. Tromba, personal communication).

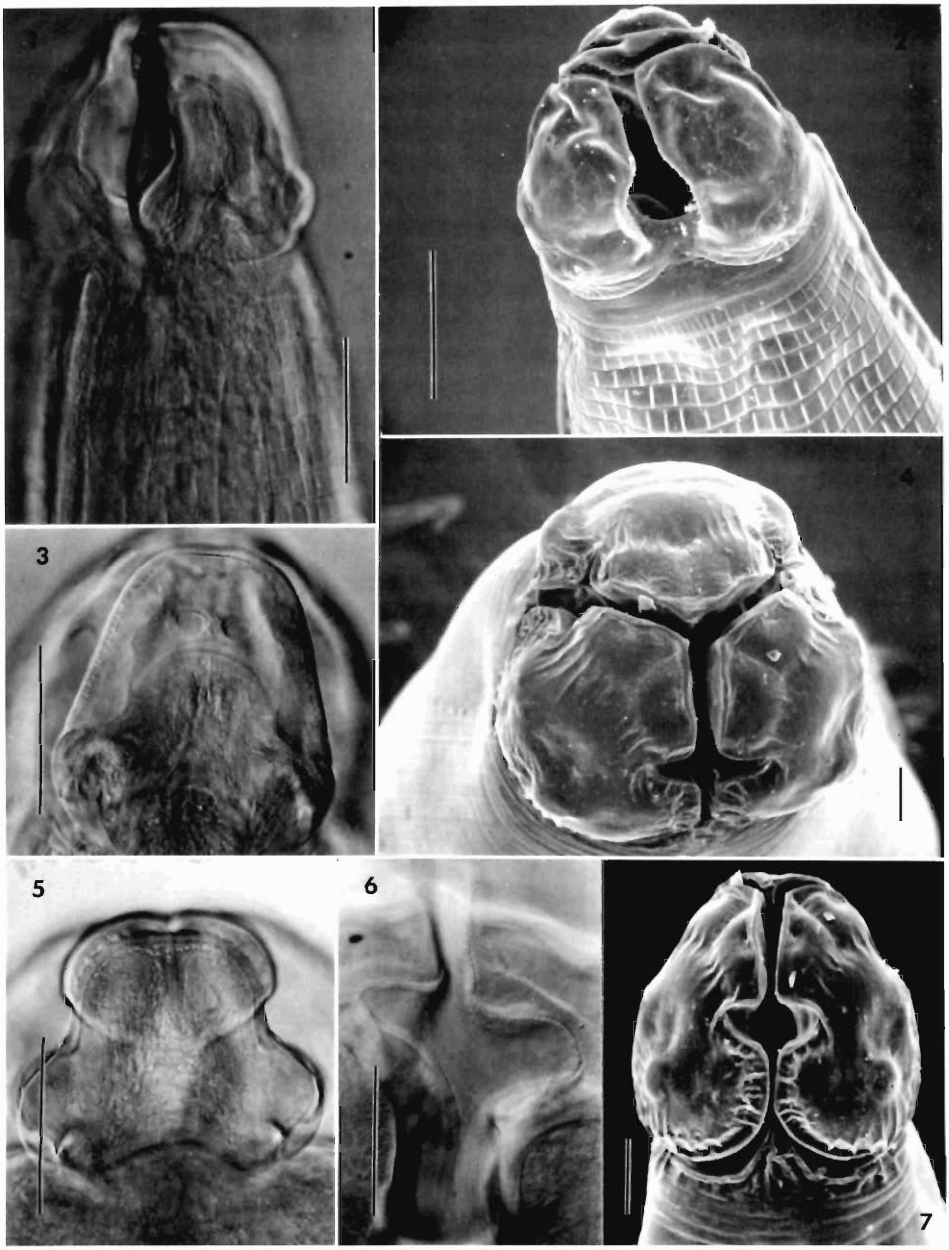
Materials and Methods

About 130 fourth-stage larvae, 1 molting fourth-stage larva, and 35 early fifth stages of *P. equorum*, collected from natural infections of yearling, mixed breed horses in Kansas were available for study. Specimens were kindly provided by Dr. Danny D. Cox of Bayvet Division, Cutter Labs., Inc., Shawnee, Kansas. Other specimens studied were obtained from the U.S. National Parasite Collection. The nematodes were cleared for study in a solution of phenol alcohol (80% melted phenol crystals, 20% absolute alcohol) in temporary wet mounts. Photomicrographs were prepared with the aid of a 35-mm camera mounted on a microscope, equipped with an interference contrast attachment, and with a 35-mm camera mounted on a dissecting microscope. Scanning electron micrographs were prepared according to the methods of Madden and Tromba (1976). In describing the cuticle, the terms striation and annule have been used as defined by Chitwood and Chitwood (1950).

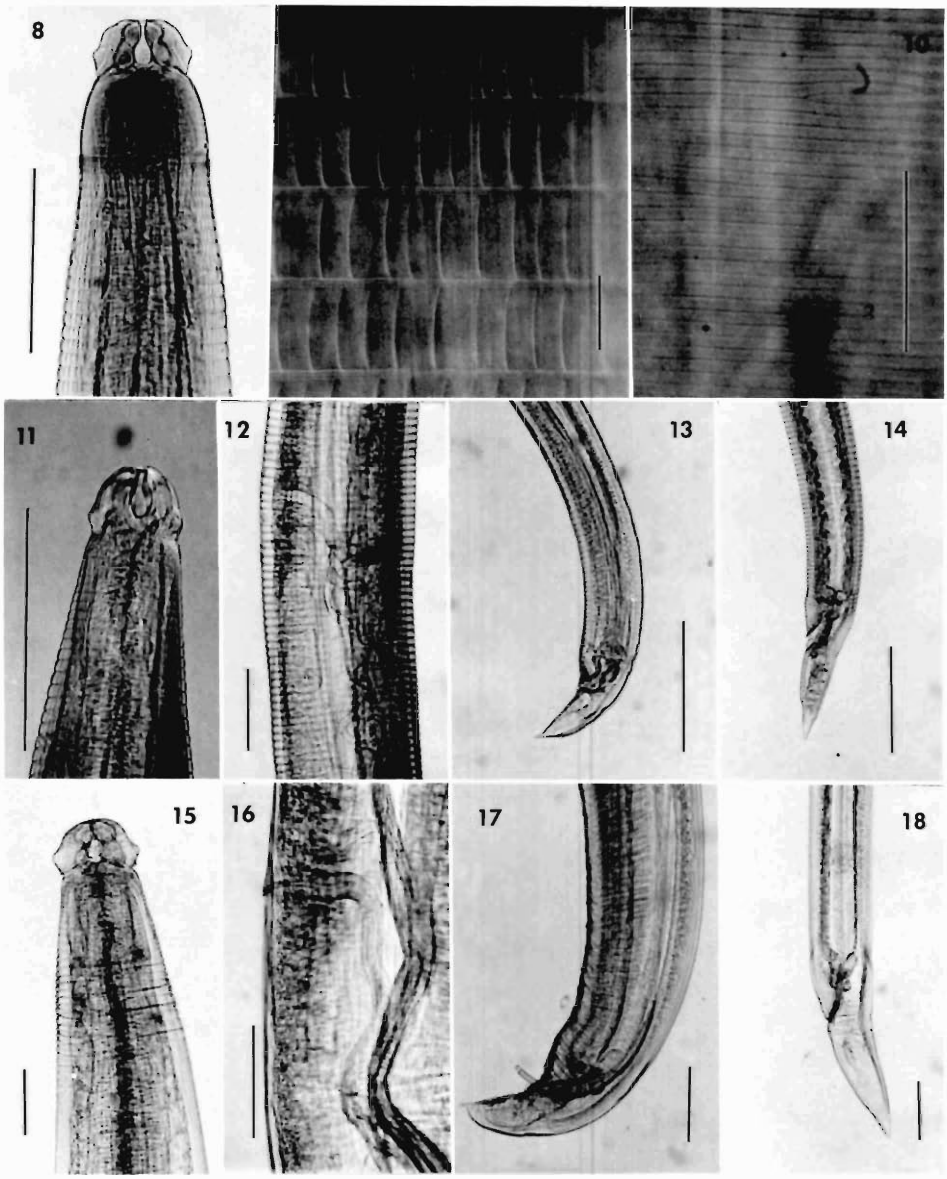
Table 1. Body measurements of fourth-stage larvae, molting fourth-stage larva, and early fifth stages of *Parascaris equorum* collected from natural infections of yearling, mixed breed horses.*

Anatomical feature	Fourth-stage larvae		Molting fourth-stage larva	Early fifth stages	
	Males	Females	Male	Males	Females
Total length	12.60–25.00 (20.00)	10.00–32.00 (22.68)	33.00	39.00–65.00 (54.80)	33.30–85.00 (66.63)
Width (maximum)	0.46– 0.91 (0.71)	0.51– 1.04 (0.78)	0.96	0.95– 1.93 (1.40)	1.13– 2.37 (1.79)
Esophagus†	1.50– 2.70 (2.18)	1.40– 2.90 (2.37)	2.90	3.80– 5.70 (4.90)	3.50– 5.90 (5.05)
Excretory pore†	0.46– 0.75 (0.62)	0.47– 0.79 (0.67)	0.71	0.91– 1.47 (1.17)	0.75– 1.49 (1.33)
Spicule length	—	—	0.42	0.62– 1.37 (1.04)	—
Vulva†	—	4.20–11.90 (8.10)	—	—	11.70–26.70 (21.05)
Tail length	0.27– 0.38 (0.33)	0.37– 0.56 (0.49)	0.38	0.47– 0.71 (0.58)	0.66– 1.29 (1.07)
Width of annule‡	0.034–0.055 (0.045)	0.021–0.063 (0.045)	0.063	0.003–0.005 (0.004)	0.003–0.005 (0.004)

* Ranges (and averages) in mm for 10 specimens except for a molting fourth-stage male in which only a single specimen was available.
† Structures were measured from the anterior end.
‡ Annule was measured in area at base of esophagus.



Figures 1–7. ***Parascaris equorum,*** **photomicrographs of late fourth-stage larvae, molting fourth-stage larva, and early fifth stages, showing labial and cuticular morphology. Scale bars 100 μm. 1. Late fourth stage, cephalic region, showing transverse cuticular striae with incomplete longitudinal ridges, longitudinal ala, and subventral lip denticles. 2. Late fourth stage, similar to Figure 1, scanning electron micrograph (SEM). 3. Late fourth stage, dorsal lip showing large, irregularly spaced denticles. 4. Early fifth stage, *en face* view, SEM, showing shamrocklike lips. 5. Dorsal lip characteristic of fifth stage in the molting fourth-stage male. 6. Early fifth stage, showing small regularly spaced denticles on subventral lip margins. 7. Early fifth stage, same specimen as in Figure 4, subventral view, SEM, showing small interlabia.**



Figures 8–18. *Parascaris equorum,* **photomicrographs of molting fourth-stage larva, late fourth-stage larvae and early fifth stages, continued. Scale bars 500 μm in Figures 8, 11–18; scale bars 50 μm in Figures 9–10. 8. Molting fourth-stage male subventral view, showing anterior end emerged from fourth-stage cuticle. 9. Cuticle (near base of esophagus) of molting fourth-stage male, showing "brickwork" pattern of complete transverse striae with incomplete longitudinal ridges. 10. Cuticle of early fifth-stage male (near base of esophagus) showing fine transverse striae. 11. Late fourth-stage larva, cephalic region, subventral view. 12. Late fourth-stage female larva showing prepatent vulva (vagina and branching uterus) beneath fourth-stage cuticle. 13. Short, ventrally curved tail of late fourth-stage male. 14. Long, straight tail of late fourth-stage female. 15. Early fifth stage, cephalic region, subventral view, showing atypical wrinkling of the cuticle. 16. Early fifth stage, patent vulva. 17. Early fifth stage, male tail. 18. Early fifth stage, female tail.**

Results

Range of measurements (and averages) of fourth-stage larvae, molting fourth-stage larva, and early fifth stages of *P. equorum* are given in Table 1. Specimens have been deposited in the National Parasite Collection as USDA Parasite Collection Nos. 67115, 67116, and 67117 for fourth stage, molting fourth stage, and early fifth stage, respectively.

Fourth-stage larvae (Figs. 1–3, 9, 11–14)

Lips narrow, rectangularly truncate (Fig. 3), not noticeably set off by constriction from rest of body (Fig. 11). Interlabia absent. Longitudinal alae present, extending from base of lips (Figs. 1–2) to phasmidial openings in tail. Denticles on lip margins few, large, widely and irregularly spaced (Fig. 3). Cuticle coarsely transversely striated; annules 0.021–0.063 mm wide, with incomplete longitudinal ridges present on annules; appearing in surface view as a brickwork pattern (Figs. 1, 2, 9).

Molting fourth-stage larva (Figs. 5, 8)

A single male specimen was available for study. The anterior end of the specimen has emerged from the fourth-stage cuticle. Lips are characteristic of the fifth stage and a small part of the body posterior to the lips has the fine striation of the fifth-stage cuticle. The rest of the body is enclosed within the fourth-stage cuticle (Fig. 8).

Early fifth stages (Figs. 4, 6–7, 10, 15–18)

Lips large, shamrocklike (Fig. 4), with deep transverse groove on medial surface (Figs. 4, 6–7); set off from rest of body by deep postlabial constriction (Fig. 15), giving body shouldered appearance. Small interlabia present (Fig. 7). Longitudinal alae absent. Many, small, fine denticles on lip margins (Fig. 6), closely and regularly spaced. Cuticle very finely striated; annules narrow (0.003–0.005 mm) without markings (Fig. 10). In some adult specimens the cuticle may appear wrinkled in various parts of the body. This atypical wrinkling (Fig. 15), possibly due to fixation, should not be confused with the coarse annulation of the fourth stage.

Discussion

The most useful characters for distinguishing late fourth-stage larvae and early fifth stages are the labial and the cuticular morphology. The size and shape of the lips and the size, shape, and spacing of the denticles around the lip margins are markedly different between the stages (Figs. 1–7). The fourth-stage cuticle is marked by longitudinal alae and complete transverse striation; the annules are wide with incomplete longitudinal ridges (Figs. 1, 2, 9) that appear in surface view as a brickwork pattern. Douvres et al. (1969) first used the term "brickwork" in describing the fourth-stage larval cuticle of *A. suum*. The cuticle of the fifth-stage *P. equorum* is finely striated, the annules narrow, without markings (Fig. 10) or alae. Hinz (1963) reported larger specimens (130–220 mm long) to have annules 0.009–0.010 mm wide.

Additional characters for separation of both stages and sexes include the lo-

cation of the vulva, the length and shape of the tail, and the total body lengths (Table 1). The prepatent vulva is slightly anterior to midbody and can be seen beneath the cuticle of the late fourth-stage larva (Fig. 12). The tail of the fourth-stage male larva is short (Fig. 13) and sharply curved ventrally; caudal alae are absent. Developing spicules can be seen in late fourth-stage male larvae. The patent vulva in the fifth-stage female is located in the anterior third of the body (Fig. 16). The tail of the early fifth-stage male (Fig. 17) is shorter than the female (Fig. 18) and is characterized by two spicules of equal length; gubernaculum and caudal alae are absent.

The fourth-stage larvae in the present study were 10 to 32 mm long and probably represent middle and late phases of fourth-stage development. Douvres et al. (1969) reported *A. suum* in an early phase of fourth-stage development to be 1.94 to 2.45 mm long. We have observed no overlap or gap in body length between the stages; however, body lengths can be expected to overlap. Douvres et al. (1969) described nine developmental phases of *A. suum* in swine based on morphological features and noted that total body measurements of late third-stage, third molt, and early fourth-stage larvae frequently overlap; therefore, body lengths are unreliable to separate these developmental stages. The morphological characters presented here permit workers to separate late developmental stages of *P. equorum*. The most useful differentiating characters are the labial and the cuticular morphology.

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Probable Establishment and Overwintering of a Mermithid Nematode Parasite of Mosquitoes in Maryland

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ABSTRACT: During the summer of 1975, a mermithid nematode parasite of mosquitoes, *Romanomermis culicivorax* (*Reesimermi snielseni*), was released into mosquito breeding areas in Maryland, and was found to occur naturally in an additional pond where it parasitized 80% of the mosquito larvae. The results showed that the Louisiana parasite probably established and overwintered in Maryland where the temperatures went down to −19°C in January 1977. It self-perpetuated and killed mosquitoes at a level of 50–100%, even 2 years after treatment. More field releases are needed in Maryland and further north. Discussions with EPA and private industry have made this parasite available on the market as the first nematode biological control agent under the name, "Skeeter Doom." This nematode locates in knots around roots of plants though it does not affect them. It does not parasitize the blackfly, *Simulium vittatum*, though infective stages were swallowed alive by this insect. Preliminary work showed that the nematode seems to be compatible with the insecticides malathion and altocid, but not abate.

Insect-parasitic nematodes, when given adequate temperature and moisture, are known to kill, sterilize, debilitate, and effectively suppress many kinds of insects such as mosquitoes, blackflies, chironomids, and certain agricultural and forest insect pests. A nematode parasite with an aquatic larval stage would have, with its high reproductive capacity, a good chance of becoming an effective biological control agent. Survey for mosquito parasites, done by James Petersen at the ARS, Gulf Coast Mosquito Laboratory, Lake Charles, Louisiana, consistently revealed high parasitism of mosquitoes by mermithid nematodes (Petersen, 1973). These mermithid parasites were identified by the author as four distinct genera and were described or redescribed along with their life cycles (Nickle, 1972). In 1974, a pilot test was attempted to determine if the mosquito mermithid, *Romanomermis culicivorax* (*Reesimermis nielseni* auct., partim.), would establish and overwinter in the northeastern part of the United States. *Romanomermis culicivorax* has been found only in a few ponds in Louisiana and Florida (Savage and Petersen, 1971). Petersen and Willis (1975) were able to successfully release and establish this parasite into several ponds in Louisiana. Other goals of the present research were to see if private industry might be interested in producing this biological insecticide commercially, and to work with EPA on the commercialization of a nematode product for control of larval mosquitoes.

Materials and Methods

Facilities for the mass rearing of 300,000 mosquitoes and 100 g of mermithids per week were set up at the Beltsville Agricultural Research Center using the procedures outlined by Petersen and Willis (1972). This mass rearing facility was productive for 100 continuous weeks. The original *Culex pipiens quinquefasciatus* mosquito colony and *R. culicivorax* cultures were obtained from Dr. J. J. Petersen, ARS, Lake Charles, Louisiana. Field studies were conducted at Beltsville and Ft. Meade, Maryland, mosquito breeding areas.

The parasites were usually released into the mosquito-breeding areas as newly hatched preparasites. I felt it was important to release the parasites several times

during the summer when susceptible mosquitoes were present to allow for establishment of the parasite in the breeding area. It is necessary for the parasites, after leaving their dying hosts, to enter the bottom of the pond in sufficient quantities in order to mate and lay eggs. Sometimes the breeding sites dried out before the mosquito larvae developed far enough to produce a viable postparasite. During this study, we had two 5-inch rains, which would have washed out the experiment if the release had been made just before the heavy rains.

Romanomermis culicivorax has a wide host range of over 60 species of freshwater mosquitoes in several genera. At least 75–100% parasitism of susceptible species of mosquito larvae after release of the parasites at about 1,000/m^2 of mosquito breeding surface can be attained. Percent parasitism is a good indicator of percent kill as all mosquito larvae with nematodes die before pupation. This treatment should not be compared with that of chemical treatment as it is something entirely different because this parasite is a self-perpetuating, biological control agent and should be compared to the release and attempted establishment of other parasites such as braconid wasps. Mosquito identifications were done by Dr. H. C. Chapman, Lake Charles, Louisiana, and the Systematic Entomology Laboratory, Beltsville, Maryland. The results are presented in two sections: those dealing with fieldwork and those experiments done in the laboratory.

Results and Discussion

The mosquito species that were common in the treated ponds were: *Anopheles punctipennis* (Say), *A. crucians* Wied., *Aedes vexans* (Meig.), *Culex restuans* Theob., *C. pipiens* L., and *C. territans* Wlk. All were identified as becoming infected by the nematode treatment except *C. territans*.

Field studies

PUBLICATIONS BUILDING, FT. MEADE, MARYLAND: This release site is a low wet area in a lawn about 30 × 20 m. Mosquito breeding sites consisted mostly of tractor ruts. Often there is 24 cm of stagnant water in each of several ruts (Fig. 1) lined with grass about 45 cm high. Occasionally during the summer this area dried out. The pH of the water was 6.6 at the time of sampling which is within the preferred range for the nematode.

This area was located on September 17, 1974, and a sample of both *Anopheles* and *Culex* mosquitoes was found not to have nematode parasites. Again on May 7, 1975, 20 larvae of both *Anopheles* and *Culex* were dissected and found to be free of nematode parasites. In nine separate releases, from May 29, 1975 till November 11, 1975, I released a total of 3 million infective stage nematodes in these pools (about $30.00 worth of material). On July 31, 1975 the area was dry. Eleven out of 12 *Anopheles* and *Culex* larvae collected on November 11, 1975 were infected by the mosquito mermithid. No nematodes were ever added to this site after November 11, 1975. The temperature went down to −12°C on January 18 and February 2, and went down to −16°C on January 19, 1976. The first mosquito larvae were observed on May 27, 1976, and 30% of the Anophelene and Culicine mosquitoes were parasitized. The area was dry from June 6 to June 16. However, on July 8, 75% of the *Anopheles* larvae were infected and on July 14, 90% of 80 *Anopheles* larvae were infected. The site was dry from August 5 to September 14. On October 1, 63% of 90 *Culex restuans* and 65% of *Anopheles*

Figure 1. Treating larval mosquitoes with preparasites of *R. culicivorax* in one of several ruts in a low area behind the Publication Building, Ft. Meade, Maryland.

were infected. On November 3, 1976 nine of nine larger *Anopheles* were infected and one of three small *Anopheles* was infected. We had the coldest winter in decades in Maryland and recorded temperatures of −18°C on January 13 and −19°C on January 17, 1977. In spite of this, on July 22, 1977 88% of the 32 *Anopheles* collected were parasitized. The next year on August 18, 1978, 30% of the *Anopheles* collected were parasitized. So it appears that this parasite has established and overwintered in this site.

ENTOMOLOGY ROAD WOODLAND POND, BELTSVILLE, MARYLAND: This pond was presampled for mosquito larvae on August 19, 1975, and was found to be

Figure 2. Harmeyer's Pond, at Ft. Meade, Maryland, found to produce a natural mermithid infection of about 80% in mosquito larvae.

free of nematode parasites. It is a circular woodland pond about 65 m in diameter, and about 1 m deep in the center. It has a dense overstory of oaks, maples, and other deciduous trees. The pH of the water was 6.58 at the time of the original sampling which is within the preferred range for the nematode. From August 19 until December 11, 1975, we released 4.7 million infective stage preparasites in seven different releases (about $47.00 worth of material). No parasites were ever added after December 11, 1975. The site experienced a low of −14°C in January of 1976. On June 25, 1976, seven out of 15 *Anopheles* were parasitized. The winter was severe for the area and we experienced −17°C at this site in January. However, on July 26, 1977, 10 of 27 *Anopheles* were parasitized by the mosquito mermithid. Twenty-five percent of the *Anopheles* larvae collected on August 21, 1978 were infected by the nematode so it appears that this parasite has become established in the pond.

CITIZEN'S ASSOCIATION "SKEETER DOOM" AREAS: Following a *Washington* Star article on the mosquito mermithid (Hahn, 1976), where the garden editor suggested a community release of *Skeeter Doom*[1], which is a commercial name for the mosquito mermithid, four local citizens' associations showed an interest in buying some nematodes to release into their mosquito breeding areas. The

[1] Mention of a trademark or proprietary product does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture and does not imply its approval to the exclusion of other products that may also be suitable.

Presley Manor Civic Association bought a case of *Skeeter Doom* via United Parcel Service and released it as a community project. They brought me six small *Culex* larvae a week after they released the parasite and three of the mosquito larvae had the parasite. We gave them an extra 835,000 infective stage nematodes on July 20, 1976. I visited their release areas for the first time on September 28, 1976, and all three areas had parasitized mosquito larvae. The areas were: (1) Park area—80% infected (sample 30); (2) Orbit Lane—30% infected (sample 20); (3) Elvis Lane—50% infected (sample 10).

In summary, these three areas were treated by laymen with material obtained from the Skeeter Doom Company by way of the United Parcel Service. They were successful in obtaining establishment of the parasite in their problem areas.

HARMEYER'S POND, FT. MEADE, MARYLAND—NATURAL INFECTION: Presampling of all treated areas was always made to see if any natural mermithids were present. Only Harmeyer's Pond had a natural mermithid infection as 20 *Romanomermis*-type mermithids emerged from 15 *Anopheles*. These mermithids were cultured for 1 yr and were found to mate with the Louisiana population, indicating it was the same species; however, it did have some biological differences. It parasitized *Culex territans* Wlk., a non-host for the Louisiana mermithid. The pond (Fig. 2), about 4 acres, has many tall dead trees and a grassy edge. The mosquito species commonly found were: *An. crucians, An. punctipennis, Cx. pipiens,* and *Cx. territans*. This area never dried out completely and normally had 1–2 m of water in the deepest spot. Mermithid parasitism averaged 80% (50–90%). It often was difficult to find mosquito larvae in the pond, taking two of us 3 hr to dip 30 mosquito larvae. There were fish and many predaceous insects in the water which had a pH of 6.5 at the time of sampling. We noted that the mermithid parasite in the pond was very tenacious. We had an 18-cm rain during the summer and Harmeyer's Pond, which is near the Little Patuxent River, became part of the flooding river. The water mark on the tree was 2.5 m above normal. However, just 3 weeks after the storm, we collected newly infested mosquito larvae. The low of 50% parasitism was experienced during an extended dry period. This lower percentage was probably caused by the fact that no water (rain) was flooding the banks and edges of the pond to hatch many of the nematode eggs. This pond also revealed another mermithid parasite which I had described from Louisiana (Nickle, 1972). It was *Corethrellonema grandispiculosum* from the chaoborid, *Corethrella brakleyi*.

Laboratory studies

Romanomermis culicivorax was reared for 100 continuous weeks on the southern house mosquito, *Cx. quinquefasciatus*. About 300,000 first instar larvae were challenged each week by 3 million infective stage nematodes and resulted in about 85% parasitism, the 15% escapees were used for the adult mosquito colony. No resistance to the parasite was noted after about 100 generations.

A laboratory study was set up to try to locate where the mermithid nematodes lived in the bottom of a pond using a long aquarium which was sloped. Gravel, water, and plants were added along with 5 g of nematodes in the deep end, at the water-gravel interface, and at the moist gravel end. Six months later the nematodes were found to be located throughout the gravel but concentrated around the roots of plants forming large knots.

An aerated aquarium was set up in the laboratory with a population of about 100 young larvae of *Simulium vittatum* at 25°C. Preparasitic *R. culicivorax* were added to the aquarium periodically. Dissections of the large blackfly larvae showed that dozens of the preparasitic mermithid nemadotes were swallowed alive and were packed in the gut. However, none entered the body cavity through the digestive tract or through the cuticle. Most of the blackflies pupated and became adults. So it appears that *S. vittatum* is not a host of the mosquito mermithid, even though the mermithid can enter the insect through its mouth opening which was considered impossible before this test.

Some preliminary tests were set up to determine whether the mosquito mermithid nematode was compatible with malathion, altocid, and abate. We found that 10 times the concentration of malathion used to kill mosquito larvae had no effect on the mermithids. Also, the mermithid was able to complete its life cycle when subjected to altocid at concentrations recommended for mosquito control. However, preliminary work showed that abate killed the nematodes at the rate used for mosquito control.

Private industry involvement

One of the goals for this pilot project was to try to interest private industry in producing the mosquito mermithid commercially. Fliers were sent out to 20 pesticide producers which had nematologists on their staff. Five showed some interest and requested to be kept informed. Representatives of the Fairfax Biological Laboratory, which makes milky disease of Japanese beetles, visited my laboratory, became interested and is now producing the mosquito nematode mermithid commercially (Nickle, 1976) under the label "Skeeter Doom" at a cost of about $5.00 for a half million parasites. Nutrilite Corporation of California and Sandoz Corporation of Florida also have pilot plants for the possible commercial production of this nematode parasite.

EPA requirements

Discussions with scientists from EPA centered about the idea that mermithids should be treated as parasites and not pesticides. Mermithids are large multicellular organisms which do not vector bacteria or viruses. Mermithids kill the host by making a large hole, like a Hymenopterous parasitoid, which causes the mosquito larvae to lose their essential fluids. Mermithids are also environmentally safe. The EPA recently determined that the *Reesimermis nielseni* mermithid is not a pesticide as determined by the Federal Insecticide, Fungicide, and Rodenticide Act, and is not under their jurisdiction, thus allowing the commercialization of the product.

Acknowledgments

The author wishes to thank Dr. J. J. Petersen, USDA, ARS, Gulf Coast Mosquito Research Laboratory, Lake Charles, Louisiana, for supplying the initial cultures of mermithids and mosquitoes, and I thank Dr. W. Klassen for encouragement throughout the project. I am indebted to Dr. H. C. Chapman and the Systematic Entomology Laboratory, Beltsville Agricultural Research Center, for the mosquito identifications. Mosquito rearing apparatus and techniques were obtained from Dr. E. J. Gerberg, Insect Control and Research, Inc., Baltimore,

Maryland. Technical assistance was provided by Patricia Pilitt, Carol Graham, Brian Feighner, and Robert Bellinger.

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REPORT ON THE BRAYTON H. RANSOM MEMORIAL TRUST FUND

Balance on hand, 1 January, 1978	$4,495.74
Receipts: Interest received in 1978	307.80
	$4,803.54
Disbursements: Grant to Helminthological Society of Washington	$ 10.00
On hand, 31 December, 1978	$4,793.54

A. Morgan Golden
Secretary-Treasurer

Proc. Helminthol. Soc. Wash.
46(1), 1979, pp. 28–35

Redescription and Notes on the Ecology of *Pterygondermatites* (*Multipectines*) *cahirensis* (Jägerskiöld, 1909) Quentin, 1969 (Nematoda:Riculariidae) from West Texas Carnivores

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ABSTRACT: *Pterygondermatites* (*Multipectines*) *cahirensis* is redescribed from specimens collected in coyotes, *Canis latrans*, from the Rolling Plains of Texas. Of numerous other carnivores examined, only nonparous females of *P.* (*M.*) *cahirensis* were collected from the bobcat, *Felis rufus*, in the same locality. The coyote is regarded as the only normal definitive host for this nematode from the study area. *Pterygondermatites* (*M.*) *splendida* and *P.* (*M.*) *affinis* are considered synonyms of *P.* (*M.*) *cahirensis*. Additionally, on the basis of existing descriptions the remaining species of the subgenus cannot be differentiated from this species. The female-male ratio of *P.* (*M.*) *cahirensis* is above unity and positively correlated with the worm burden in the coyote. Attempts to explain the positive association in terms of frequency of occurrence of *P.* (*M.*) *cahirensis* with a sympatric species, *A. caninum*, on a physiological basis indicated that size and biomass of parous females of the former species were not correlated with intensity of infection of *A. caninum*. A likely explanation for this association is the apparently independent preference of both species for younger immunologically tolerant hosts.

Ricularia splendida was described by Hall (1913) from specimens in a coyote, *Canis latrans*, collected in Colorado. This species and *Ricularia affinis* Jägerskiöld, 1909 were considered synonyms of *Ricularia cahirensis* Jägerskiöld, 1909 by Gibbs (1957) after examining specimens from Egyptian foxes, *Vulpes* sp. After comparing these specimens with published descriptions of *R. affinis*, *R. splendida*, and *R. cahirensis* this author could find no valid criteria for differentiating these species. Quentin (1969) reviewed the Ricullariidae and established two genera within the family, *Ricularia* and the new genus *Pterygondermatites*. The species *affinis*, *cahirensis*, *splendida*, and several others from carnivores were placed in the latter genus. A new subgenus, *Multipectines*, was established for these species from mustelids, felids, and canids.

In continuing studies on the ecology of helminth parasitism of carnivores in the Rolling Plains of West Texas, numerous specimens of a commonly occurring (37% prevalence) ricullariid nematode identified as *P.* (*M.*) *cahirensis* were recovered from the coyote and less frequently (3% prevalence) from the bobcat, *Felis rufus* (Stone and Pence, 1978; Pence and Meinzer, In press). In the coyote there was a highly significant positive association in terms of frequency of occurrence between *P.* (*M.*) *cahirensis* and *Ancylostoma caninum*. Also, *P.* (*M.*) *cahirensis* occurred significantly more frequently in younger hosts.

The purpose of this study is to provide a redescription of *P.* (*M.*) *cahirensis*, further establish its systematic affinities and determine certain additional ecological implications regarding the biology of this species. The latter include sex ratios and affinities with its closest ecological equivalent in terms of location, *A. caninum*, in the upper intestine of its normal host, the coyote.

Materials and Methods

The study area, host necropsy procedures and prevalence of helminths have been described elsewhere (Stone and Pence, 1978; Pence and Meinzer, In press).

Nematodes were fixed in glacial acetic acid and stored in a mixture of 5% glycerine in 70% ethyl alcohol. These were later examined in glycerine wet mounts after evaporation of the alcohol. *En face* preparations utilized glycerine-jelly mounts. Figures were prepared with the aid of a Leitz drawing tube. All measurements are in μm unless otherwise indicated. In the following description the means follow in parentheses the range of all measured values. A coefficient of correlation (r) was calculated for intensity of infection (worm burden) and parasite female-male ratios (FMR) for male, female, and combined sexes of the coyote. Significance of r values was obtained for each relationship using t-tests (Sokal and Rohlf, 1969). For determining physiological implications in the sympatric relationships of *P. (M.) cahirensis* and *A. caninum* a coefficient of correlation (r) was determined as above for worm burdens of *A. caninum* and biomass (mean wet weights of fixed nematodes) and size (mean total lengths) of *P. (M.) cahirensis* in concurrent infections of both species. To further determine the relationships of frequency of occurrence and age of coyotes infected with *P. (M.) cahirensis* and *A. caninum,* hosts were divided into age catagories of ½ yr, 1½–2½ yr, 3½–4½ yr, and 5½ yr. A chi-square analysis (Sokal and Rohlf, 1969) was performed to determine if a significant change in prevalence occurred with increase in host age.

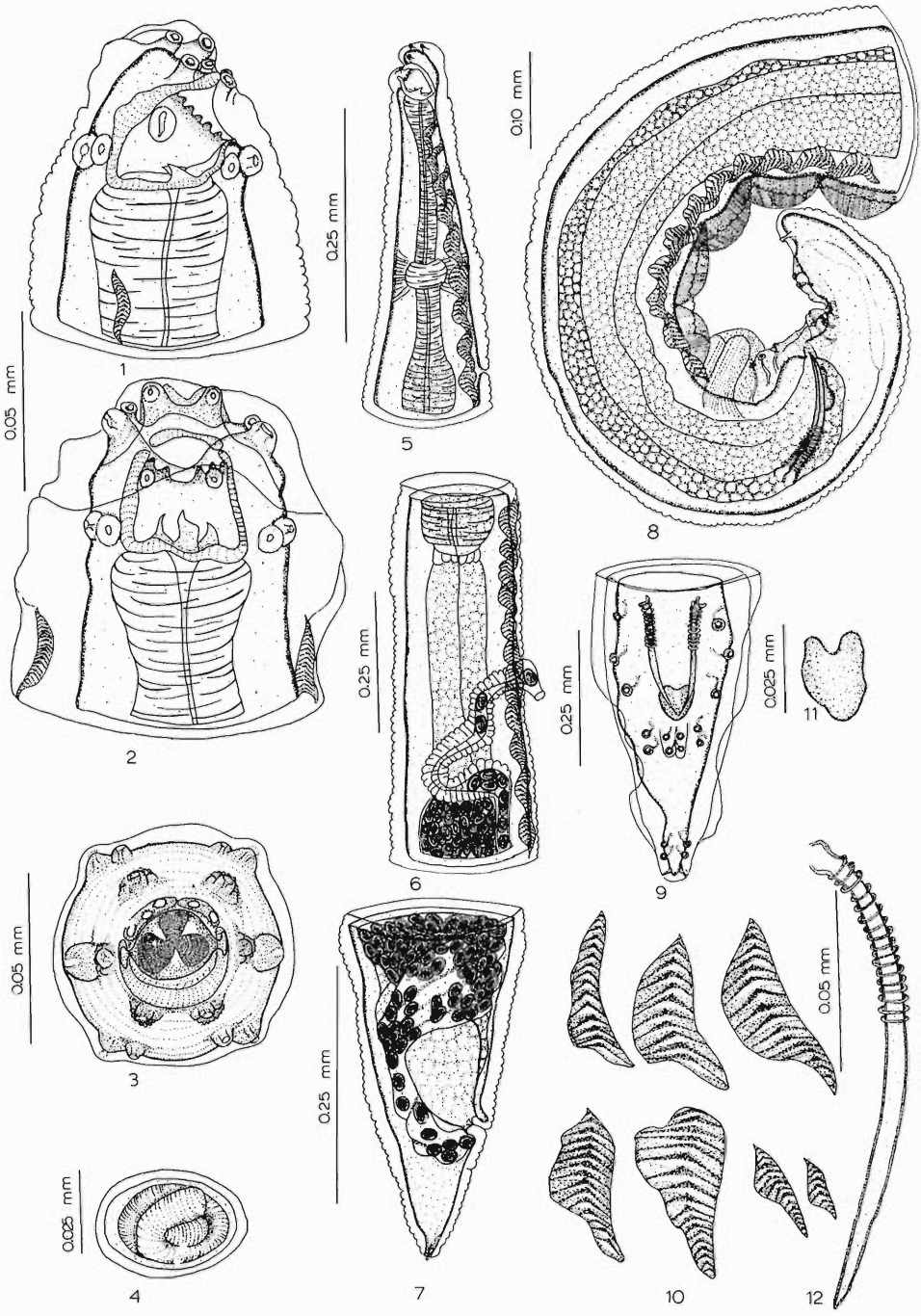
Results

Pterygondermatites (Multipectines) cahirensis (Jägerskiöld, 1909) Quentin, 1969 (Figs. 1–12)

HOST RECORDS: 552 specimens from 55 of 150 coyotes, *Canis latrans,* examined from King, Knox, and Dickens counties, Texas, collected from 1973 to 1977 by D. B. Pence. Three nematodes from 2 of 66 bobcats, *Felis rufus,* examined from Knox Co., Texas, collected in 1975 by J. E. Stone.

DESCRIPTION: Slender, white to pink nematodes, progressively increasing in diameter from anterior to posterior extremity. Mouth dorsal. Buccal capsule well sclerotized, anterior dorsal margin with 5–6 denticles (teeth), anterior ventral margin without denticles, 3 large toothlike sclerotizations at base (Figs. 1, 2, 3). Six small papillae in inner circle, a pair of double ventrolateral and dorsolateral papillae in outer circle, amphids lateral (Fig. 3). Esophagus with anterior muscular and posterior glandular portions (Figs. 5, 6). Excretory pore ventral near anterior end of glandular esophagus (Fig. 5). Nerve ring surrounds midregion of muscular esophagus (Fig. 5). Cuticle with 2 ventrolateral rows of spines extending to near posterior, changing in appearance and morphology from anterior to posterior (Fig. 10). Cuticle with faint transverse striations. A pair of phasmids near tip of posterior extremity (Fig. 9).

MALE (based on 30 specimens from 11 coyotes): 7.88–11.58 (9.64) mm long. 236–375 (314) wide (maximum). Buccal capsule 42–57 (52) long, 12–43 (29) wide (maximum). Muscular esophagus 272–442 (399) long, glandular esophagus 1.52–2.83 (2.19) mm long. Nerve ring and excretory pore 204–412 (308) and 289–453 (398) from anterior extremity, respectively. Cuticular spines increase in size to near level of cloaca, gradually increasing in width from anterior to posterior, 89–115 (105) pairs spines present. Eight cuticular semicircular fans located ventrally



Figures 1–12. ***Pterygondermatites* (*Multipectines*) *cahirensis*** **from West Texas coyotes. 1. Lateral view of male head. 2. Ventral view of male head. 3.** ***En face*** **view of male head. 4. Egg. 5. Anterior extremity of female. 6. Vulvar region of female. 7. Female posterior extremity. 8. Lateral view of male posterior extremity. 9. Ventral view of male posterior extremity. 10. Body spines of female. 11. Gubernaculum. 12. Spicule.**

between ventrolateral rows of spines just anteriad to cloaca (Fig. 8). Small caudal alae present. Cloaca surrounded by 3-lobed fleshy cuticular expansion (Fig. 8). Three preanal pairs, 5–6 postanal pairs pendunculate papillae (Figs. 8, 9). Spicules equal and similar, 170–339 (216) long, 10–15 (12) wide at proximal end, proximal ⅓ of spicules surrounded by 16–18 sclerotized rings (Fig. 12). Gubernaculum well sclerotized, 53–99 (78) long, 14–25 (19) wide (Fig. 11). Posterior extremity coiled, tip of tail blunt, distance from cloaca to caudal extremity 213–380 (270).

FEMALE (based on 32 specimens from 15 coyotes): 11.69–20.46 (16.81) mm long. 324–574 (560) wide (maximum). Buccal capsule 48–74 (60) long, 26–51 (39) wide (maximum). Muscular esophagus 403–596 (488) long, glandular esophagus 2.11–3.73 (3.13) mm long (Fig. 5). Nerve ring and excretory pore 268–427 (321) and 359–544 (468) from anterior extremity, respectively. Cuticular spines increase gradually in size posteriorly to approximately $^{1}/_{11}$ of body length then at $^{7}/_{11}$ gradually decrease in size ending near posterior $^{9}/_{11}$ of body, morphology changing as illustrated (Fig. 10). Total cuticular spines 120–138 (129) pairs, 46–54 (52) prevulvar pairs, 68–89 (79) postvulvar pairs. Vulva often partially extruded, 3.17–4.25 (3.78) mm from anterior extremity, vagina muscular (Fig. 6). Anus 125–335 (202) from caudal extremity. Tail blunt with terminal spine (Fig. 7). Eggs with well developed larvae, 36–43 (40) long, 28–33 (30) wide (maximum) (Fig. 4).

DISPOSITION OF SPECIMENS: 2 ♂♂ and 2 ♀♀ USNM Helm. Coll. No. 73893. Remaining specimens in Medical Zoology Collection, The Museum of Texas Tech University (Nos. 8501–8543).

PATHOLOGY: None apparent.

Taxonomic remarks

Pterygondermatites (*M.*) *cahirensis* is differentiated from other species of the genus by the absence of denticles on the ventral anteriad border of the buccal capsule, pedunculate cloacal papillae in the male, and the number of prevuluar spines in the female. The conclusions of Gibbs (1957) that *P.* (*M.*) *splendida* and *P.* (*M.*) *affinis* are synonyms of *P.* (*M.*) *cahirensis* are substantiated. Male and female taxonomic characteristics of these three species are compared with specimens collected in the present study in Table 1. The range of virtually all metric values of specimens from the coyote overlap those of previously described species. There are no morphological criteria for separation of these species. Additionally, on the basis of existing descriptions the two remaining species placed in the subgenus *Multipectines* by Quentin (1969), *P.* (*M.*) *petrovi* (Sadykhov, 1955) Quentin, 1969, and *P.* (*M.*) *vulpis* (Galli-Valerio, 1932) Quentin, 1969 cannot be adequately differentiated from the above species. Possibly, there is only a single riculariid species, *P.* (*M.*) *cahirensis*, parasitic in carnivores.

Specimens collected from the bobcat in this study consisted of three small ($\bar{X}$ = 10.48 mm long, 228 wide) nonparous females. This suggests that the bobcat may be an unsuitable host for this nematode. It was not collected from numerous other specimens of carnivores (foxes, skunks, badgers, domestic dogs, and cats) in the same area.

Ecological implications

The FMR was determined independently for male, female, and both sexes combined for 41 coyotes of the 55 infected with *P.* (*M.*) *cahirensis* (Table 2). In

Table 1. Comparison of *Pterygondermatites* spp. from carnivores.

	P. affinis Jägerskiöld, 1909	*P. cahirensis*		*P. splendida* Hall, 1913	Present study
		Jägerskiöld, 1909	Gibbs, 1957		
No. pairs pre-vulvar spines	45–46	46–52	45–56	55	46–54 (52 ± 2.28)
No. total pairs spines ♀	124–151	126–135	124–151	136–138	120–138 (130 ± 5)
No. total pairs spines ♂	78–94	90–130	97–113	108–109	89–115 (105 ± 2.05)
Length* spicules	220–230	169	195–230	207	170–339 (216 ± 27)
Length × width* eggs	36–38 × 24–26	39–42 × 26–28	39–46 × 30–35	38–42 × 32–34	36–43 × 28–33 (40 ± 2 × 30 ± 1)
Total† length ♀	13.5–20.5	10.5–13.5	12.4–30.1	8.4–10.6	11.7–20.5 (16.8 ± 2.1)
Total‡ length ♂	7.0–8.5	4.8	9	4.8	7.9–11.6 (9.6 ± 1.0)
No. pre-cloacal fans	6	7	7–9	8	8

* μm.
† mm.

all cases the FMR's were higher than unity. The raw data suggest that the FMR's are higher in light infections, the relative number of male nematodes increasing as intensities of infection increase. The FMR's for the above three catagories are 1:3.40, 1:2.00, and 1:2.25 respectively. The r values were 0.745, 0.758, and 0.751, respectively, between worm burdens and relevant FMR's (Table 2). Calculated t values were highly significant ($P < 0.001$) indicating a correlation between worm burdens and the relevant FMR's. Simply stated, as numbers of total worms increase within the host the relative number of males to female worms increase, thus decreasing the FMR.

To further elucidate the positive species association and sympatric relationship of *P. (M.) cahirensis* and *A. caninum* found in the same region of the coyote small intestine, a correlation coefficient (r) was calculated between size and biomass of parous females from 39 and 36 hosts, respectively, and the concurrent worm burdens of *A. caninum*. The r values for mean length of *P. (M.) cahirensis* versus worm burden of *A. caninum* and mean wet weights of *P. (M.) cahirensis* versus *A. caninum* worm burdens were 0.166 and 0.205, respectively. Calculated t values were 0.9798 and 1.2700, respectively. Both were not significant at $P <$

Table 2. FMR of *Pterygondermatites (M.) cahirensis* in West Texas coyotes.

Host	No. worms ♀	No. worms ♂	FMR	r	t	P
♂ (16)	91	27	1:3.40	0.745	4.170	<0.001
♀ (25)	224	113	1:2.00	0.758	5.560	<0.001
Both sexes (41)	315	140	1:2.25	0.751	7.110	<0.001

Table 3. Comparison of age classes with frequency of occurrence of *A. caninum* and *P. (M.) cahirensis* in West Texas coyotes (N = 104).

Parasite	≤½ yr. (35)	1½–2½ (33)	3½–4½ (24)	≥5½ (12)	Total χ^2	*P*
A. caninum	100	88	83	58	1.8505	>0.01
P. (M.) cahirensis	69	52	25	0	11.6400	<0.01

0.050 indicating no correlation between size or biomass of *P. (M.) cahirensis* and intensity of infection of *A. caninum*.

Although there is a definite trend of decrease in frequency of occurrence (% prevalence) in *A. caninum* with host age from 100% of coyotes ≤6 mo of age to 58% prevalence in animals >5½ yr of age, this decrease is not significant by chi-square analysis ($P > 0.010$, 3 df) (Table 3). In contrast, *P. (M.) cahirensis* varies from 67% prevalence in coyotes ≤6 mo of age to 0% prevalence in animals >5½ yr old. This indicates significantly ($P < 0.010$, 3 df) higher % prevalence in younger animals (Table 3).

Discussion

This study, based on a large series of specimens, substantiates the conclusions of Gibbs (1957) that both *P. (M.) affinis* and *P. (M.) splendida* are synonyms of *P. (M.) cahirensis*. On the basis of existing descriptions and material collected in the present study there is apparently considerable intraspecific variation and a cosmopolitan distribution of this species from numerous species of carnivores.

During the course of this investigation it was noted that female worms were more frequently collected than males. The numerous specimens collected from a large series of hosts provided an opportunity to determine the FMR and its correlation with the worm burden of *P. (M.) cahirensis*. As noted by Roche and Patrzek (1966) in *A. caninum* from dogs, and Singhvi and Johnson (1977) in *Aspiculuris ratti* and *Syphacia muris* from house rats, the FMR is higher than unity. However, there was no correlation between worm burden and the relevant FMR in these studies. The present study indicates a highly significant correlation between worm burdens and the FMR of *P. (M.) cahirensis*. As worm burdens increase the FMR decreases. The data of Roche and Patrzek (1966) suggested similar results, that "roughly speaking, the larger FMR's are often found in infections with a scanty number of worms," but *r* values between total number of worms and FMR were not significant. There is no satisfactory explanation for the correlation between worm burden and FMR in *P. (M.) cahirensis*. Perhaps, as in hookworm infections, there is a positive correlation between age of infection and FMR (Roche and Patrzek, 1966). Also, the explanation for high FMR's in nematode populations is unclear. As suggested by Singhvi and Johnson (1977) a basic shorter life span of the male nematode coupled with certain other unknown factors may account for higher FMR's.

In a study on the ecology of helminth parasitism in the coyote, Pence and Meinzer (In press) found significant positive associations in terms of frequency of occurrence between *P. (M.) cahirensis* and *Physaloptera rara, Mesocestoides corti,* and *A. caninum*. The former two of these relationships were explained in terms of the common utilization of intermediate and paratenic hosts. The latter

relationship between *P.* (*M.*) *cahirensis* and *A. caninum* was more difficult to interpret. The two species occur sympatrically in the upper portions of the small intestine, but do not have similar life histories. Such a relationship could result from (1) ecological implications such as common utilization of paratenic or intermediate hosts or the common occurrence of both species in specific isolated geographic localities related to transmission and/or (2) physiological factors such as age or sex of the host, immunological state of the host, physiological condition or other hereto not understood factors. Since *A. caninum* has a direct life cycle and *P.* (*M.*) *cahirensis* undoubtedly utilizes arthropod intermediate and vertebrate paratenic hosts, and all hosts were collected from the semiarid Rolling Plains of Texas which is noted for ecological uniformity of flora and fauna, there seems to be little evidence for ecological implications influencing the positive association of these two species.

To determine the possible physiological implications of the above association, a coefficient of correlation was computed between the size and biomass of *P.* (*M.*) *cahirensis* and concordant worm burdens of *A. caninum*. A positive correlation would indicate possible intrinsic physiologic compatibility of the two species. No significant correlation was noted.

It was previously noted (Pence and Meinzer, In press) that *A. caninum* occurred more frequently in older (≥2 yr) animals, but that worm burdens were significantly higher in coyotes ≤1 yr of age. If, however, these data are further categorized into age-classes of ≤½, 1½–2½, 3½–4½, and ≥5½ yr there is a decline, though not statistically significant, in prevalence with increased age. A significant decline in prevalence with increasing age was noted in *A. caninum* from Iowa coyotes by Franson et al. (1978). Likewise, *P.* (*M.*) *cahirensis* occurs significantly more frequently in younger animals. These results coupled with the noncorrelation of biomass and size of the riculariids compared to the intensity of *A. caninum* infections indicate the positive association in terms of frequency of occurrence may be a result of both species being better tolerated in younger immunologically tolerant hosts.

Thus, *P.* (*M.*) *cahirensis* appears to be a highly variable, widely distributed species in New and Old World carnivores exhibiting an elevated FMR positively correlated with worm burdens. Ecologically, this species appears to share intermediate and/or paratenic hosts with *P. rara* and *M. corti*. It is sympatric with *A. caninum* in the upper small intestine of coyotes showing a positive association in terms of frequency of occurrence with this species. The only apparent normal definitive host in the Rolling Plains of Texas is the coyote and infections occur significantly more frequently in younger animals.

Acknowledgments

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Editor's Note

Authors submitting manuscripts of a survey or taxonomic nature for publication in the Proceedings of the Helminthological Society of Washington are urged to deposit representative specimens in a recognized depository such as the National Parasite Collection at Beltsville, Maryland and include the accession numbers in the manuscript.

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A Redescription of *Dentostomella translucida* Schulz and Krepkorgorskaja, 1932 (Nematoda: Heteroxynematidae) Parasite of Domestic Mongolian Gerbils, *Meriones unguiculatus* Milne-Edwards

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ABSTRACT: *Dentostomella translucida* Schulz and Krepkorgorskaja, 1932 is redescribed in laboratory Mongolian gerbils, *Meriones unguiculatus* Milne-Edwards in a colony maintained at the University of Missouri, Columbia, Missouri. The nematode parasite is characterized by: a long uterine tube that remains narrow posterior to the level of the vulva, female body configuration long and evenly proportioned, vulva anterior to midbody, spicule tip bifid in ventral view, and five teeth per esophageal sector. *Dentostomella translucida* in Mongolian gerbils shows a different range in size than that in specimens originally described in the great gerbil, *Rhombomys opimus* Lichtenstein collected in Kazakhstan, USSR. In nematodes from Mongolian gerbils, females are 9.6–31 mm long and males are 6.1–13.1 mm long; in nematodes from great gerbils, females are 21.8–40.4 mm long and males are 14.2–18.3 mm long. Additional observations in *D. translucida* include the presence of cervical inflations in the cuticle in both sexes, a pair of papillae on the postanal protuberance in males, and new information on the denticular morphology studied by scanning electron microscopy. Of the five teeth per esophageal sector, the conical, median tooth is the largest and set deep in the buccal cavity; the two perimeter teeth are conical, medium-sized, and not set as deep. The two small teeth, between the large tooth and the perimeter teeth, are short, thin, and set at the anteriormost edge of the buccal cavity.

Dentostomella translucida Schulz and Krepkorgorskaja, 1932 is redescribed in natural infections of laboratory Mongolian gerbils, *Meriones unguiculatus* Milne-Edwards from the Sinclair Comparative Medicine Research Farm, University of Missouri, Columbia, Missouri. The redescription is based on specimens previously reported by Wightman et al. (1978).

Domestic Mongolian gerbils have been used as experimental hosts for a variety of parasitic helminths (Robinson, 1975), and naturally occurring parasitic infections have rarely been reported in domesticated gerbils (Wightman et al., 1978); however, such infections are more frequently reported in wild animals. Schulz and Krepkorgorskaja (1932) first collected and described *D. translucida* in great gerbils, *Rhombomys opimus* Lichtenstein, in Kazakhstan, USSR. Schulz and Landa (1935) and Shleikher and Samsonova (1954) reported *D. translucida* as one of several nematode species most frequently recovered in great gerbils from the plateau and desert regions of Kazakhstan and Uzbekistan, USSR. In 1951, R. E. Kuntz collected two female *Dentostomella* sp. in a Yemen rat, *Myomys fumatus yemeni* Sanborn and Hoogstraal, which were later identified by M. B. Chitwood as *D. translucida* (Chitwood, 1963; Kuntz and Myers, 1968).

Dentostomella belongs to the superfamily Oxyuroidea, family Heteroxynematidae Skrjabin and Shikobalova, 1948 (Skrjabin et al., 1960; Petter and Quentin, 1976). The major characteristics of the Heteroxynematidae are the arrangement of the genital papillae surrounding the cloaca, spicule weakly sclerotized or absent, presence of cervical inflations in both sexes, and cuticular ornamentation

of the male tail anterior to the cloaca in form of curry-combs or a suckerlike organ. Myers (1961) first used the term "fleshy bursa" in describing the male tail of *Dentostomella kuntzi*.

Materials and Methods

Necropsies of 43 Mongolian gerbils in the Sinclair Farm colony showed 39 parasitized by *D. translucida* with recovery of more than 100 nematodes (about 60 females and 40 males). Five additional pet gerbils from a local pet store (Columbia) were also parasitized. The nematodes were first discovered during routine postmortem examinations of two gerbils that died from causes unrelated to parasitism.

Nematodes were cleared for study in temporary wet mounts in a solution of phenol-alcohol. Some males were mounted in lactophenol or evaporated in glycerine to prevent overclearing of the spicules. *En face* views of several specimens were mounted and studied in glycerine jelly. The two female specimens of *D. translucida* from Yemen and the type specimens of *D. kuntzi* Myers, 1961 and *Dentostomella grundmanni* Chitwood, 1963, borrowed from the U.S. National Museum Helminthological Collection, were studied for comparative purposes. Efforts to obtain the type specimens of *D. translucida* from great gerbils of Kazakhstan were unsuccessful. Photomicrographs were prepared with a 35-mm camera mounted on a light microscope equipped with a differential interference contrast attachment. Scanning electron micrographs taken according to the methods of Madden and Tromba (1976) were supplied by Philip A. Madden, Animal Parasitology Institute. Drawings were prepared with the aid of a camera lucida. All measurements are in millimeters; the range is followed by the average in parentheses.

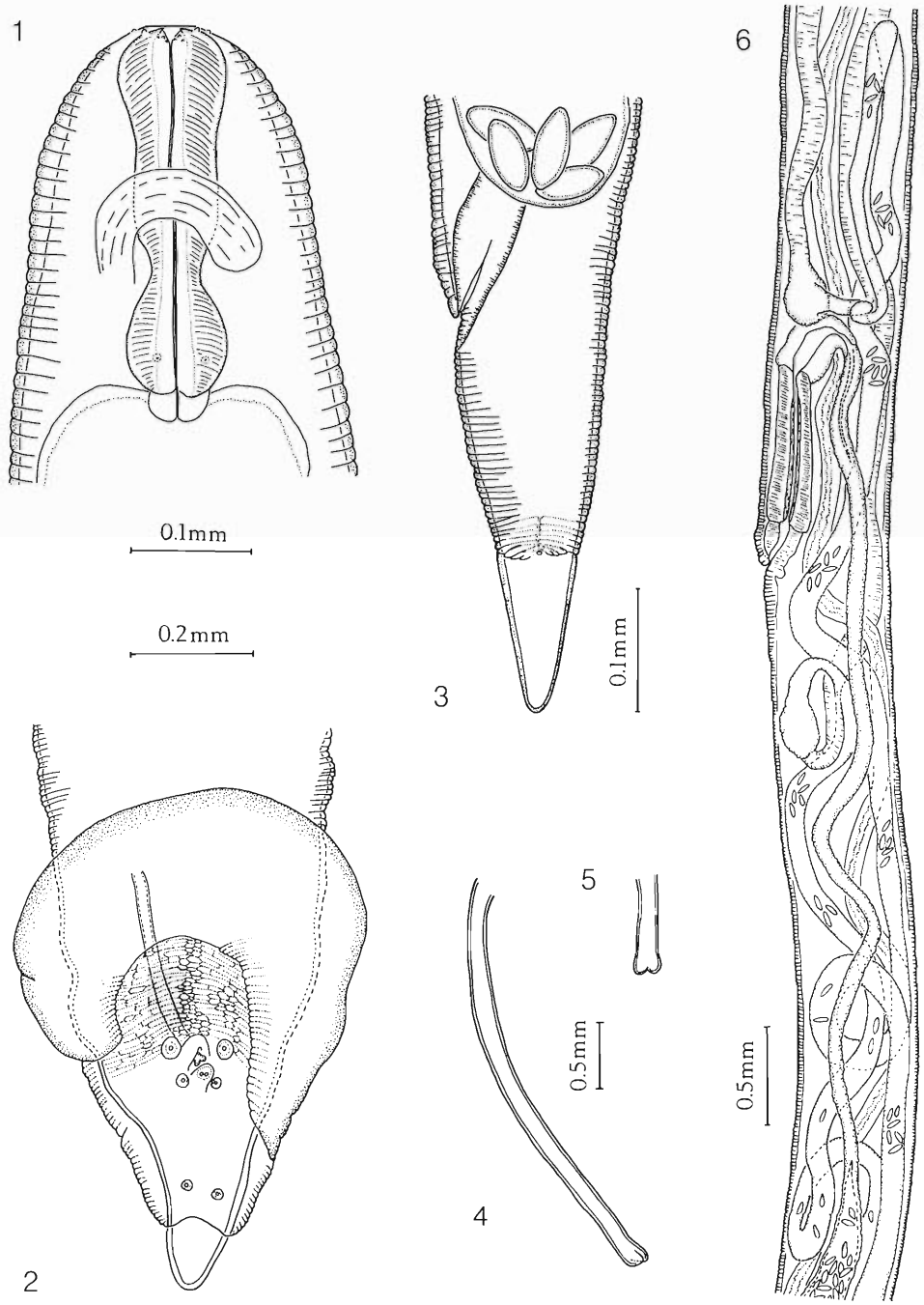
Dentostomella translucida Schulz and Krepkorgorskaja, 1932

Figures 1–15

Redescription

DIAGNOSIS: Heteroxynematidae: Cuticle in both sexes thick, transparent, coarsely transversely striated with fine, sinuous, longitudinal ridges on annules; lateral cervical inflation present in both sexes. Head with 4 small submedian papillae (Fig. 14) and 2 amphids in external circle (6 small papillae of internal circle were not seen in our specimens). Lips absent, buccal cavity shallow with 5 teeth per esophageal sector. Large (median) teeth are thick, conical, and set deep in the buccal cavity; perimeter teeth are also thick, conical, but not set as deep; small teeth, appearing to be connected at their bases, are short, thin, and located at the anteriormost edge of buccal cavity (Fig. 15). Median and perimeter teeth sharply project anteriorly toward oral opening. Esophagus short, thick, muscular, with constriction in area of nerve ring; posterior part bulbar without armament; esophago-intestinal valve present.

FEMALES: (10) Length 9.63–31.00 (20.29), maximum width 0.375–0.996 (0.717). Esophagus 0.344–0.432 (0.377) long; nerve ring 0.176–0.223 (0.193); excretory pore 1.93–4.04 (2.96); and vulva 4.48–12.87 (8.92) from anterior end. Tail conical to bluntly rounded, 0.432–0.714 (0.597) long (Figs. 3, 12). Reproductive system opisthodelphic. Both ovaries anterior to vulva. Two small seminal receptacles lie



Figures 1–6. ***Dentostomella translucida*** **from Mongolian gerbils. 1. Anterior end of male, lateral view, showing cervical inflation. 2. Ventral view of male tail, showing number and arrangement of genital papillae. 3. Lateral view of female tail. 4. Lateral view of spicule. 5. Ventral view of spicule tip. 6. Lateral view of vulva, showing long, narrow uterine tube that widens posteriorly into common egg chamber.**

between ovary and oviduct, one pre- and one postvulva. Vulva transverse slit, anterior to midbody, opening into muscular, thick walled, anteriorly directed vagina vera (Figs. 6, 10). Vagina uterina directed anteriorly in part, reflexes and continues posteriorly as an unpaired uterine tube. Uterine tube long 2.20–4.15 (3.33) and narrow, remaining narrow 1.66–2.99 (2.26) posterior to vulva, where it widens into common egg chamber (Figs. 6, 11). Egg chamber divides into 2 posteriorly directed uteri, 1 uterus turning anteriorly, the other posteriorly directed. Both uteri confined to posterior half of body, posteriorly directed uterus turns forward less than one body width anterior to anus. Eggs oval, asymmetrical 0.097–0.134 (0.116) × 0.040–0.050 (0.044).

MALES: (10) Length 6.14–13.14 (10.29); width 0.374–0.531 (0.455). Esophagus 0.294–0.319 (0.306) long; nerve ring 0.147–0.189 (0.165); and excretory pore 2.41–3.49 (2.29) from anterior end. Tail 0.332–0.457 (0.374) long. Cuticular ornamentation of tail anterior to cloaca in form of fleshy bursa 0.498–0.726 (0.604) long, ending 0.091–0.141 (0.116) from tail tip; bursa without supporting rays, but rugose in appearance due to transverse striae and plaquelike markings of ventral surface (Figs. 2, 8). Spicule single, 0.257–0.323 (0.306) long, weakly sclerotized; tip bluntly rounded in lateral view, bifid in ventral view (Figs. 4, 5, 8). Four pairs of caudal papillae: 1 large adanal pair; 1 pair on postanal protuberance posterior to cloaca, flanked by pair of laterals; and 1 pair asymmetrically arranged 0.113–0.227 (0.169) and 0.160–0.231 (0.181), respectively, from tail tip (Figs. 2, 9).

HOST: *Meriones unguiculatus* Milne-Edwards.

LOCATION: Small intestine.

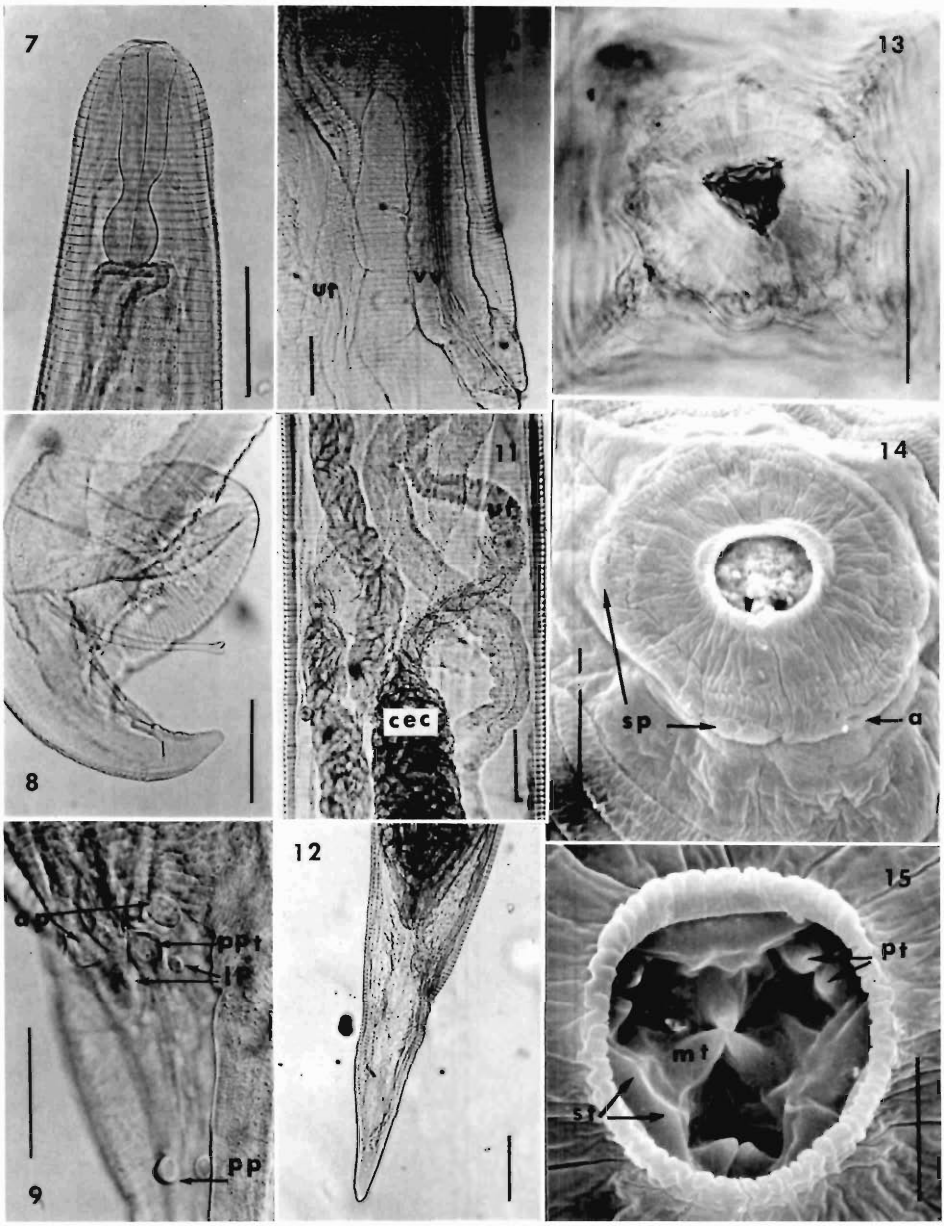
LOCALITY: Sinclair Comparative Medicine Research Farm, University of Missouri, Columbia, Missouri.

SPECIMENS STUDIED: 42 (10 of each sex measured).

SPECIMENS DEPOSITED: National Parasite Collection as USNM Helm. Coll. No. 73915.

Discussion

Morphological differences between *D. translucida* in Mongolian gerbils and in the great gerbil have been observed. New findings include the presence of small lateral cervical inflations of the cuticle in both sexes, a pair of papillae on the postanal protuberance, specimens slightly smaller than previously described, and new information on the morphology of the esophageal teeth. Although Schulz and Krepkorgorskaja (1932) did not include a cephalic inflation in their illustration of the female, specimens in the Mongolian gerbils have lateral cervical inflations of the cuticle that are small and narrow in both sexes (Figs. 1, 7). The two female specimens collected by Dr. R. E. Kuntz in Yemen and identified as *D. translucida* also have lateral cervical inflations. Posterior to the cloaca, males of *D. translucida* have a large unpaired protuberance that bears a *pair* of papillae (Figs. 2, 9) that are probably characteristic of the genus and are also present in *D. grundmanni*. Schulz and Krepkorgorskaja (1932) described only a single papilla on this protuberance. The tip of the spicule is blunt in lateral view (Fig. 4) and bifid in ventral view (Fig. 5), closely resembling the original illustration. No sensory endings are present on the circumanal ridge of *D. translucida* as reported for *D. kuntzi* by Myers (1961). Although the morphometric data of *D. translucida* from Mongolian gerbils are larger than data reported for the other two species in the



Figures 7–15. Photomicrographs of *Dentostomella translucida* from Mongolian gerbils. Figs. 7, 8, 10–12: scale bars 0.2 mm; Fig. 9: scale bar 0.1 mm. 7. Anterior end of male, lateral view. 8. Lateral view of male tail. 9. Part of male tail, ventral view, showing large adanal papillae (ap), single postanal protuberance, bearing a pair of papillae (ppt), lateral papillae (lp), and third pair of postanal papillae (pp). 10. Vulva, vagina vera (vv), vagina uterina (vu), and proximal part of the uterine tube (ut) of female, lateral view. 11. Distal part of uterine tube (ut) where it widens into the common egg chamber (cec). 12. Lateral view of female tail, showing egg-filled uterus just anterior to the rectum. Figs. 13–15: scale bars 0.1 mm. 13. *En face* view of female, showing 3 of the 5 esophageal teeth per sector. 14. Scanning electron micrograph (SEM) of head, showing the 4 submedian papillae (sp), an amphid (a), and the oral opening. 15. SEM of the oral opening, showing median teeth (mt), perimeter teeth (pt), and small teeth (st).

genus, some females are slightly smaller in total length (9.6–31.0 mm) but otherwise fall within the range (21.8–40.4 mm) reported for females from the great gerbil. Some body structures of females from Mongolian gerbils are proportionately shorter (esophagus = 0.334–0.432 mm; vulva = 9.80–17.30 mm from anterior end) than these structures in nematodes from the great gerbil. Male *D. translucida* from Mongolian gerbils are smaller in all morphometric data (length = 6.14–13.14 mm) than are males from the great gerbil (length = 14.2–18.3 mm).

The arrangement of the esophageal teeth is similar to that in original description and can be characterized by size, shape, and depth of location in the buccal cavity. Five teeth per esophageal sector are present, only three of which are distinct in light microscopy (Fig. 13); the median tooth is the largest (open stoma). In scanning microscopy, the three large teeth converge in the center of the oral opening (closed stoma); six medium-sized perimeter teeth are present at the edges of the esophageal sectors; and two small teeth are present between the large and the perimeter teeth (Fig. 15).

Dentostomella translucida can be separated from the other two species in the genus, *D. kuntzi* and *D. grundmanni,* by: width and length of proximal part of the uterine tube, body configuration of females, location of the vulva, and size of the cervical inflations. The uterine tube in *D. translucida* from Mongolian gerbils remains narrow about 2.26 mm posterior to the vulva before widening into the common egg chamber (Figs. 6, 11). Schulz and Krepkorgorskaja (1932) did not give the length of the uterine tube in nematodes from great gerbils but illustrated the tube remaining narrow about 3.5 mm posterior to the vulva. The uterine tube in *D. kuntzi* is narrow just to the level of the vulva in *D. grundmanni* widens immediately into the common egg chamber. The body configuration of females of *D. translucida* is long and evenly proportioned; females of *D. kuntzi* are very slender. The vulva of these two species is anterior to midbody; whereas, in females of *D. grundmanni,* the body is stout in the postvulvar region, and the vulva is posterior to midbody. The cervical inflations are small and narrow in *D. translucida,* are limited to small inflated areas in *D. grundmanni,* and are greatly enlarged in *D. kuntzi.* Although *D. translucida* was originally reported in the large intestine of the great gerbil, Shleikher and Samsonova (1954) later reported finding the species in the stomach, small and large intestine of great gerbils; the number of parasites per animal ranged from one to 17, and females outnumbered males. The *D. translucida* in Mongolian gerbils were most often found in the anterior one-third of the small intestine; the number of parasites per animal ranged from one to 11, with a mean parasite load of five, and females outnumbered males (Wightman et al., 1978). Myers (1961) described *D. kuntzi* as a parasite in the large intestine of two species of spiny mice, *Acomys russatus* (Wagner) and *Acomys cahirinus* (Desmarest), collected in Egypt. *Dentostomella kuntzi* has also been reported in other rodents: *Gerbillus campestris* Levaillant, *Rattus rattus* (L.), *Mus musculus* L. by Myers et al. (1962), *Rattus rattus alexandrinus* (E. Geoffroy St. Hilaire), and *Rattus rattus frugivorus* (Rafinesque) by Rifaat et al. (1969). Chitwood (1963) reported *D. grundmanni* as an intestinal parasite of the western chipmunk, *Eutamias quadrivittatus* (Say), in Utah.

According to the descriptions, *D. translucida* can also be separated from the other two species by the tip of the spicule and by the number of teeth per esophageal sector. *Dentostomella translucida* has five teeth per sector, and the spicule

tip is bifid in ventral view. The shape of the spicule tip and the number of teeth cannot be confirmed in *D. kuntzi* or in *D. grundmanni* because the number of specimens available for study is limited. Type specimens include two males of *D. kuntzi* and three males of *D. grundmanni*. Only one *D. grundmanni* male has a spicule that has not been destroyed by clearing; the spicule in the other two males disappeared with clearing in phenol-alcohol (M. B. Chitwood, personal communication). The spicule in some *D. translucida* males also disappeared when cleared in phenol-alcohol. Subsequent specimens were cleared in either lactophenol or glycerine. The number of teeth in *D. kuntzi* and *D. grundmanni,* studied by us in lateral view whole mounts, appears to be as originally described; however, because of the lack of sufficient specimens, these two species have not as yet been studied by *en face* views or by scanning microscopy. Separation of species on the basis of spicule tip and number of teeth will have to await the availability of additional specimens.

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Vertical Migration by Nematode Larvae of Cattle Parasites Through Soil

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ABSTRACT: Cattle feces containing *Ostertagia ostertagi* eggs were buried at varying depths in a swine pasture. Herbage samples taken weekly above the buried feces revealed that *O. ostertagi* larvae can migrate at least 12.5 cm vertically through the soil. In the laboratory, *O. ostertagi* larvae migrated 15 cm vertically through soil in glass tubing whereas *Cooperia* spp. migrated up to 25 cm.

The life cycle of most nematode parasites of grazing animals involves the migration of infective larvae onto vegetation when temperature and moisture conditions are favorable. Vertical migration of the infective larvae of these parasites has been documented (Michel, 1969; Croll, 1972), but results were usually obtained from feces deposited on pasture. In the southeastern United States, cattle feces may remain on pasture surfaces for several months because the native dung beetle population has not increased in the same proportion as livestock and feces. However, in countries that have greater numbers of endemic species of grazing animals, many species of dung beetles have evolved that are capable of burying the feces of native and introduced livestock within a few days after deposition. Feces remaining on the surface of pastures serve as reservoirs for parasite larvae and as breeding media for pest flies.

The effectiveness of dung beetles as biological control agents for gastrointestinal parasites of livestock (Bryan, 1973; Fincher, 1973, 1975) and for insect pests that breed in livestock feces (Bornemissza, 1970; Blume et al., 1973) has been shown. However, some reports indicate that parasite larvae migrate onto vegetation from feces buried by dung beetles (Bryan, 1973; Fincher, 1973). The depth that feces are buried is dependent upon the species of dung beetle involved. Some beetles bury feces only a few centimeters below the soil surface whereas other species may bury them 1 m deep.

Foreign species of dung beetles that are capable of rapid burial of feces are currently being introduced to aid native beetles in disposing of livestock feces before it dries on pasture. The purpose of this study was to determine the distance parasite larvae migrate upward through soil. These data would be valuable in selecting for introduction into this country species of dung beetles that will hinder rather than enhance parasite transmission to grazing animals.

Materials and Methods

Cattle feces, averaging 214 *Ostertagia ostertagi* eggs/g, were weighed into 1,000-g pats and placed 2.5, 5.0, 7.5, 10.0, 12.5, 15.0, 20.0, and 30.0 cm below the surface of a swine pasture with a Tifton sandy loam type soil. Each treatment was replicated once. The pasture had not been used in 5 yr and was considered free of cattle parasites. Vegetation consisted of about 80% common Bermuda

[1] In cooperation with the University of Georgia, College of Agriculture Experiment Stations, Coastal Plain Station, Tifton, Georgia 31794.

Table 1. Average number of *Ostertagia ostertagi* larvae from herbage samples above feces buried at varying depths in a swine pasture.

Weeks after burial	Depth (cm) of feces below the soil surface							
	2.5	5	7.5	10	12.5	15	20	30
2	5.0	0.0	0.0	0.0	0.0	0	0	0
4	10.5	3.0	13.5	49.0	1.5	0	0	0
6	28.5	89.0	14.5	23.5	10.0	0	0	0
8	3.5	0.5	0.0	8.5	1.5	0	0	0
10*	0.0	1.0	0.0	0.0	0.0	0	0	0

* No larvae were recovered after the 10th week, although samples were examined on weeks 12, 14, and 16.

grass *(Cynodon dactylon),* and the other 20% was large crabgrass *(Digitaria sanguinalis),* yellow woodsorrel *(Oxalis stricta),* and a few other grasses and herbs. The grass was about 6 cm tall when the test began.

Circular holes 14 cm in diameter were dug with a posthole digger to depths allowing the desired measurements from the top of the feces to the soil surface. The top 2–3 cm of soil (the grass sod) was removed intact and replaced after the feces were added. Care was taken to avoid contaminating the soil above the desired burial depth with feces. After the feces were placed in the holes, soil was added, and the grass sod was replaced to approximate the undisturbed environment. Loose soil was then gently packed around the replaced sod. The holes were 50 cm apart and arranged in two parallel rows 45 cm apart. A small wooden stake was placed 25 cm from the center of each hole to mark the position of the buried feces.

Herbage samples, including the matting, were taken from above the buried feces at 2-week intervals for 16 weeks. Each sample area was pie-shaped and equalled 25% of the area above the buried feces and included an area extending 7.5 cm beyond the outer rim of the replaced grass sod. Samples were taken between 8 and 9 A.M. while dew was present and Baermannized in funnels 24 cm in diameter for 4 hr at room temperature. Twenty milliliters of water was then taken from the bottom of each funnel and examined for nematode parasites under a dissecting microscope. Precipitation on the pasture during the experiment was approximately 37 cm.

The second part of the experiment was performed in the laboratory; glass tubing with an inside diameter of 1 cm was used. Two grams of cattle feces averaging 1,458 worm eggs/g were placed in one end of a series of glass tubing that was cut to allow a depth of 0.0, 2.5, 5.0, 7.5, 10.0, 12.5, 15.0, and 25.0 cm of soil above the feces plus an additional distance of 1 cm for insertion of a cotton plug. The eggs were 90% *Cooperia* spp. *(Cooperia oncophora, Cooperia pectinata,* and *Cooperia punctata),* and the other 10% was a mixture of *O. ostertagi* and *Haemonchus placei.* The space above the feces in the tubes was then filled with dry Tifton sandy loam soil that had been sifted through a 40-mesh sieve (15 squares/cm) to within 1 cm of the top. Each treatment was replicated 9 times. Water was added, drop by drop, to the soil until moisture was noted throughout the tube. A small plug of cotton was placed in each tube in contact with the soil (or feces) and moistened with six drops of water. The tubes were then arranged upright in rows in moist, sterile soil in a 40 × 40 × 10-cm metal container. Ten

Table 2. Average number of nematode larvae migrating up through soil in glass tubes to cotton plugs.*

Weeks after burial	Depth (cm) of feces below soil surface							
	0.0	2.5	5.0	7.5	10.0	12.5	15.0	25.0
1	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	3.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0
3	34.1	1.9	0.8	0.1	0.0	0.0	0.0	0.0
4	20.8	1.8	1.5	0.1	0.1	0.4	0.0	0.0
5	4.9	0.9	1.8	0.2	0.1	1.3	0.4	0.0
6	1.3	0.9	1.2	0.4	0.0	0.2	0.3	0.0
7	0.3	1.4	0.0	1.5	1.6	0.0	0.2	0.1
8	0.0	0.0	0.0	0.9	0.8	0.0	0.0	0.2
9	0.0	0.0	0.1	0.2	0.4	0.0	0.3	0.0
10	0.0	0.0	0.0	0.3	0.2	0.1	0.0	0.0
11–19	0.0	0.1	0.0	0.1†	0.2‡	0.0	0.4§	0.0

* Nematode species were *Cooperia pectinata*, *Cooperia punctata*, and *Ostertagia ostertagi*.
† Larvae recovered on 15th week only
‡ Equal number of larvae recovered on 14th and 15th weeks.
§ 0.2, 0.1, and 0.1 average number of larvae recovered on 12th, 13th, and 17th weeks, respectively.

holes, slightly larger than the diameter of the tubing, and separated by a distance of 2.5 cm, were made in rows 2.5 cm apart in the moist soil. Tubes containing feces with the same treatment were then inserted in each row, and the soil was gently packed at the base of each tube to provide necessary upright support.

The container with the glass tubes was maintained without light in an environmental chamber at a constant temperature of 27°C and relative humidity of approximately 95%. Each week, for 19 weeks, the container was removed from the chamber, and the cotton plugs were Baermannized in funnels 10 cm in diameter for 2 hr at room temperature. New cotton plugs were immediately placed in each tube when the old plugs were removed and were moistened with six drops of water, and the container was returned to the chamber. Approximately 20 ml of water was added weekly to the soil in the container to compensate for moisture loss. After 20 weeks, the soil in the metal container was Baermannized in layers of 3 cm each.

Results and Discussion

Recovery of larvae from feces buried in the swine pasture is shown in Table 1. No larvae were recovered after 10 weeks or from feces buried below 12.5 cm. Results of larvae migrating in the glass tubes are shown in Table 2. No larvae were recovered after 17 weeks. Larvae were recovered from all depths in the tubes, and the number recovered was inversely proportional to the distance of migration. Larvae from the 25.0-cm level in the tubes migrated twice as far as larvae in the pasture experiment although different species were involved. However, in the tubes, larvae were found in only two of the 10 replicas with 25.0 cm of soil; they were found in nine of the 10 replicas with 15.0 cm of soil and 10 of the 10 replicas in the other soil levels. Migration of larvae may have been aided by the constant film of moisture in the tubes.

Larvae recovered from the swine pasture were *O. ostertagi* whereas most larvae recovered from the glass tubes were *Cooperia* spp. (*C. pectinata* and *C.*

punctata). Cooperia larvae migrated the maximum 25 cm distance used in the tubes whereas *O. ostertagi* migrated only 15 cm. No *C. oncophora* or *H. placei* larvae were recovered from the cotton plugs. The top 3 cm of soil from the metal container yielded 15 *Cooperia* larvae, the middle 3 cm yielded one *O. ostertagi* and one *H. placei* larvae, and the bottom 3 cm yielded one *Cooperia* and one *O. ostertagi* larvae. Again, no *C. oncophora* larvae were recovered. The soil and feces in the tubes were negative when Baermannized.

Dung beetles can be separated into three groups according to how they provide nests for their young. The better known group is the "tumble-bug" group that forms fecal balls that are rolled away from the fecal deposit and buried a few centimeters below the soil surface. A second group of dung beetles buries feces under or beside fecal deposits. Such "dung-burying" beetles pack a mass of feces inside a burrow or form a brood ball inside an underground chamber at depths of a few centimeters to 1 m below the soil surface. Sometimes, the ball of feces is coated with a protective clay shell. A third group of dung beetles does not bury feces but completes its life cycle in fecal deposits.

Bryan (1973) stated that nematode larvae leave buried feces and migrate into the soil at random. A clay shell on a brood ball would hinder the migration of parasite larvae from the enclosed feces. The burial of coated brood balls approximately 1 m below the soil surface by beetles similar to *Phanaeus vindex* (Fincher, 1972), would effectively prevent migration of nematode larvae to the pasture surface. The "tumble-bug" group of dung beetles might actually disseminate eggs and larvae on pasture while rolling fecal balls. Feces buried only a few centimeters below the soil surface could enhance survival of the larval stages of parasites during adverse weather conditions. Soil organisms such as earthworms and other soil inhabiting insects may also affect the migration of nematode parasites from buried feces.

Overall, the data indicate that on pastures with Tifton sandy loam soil, cattle feces containing eggs of the most common species of nematode parasites in the southeast should be buried at least 15 cm below the soil surface to prevent larval migration to the pasture surface.

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46(1), 1979, pp. 47–51

Lissorchis kritskyi sp. n. (Digenea: Lissorchiidae) from the River Carpsucker, *Carpiodes carpio* (Rafinesque)

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ABSTRACT: *Lissorchis kritskyi* sp. n. is described from the intestine of *Carpiodes carpio* in the Des Moines River, Iowa. The new species is most similar to *L. simeri*, but differs in having a short posttesticular body space and smaller eggs. It differs from *L. fairporti*, *L. gullaris*, *L. polylobatum*, *L. crassicrurum*, and *L. heterorchis* by its uniformly trilobed ovary; and from *L. translucens*, *L. attenuatum*, *L. hypentelii*, and *L. garriki* by presence of a bipartite seminal vesicle with the distal portion smaller than the proximal. Unlike *L. mutabile* it has a protrusible cirrus and has no vas deferens.

In the course of a survey of the helminth parasites of Iowa fishes (Barnhart et al., 1976) several specimens of river carpsucker from the Des Moines River were examined. Numerous specimens of a new species of the genus *Lissorchis* were recovered from the intestines, in infections ranging from three to 25 worms per fish. The trematodes were fixed with ethanol-formalin-acetic acid under slight cover glass pressure and stained with Semichon's acetocarmine; some specimens were counterstained with fast green to accent surface features. Figures were drawn with the aid of a camera lucida and microprojector. All measurements are given in micrometers unless otherwise stated. Dimensions of organs are stated as length by width.

Lissorchis kritskyi sp. n.

Type host: *Carpiodes carpio* (Rafinesque).

Type locality: Des Moines River in Polk and Boone Counties, Iowa.

Location in host: Intestine.

Type specimens: Holotype USNM Helm. Coll. No. 74870; paratypes USNM Helm. Coll. Nos. 74871 and 74872.

Description: Measurements based on 25 mature specimens. Body elongate, tapering at both ends, 1.12 mm (0.68–1.58 mm) by 0.37 mm (0.24–0.50 mm), widest at level of acetabulum. Spines less than 7.2 present on ventral surface from acetabulum to posterior end, and around oral sucker; absent on margins, dorsally or between oral sucker and acetabulum ventrally. Oral sucker slightly subterminal, 192 (130–245) by 226 (170–300). Prepharynx short; pharynx muscular, 90 (62–125) by 82 (50–145). Esophagus 102 (48–190) long, ceca bifurcating anterior to acetabulum, extending posteriorly to posteriormost 10–15% of body. Acetabulum 294 (180–390) by 293 (180–385), in anterior ½ of body. Testes tandem, often irregular in outline, in posterior ½ of body; anterior testis 265 (150–415) by 187 (150–285); posterior testis larger and slightly overlapping anterior testis, 328 (205–450) by 171 (105–300). Cirrus sac oblique, 286 (175–485) by 95 (48–130), opening near left body margin at midlevel of acetabulum. Cirrus bulbous, tapering distally when protruded; armed with very minute spines. Seminal vesicle bipartite with distal portion about ⅓ as large as proximal. Prostatic gland

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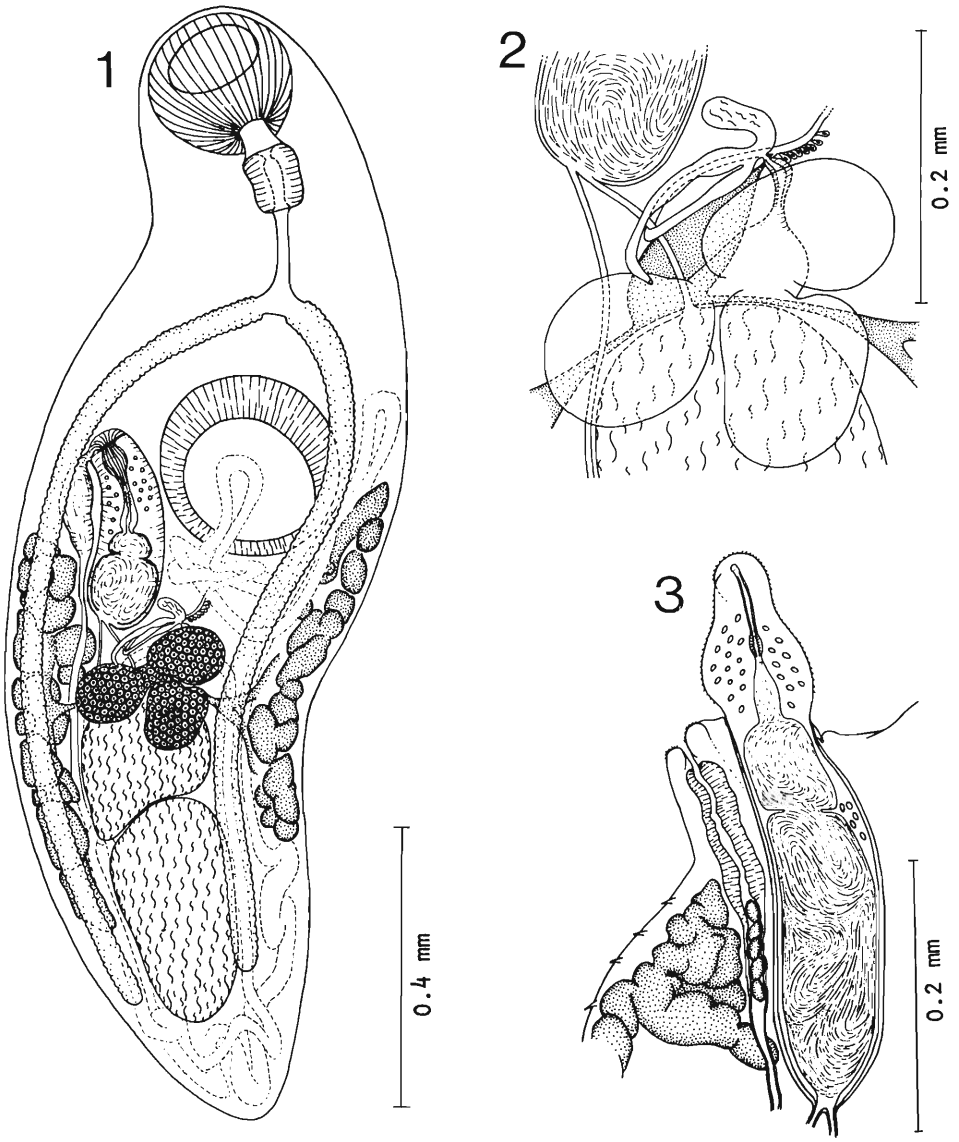

Figures 1–3. ***Lissorchis kritskyi*** **sp. n. 1. Dorsal view of holotype. 2. Female genital complex, dorsal view showing arrangement of ovary, oviduct, vitelline reservoir, Mehlis' gland, seminal receptacle, and Laurer's canal. 3. Terminal genitalia showing metraterm and protruded cirrus.**

cells numerous in anterior ½ of cirrus sac. Vasa efferentia discharge directly into seminal vesicle. Vas deferens absent. Posttesticular body space slightly less than 10% of body length. Ovary 216 (160–295) by 205 (160–250), trilobate with lobes of equal size, lobes attached to a central portion which gives rise to an oviduct. Oviduct passes just anterior to ovary, where joined by seminal receptacle and Laurer's canal, extending left, loops around the right vas efferens and returns right past seminal receptacle; at this point it is joined by the vitelline duct. Laurer's canal prominent, extending left and opening dorsally above anterior

margin of ovary. Mehlis' gland cells not numerous (in holotype apparent on only 1 side of oviduct). Uterus makes several loops before descending on right side to posterior end where it coils, usually with 1 loop ascending a short distance on left side, returning anteriorly on right and crosses left anterior to the ovary, then loops posteriorly on left before ending in a muscular metraterm posterosinistral to cirrus sac. Vitelline glands follicular, broadly interconnected, extending approximately from midlevel of acetabulum to midlevel of posterior testis. Lateral vitelline ducts join in vitelline reservoir which lies ventral to the ovary. Mature uterine eggs amber, 16.0 (14.4–18.0) by 9.1 (8.4–10.8). Excretory pore terminal on posterior end. Excretory bladder tubular, extending anteriorly to level of anterior testis.

Discussion

Haderlie (1950) reviewed the early literature concerning the genera *Lissorchis* Magath, 1917 and *Triganodistomum* Simer, 1929. Smith (1968) compared the two genera and concluded that they were synonymous. We follow this conclusion, as did Krygier and Macy (1969) and consider *Triganodistomum* to be a synonym of *Lissorchis*.

Kritsky et al. (1972) reported *Lissorchis* sp. from river carpsucker taken in the Missouri River in North and South Dakota. They considered their specimens to represent at least two species, but found the material inadequate for descriptive purposes. Examination of these specimens showed that most of them can be assigned to *L. kritskyi,* which is named in recognition of Dr. Kritsky's contributions to helminthology.

Some distinctive features of *L. kritskyi* appear to be the looping of the oviduct around the right vas efferens, the short distance between the posterior testis and the posterior end of the body, the cirrus shape, and the distribution of the tegumental spines. The looping of the oviduct around the right vas efferens was noted in all specimens in which the oviduct could be traced; it was not observed in type specimens of *L. simeri, L. fairporti, L. heterorchis, L. polylobatum,* or *L. attenuatum*. We could not trace the oviduct on specimens of other species. *Lissorchis kritskyi* can be distinguished from *L. fairporti* Magath, 1917, *L. gullaris* Self and Campbell, 1956, *L. polylobatum* (Haderlie, 1950), *L. crassicrurum* (Haderlie, 1953), and *L. heterorchis* Krygier and Macy, 1969 by its uniformly trilobed ovary, and from *L. translucens* (Simer, 1929), *L. attenuatum* (Van Cleave and Mueller, 1932), and *L. hypentelii* (Fishthal, 1942) by the bipartite seminal vesicle with distal portion smaller than proximal. It differs from *L. mutabile* (Cort, 1918) in having a protrusible cirrus and lacking a vas deferens. It appears to be most similar morphologically to *L. simeri* (Mueller and Van Cleave, 1932). Both Mueller (1934) and Mueller and Van Cleave (1932) found *L. simeri* to have eggs about 24 × 12 μm whereas those of *L. kritskyi* are only 16 × 9.1 μm. The posttesticular body length for *L. simeri* is described by Mueller and Van Cleave (1932) as being ". . . roughly equivalent to the length of the three gonads taken together," which is larger than the less than 10% of body length as found in *L. kritskyi.*

One other species of *Lissorchis* has been described from the genus *Carpiodes*: *L. garricki* (Simer, 1929) from *Carpiodes difformis* in the Tallahatchie River, Florida. Unfortunately, the description of *L. garricki* is superficial and based on only three specimens. However, *L. kritskyi* differs from *L. garricki* in size, being

nearly twice as long, in the presence of a seminal receptacle, and in having three equal ovarian lobes. We were unable to obtain specimens of *L. garricki* for comparative purposes, but we believe the differences noted are significant.

Recently, Aliff (1973) in his Ph.D. dissertation noted an apparent new species of *Lissorchis* which he called *L. fischthali* from *Minytrema melanops*. In the subsequent publication of his dissertation material, Aliff (1977) did not describe the new species but referred to it as *Lissorchis* sp. Until more information is forthcoming, *L. fischthali* should be considered a *nomen nudum*.

Krygier and Macy (1969) considered the lobed testes a distinguishing character of *L. heterorchis*. In *L. kritskyi,* however, this is not a constant character; in some specimens the testis are quite smooth in outline while in others the degree of lobateness nearly equals that found in *L. heterorchis*. Several other authors (Simer, 1929; Mueller and Van Cleave, 1932; Haderlie, 1953) have stated that the testis were "irregular in outline" in describing members of this genus.

The genus *Lissorchis* is obviously controversial and there is need for further investigations including studies on life histories, host specificity, allometric growth, and host induced intraspecific variation. Based on the information now available, however, *L. kritskyi* appears to be a species new to science. We agree with Duncan (1972) about the difficulties in making valid comparisons of species of lissorchids based upon the available information, but until more critical investigations are made, we must rely on what is available.

Acknowledgments

We would like to thank Mr. Gregg Calderwood, Dr. Ross Bulkley, Mr. Tom Putnam, and the Iowa State Conservation Commission for help in collection of fishes; and Dr. Delane Kritsky for the loan of specimens. Some specimens used in this description were collected in the course of a project funded by the National Science Foundation Undergraduate Research Program (Grant GY-11135).

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SECOND INTERNATIONAL CONGRESS OF SYSTEMATIC AND EVOLUTIONARY BIOLOGY (ICSEB-II)

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6. Green algae and land plant origins
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8. Allozymes and evolution
9. Coevolution and foraging strategy
10. Evolution of colonizing species
11. Rare species and the maintenance of gene pools
12. Paleobiology of the Pacific Rim

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Paravitellotrema overstreeti sp. n. (Digenea: Hemiuridae) from the Colombian Freshwater Stingray *Potamotrygon magdalenae* Dumeril[1]

DANIEL R. BROOKS,[2] MONTE A. MAYES,[3] AND THOMAS B. THORSON[4]

ABSTRACT: *Paravitellotrema overstreeti* from the freshwater stingray *Potamotrygon magdalenae* in northern Colombia most closely resembles *P. thorsoni* by possessing a muscular sinus organ and sinus sac as well as exhibiting a saccate rather than elongate prostatic vesicle. It differs by possessing lobate rather than spherical vitellaria, a smaller sinus organ and sinus sac, elongate rather than diamond-shaped prostatic cells enclosed in a delicate membrane rather than free in the parenchyma, and a metraterm joining the hermaphroditic duct immediately anterior to the prostatic vesicle rather than at the base of the sinus organ.

Digeneans of the family Hemiuridae Lühe, 1901, subfamily Halipeginae Ejsmont, 1931 parasitize marine, brackish, and freshwater fishes, amphibians, and occasionally snakes. Twelve of 39 (30.7%) specimens of the freshwater stingray *Potamotrygon magdalenae* Dumeril collected in "cienagas" of the Rio Magdalena in northern Colombia during the summers of 1975 and 1976 hosted one to 13 specimens of a new species of halipegine. This is the first report of an halipegine occurring as an apparently normal constituent of any elasmobranch's helminthofauna.

The digeneans were removed from hosts, flattened with minimal coverslip pressure, fixed with warm AFA, and stored in 70% ethanol. They were stained with Mayer's or Van Cleave's hematoxylin and mounted in Histoclad for study as whole mounts. Measurements are in micrometers unless otherwise stated; figures were drawn with the aid of a drawing tube.

Paravitellotrema overstreeti sp. n. (Figs. 1–3)

DESCRIPTION (based on 25 specimens): Body elongate, subcylindrical, lacking ecsoma, 1.60–2.38 mm long by 0.56–0.74 mm wide at acetabulum. Preoral lobe present. Oral sucker 174–228 long by 216–264 wide, subterminal. Acetabulum 300–438 long by 325–444 wide. Forebody 38–43% (40%) of total body length. Ratio of oral sucker width to acetabular width 1:1.48–1.57 (1:1.53). Prepharynx lacking. Pharynx 72–114 long by 78–108 wide. Ratio of oral sucker width to pharyngeal width 1:0.34–0.38 (1:0.36). Esophagus lacking; saccate crop present at cecal bifurcation. Cecal bifurcation 28–33% (30%) of total body length from anterior end; ceca extending near posterior end of body.

Testes in anterior half of hindbody, spherical to subspherical, diagonal, intercecal or ventral to ceca. Left testis 156–180 long by 150–204 wide; right testis 150–186 long by 150–192 wide. Posttesticular space 28–32% (30%) of total body length.

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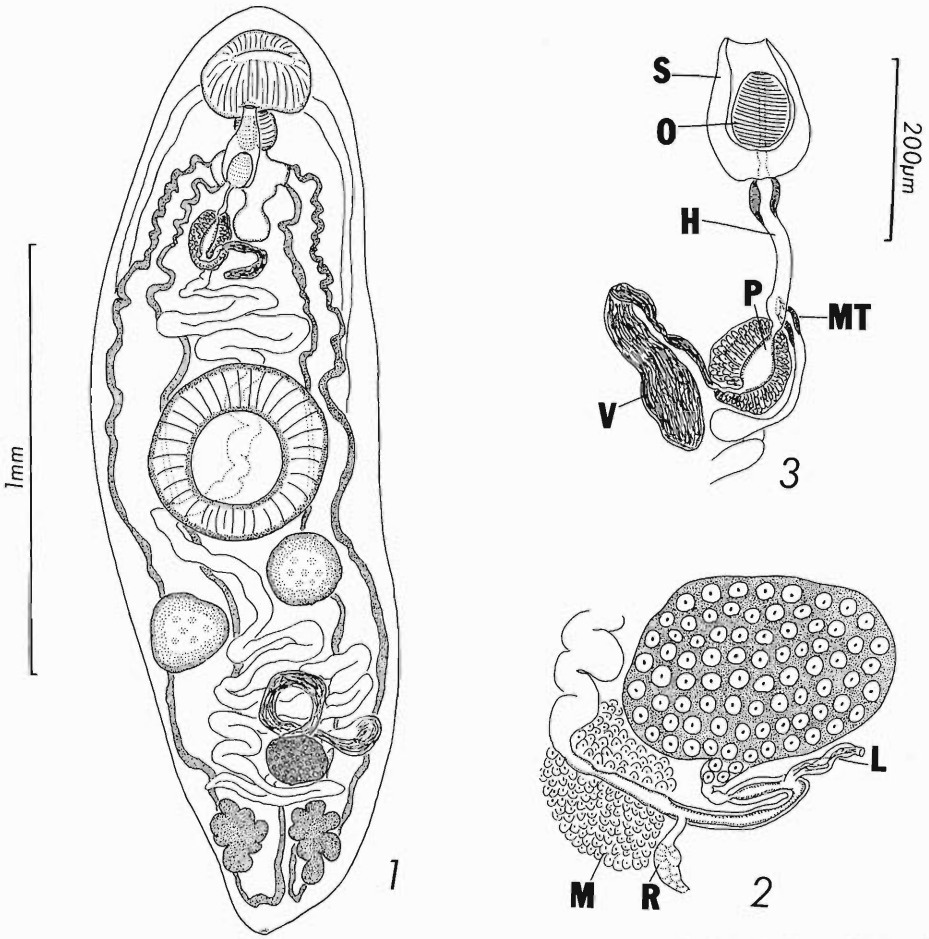

Figures 1–3. ***Paravitellotrema overstreeti.*** **1. Ventral view of holotype. 2. Female ducts. 3. Terminal genitalia. Abbreviations: L = Laurer's canal; M = Mehlis' gland; MT = metraterm; H = hermaphroditic duct; O = sinus organ; P = prostatic vesicle; R = vitelline receptacle; S = sinus sac; V = seminal vesicle.**

Seminal vesicle preacetabular, elongate to C- or U-shaped, 144–247 long. Narrow tubular anterior portion of seminal vesicle entering saccate prostatic vesicle 58–100 long by 29–102 wide; prostatic vesicle surrounded by elongate prostatic cells enclosed in delicate membrane; limits of membrane 102–157 long by 78–137 wide. Prostatic vesicle joining tubular hermaphroditic duct emptying into muscular protrusible sinus organ 44–96 long by 41–87 wide at widest point when not protruded. Sinus organ surrounded by thick-walled sinus sac 90–200 long by 80–176 wide. Genital pore ventral to posterior part of oral sucker, 9–12% (10%) of total body length from anterior end.

Ovary posttesticular, 11–16% (12%) of total body length from posterior end, spherical to subspherical, 96–144 long by 96–150 wide. Uterine seminal receptacle present. Mehlis' gland and Laurer's canal postovarian. Laurer's canal a simple tube opening dorsally. Vitellaria compact, paired, deeply to shallowly lobate, ventral to ceca, immediately postovarian. Left vitellarium 90–210 long by 90–126 wide; right vitellarium 120–204 long by 90–150 wide. Uterus looping in intercecal

space from posterior margin of ovary to near level of prostatic vesicle; terminating in short muscular metraterm entering hermaphroditic duct immediately anterior to prostatic vesicle. Eggs with single polar filament, 44–46 (45) long by 20–23 (21) wide excluding filament; polar filament 2–3 times longer than egg.

Excretory pore terminal; vesicle Y-shaped with arms uniting dorsal to pharynx.

HOST: *Potamotrygon magdalenae* Dumeril, Colombian freshwater stingray.

SITE OF INFECTION: Stomach.

LOCALITIES: Cienaga Jobo, Rio Magdalena, vic. San Cristòbal, Bolivar, Colombia (type); Cienaga de Rabon, Rio Magdalena, vic. San Cristòbal, Bolivar, Colombia.

HOLOTYPE: USNM Helm. Coll. No. 74730.

PARATYPES: USNM Helm. Coll. No. 74731.

ETYMOLOGY: The species is named in honor of Dr. Robin M. Overstreet, Gulf Coast Research Laboratory, in recognition of his contributions to helminth taxonomy and ecology.

Remarks

Watson (1976) proposed the genus *Paravitellotrema* for two species parasitizing Nicaraguan freshwater fishes which resembled *Vitellotrema* Guberlet, 1928 by having the seminal vesicle and prostatic vesicle free in the parenchyma but which differed in possessing a sinus sac and in lacking the swollen terminal portion of the uterus unique to *Vitellotrema*. *Paravitellotrema overstreeti* most closely resembles *P. thorsoni* Watson, 1976 by possessing a protrusible sinus organ and saccate rather than elongate prostatic vesicle. It differs by having lobate rather than smooth vitellaria, a smaller sinus organ and sinus sac, elongate rather than diamond-shaped prostatic cells which are enclosed in a delicate membrane rather than free in the parenchyma, and a metraterm joining the hermaphroditic duct immediately anterior to the prostatic vesicle rather than at the base of the sinus organ. *Paravitellotrema astyanactis* Watson, 1976, the only other member of the genus, lacks both sinus organ and saccate prostatic vesicle, characteristics which Manter (1969, 1970) and Watson (1976) did not consider of generic importance.

Acknowledgments

We express appreciation to Guillermo Quiñones Gonzales, Director, Centro de Investigaciones Limnologicos y Piscicola, INDERENA/FAO–San Cristòbal, for aid and cooperation during the course of our study.

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Neopronocephalus orientalis sp. n. (Digenea: Pronocephalidae) and *Spirhapalum elongatum* Rohde, Lee, and Lim, 1968 (Digenea: Spirorchiidae) from *Cuora amboinensis* (Daudin) in Malaysia

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ABSTRACT: *Neopronocephalus orientalis* from *Cuora amboinensis* in Malaysia most closely resembles *N. spinometraterminis* from *Kachuga tectum tentoria* in India by possessing postovarian cecal tips and an average of more than 30 vitelline follicles, but differs by having equatorial rather than preequatorial testes which are mostly intercecal rather than extracecal and a slightly smaller cirrus sac. *Neopronocephalus spinometraterminis* purportedly has spines in the metraterm and a common genital pore, whereas *N. orientalis* exhibits nonstaining wrinkled epithelium lining the metraterm and separate genital pores. *Spirhapalum elongatum* was also collected from its type host near the type locality.

Specimens forming the basis of this report were collected by the second author as part of a continuing survey of the helminth fauna of Malaysian reptiles and amphibians. Worms were collected from hosts, flattened with minimal coverslip pressure, fixed with AFA, and stored in 70% ethanol. They were stained with acetocarmine and mounted in Histoclad for study as whole mounts. Figures were drawn with the aid of a drawing tube; measurements are in micrometers unless otherwise stated.

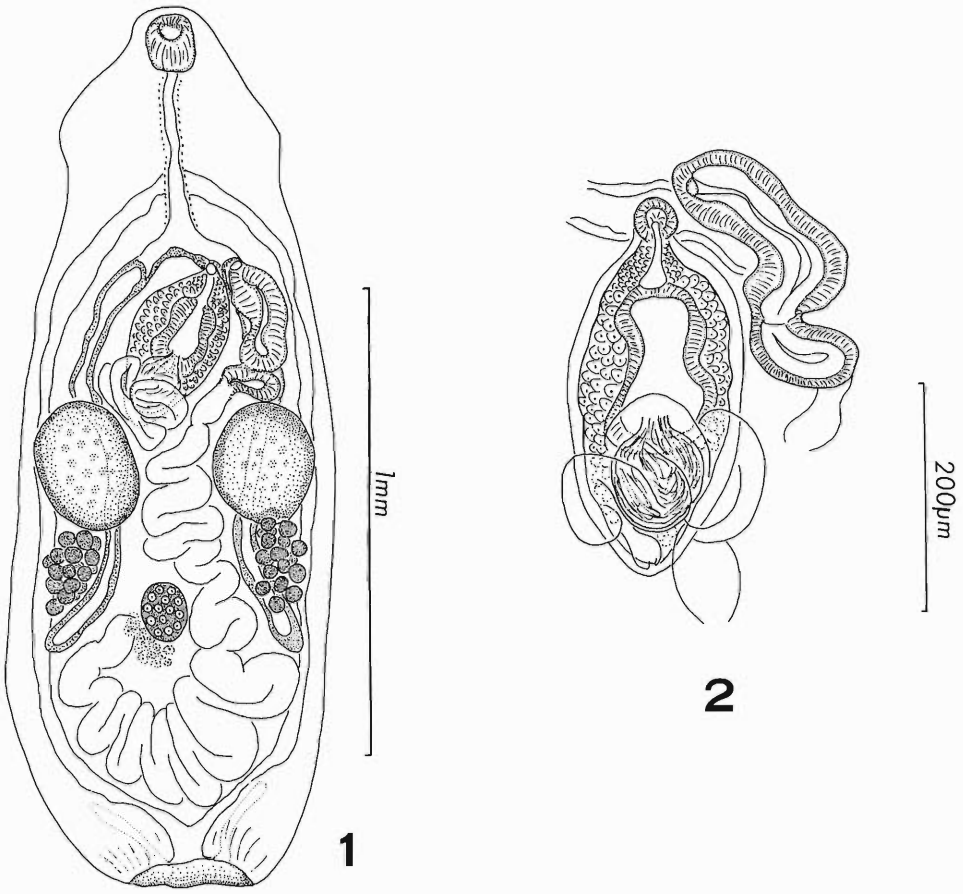
Neopronocephalus orientalis sp. n. (Figs. 1–2)

DESCRIPTION (based on 14 specimens, 10 measured): Body elongate with truncate posterior end, 1.08–2.01 (1.60) mm long by 0.46–0.78 (0.63) mm wide at midbody. Tegument aspinose; diffuse eyespot pigment present anteriorly. Cephalic collar 340–510 (450) wide. Oral sucker subterminal, 87–125 (103) long by 81–116 (99) wide. Esophagus 218–392 long, unlined; cecal bifurcation 23.0–28.6% (26.3%) of total body length from anterior end; ceca extending to within 22.7–27.3% (24.4%) of total body length from posterior end; ceca lined.

Testes equatorial, symmetrical, ventral to ceca, subspherical. Left testis 116–261 (190) long by 128–232 (201) wide, right testis 125–290 (201) long by 125–238 (174) wide. Posttesticular space 35.7–47.2% (40.3%) of total body length. Cirrus sac intercecal, pretesticular, surrounded at distal end by coiled external seminal vesicle; cirrus sac 160–405 (303) long by 87–183 (137) wide, not reaching dextral testis; wall of cirrus sac 10–15 thick. Cirrus sac containing saccate internal seminal vesicle 70–120 long, eversible cirrus, and prostatic cells; prostatic cells globular surrounding seminal vesicle and spherical surrounding cirrus. Male genital pore sinistral, 30.7–36.1% (33.1%) of total body length from anterior end, ventral to or immediately medial to cecum.

Ovary posttesticular, slightly but consistently anterior to level of cecal tips,

[1] This study was supported in part by a grant AI 10051 (UC ICMR) to the Department of International Health, School of Medicine, University of California, San Francisco, from the National Institute of Allergy and Infectious diseases, National Institutes of Health, U.S. Public Health Service.



Figures 1–2. ***Neopronocephalus orientalis*. 1. Ventral view of holotype. 2. Terminal genitalia.**

submedian, subspherical, 90–174 (121) long by 81–131 (103) wide. Mehlis' gland and Laurer's canal dorsal to ovary. Vitellaria paired, follicular, extracecal posterior to testes; 15–20 (17.5) sinistral follicles, 15–19 (16.9) dextral follicles, 32–38 (34.4) total follicles; follicles 23–29 (26) long by 18–29 (23) wide. Uterus coiled from postovarian region to near cecal bifurcation, extending posteriorly to 8.6–16.7% (12.9%) of total body length from posterior end; uterus terminating with extracecal muscular metraterm 110–304 (183) long by 52–102 (74) wide. Female separate from but proximate to male pore. Eggs mostly collapsed, 20–30 long by 10–13 wide, nonfilamented.

Excretory system composed of Y-shaped excretory vesicle bifurcating immediately posterior to posteriormost uterine extent; arms extending anteriorly, uniting dorsal to midesophagus; pore dorsal, subterminal. Portion of body containing excretory pore enclosed in velumlike posterior portion of body.

HOST: *Cuora amboinensis* (Daudin), Malaysian box turtle.

SITE OF INFECTION: Upper third of small intestine.

LOCALITY: Vicinity of Kuala Lumpur, Malaysia.

HOLOTYPE: USNM Helm. Coll. No. 73053.

PARATYPES: USNM Helm. Coll. No. 73054; Univ. Nebraska State Museum, Manter Laboratory No. 20866.

ETYMOLOGY: The specific name means "eastern" and refers to the fact that all previously named species of *Neopronocephalus* occur west of Malaysia.

Remarks

Six species of *Neopronocephalus* Mehra, 1932 have previously been described, five from Indian freshwater turtles and one from a Burmese freshwater turtle. Only one of those, *N. spinometraterminis* Rao, 1975 from *Kachuga tectum tentoria* Gray in India, possesses postovarian cecal tips and more than 30 vitelline follicles as exhibited by *N. orientalis*. The latter species differs from the former by having equatorial rather than preequatorial testes which are primarily intercecal rather than extracecal, and a slightly smaller cirrus sac (160–405 vs. 330–580 μm long). Additionally, Rao (1975) described *N. spinometraterminis* as possessing a common genital pore and spines lining the metraterm. The new species possesses separate genital pores and exhibits nonstaining, wrinkled epithelium lining the metraterm which gives the appearance of tegumental spines.

We also collected, from the same host species (type) and near the type locality, a single specimen of *Spirhapalum elongatum* Rohde, Lee, and Lim, 1968 which agreed in all respects with the original description by Rohde et al. (1968) and which has been deposited as USNM Helm. Coll. No. 73055.

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Proc. Helminthol. Soc. Wash.
46(1), 1979, pp. 58–63

Prevalence of Dermatitis-Producing Schistosomes in Natural Bird Populations of Lower Michigan[1]

BRIAN D. GUTH,[2] HARVEY D. BLANKESPOOR,[2] RONALD L. REIMINK,[2] AND WILBUR C. JOHNSON[3]

ABSTRACT: Fecal samples from 1,244 birds representing seven orders, 19 families, and 43 species were examined for patent schistosome infections in lower Michigan during the summers of 1977–1978. An infection rate of 13.6% was found in all birds examined. Whereas after hatching-year anseriforms had an infection rate of 12.0%, hatching-year anseriforms had a much higher rate (46.3%). Following the first hatching-year infection (June 21), 57.1% of the hatching-year birds were infected. Infections in all other birds examined were limited to the families Corvidae (1.6%), Mimidae (3.3%), and Paridae (2.5%). Differences in infection rates between hatching-year and after hatching-year passeriforms were insignificant. No patent infections were found in hatching-year passeriforms prior to July 14. The infections in the blue jay (*Cyanocitta cristata*), gray catbird (*Dumetella carolinensis*), and the tufted titmouse (*Parus bicolor*), represent new host records for *Gigantobilharzia*.

The occurrence of schistosome dermatitis, commonly referred to as "Swimmer's itch," has become increasingly common in recent years as recreational demands on inland lakes in the Midwest have grown. Avian schistosomes, particularly of the genera *Gigantobilharzia* and *Trichobilharzia*, have been found to be the causative agents of schistosome dermatitis in this area. Development of an effective control method for these blood flukes is hampered by insufficient knowledge of their biology.

This study was undertaken to survey natural bird populations for patent schistosome infections and to correlate infections with the age of the host and the time of the year.

Materials and Methods

Birds examined in this study were live-trapped at the following locations: (1) W. K. Kellogg Biological Station (Michigan State University) in Kalamazoo County, (2) Gun Lake State Park in Barry County, and (3) University of Michigan Biological Station in Cheboygan and Emmet counties. Birds were captured from May through August in drop-in and walk-in traps baited with corn and in mist nets (36- and 61-mm mesh). They were identified, aged, sexed, and then maintained in captivity until fecal samples were obtained. Fish and wildlife service bands were placed on selected species for individual identification. Avian nomenclature follows the AOU Checklist (1957) and the 32nd Supplement to the AOU Checklist (1973).

Fecal specimens were placed with lake water in a Stender or petri dish and then teased apart with forceps. After allowing the particulate material to settle, the supernatant was decanted and more lake water added. The diluted samples were then subjected to fluorescent light for at least 2 hr to induce hatching of

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schistosome eggs. A dissecting microscope was used to confirm the presence of miracidia. Generic identification of the schistosomes was based on egg shape, and on epidermal plate arrangement, host specificity, and behavior of the miracidium.

Results

A total of 1,244 birds representing 43 species, 19 families, and seven orders were examined for patent schistosome infections (Table 1). Of all the birds examined, 13.6% harbored patent infections. Of the 318 anseriforms examined, 35.5% had gravid worms. However, only 6.0% of passeriforms were passing schistosome eggs. Fifty of the 56 infections found in passeriforms were from the family Icteridae (blackbirds). Infections found in the blue jay (*Cyanocitta cristata*), gray catbird (*Dumetella carolinensis*), and tufted titmouse (*Parus bicolor*) represent new host records for *Gigantobilharzia*.

Of the 113 anseriforms found to have patent infections, only 12 were after hatching-year (AHY) birds. Of the 218 hatching-year (HY) anseriforms examined, 101 (46.3%) had patent infections, whereas only 12% (12/100) of the AHY anseriforms were infected. After the first HY anseriform infection was found (June 21), the infection rate for HY birds was 56.8% (100/176) while only seven of the 49 (14.3%) AHY anseriforms were infected. None of the 28 AHY Canada geese (*Branta canadensis*) harbored patent infection after July 10.

The dynamics of schistosome infections in passeriforms was quite different from those of anseriforms. In the passerine family Icteridae, 16.3% (33/202) of the AHY birds had patent schistosome infections against 6.5% (17/260) of the HY population. No significant difference was found between infection rates in male and female birds.

Discussion

Experiments by Rau et al. (1975) indicated that in ducks, *Trichobilharzia ocellata* adults produced eggs for only a short time after initial exposure and that eggs were not produced after subsequent challenge infections. It is interesting, therefore, that in this study, no AHY Canada geese were found to harbor patent *Trichobilharzia* infections after July 10. In three flocks of Canada geese examined in late June and early July of 1977–1978, 30 of 59 (50.8%) HY birds harbored patent infections but only two of the 29 (6.9%) AHY birds were found to be infected. McLeod (1937) found a similar (60%) infection rate among blue-winged teal (*Anas discors*), however, no age differentiation was made. A system such as this may serve as a model for the study of mechanisms of immunity to schistosomes.

Infections of *Gigantobilharzia* among passeriforms were found to be concentrated in birds of the family Icteridae. Fifty of 56 infections encountered were either in common grackles or red-winged blackbirds. Infection rates in these birds, 14.0 and 11.0%, respectively, were far below the infection rates of 83% in yellow-headed blackbirds (*Xanthocephalus xanthocephalus*) and 60% in red-winged blackbirds (*Agelaius phoeniceus*) reported by Brackett (1942) in marsh habitats of Wisconsin. Brackett noted, however, that population infection rates were geographically variable and that the sample size (13) was small; considerably

Table 1. Summary of birds examined for patent schistosome infections during the summers of 1977–1978.

	Total no.exam.	Hatch-year birds			After hatch-year birds			Total %
		No.	Inf.	%	No.	Inf.	%	
Order Anseriformes								
Family Anatidae								
Cygnus olor (Gmelin) (Mute Swan)	1	1	1	100	0	—	—	100
Olor columbianus (Ord) (Whistling Swan)	2	2	1	50	0	—	—	50
Branta canadensis (Linnaeus) (Canada Goose)	224	137	54	39	87	7	8	27
Anas platyrhynchos Linnaeus (Mallard)	68	63	40	63	5	2	40	62
Anas rubripes Brewster (American Black Duck)	3	2	1	50	1	1	100	67
Aix sponsa (Linnaeus) (Wood Duck)	19	13	4	31	6	2	33	32
Aythya affinis (Eyton) (Lesser Scaup)	1	0	—	—	1	0	0	0
Order Galliformes								
Family Meleagrididae								
Meleagris gallopavo Linnaeus (Wild Turkey)	1	1	0	0	0	—	—	0
Order Charadriiformes								
Family Charadriidae								
Charadrius vociferus Linnaeus (Killdeer)	1	0	—	—	1	0	0	0
Order Columbiformes								
Family Columbidae								
Zenaida macroura (Linnaeus) (Mourning Dove)	2	0	—	—	2	0	0	0
Order Cuculiformes								
Family Cuculidae								
Coccyzus erythropthalmus (Wilson) (Black-billed Cuckoo)	2	2	0	0	0	—	—	0
Order Piciformes								
Family Picidae								
Centurus carolinus (Linnaeus) (Red-bellied Woodpecker)	2	0	—	—	2	0	0	0
Dendrocopos villosus (Linnaeus) (Hairy Woodpecker)	3	1	0	0	2	0	0	0
Dendrocopos pubescens (Linnaeus) (Downy Woodpecker)	3	1	0	0	2	0	0	0
Order Passeriformes								
Family Tyrannidae								
Tyrannus tyrannus (Linnaeus) (Eastern Kingbird)	1	1	0	0	0	—	—	0

Table 1. Continued.

	Total no.exam.	Hatch-year birds			After hatch-year birds			Total %
		No.	Inf.	%	No.	Inf.	%	
Family Corvidae								
*Cyanocitta cristata** (Linnaeus) (Blue Jay)	63	26	0	0	37	1	3	2
Family Paridae								
Parus atricapillus Linnaeus (Black-capped Chickadee)	20	12	0	0	8	0	0	0
*Parus bicolor** Linnaeus (Tufted Titmouse)	20	6	0	0	14	1	7	5
Family Sittidae								
Sitta carolinensis Latham (White-breasted Nuthatch)	3	1	0	0	2	0	0	0
Family Mimidae								
*Dumetella carolinensis** (Linnaeus) (Gray Catbird)	28	0	—	—	28	1	4	4
Toxostoma rufum (Linnaeus) (Brown Thrasher)	2	0	—	—	2	0	0	0
Family Turdidae								
Turdus migratorius Linnaeus (American Robin)	54	18	0	0	36	0	0	0
Catharus ustulatus (Nuttall) (Swainson's Thrush)	3	0	—	—	3	0	0	0
Family Bombycillidae								
Bombycilla cedrorum Vieillot (Cedar Waxwing)	4	0	—	—	4	0	0	0
Family Sturnidae								
Sturnus vulgaris Linnaeus (European Starling)	10	5	0	0	5	0	0	0
Family Vireonidae								
Vireo gilvus (Vieillot) (Warbling Vireo)	1	1	0	0	0	—	—	0
Family Parulidae								
Vermivora peregrina (Wilson) (Tennessee Warbler)	1	0	—	—	1	0	0	0
Dendroica petechia (Linnaeus) (Yellow Warbler)	1	1	0	0	0	—	—	0
Dendroica magnolia (Wilson) (Magnolia Warbler)	1	0	—	—	1	0	0	0
Seiurus noveboracensis (Gmelin) (Northern Waterthrush)	2	0	—	—	2	0	0	0
Geothlypis trichas (Linnaeus) (Common Yellowthroat)	4	0	—	—	4	0	0	0
Family Ploceidae								
Passer domesticus (Linnaeus) (House Sparrow)	179	140	0	0	39	0	0	0
Family Icteridae								
Agelaius phoeniceus (Linnaeus) (Red-winged Blackbird)	70	7	1	14	63	9	14	14

Table 1. Continued.

	Total no.exam.	Hatch-year birds			After hatch-year birds			
		No.	Inf.	%	No.	Inf.	%	Total %
Icterus galbula (Linnaeus) (Northern Oriole)	3	0	—	—	3	0	0	0
Quiscalus quiscula (Linnaeus) (Common Grackle)	357	228	16	7	129	24	19	11
Molothrus ater (Boddaert) (Brown-headed Cowbird)	32	25	0	0	7	0	0	0
Family Fringillidae								
Cardinalis cardinalis (Linnaeus) (Northern Cardinal)	10	0	—	—	10	0	0	0
Pheucticus ludovicianus (Linnaeus) (Rose-breasted Grosbeak)	3	0	—	—	3	0	0	0
Passerina cyanea (Linnaeus) (Indigo Bunting)	1	0	—	—	1	0	0	0
Spinus tristis (Linnaeus) (American Goldfinch)	3	0	—	—	3	2	67	67
Zonotrichia leucophrys (Forster) (White-crowned Sparrow)	3	0	—	—	3	0	0	0
Melospiza georgiana (Latham) (Swamp Sparrow)	1	1	0	0	0	—	—	0
Melospiza melodia (Wilson) (Song Sparrow)	32	21	1	5	11	0	0	3
Totals	1,244	716	119	16.6	528	50	9.5	13.6

* Represent new host records for *Gigantobilharzia*.

more icterids (462) were examined during this study. Furthermore, Brackett sacrificed birds, thereby counting both patent and nonpatent infections.

The first HY passerine patent infection was found on July 14. Because approximately 35–40 days are required for the development of a patent infection of *Gigantobilharzia* (Najim, 1956), this infection was probably acquired in the first week of June, shortly after fledging. There appears to be no suppression of parasite egg production in AHY passeriforms as was observed in infected Canada geese. It has been the authors' experience that experimentally infected canaries can harbor patent *Gigantobilharzia* infections for over a year. The infection rate for passeriforms varied little throughout the study, suggesting that HY birds were not more susceptible to infection than AHY birds.

The intricacies of the avian schistosome's relationship to its definitive host as well as its intermediate and "accidental" hosts (man) are still unknown. Additional studies on the timing and location of cercarial infection and the duration of egg production and release by the avian hosts of *Gigantobilharzia* and *Trichobilharzia* are needed before effective control of schistosome dermatitis can be realized.

Acknowledgments

This study was conducted at the W. K. Kellogg Biological Station of Michigan State University (Contribution 332) and the University of Michigan Biological Station. Appreciation is extended to Ms. Kate Roney, Dr. Henry van der Schalie, Mr. Sam Loker, and Mr. Nicholas L. Rodenhouse for their assistance.

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The Editor

Proc. Helminthol. Soc. Wash.
46(1), 1979, pp. 64–69

Histochemistry of the Miracidial and Early Redial Stage of *Cyclocoelum oculeum* (Trematoda: Cyclocoelidae)[1]

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ABSTRACT: The miracidia of *Cyclocoelum oculeum* each contain a fully formed redia, and histochemical tests can be performed on both stages simultaneously. Glycogen is present in miracidial epidermal plates, penetration glands and apical gland as revealed by positive staining with Best's carmine, Bauer-Feulgen, and PAS and malt diastase lability. The redial esophageal glands were PAS-positive but resistant to digestion. The apical gland is selectively stained by Victoria blue. The miracidial tegument is covered by a thin layer of mucoprotein/polysaccharide as revealed by Alcian blue staining (pH 1 and 2.5) and colloidal iron. The redia, which along enters the snail, does not show the presence of mucoid material on its external surface. Berenbaum's method for bound lipids was positive for the apical gland, flame cells, and the redia. Other lipid stains—Sudan IV, Sudan black B, osmic acid, oil red O—failed to stain either miracidia or rediae. Histochemical tests for proteases, nonspecific esterases, and aminopeptidases were negative. Acid phosphatase activity was observed in epidermal plates, the apical gland, and redial intestine; alkaline phosphatase activity in the epidermal plates; and lipase activity in eggs containing miracidia.

No histochemical studies have been published on cyclocoelids. A comprehensive histochemical study of the miracidium of *Cyclocoelum oculeum* and the redia contained within was undertaken. Previously published histochemical investigations of other species of miracidia (Axmann, 1947; Bogomolova, 1957; Wilson, 1969, 1971; Kinoti, 1971; Buzzell, 1974; Wikel and Bogitsh, 1974) were used as a guide in this study.

Materials and Methods

Gravid *Cyclocoelum oculeum* were removed from the orbits of American coots (*Fulica americana*), placed in previously boiled aquarium water and dissected. Uteri with miracidia and recently hatched miracidia were fixed in 6% neutral formalin, Gendre's fluid, or 3% polyvinyl alcohol. Miracidia allowed to attach to *Physa gyrina* or *Gyraulus hirsutus* were fixed in Gendre's fluid 0.5–1.5 hr post-attachment.

PVA and some formalin-fixed material was frozen and cut at 16 μm with a cryostat. Cryostat sections were stained with oil red O, osmic acid, Sudan IV, and Sudan black B to detect lipids (Humason, 1972). Techniques employed for enzymes were: the Gomori method for alkaline and acid phosphatases, and lipases as reported by McManus and Mowry (1960); the Burstone and Folk technique for aminopeptidases and the procedure for nonspecific esterases after Moloney et al. as outlined by Humason (1972). Attempts to detect proteolytic enzyme activity utilized the method of Fried et al. (1976). Positive and negative controls were used in all enzyme studies. Material not frozen was embedded in paraplast and cut at 5–10 μm on a rotary microtome. These sections were stained with PAS, Best's carmine, Bauer-Feulgen, and Alcian blue at pH 1.0 and 2.5, and colloidal iron to check for polysaccharides and polysaccharide-protein complexes (Pearse, 1960; Humason, 1972). Sections both treated and untreated with malt

[1] Supported in part by research grant 8408 from the Wisconsin State University Regents.

diastase were used with the first three stains to check for glycogen. Proteins were observed using the mercuric bromphenol blue method (Mazia et al., 1953). Bound lipids were tested for after Berenbaum (1954). Victoria blue was used as an apical gland stain (Buzzell, 1974).

Results

Best's carmine and Bauer-Feulgen (using malt diastase-treated sections as controls) indicated large concentrations of glycogen in the epidermal plates, and lower concentrations in the apical and penetration glands (Figs. 1, 2). These areas were also PAS-positive, however, a small amount of PAS-positive material still remained after malt diastase digestion. The esophageal glands were PAS-positive, but malt diastase resistant (Fig. 2). The apical papilla, anterior pit, cytoplasmic ridges, and redia did not stain with PAS. The apical gland is selectively stained with Victoria blue.

Alcian blue pH 1.0 and 2.5 and colloidal iron indicated mucosubstances immediately external to the bases of the cilia. With all three stains the reaction was weak. No such staining for mucosubstances was associated with the redia.

Mercuric bromphenol blue intensely stained the longitudinal and circular muscles of the apical papilla and redia (Fig. 3), moderately stained subepidermal muscles (Fig. 4), apical gland contents (Fig. 5), and flame cells (Fig. 6), and weakly stained subepidermal plates (Fig. 3).

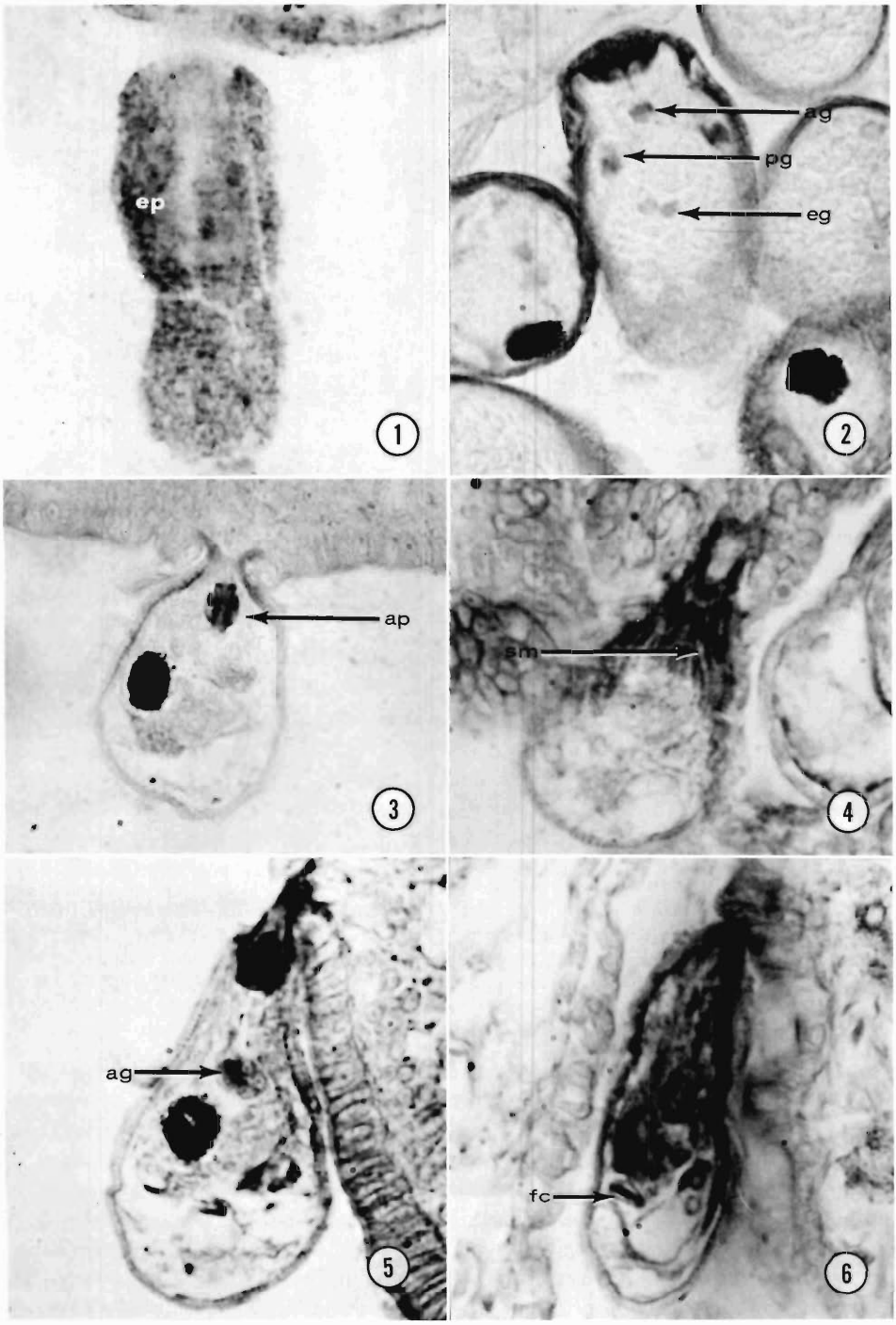
Sudan IV, Sudan black B, osmic acid, and oil red O did not indicate the presence of lipids in either miracidium or redia. However, Berenbaum's acetone Sudan black method for bound lipids revealed large amounts of such lipids in the epidermal plates and apical gland, and lesser amounts in flame cells (Fig. 7). Rediae also stained intensely for bound lipids.

The Gomori acid phosphatase reaction was weak and diffuse in the apical gland (Fig. 8) and epidermal plates, and strong in the redial intestine (Fig. 9). A weak alkaline phosphatase reaction was observed in the epidermal plates and flame cells. The lipase reaction was strong within eggs containing miracidia (Fig. 10), but reaction products for proteases, aminopeptidases, and nonspecific esterases were not detectable in the egg, miracidium, or redia.

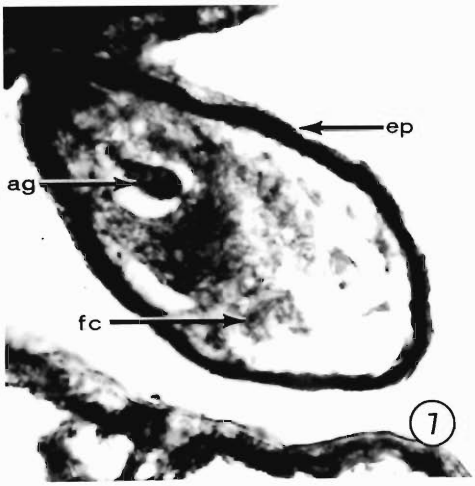
Discussion

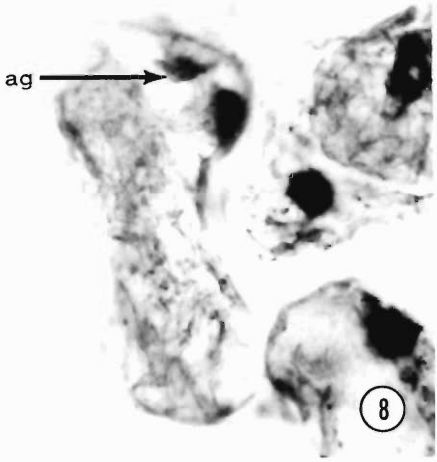
Cyclocoelum oculeum miracidia have large concentrations of glycogen in the epidermal plates and lesser amounts in the penetration and apical glands. Various authors have observed glycogen in miracidia. Axmann (1947) observed it in the subepithelium and parenchyma of *Schistosoma mansoni* and *Schistosoma japonicum,* Bogomolova (1957) in parts of the tegument and areas surrounding embryonal cells of *Fasciola hepatica,* Wilson (1969) below the ciliary roots of *F. hepatica,* and Wikel and Bogitsh (1974) in the epidermal plates and penetration and apical glands of *S. mansoni.* The association of glycogen deposits within epidermal plates suggests its use as a substrate for enzymatic reactions required for ciliary movement.

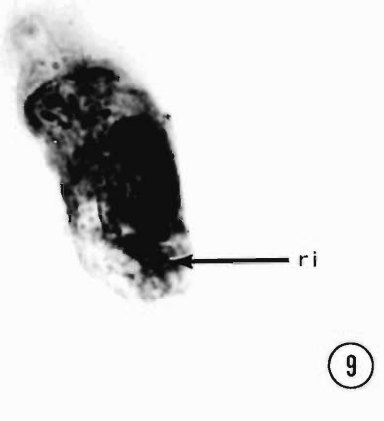
Cyclocoelum oculeum miracidia have apical glands staining with Victoria blue and PAS. This method was developed by Buzzell (1974) to differentiate between the apical gland (Victoria blue positive) and penetration glands (PAS-positive) of

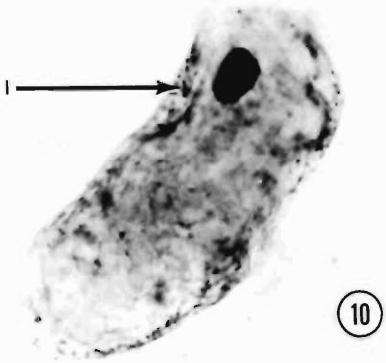


Figures 1–10. ***Cyclocoelum oculeum*** **miracidia and redia. 1. Glycogen present in epidermal (ep) plates after staining with Best's carmine. 2. PAS-positive material is revealed in miracidial penetration glands (pg) and redial esophageal glands (eg). Apical gland (ag) contents stained with Victoria blue. 3. Longitudinal and circular muscles of the apical papilla (ap) stain intensely with mercuric bromphenol**









blue (Hg BPB). 4. Longitudinal and circular subepidermal muscles (sm) stained with Hg BPB. 5. Apical gland (ag) contents stained with Hg BPB. 6. Flame cells (fc) stained with Hg BPB. 7. Bound lipids are observed in epidermal plates (ep), apical gland (ag), and flame cells (fc). 8. A weak diffuse reaction for acid phosphatase in apical gland (ag). 9. A strong reaction for acid phosphatase in redial intestine (ri). 10. Strong reaction for lipase (l) inside egg containing miracidium. All figures 640×, except Figs. 3 and 9 which are 320×.

certain fasciolid miracidia. He found, however, that Victoria blue did not stain apical glands of miracidia of several genera from five other trematode families. The common staining affinities of *C. oculeum* miracidial apical glands and those of fasciolids may reflect chemical and/or functional similarities.

Using Alcian blue as a vital stain for acid mucopolysaccharides Wilson (1969) found positive material on the surface of *F. hepatica* miracidia. He hypothesized that such mucosubstances might protect penetrating miracidia from the host's enzymes. Since the miracidium of *C. oculeum* does not penetrate its host, the extremely weak Alcian blue staining might be a corollary of Wilson's hypothesis. However, the lack of Alcian blue positive mucosubstances on the tegument of rediae recently intruded into snails argues against this for *C. oculeum*.

Muscles of the apical papilla and subepidermis, apical gland contents, miracidial flame cells, epidermal plates, and the redia stained variously with mercuric

bromphenol blue, a general protein stain. Mazia et al. (1953) reported a good correlation between protein concentration and dye binding. The intense staining of apical gland contents indicates the presence of high concentrations of protein. Whether these are structural or enzymatic proteins has not been resolved by the enzymatic histochemical studies performed.

The strong Berenbaum acetone Sudan black staining of the apical gland, flame cells, and epidermal plates indicates high levels of "bound lipids"; i.e., lipids in close association with proteins, carbohydrates, and/or nucleic acids (Berenbaum, 1954). The strong reaction was expected in the epidermal plates because of the proliferation of lipid-protein-rich cytomembranes in these areas. The significance of bound lipids in the lumen of the apical gland is not yet known but may be clarified by ultrastructural studies of the miracidium (Taft, unpublished). Erasmus (1967) noted lipid droplets in the excretory ducts of *Cyathocotyle bushiensis* adults. He speculated that in adults it is an excretory product, but in other stages it may be an energy source. The absence of free lipids in *C. oculeum* miracidia as determined by conventional lipid staining may indicate lipids are not a major energy substrate in this larval stage.

Characterization of miracidial enzymes has proved difficult. Histochemical tests for aminopeptidases, nonspecific esterases, and proteases in *C. oculeum* miracidia and rediae were negative. Lipase was observed within eggs containing *C. oculeum* miracidia, but not in the miracidia or rediae themselves. Lipase is thought to be produced by the miracidium and may be involved in the hatching of the egg. Rogers (1958) isolated hatching fluid consisting of chitinase, lipase, and probably a protease from the eggs of *Ascaris lumbricoides*. Studies by Andrade and Barka (1962) on *S. mansoni* ova containing miracidia demonstrated aminopeptidases, acid phosphatases, and nonspecific esterases in the penetration glands as well as nonspecific esterases and phosphatases in the ovum. These findings are not always consistent. Pepler (1958), for example, working with the same species, found no evidence of nonspecific esterases in *S. mansoni* miracidia. Kinoti (1971) did not observe aminopeptidase in the penetration glands of either *S. mansoni* or *S. mattheei* miracidia.

The presence of alkaline phosphatase in epidermal plates and flame cells, and acid phosphatases in epidermal plates, apical gland, and redial intestine of *C. oculeum* is consistent with previous studies of trematode larvae. Wilson (1971) found a strong acid phosphatase reaction in the epidermal plates and a diffuse reaction in the apical gland of *F. hepatica* miracidia. Numerous authors including Cheng (1964), Probert (1966), and Moore and Halton (1975) have demonstrated acid and alkaline phosphatases in the redial tegument and intestine. The presence of acid and alkaline phosphatase activities in the tegument, gut, and excretory systems of trematodes suggests the presence of active transport systems in these tissues.

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I would like to thank Dr. Lyle Nauman, Alan Balliett, and Jerry Bartelt for aid in collecting American coots, Dr. Robert Simpson and Dr. Joseph Harris for advice concerning histochemical techniques, and Dr. Robert Simpson and Dr. Sol Sepsenwol for critically reading the manuscript.

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Further Studies on the Development of *Leucochloridiomorpha constantiae* (Trematoda) Metacercariae on the Chick Chorioallantois

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ABSTRACT: *Leucochloridiomorpha constantiae* (Trematoda) metacercariae were cultivated in 3-day-old chick embryos and on 8- to 12-day-old chick chorioallantoic membranes. Worms grown singly in chick embryos were capable of self-fertilization and produced eggs with miracidia. Worms attached to the surface of the chorioallantois with the aid of the acetabulum. Attachment appeared similar to that observed in the bursa of Fabricius of the domestic chick.

Leucochloridiomorpha constantiae (Trematoda) metacercariae have been cultivated on the chick chorioallantoic membrane (CAM) (Harris et al., 1972) using the classical procedure of Woodruff and Goodpasture (1931) as described in Fried (1962). Information on the cultivation of this fluke in 3-day-old chick embryos using the Zwilling (1959) procedure as modified by Fried (1973) for the cultivation of *Leucochloridium variae* McIntosh, 1932 metacercariae is not available. Moreover, the ability of single-worms of *L. constantiae* to self-fertilize on the CAM is not known. This study provides further information on the cultivation of *L. constantiae* on the CAM.

Materials and Methods

Free metacercariae of *L. constantiae* were dissected from the uterus of *Campeloma decisum* snails and prepared for transplantation to chick embryos as described previously (Harris et al., 1972). Metacercariae were placed either singly (Exp. B) or multiply (Exp. A) into 9- to 14-day-old CAM's as described by Fried (1962). Additional experiments used the Zwilling (1959) procedure as described in Fried (1973) to transfer worms either singly (Exp. D) or multiply (Exp. C, E) into 3-day-old chick embryos. Eggs were maintained at 39.5°C and were examined from 1 to 14 days postinoculation. In Exp. A to D the surface of the CAM was examined for worms, whereas the entire egg was examined in Exp. E. Some worms were fixed in hot AFA and prepared as whole mounts stained in Gower's carmine, whereas others were fixed in neutral buffered formalin, prepared as paraffin sections and stained with Harris' hematoxylin and eosin (H and E). Some of the worms attached to the CAM were sectioned on a cryostat and stained with H and E.

→

Figures 1–4. Photomicrographs of *Leucochloridiomorpha constantiae* grown in chick embryos. 1. Live worm grown for 10 days on 3-day-old embryo (Exp. D). 2. Eggs from worm in Figure 1. Miracidia in various stages of development. 3. Paraffin section stained with H and E of worm shown in Figure 1. Some of the eggs in the top of the field are distorted and contain abnormal capsules; the 3 eggs at the bottom of the field contain developing miracidia. 4. Cryostat section of ovigerous worm attached to the CAM; note tissue plug in the acetabulum. Scale bars = 100 μm in Figures 1 and 4, and 10 μm in Figures 2 and 3.

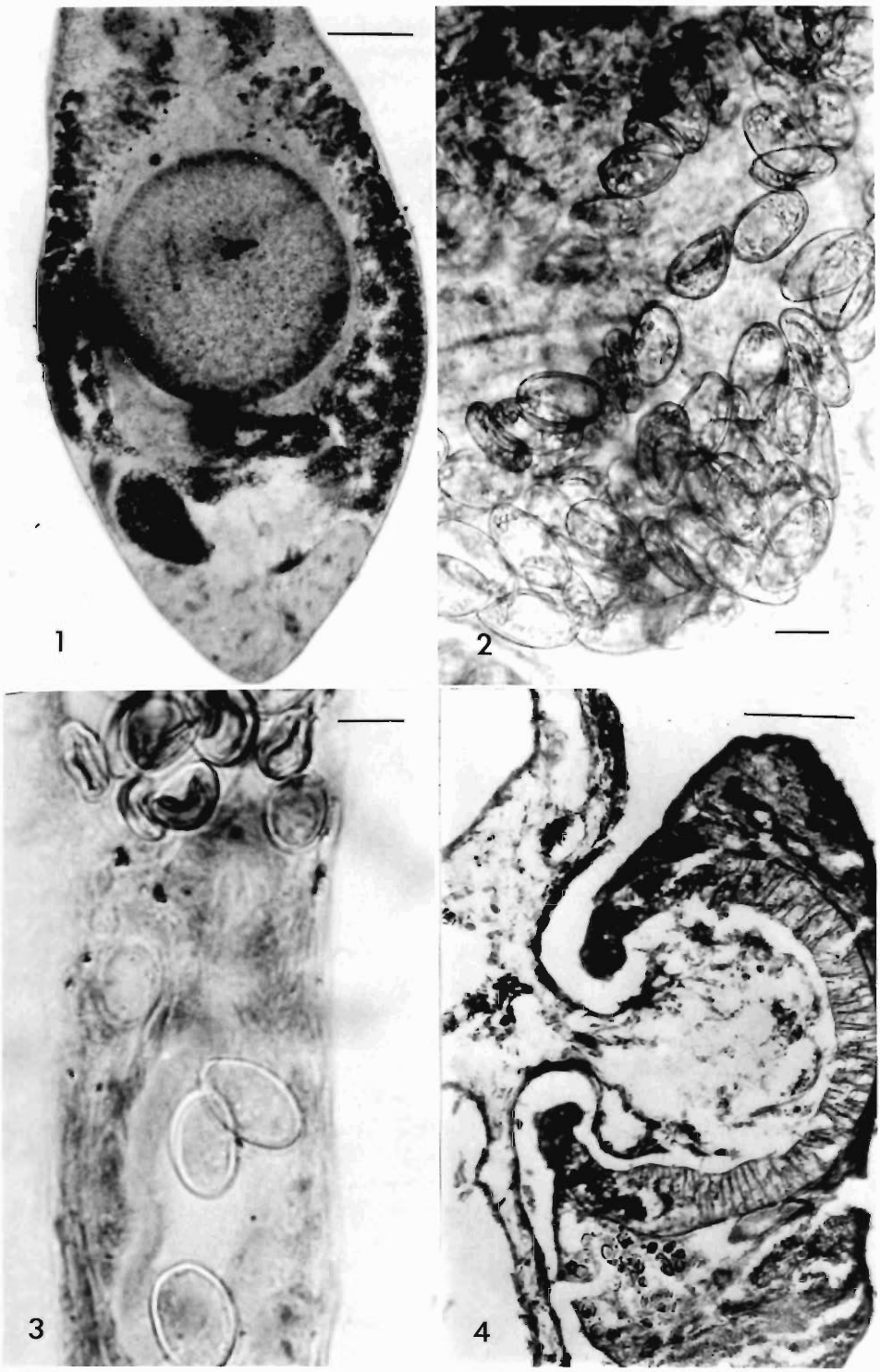

Table 1. Summary of single- and multiple-worm infections of *L. constantiae* on the chick chorioallantois.*

Exp.†	No. of eggs used	Age of eggs at inoculation (days)	No. of postinoculation eggs	No. of worms implanted per egg	Age of worms at recovery (days)	Total no. of worms recovered‡
A	22	9–14	13	12–20	4–6	63
B	14	10–11	5	1	7–8	5
C	41	3	22	6–15	7–14	66
D	7	3	1	1	10	1
E	8	3	8	12–20	1–7	53

* Exp. A, C, and E are multiple-worm infections; Exp. B and D are single-worm infections.

† Exp. A and B used transfer procedure of Fried (1962); Exp. C, D, and E used transfer procedure of Zwilling (1959) as described in Fried (1973).

‡ Worms recovered only from the surface of the chorioallantois in Exp. A–D; in Exp. E worms recovered from various sites in the egg as discussed in text.

Results

Results of the CAM infections are summarized in Table 1. Regardless of the implantation procedure used, worms were recovered from the surface of the CAM (A vs. C). As reported previously, most CAM-worms became ovigerous by day 4, and eggs containing fully developed miracidia were seen by days 7 or 8 (Harris et al., 1972). The single-worm recovered from Exp. D and most of the single-worms from B had eggs with developing miracidia (Figs. 1–3). Autocopulation, i.e., insertion of the cirrus into the metraterm was seen in most single-worms. Although worms usually clustered or paired on the CAM as reported previously (Fried and Roberts, 1972), no evidence of cross-copulation was noted. Worms from single- or multiple-infections attached tenaciously to the CAM with the aid of the acetabulum and a tissue plug was evident (Fig. 4). In Exp. E, eight of the 53 worms (Table 1) were recovered from extraembryonic membranes whereas the remainder were mainly in the albumen. Worms from the albumen showed no postmetacercarial development.

Discussion

The Zwilling (1959) procedure has been used to cultivate metacercariae of *Leucochloridium variae, Echinostoma revolutum,* and *Leucochloridiomorpha constantiae* in 3-day-old chick embryos (Fried, 1973; Fried and Butler, 1977; present study). A recent study (Fried and Nelson, 1978) indicated that *Zygocotyle lunata* metacercariae could not be cultivated in 3-day-old chick embryos.

Results of the single-worm experiments indicate that *L. constantiae* is capable of self-fertilization on the CAM. Although pairing and clustering occur in multiple-worm infections (Fried and Roberts, 1972), we have no evidence that *L. constantiae* is capable of cross-fertilization on the CAM.

Leucochloridiomorpha constantiae attaches tenaciously to the CAM. Results of the present study indicate that acetabular attachment to the CAM is similar to attachment seen in the bursa of Fabricius of the chick (Fried and Lang, 1971).

Acknowledgments

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Two New Genera of Pseudophyllidean Cestodes from Deep-Sea Fishes

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ABSTRACT: Two new genera of pseudophyllidean cestodes are described from the deep-sea teleost *Alepocephalus agassizi* Goode and Bean, 1883. *Probothriocephalus muelleri* gen. et sp. n. is a parabothriocephalid distinguished by the combination of a neck, marginal genital pores, indistinct metamerism, unarmed cirrus, and circumcortical vitellaria. Philobythiidae Campbell, 1977 is emended to include a new genus, *Philobythoides*, which differs from *Philobythos* in having the testes restricted to the extreme anterior region of the segment, a single embryo per capsule, and scolex lacking an apical disk.

Adult cestodes have been infrequently encountered among more than 1,700 deep sea engybenthic teleosts examined from trawls in the environs of Hudson Submarine Canyon, northwest Atlantic (39°27′N, 70°28′W). Among those recovered are two new genera of pseudophyllideans from the intestine and pyloric ceca of *Alepocephalus agassizi* Goode and Bean, 1883. Mixed infections were observed on several occasions. Fish were caught in trawls at mean depths of 1,691 to 2,293 m and worms removed and processed from both freshly caught and preserved hosts by methods previously described (Campbell, 1977). Whole mounts were stained with Mayer's paracarmine or Ehrlich's acid hematoxylin and mounted in Kleermount or Canada balsam. Frontal and transverse serial sections of the strobilas were cut at 10 μm and stained with Harris' hematoxylin and eosin. Descriptive measurements are expressed as length by width, include the range, and the mean in parentheses. Measurements are in micrometers unless otherwise indicated.

Probothriocephalus gen. n.

DIAGNOSIS: Pseudophyllidea; Parabothriocephalidae. Scolex linguiform, bothria shallow, apical disk lacking. Neck present. External segmentation indistinct, internal segmentation lacking. Genital pores marginal, irregularly alternate. Cirrus unarmed. Testes medullary, in lateral fields, continuous in postovarian space and between segments. Ovary in posterior medulla. Vagina enters genital atrium posterior to cirrus pouch. Uterine duct and sac median, invading adjoining proglottis; uterine pores midventral. Vitellaria cortical, continuous. Eggs operculate, unembryonated. Parasites of marine teleosts.

TYPE AND ONLY SPECIES: *Probothriocephalus muelleri* sp. n.

Probothriocephalus muelleri sp. n. (Figs. 1, 5, 6, 7, 9, 10)

DESCRIPTION (based on 17 specimens; 5 measured): *Probothriocephalus*. Scolex somewhat elongate, tapering anteriorly, 1.4–1.9 mm by 700–940. Neck about 780 by 740. Strobila fairly broad and uniform, 10.5–41.7 cm by 1.7–2.3 mm, longitudinal furrows lacking. Segmentation poorly developed, proglottisation uniform. All segments broader than long, anterior and posterior borders marked by presence of uterine sacs. Mature segments 0.8–1.1 mm by 2–2.1 mm; gravid

segments 1.3–1.4 mm by 2.1–3.4 mm. Genital pores marginal, irregularly alternate, postequatorial. Cirrus pouch (5 worms, 24 pouches) 253–371 (298) by 63–136 (89), small, thin walled, tapering medially to join highly coiled vas deferens. Testes subspherical, 64–112 by 32–48, forming 2 continuous longitudinal bands in lateral medulla, joining in postovarian space; 52–83 (62) per proglottis (5 worms, 30 proglottids). Vitelline follicles irregular, distinctly circumcortical and continuous, 24–56 in diameter. Vagina narrow, nonmuscular, parallel to cirrus pouch along posterior border then turns posteriad near midline to join ootype. Vaginal sphincter lacking. Seminal receptacle absent. Ovarian lobes (5 worms, 50 lobes) 237–427 (308) by 120–237 (192), transversely elongate, bilobed; isthmus narrow, 140–180 by 16. Mehlis' gland posteroventral to ovary, uterine duct highly coiled, passing dorsal to ovarian isthmus and ascending in midline to uterine sac at anterior margin of proglottis. Uterine sac invades preceding proglottis when gravid. Eggs (5 worms, 40 eggs) 95–114 (103) by 61–72 (64), operculate, thin shelled, unembryonated, poles with numerous tubercles.

HOST: *Alepocephalus agassizi* Goode and Bean, 1883 (Alepocephalidae).

LOCALITY: Hudson Submarine Canyon in northwest Atlantic and adjacent continental slope.

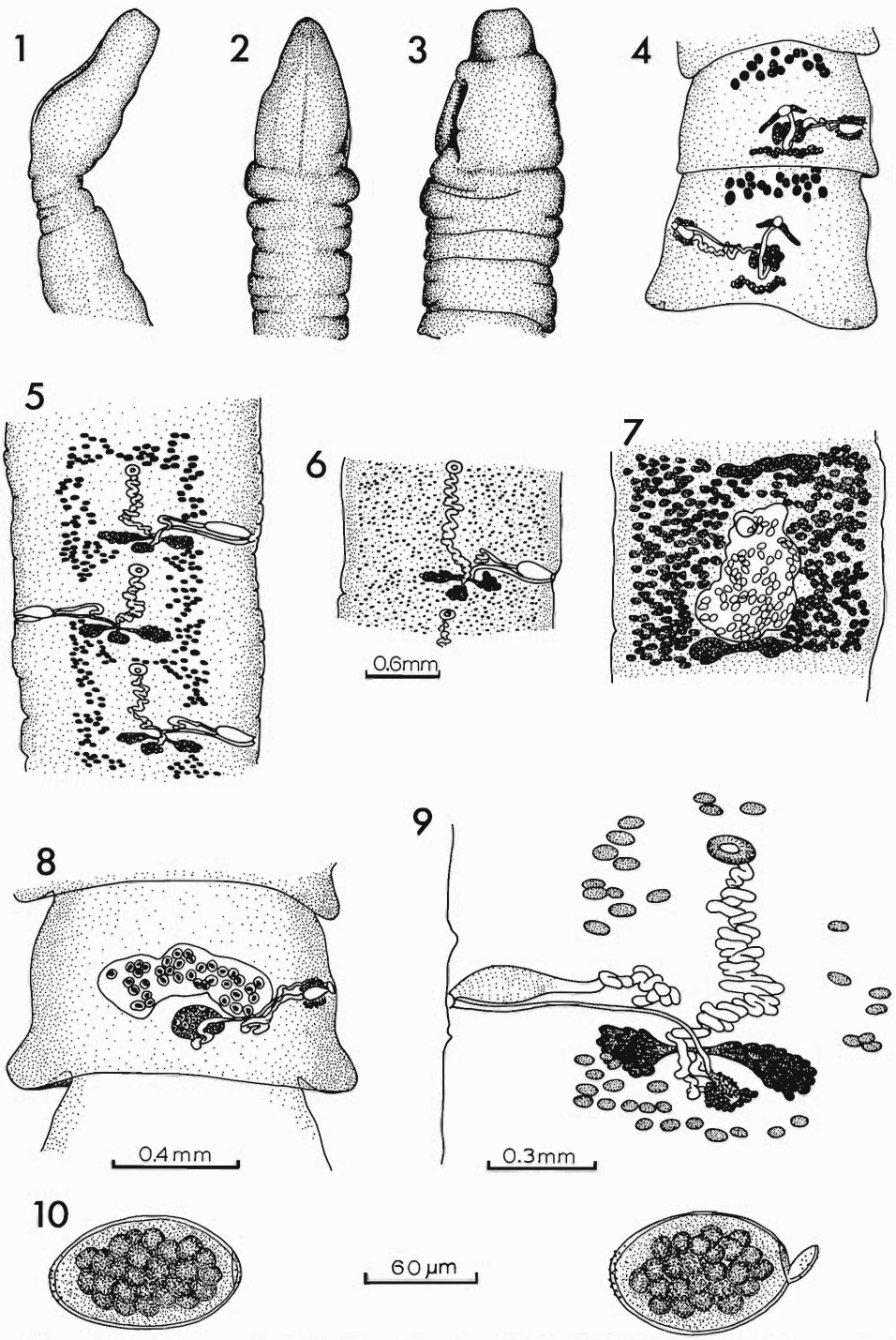
HOLOTYPE AND PARATYPE: USNM Helm. Coll. Nos. 74875 and 74876.

ETYMOLOGY: The species is named after Dr. Justus F. Mueller, parasitologist, S.U.N.Y. Upstate Medical Center, Syracuse, New York.

Remarks

The presence of operculate, unembryonated eggs in this species in combination with its other features does not clearly separate it from the Amphicotylidae Ariola, 1899. Amphicotylids having cortical vitellaria and marginal genital pores like *Probothriocephalus* are *Eubothrium, Amphicotyle,* and *Pseudamphicotyla* and comprise the subfamily Amphicotylinae Lühe, 1902. In addition to the differences in eggs, features differentiating *Probothriocephalus* from these genera are: the lack of dorsal and ventral median furrows and distinct segmentation, and the vagina opening posterior to the cirrus instead of anteriorly as in *Eubothrium*; the possession of simple bothria and ventral uterine pore instead of the dorsal pore and bothridial suckers of *Amphicotyle*; and, by lacking the loculate bothria, terminal disk, and segmentation of *Pseudamphicotyla*.

Using the keys of Wardle and McLeod (1952), Wardle et al. (1974), Joyeux and Baer (1961), and Yamaguti (1959) *Probothriocephalus* can be keyed to the Bothriocephalidae Blanchard, 1849 or Parabothriocephalidae Yamaguti, 1959. Yamaguti (1959) separated *Parabothriocephalus, Parabothriocephaloides,* and *Glossobothrium* from the Bothriocephalidae and placed them in Parabothriocephalidae. *Probothriocephalus* is clearly closely related to the three genera in this family, especially *Parabothriocephaloides* and *Glossobothrium* which have cortical vitellaria. *Parabothriocephalus gracilis,* the genotype, has medullary vitellaria but *P. johnstoni* Prudhoe, 1969 from *Coryphaenoides whitsoni* has vitellaria intruding from the cortical into the medullary zone. These genera differ from *Probothriocephalus* in having a dorsosubmarginal cirrovaginal aperture, distinct segmentation, vagina divided into two distinct regions, and in lacking a neck. In addition *Glossobothrium* has bothrial appendages and an apical disk. Members of the Bothriocephalidae are widespread among shallow dwelling marine teleosts of the



Figures 1–10. Deep-sea Pseudophyllidean Cestodes. 1, 5, 6, 7, 9, 10. *Probothriocephalus muelleri*: 1. Scolex. 5. Mature proglottids showing testes. 6. Mature proglottid showing vitellaria. 7. Gravid proglottid. 9. Detail of reproductive system. 10. Eggs. 2, 3, 4, 8. *Philobythoides stunkardi*: 2–3. Scolices. 4. Mature segments. 8. Gravid segment.

world. Yamaguti's Parabothriocephalidae, included in the Bothriocephalidae by some authors, is known only from inshore teleosts except for *Parabothriocephalus johnstoni* from an Antarctic macrourid (Prudhoe, 1969).

Philobythoides gen. n.

DIAGNOSIS: Pseudophyllidea; Philobythiidae. Scolex conical, bothria well formed, apical disk absent. Segments markedly craspedote. Strobila anapolytic. Testes medullary, clustered near anterior border of segment. Uterus with lateral diverticula forming an inverted V. Embryos develop individually within membranous capsules. Parasites of marine teleosts.

TYPE AND ONLY SPECIES: *Philobythoides stunkardi* sp. n.

ETYMOLOGY: The genus is named for its similarity to *Philobythos*.

Philobythoides stunkardi sp. n. (Figs. 2, 3, 4, 8)

DESCRIPTION (based on 6 gravid specimens and numerous fragments): *Philobythoides*. Scolex weakly developed, 504–568 (540) by 376–416 (392). Neck absent. Strobila serrate, 7–19 mm (15 mm) by 1.02–1.2 mm (1.12 mm), consisting of 62–188 markedly craspedote segments. Internal segmentation distinct. All segments wider than long; mature, 304–672 by 0.424–1.12 mm; gravid, 700–900 by 0.94–1.2 mm. Cirrus pouch (5 worms, 30 pouches) 73–83.6 (79) by 45.6–49.4 (47), pyriform, delicate, surrounded by glandlike cells. Unarmed cirrus present. Genital atrium protrudes in distinct marginal papilla; pore postequatorial, irregularly alternate. Testes subspherical, 23–48 by 19–40, medullary, clustered in median field of anterior ¼ of segment. Testes per segment (5 worms, 25 segments) 16–25 (20). Vagina opens anterior to cirrus pouch. No seminal receptacle observed. Ovary bilobed, maximum dimensions 114–190 by 32–80. Uterine duct extends anteroventral to ovary to join uterus. Uterus with 2 preformed diverticula. Gravid uterus forms a transverse sac. Uterine pore median. Embryos develop singly within membranous capsules 38–84 in diameter; hexacanths (5 worms, 20 embryos) 56–80 (72) by 34–45 (40). Vitellarium medullary, transversely elongate, 216–456 by 32–80, immediately postovarian. Testes and vitellarium degenerate in gravid segments.

HOST: *Alepocephalus agassizi* Goode and Bean, 1883 (Alepocephalidae).

LOCALITY: Hudson Submarine Canyon and adjacent continental slope.

HOLOTYPE AND PARATYPE: USNM Helm. Coll. Nos. 74873 and 74874.

ETYMOLOGY: The species is named after Dr. Horace W. Stunkard, parasitologist, at the American Museum of Natural History, New York.

Remarks

Presently, the family Philobythiidae Campbell, 1977 is monotypic being based on a single species, *Philobythos atlanticus*. *Philobythoides* resembles *Philobythos* in its markedly craspedote strobila, transversely elongate vitellarium, small cirrus pouch, uterus with preformed diverticula, and embryos developing in membranous capsules. However, *Philobythoides* differs from *Philobythos* in having a scolex lacking any evidence of an apical disk, testes restricted to the extreme anterior portion of the segment, and a single hexacanth embryo instead of multiple embryos per capsule.

In view of the discovery of a second genus the family diagnosis is emended and *Philobythos* separately defined as follows:

Philobythiidae Campbell, 1977, emended

DIAGNOSIS: Pseudophyllidea. Small worms with scolex more-or-less well-developed and bearing bothria. Apical disk weakly developed or absent. Neck present or absent. Strobila distinctly segmented. One set of reproductive organs per segment. Testes medullary, medial to nerve trunks. Cirrus pouch contains unarmed cirrus. Genital pores marginal, irregularly alternate. Vagina enters anterior to cirrus pouch. Ovary in posterior medulla. Vitellarium medullary, postovarian. Uterus with preformed diverticula and ventromedian pore. Oncospheres develop singly or in clusters within membranous capsules. Parasites of marine teleosts.

TYPE GENUS: *Philobythos* Campbell, 1977.

Philobythos Campbell, 1977, emended

DIAGNOSIS: Pseudophyllidea; Philobythiidae. Scolex with bothria and weakly developed apical disk. Strobila craspedote, anapolytic. Primary and secondary segmentation precede proglottisation. Testes medullary, surrounding female reproductive system. Uterus with lateral diverticula forming an inverted V. Oncospheres develop in clusters within membranous capsules. Parasites of marine teleosts.

TYPE AND ONLY SPECIES: *Philobythos atlanticus* Campbell, 1977.

Remarks

The genera are distinguished as follows: *Philobythos,* with characters of the family; scolex with weakly developed apical disk, testes surrounding female reproductive system, multiple embryos per capsule.

Philobythoides, with characters of the family: scolex lacking apical disk, testes restricted to extreme anterior portion of segment, a single embryo per capsule.

Acknowledgments

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Proc. Helminthol. Soc. Wash.
46(1), 1979, pp. 79–83

Fuhrmannetta (*Fuhrmannetta*) *bandicotensis* sp. n. of Cestode (Eucestoda, Davaineidea, Davaineidae) from the Bandicoot (*Bandicota indica nemorivaga* Hodgson, 1836) from Taiwan[1]

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ABSTRACT: The only other species of this genus and subgenus known from mammals is *Fuhrmannetta* (*F.*) *salmoni* (Stiles, 1895) from rabbits (*Sylvilagus* spp.) and hares (*Lepus* spp.) in North America. *Fuhrmannetta* (*F.*) *bandicotensis* with larger strobilae, rostellar hooks 16 μm long, walls of the cirrus pouch 5 μm thick, 17–25 testes, genital ducts passing between the excretory canals, and uterine capsules with 2–6 eggs differs from the smaller *F.* (*F.*) *salmoni* with rostellar hooks 20 μm long, walls of the cirrus pouch 12–20 μm thick, 45–50 testes (as indicated in drawings), genital ducts passing dorsal to the excretory canals, and uterine capsules with 3–15 eggs.

Davaineid cestodes collected from bandicoots (*Bandicota indica nemorivaga* Hodgson, 1836) captured in Ali-Lao, Taipei Hsien (county), Chao Chou, Ping Tung Hsien, and Yung Foh Lee, Yang Ming Shan (district) on Taiwan constitute an undescribed species of the genus *Fuhrmannetta* Movsesian, 1966.

The collection consists of 27 scolices most of which are attached to incomplete strobilae, a few of what appear to be entire mature strobilae, and none to fully developed strobilae with ripe proglottids. There are many parts of strobilae comprising chains of proglottids of varying lengths and all stages of development.

Materials and Methods

The specimens were collected in 1958 and in 1960. Some have been stored in alcohol until the present. Some were stained and mounted on slides at an unknown date by unidentified persons. Specimens in both cases are fragmented to the point where correlation of related parts into an entire strobila is impossible. The minute spines on the margins of the openings of the suckers have been lost in their entirety in some instances, on some suckers but not others on the same scolex, and partially on individual suckers in other cases.

Specimens from the alcoholic preservative were stained with Semicohn's acid carmine. Specimens from slides were restained with Semicohn's and remounted.

Illustrations were made with the aid of a camera lucida, except Figure 6 which was done freehand. Measurements are given in micrometers except when stated otherwise. Numbers in parentheses represent the average of 10 specimens.

Fuhrmannetta (*Fuhrmannetta*) *bandicotensis* sp. n.

Description: With the characters of the genus and subgenus. Maximum length of longest intact but incomplete strobila 121 mm. Width of proglottis 1.93–2.09 mm (2 mm), length 409–499 (440); anterior end of strobila equal to or slightly narrower than scolex (Fig. 1), depending on degree of contraction. Proglottids

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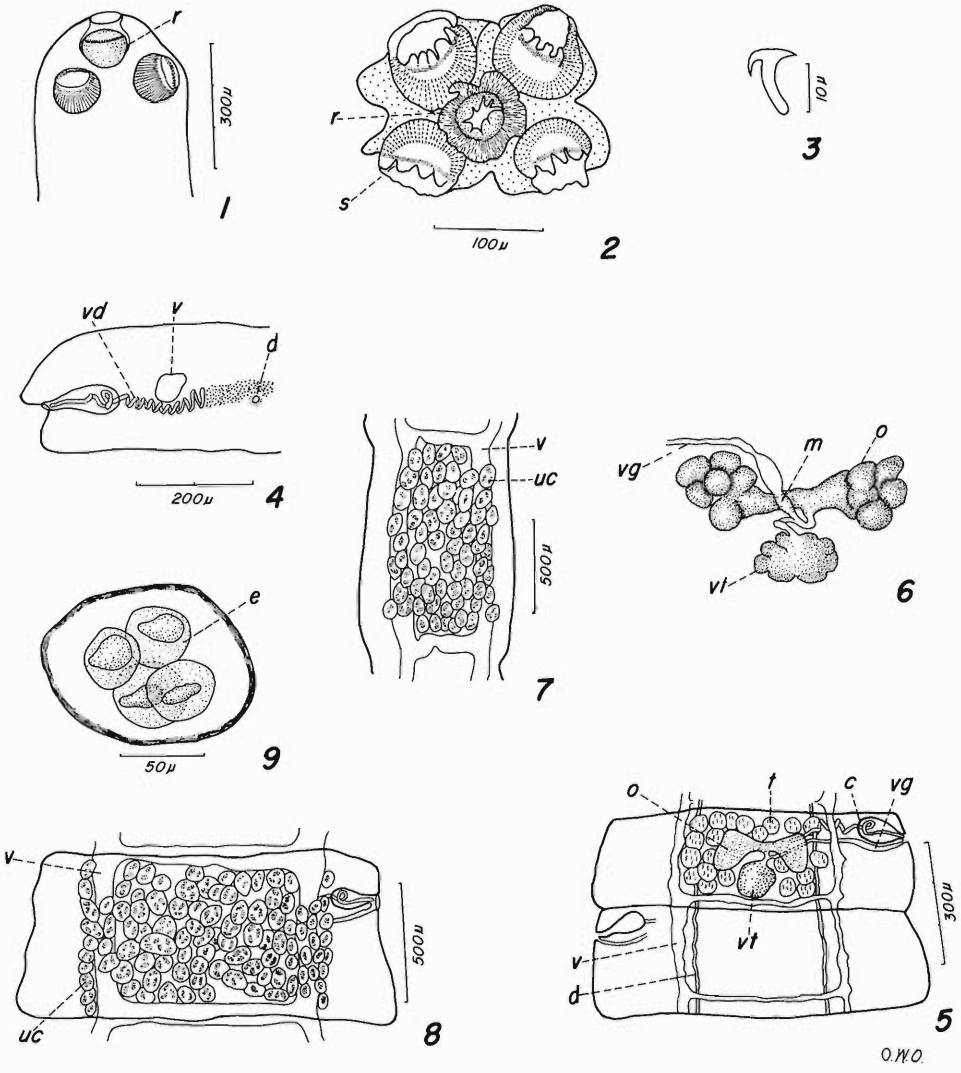

Figures 1–9. 1. Scolex from side view. 2. Scolex from anterior view. 3. Rostellar hook. 4. Anterior view of proglottid, showing course of genital ducts between excretory canals. 5. Mature proglottid. 6. Detailed illustration of female reproductive organs (freehand drawing). 7. Elongated terminal gravid proglottid. 8. Gravid proglottid not yet elongated. 9. Uterine capsule containing four eggs. c, cirrus pouch; d, dorsal excretory canal; e, embryonated egg in uterine capsule; m, Mehlis' gland; o, ovary; r, rostellum; s, sucker with band of minute spines; t, testes; uc, uterine capsule containing eggs; v, ventral excretory canal; vd, vas deferens; vg, vagina; vt, vitelline gland.

craspedote. Neck up to 3.8 mm long. Scolex 237–401 (300) wide by 148–325 (237) long; suckers 72–133 (100) wide by 53–106 (81), each with opening armed by a band of minute spines that could not be counted nor measured (Fig. 2). Rostellum 61–97 (71) long by 61–97 (75) wide, armed with a double row of 100–120 small hammer-shaped hooks 16 long (Fig. 3). Genital pores located near anterior margin of proglottids, irregularly alternate but somewhat infrequently so (Figs. 4, 5, 8). Ventral excretory canal varying greatly in diameter, up to 53 wide in mature

proglottids; dorsal excretory canal consistently around 5 in diameter, medial to ventral one; transverse canals large (Fig. 5). Cirrus pouch pear-shaped, 90–101 (96) long, reaching about midway between margin of proglottid and ventral excretory canal (Figs. 4, 5, 8), by 35–48 (43) in greatest diameter, wall 5 thick; no internal seminal vesicle occurs; a few internal coils of vas deferens present. External to cirrus pouch vas deferens is elaborately coiled in region of excretory canals and medial toward ovary (Figs. 4, 5); no external seminal vesicle. Cirrus aspinose, uniform in diameter. Genital ducts pass between dorsal and ventral excretory canals (Figs. 4, 5). Testes 17–25 (22) with 5–11 (7) poral to ovary and 11–18 (15) aporal, filling space between ventral excretory canals and extending somewhat beyond (Fig. 5), 29–53 by 27–32 (40 by 31) in size. Ovary median or slightly poral in location, 106–170 (141) wide and somewhat less in anterior–posterior direction, lobulate (Fig. 5); vagina without seminal receptacle, arches from common genital atrium to posterior side of middle part of ovary where it unites with vitelline duct. Vitelline gland posterior to ovary, somewhat regular in outline, oval in shape, vesicular in appearance at times (Figs. 5, 6), and 67–125 (87) wide by 53–67 (60) in anterior–posterior direction. Uterus breaks up into numerous uterine capsules (Figs. 7, 8), up to 100 counted in one plane, capsules 106–146 (129) long by 80–96 (87) wide, each with 2–6 eggs 24–32 (27) in size.

HOST: *Bandicota indica nemorivaga* Hodgson, 1837.

SITE: Small intestine.

LOCALITY: Ali-Lao, Taipei Hsien (county); Chao Chou, Ping Tung Hsien; and Yung Foh Lee, Yang Ming Shan (district), Taiwan.

HOLOTYPE: USNM Helm. Coll. No. 73876.

PARATYES: USNM Helm. Coll. No. 73877.

ADDITIONAL SPECIMENS: USNM Helm. Coll. No. 73878.

Discussion

Wardle, McCleod, and Radinovsky (1974) raised the former cyclophyllidean family Davaineidae to the ordinal rank of Davaineidea. This action was based on the characteristic features of the holdfast with its unique hooks, mature proglottids, and life cycle of these cestodes. Of the genus *Fuhrmannetta* from mammals, only *F.* (*F.*) *salmoni* (Stiles, 1895) was known prior to finding *F.* (*F.*) *bandicotensis* in bandicoots.

Stiles (1895) found the cestodes in hares (*Lepus melanotis* = *Lepus californicus melanotis*) and cottontail rabbits (*Lepus sylvaticus* = *Sylvilagus floridanus floridanus*) in North America. In this species the genital pores are irregularly alternating, the rostellum and suckers are armed with minute hooks, and the eggs are in packets. He named it *Davainea salmoni* but provided no description at that time. He (Stiles, 1896) later described the species in detail, providing figures of the rostellar and sucker hooks, immature proglottids, an outline in natural size of a complete strobila, and also what was considered as some larval stages found in leporines by Curtice. Stiles pointed out that while the genital pores were irregularly alternating in the adult strobilae, there was a tendency for a greater proportion of the pores to occur on the same side, with a few strobilae in which they appeared to be regularly unilateral.

Of the larval stages found by Curtice and reported on separately by him at a meeting (Stiles, 1896), he noted that the smaller (younger) forms bore rostellar

hooks, whereas the larger (older) ones were hookless. He concluded that as the larval stages (cysticercoids) mature, the hooks are lost and the adult worms are hookless. Stiles (1896), on the other hand, believed that two species of cestodes were represented, the hookless larvae being *Cittotaenia variabilis* (Anoplocephalidae) and the hooked ones *Davainea salmoni* (Davaineidae).

Braun (1896) accepted Curtice's conclusion (Stiles, 1896) that the young with rostellar hooks developed into hookless adult worms, and considered Stiles' conclusion that two species were involved to be erroneous.

Stiles and Orleman (1926) established the subgenus *Fuhrmannetta* for those species of *Raillietina* bearing a ring of minute spines on the suckers and with irregularly alternating genital pores, with *R. crassula* Rudlophi, 1819 as type species.

Hughes (1941) considered *Taenia salmoni* (Stiles, 1895) Braun, 1896 as *Raillietina stilesiella* nomen novum. He and Schultz (1942) listed it as *R. stilesiella* Stiles, 1895 in their monograph on the *Raillietina*.

Wardle and McLeod (1952) considered *Raillietina stilesiella* Hughes, 1941 as belonging in the subgenus *Fuhrmannetta*. They reported that there are 200 testes, although Stiles (1896) does not mention the number. His figures, however, suggest 45 to 50 testes in the older proglottids illustrated.

Yamaguti (1959) accepted the subgeneric rank of *Fuhrmannetta* Stiles and Orleman, 1926. He rejected *Raillietina stilesiella* Hughes, 1941, giving it as a synonym of *Davainea salmoni* Stiles, 1895, but included *Raillietina demerariensis* Daniels, 1895. The latter with unilateral genital pores must be excluded from *Fuhrmannetta* which has irregularly alternating genital pores.

Movsesian (1966) raised the subgenus *Fuhrmannetta* Stiles and Orleman, 1926 to generic rank and established the subgenera *Fuhrmannetta* and *Mathevossianetta*. He (Movsesian, 1967) presented in tabular form measurements of chief organs used in separating the species of the subgenera *Fuhrmannetta* and *Mathevossianetta* of the genus *Fuhrmannetta* from birds and mammals. He retained *F.* (*F.*) *stilesiella* Hughes, 1941. Movsesian (1967) did not include *Raillietina demerariensis* Daniels, 1895 in the genus *Fuhrmannetta* because the genital pores are unilateral.

Movsesian's (1967) inclusion of *F.* (*F.*) *stilesiella* (Hughes, 1941) cannot stand, as noted by Yamaguti (1959), because it is identical with *F.* (*F.*) *salmoni* (Stiles, 1895) and of which it is a synonym.

In his *How to Know the Tapeworms,* Schmidt (1970) listed *Fuhrmannetta* as a subgenus of *Raillietina,* based on the designation of Stiles and Orleman (1926).

Fuhrmannetta (*F.*) *bandicotensis* sp. n. differs conspicuously from *F.* (*F.*) *salmoni* in a number of anatomical features. The strobila of *F.* (*F.*) *bandicotensis* is longer, being 121 mm or more in length as opposed to 86 mm for *F.* (*F.*) *salmoni*. The scolex of *F. salmoni* being 736 μm wide by 496 μm long is larger than that of *F. bandicotensis* at 237–401 μm wide by 148–235 μm long. The rostellum of *F. salmoni* is 144 μm in diameter with hooks 20 μm long, whereas in *F. bandicotensis* they are 60–97 μm and 16 μm, respectively. The size of the cirrus pouches in the two species overlap but the thickness of the wall differs, being 12–20 μm thick in *F. salmoni* and 5 μm in *F. bandicotensis*.

The number of testes in *F. stilesiella* Hughes, 1941 is given by Movsesian (1967) as 200. Stiles (1896) did not give a number but stated that the testes begin

about the 230th proglottid. His figures suggest between 45 and 50 rather than 200. The number could not be determined from examination of the type specimen. There are 17–25 testes in *bandicotensis*.

The genital ducts of *F. salmoni* pass dorsal to both excretory canals, according to Stiles' (1896) figures. Examination of the type specimens neither verified nor contradicted the illustrations. In *F. bandicotensis* the genital ducts pass between the canals.

Egg capsules in *F. salmoni* contain 3–15 eggs whereas in *F. bandicotensis* there are 2–6.

Acknowledgments

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Penarchigetes fessus sp. n. from the Lake Chubsucker, *Erimyzon sucetta* (Lacépède) in the Southeastern United States[1]

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ABSTRACT: *Penarchigetes fessus* sp. n. is described from the lake chubsucker, *Erimyzon sucetta* (Lacépède) from Alabama. *Penarchigetes fessus* varies from the only other known species of the genus, *P. oklensis* Mackiewicz, 1969, in scolex shape, development of neck, and number of testes.

Mackiewicz (1969) described a new genus, *Penarchigetes* (Cestoda: Caryophyllaeidae) represented by a single species from the spotted sucker, *Minytrema melanops* (Rafinesque) (Catostomidae: Osteichthyes) in Oklahoma. The following is a description of a new species of *Penarchigetes* from the southeastern United States.

Materials and Methods

Host fishes were collected with 10- and 50-ft seines, boat and backpack shocker, monofilament gill nets and trammel nets, and all were examined within 12 hr of capture. Cestodes were fixed in hot 5% formalin. Paraffin sections 12 μm thick were prepared and stained with hematoxylin and eosin, whole mounts were stained with Semichon's carmine. Sections and whole specimens were mounted in Permount. Measurements were based on relaxed, unflattened specimens. Measurements of testes and vitellaria follow Mackiewicz (1963). Egg size is based on 10 from the uterus of each specimen measured. Average measurements are given in micrometers unless otherwise stated, with ranges in parentheses; drawings were made with the aid of a Bausch and Lomb Tri-symplex microprojector and a camera lucida. Comparative material, from the U.S. National Museum (USNM) Helminth Collection, consisted of a paratype of *Penarchigetes oklensis* (71263).

Penarchigetes fessus sp. n. (Figs. 1–7)

TYPE HOST AND LOCALITY: Lake chubsucker, *Erimyzon sucetta* (Lacépède), Uphapee Creek, northeast of Tuskegee, Macon County, Alabama (31 December 1970 through 30 March 1972).

SPECIMENS STUDIED: 176 (10 measured) (2 cross-sectioned, 2 sagittally sectioned).

TYPE SPECIMENS: Holotype and 11 paratypes, USNM Helm. Coll. Nos. 72543 and 72544–74354; 10 paratypes in author's collection.

HABITAT: Intestine, loosely attached.

DESCRIPTION: Gravid adults 1.8 mm (1.2–2.5 mm) long and 404 (258–505) wide at gonopore. Length 3.4 (2.5–3.9) times combined length of neck and scolex. Scolex 389 (330–430) wide. Neck distinct. Outer longitudinal muscles poorly developed. Inner longitudinal muscles consisting of small fascicles. Testes number

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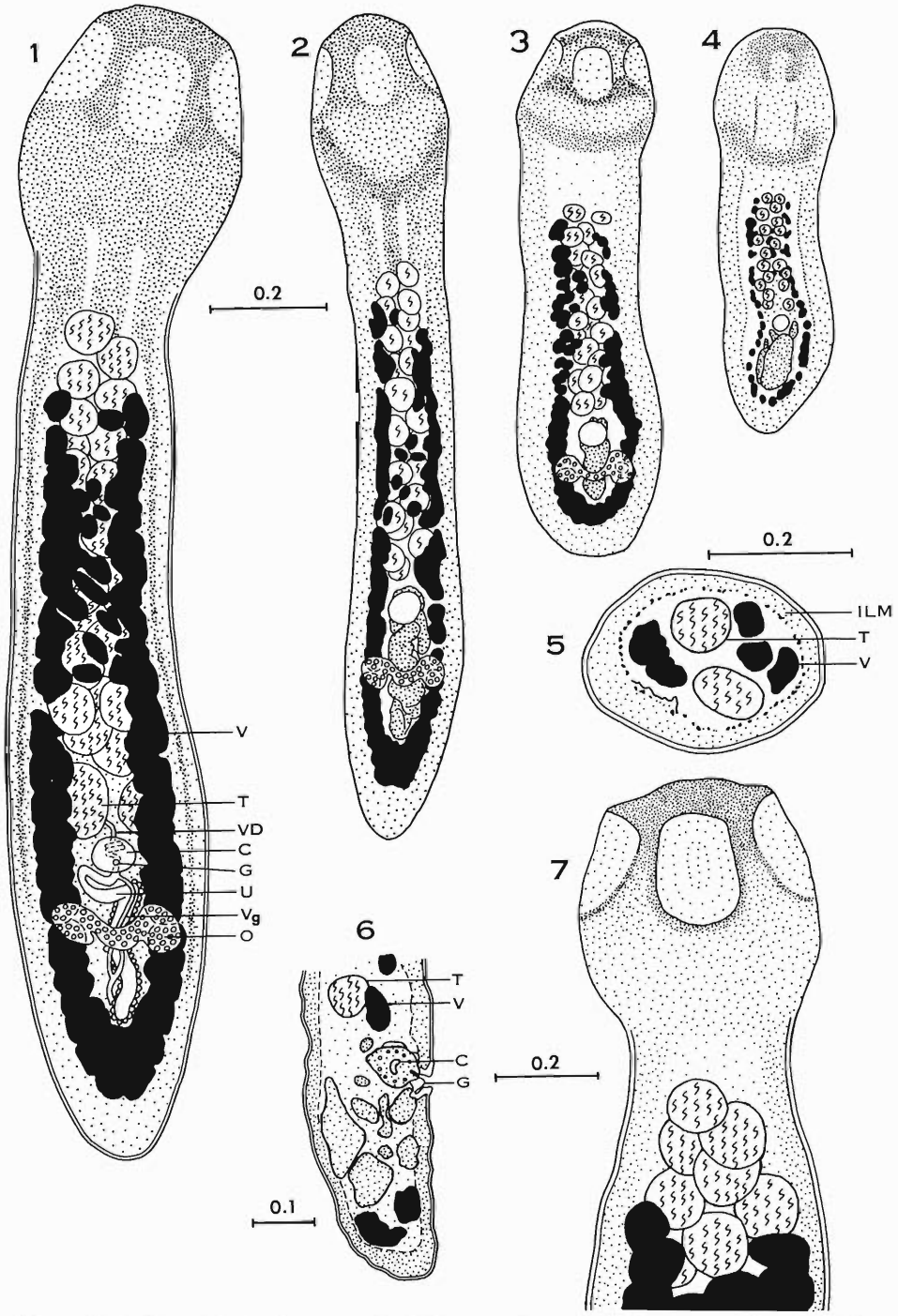

Figures 1–7. ***Penarchigetes fessus*** **sp. n. 1. Mature specimens. 2–4. Immature specimens. 5. Cross section through testicular region. 6. Sagittal section through gonopore. 7. Scolex. Abbrevations: C—Cirrus; G—Gonopore; ILM—Inner longitudinal muscle; O—Ovary; T—Testis; U—Uterus; V—Vitelline follicle; VD—Vas deferens; Vg—Vagina.**

23 (20–26), randomly arranged. Testes measure 97 (66–120) by 89 (60–117). Testes begin 527 (412–650) from tip of scolex and extend to near anterior level of cirrus sac. Cirrus sac round 95 (85–112); cirrus eversible. Genital aperture 472 (293–576) from posterior end. Preovarian vitellaria 69 (39–100) by 49 (34–73) beginning 653 (522–860) from tip of scolex, continuous with postovarian vitellaria over dorsal part of ovary. Postovarian vitelline field longer than ovary. Ovarian commisure forms an open "V." Wings of ovary large, expanded-rounded, wings 94 (62–117) long. Seminal receptacle absent. Osmoregulatory canals diffuse with no specific number in midpart of body. Egg with smooth shell 57 (54–58) by 38 (37–39) (in utero); presence or absence of operculum could not be definitely established.

Remarks

Penarchigetes fessus closely resembles *P. oklensis* Mackiewicz, 1969 in general body size and shape. It differs from *P. oklensis* by having a large instead of a small terminal disc; scolex of "disc-type" instead of expanded; neck distinct instead of indistinct.

Mackiewicz (1969) did not give measurements for the testes of *P. oklensis* nor mention their shape. His plate of *P. oklensis* shows spherical testes which measure less than 50. The testes of the paratype (USNM 71262) agree with those of his plate in size and shape. The testes of *P. fessus* are spherical to oblong in shape and average 89 × 97 in size. Mackiewicz (1969) stated that in all gravid specimens of *P. oklensis* the testes contained only a few spermatogonial cells along the testis membrane, making counting the testes difficult. In the present study, testes of *P. fessus* contained numerous spermatogonial cells and were very distinct in stained specimens.

The range of vitelline distribution mentioned by Mackiewicz (1969) as an intermediate condition between a continuous and discontinuous vitelline condition in *P. oklensis* did not occur in *P. fessus*. The preovarian and postovarian vitellaria in *P. fessus* were always continuous. The vitelline cells of *P. fessus* have vacuolated nuclei as described by Mackiewicz (1968). Shape of vitelline follicles may possibly vary with the age and development of a worm or with the method of fixation (room temperature 5% formalin for *P. oklensis* and hot formalin for *P. fessus*). However, the shape of the vitelline follicles in adult *P. oklensis* was elongate to very elongate, while the follicles of *P. fessus* were short and spherical.

An oblong area of intestine 10 mm by 7 mm in one *E. sucetta* was covered by 122 closely packed, attached *P. fessus*. No pit or irritation was evident. One mature and one immature specimen of *Isoglaridacris agminis* Williams and Rogers, 1972 were loosely attached in another portion of the same host's intestine. One immature specimen of *Camallanus* sp. (Nematoda) and 104 specimens of *Triganodistomun* sp. (Digenea) also occurred in the intestine of this host. The only closely associated parasite was an acanthocephalan, *Neoechinorhynchus cylindratum* (Van Cleave, 1913) Van Cleave, 1919.

Level of infection of *P. fessus* varied from eight to 122 specimens per fish. Host total length ranged from 17.8 to 25.4 cm, and averaged 23.7 cm.

The collection locality for *P. fessus* is interestingly similar to the collecting locality described for *P. oklensis* (Mackiewicz, 1969). The latter was a shallow, 10-acre lake periodically confluent with the Illinois River. The locality for *P.*

fessus was a shallow, 7-acre lake periodically confluent with Uphapee Creek through a complex of quarry lakes and beaver ponds. *Erimyzon sucetta* from five other collecting sites in the same area failed to harbor *P. fessus*. One hundred and forty-six specimens of the type host ranging in length from 13.0 to 36.5 cm and averaging 28.4 cm, examined from 23 collecting localities in Alabama, Georgia, and Florida, were negative for *P. fessus* or *P. oklensis*.

Spotted suckers, *Minytrema melanops* (Rafinesque), the definitive host of *P. oklensis*, from the type locality of *P. fessus* were not infected with *P. fessus* or *P. oklensis*. Two hundred and eighty-one spotted suckers examined by the author from 26 collection localities in Alabama, Georgia, and Florida were negative for *Penarchigetes* spp. They ranged in total length from 9.0 to 48.2 cm and averaged 34.7 cm.

The name is Latin (*fessus*—weary, tired, exhausted), and refers to the posterior bend of the ovarian commisure.

Mackiewicz (1969) assumed that the intermediate condition between continuous and discontinuous preovarian and postovarian vitelline fields, as found in *Biacetabulum carpiodi* Mackiewicz, 1969, *Caryophyllaeides fennica* (Schneider, 1902), *Khawia baltica* Szidat, 1942, and *Penarchigetes oklensis* Mackiewicz, 1969, was a variation of the discontinuous distribution of vitellaria. The completely continuous condition in *P. fessus* implies that the intermediate condition in this genus is a variation of the continuous distribution.

The genus *Archigetes* contains the only known caryophyllid species capable of becoming gravid in the fish and invertebrate hosts (Kennedy, 1965). However, the two species of the genus *Penarchigetes* are well under the minimum size (Mackiewicz and Deutsch, 1976) for neotenic development in the tubificid intermediate host, are at least morphologically similar to members of the genus *Archigetes*, and their life cycles are unknown. It is possible that progenetic development could occur in members of the genus *Penarchigetes*.

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Proc. Helminthol. Soc. Wash.
46(1), 1979, pp. 88–97

Synonymy of the Phyllobothriid Genera *Rhodobothrium* Linton, 1889, *Inermiphyllidium* Riser, 1955, and *Sphaerobothrium* Euzet, 1959 (Cestoda: Tetraphyllidea)

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ABSTRACT: A comparison of whole mounted and sectioned specimens of *Rhodobothrium, Inermiphyllidium,* and *Sphaerobothrium* from the type hosts has been made and their validity assessed. The genus *Rhodobothrium* Linton, 1889 is emended and considered to be the senior synonym of the latter genera. Detailed description of *R. pulvinatum* Linton, 1889 is given based on material from the type host, *Dasyatis centroura* (Mitchill), and the new host *D. americana* Hildebrand and Schroeder. *Rhodobothrium lubeti* (Euzet, 1959) comb. n. and *R. brachyascum* (Riser, 1955) comb. n. are included in the genus. The adult and plerocercus of another species new to the genus, *R. mesodesmatum* (Bahamonde and Lopez) comb. n., is described from *Myliobatis chilensis* Philippi, and the clam *Mesodesma donacium* Lamarck, taken in Chilean coastal waters.

Linton (1889) used the name *Rhodobothrium pulvinatum* in a communication to the American Journal of Science for a phyllobothriid cestode found in *Dasyatis centroura* (Mitchill). Despite the fact that he never fully described *Rhodobothrium,* instead describing *Anthobothrium pulvinatum* Linton, 1890, the genus has been regarded as valid in recent systematic reviews (Yamaguti, 1959; Saoud, 1963). Riser (1955) was the first to recognize that Linton's *A. pulvinatum* (USNM 7731) was indeed representative of a new genus. He subsequently erected *Inermiphyllidium,* making *I. pulvinatum* (Linton, 1890) type species, and included a new species from California waters. Publication of Euzet's thesis in 1959 added another new genus, *Sphaerobothrium*, from European waters which Williams (1968) noted was very similar to *Rhodobothrium.* After reviewing the literature and examining and sectioning specimens of *R. pulvinatum* and *S. lubeti* from the type hosts, and *R. mesodesmatum* comb. n. from Chilean waters, we concluded that both *Sphaerobothrium* and *Inermiphyllidium* should be considered junior synonyms of *Rhodobothrium.* Specimens of *R. pulvinatum* sectioned and measured included one of Linton's paratypes, fresh material from the type host, *D. centroura,* from southern New England waters, and a new host, *D. americana* Hildebrand and Schroeder from Chesapeake Bay, Virginia. The adult of *Rhodobothrium mesodesmatum* (Bahamonde and Lopez) comb. n. is described from *Myliobatis chilensis* Philippi and its plerocercus from the clam *Mesodesma donacium* Lamarck.

Materials and Methods

Elasmobranchs were collected from Atlantic coastal waters at Chesapeake Bay, Virginia, Sakonnet Point, Rhode Island, and Pacific coastal waters off San Antonio, Coquimbo, Penuelas, and Antofagasta, Chile. Specimens of *Sphaerobothrium lubeti* from *Myliobatis aquila* (L.) taken east of Fife, Scotland (56°10′N, 2°30′W) were furnished by Dr. H. Harford Williams. Infected clams were obtained from Morrillos, 30 km south of Coquimbo, Chile. Cestodes were either

fixed in situ or removed and studied alive prior to fixation in AFA or 10% formalin. Some specimens were relaxed with 10% magnesium chloride. Whole mounts stained with hematoxylin or carmine stains were dehydrated and mounted according to standard procedures. Serial sections, cut at 8–12 μm, were made of specimens from all collections including a paratype (USNM 7731) of *Anthobothrium pulvinatum,* to clarify internal anatomical details. Sections were stained with Harris' hematoxylin and counterstained with eosin. Drawings were made with the aid of a microprojector or drawing tube. All measurements are length vs. width, include the mean, and range in parentheses. The standard deviation is given for some characters. Number of objects measured is indicated as (N) if different from the number of specimens measured.

Rhodobothrium Linton, 1889, emended

EMENDED DIAGNOSIS: Phyllobothriidae. Scolex with 4 large, subspherical bothridia supported by pedicels. Bothridia trumpet-shaped when relaxed but adherent surfaces convex and traversed by numerous convolutions forming an irregular pattern. Bothridial faces round or subtriangular in cross section, margins ruffled. Neither accessory suckers or rostellum present. Neck present. Segments numerous, strobila apolytic. Testes numerous, sometimes occupying postovarian space; may be retained in degenerating segments. Gravid segments triangular, uterine pore present. Ovary tetralobed in cross section. Vitellaria lateral, arching mediad around lateral testes. Uterus median, saccate, may form lateral diverticula. Ventral osmoregulatory ducts distinctly medial to dorsal ducts, with tendency to lie in same horizontal plane. Parasites of elasmobranchs.

TYPE SPECIES: *Rhodobothrium pulvinatum* Linton, 1889.

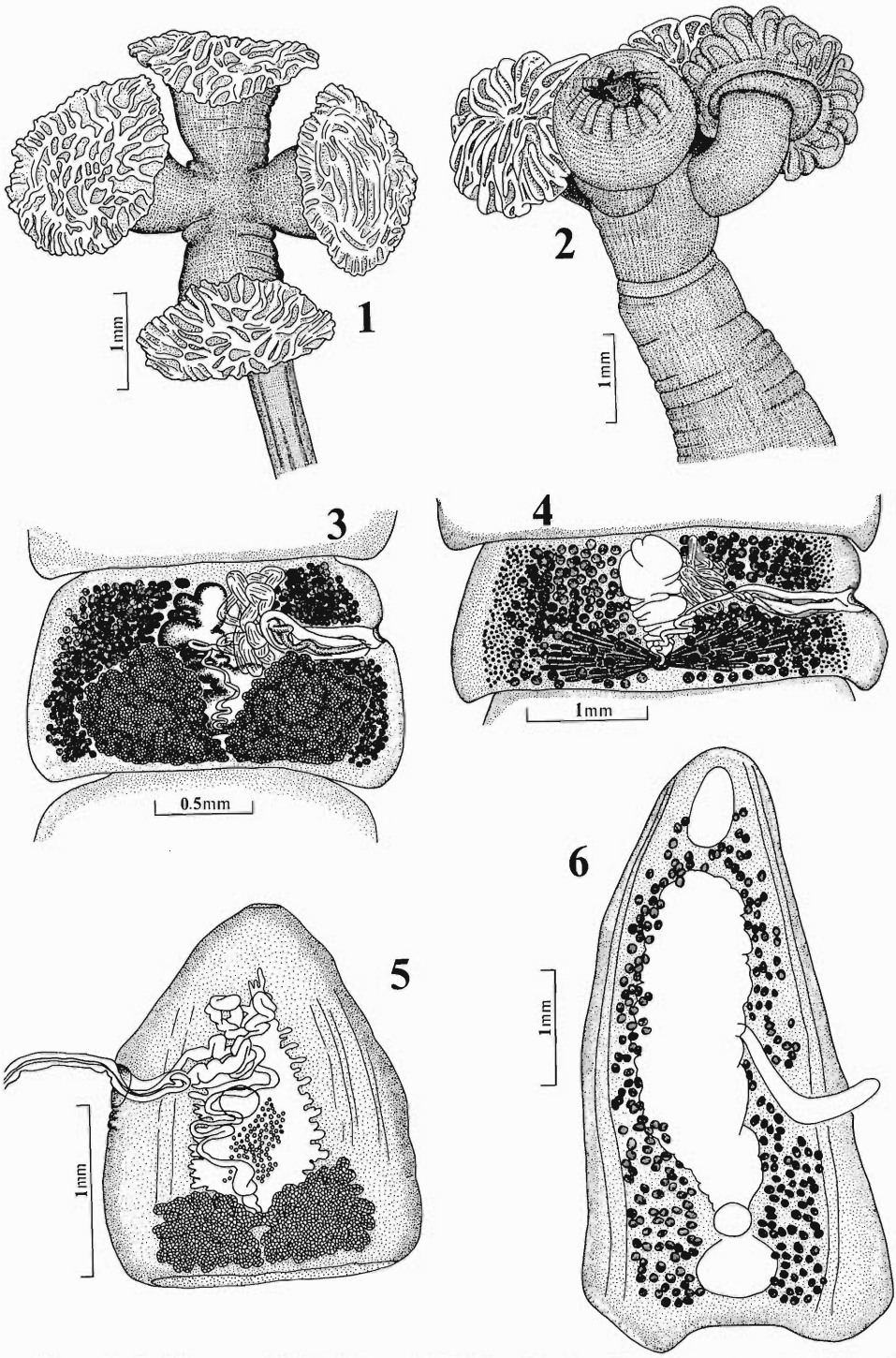
Remarks

This emended diagnosis is essentially new as compared with that of Riser (1955) or Yamaguti (1959). Yamaguti (1959) evidently rewrote Riser's diagnosis of *Inermiphyllidium* but considered it a synonym of *Rhodobothrium* without explanation or indication of having examined specimens. His indication of "neck absent" is incorrect. Our diagnosis incorporates verified characteristics noted by Linton and Riser but focuses attention on scolex morphology and internal anatomy based upon study of the species discussed below. A major characteristic to be noted for these worms is the nature of the bothridia which are globular when contracted leaving only an apical opening resulting from closure of the bothridial margins about its center.

Rhodobothrium pulvinatum Linton, 1889 (Figs. 1, 3, 5, 8)

SYNONYMS: *Anthobothrium pulvinatum* Linton, 1890, 1897, 1900, 1901, 1905, 1910, 1911, 1924; Southwell, 1925 *pro parte;* Joyeux and Baer, 1936; *Inermiphyllidium pulvinatum* (Linton, 1890) Riser, 1955.

DESCRIPTION (based on 8 specimens; 5 complete specimens measured): Tetraphyllidea; Phyllobothriidae; *Rhodobothrium.* Strobila craspedote, serrate posteriorly, maximum dimensions 10.4–18.5 cm by 2.5–4 mm. Scolex 2.5–3.4 mm by 3.4–5 mm. Bothridia round in cross section, (N = 28) to 1.9 mm by 1.9 mm. Peduncle about 1 mm long. Neck 6–10 mm by 472–570. Number of segments



Figures 1–6. The genus *Rhodobothrium*. 1, 3, 5. *R. pulvinatum* from *D. americana*. 1. Scolex. 3. Mature segment. 5. Gravid segment. 2, 4, 6. *R. mesodesmatum*. 2. Scolex. 4. Mature segment. 6. Gravid segment.

853–1,174. Immature and mature segments wide and narrow; semigravid segments tend to be square; detached segments triangular. Mature segments (N = 25) 230–575 by 2.7–4 mm; gravid segments (N = 25) 0.46–2.1 mm by 2–2.9 mm; detached segments (N = 2) 2.1–2.4 mm by 575–595. Genital pores preequatorial; irregularly alternate; atrium well developed. Cirrus pouch saccate, slender (N = 30) 615 ± 70.3 (440–700) by 238 ± 41.3 (160–288); cirrus spines numerous, 9.6 long. Testes number about (N = 27) 117–149 per segment, distributed as: 22–27 prevaginal; 37–53 postvaginal; 52–74 antiporal. Testes subspherical, 70–120 by 50–60. Testes not retained in gravid segments. Vas deferens highly coiled on poral side slightly displacing uterus. Vagina enters genital atrium anterior to cirrus pouch. Ovarian lobes narrow in young segments, squarish in older segments, (N = 25) 0.828–1.1 mm by 150–782, follicular in appearance. Vitelline follicles subspherical, 30–40 in length, forming lateral bands that envelop lateral testes. Uterus saccate with irregular diverticula. Oncospheres about 18 in diameter (sections), released through uterine pore in posterior half of segment. Ventral osmoregulatory ducts largest, medial to dorsal ducts; in the same horizontal plane.

HOSTS AND LOCALITIES: *Dasyatis centroura* (Mitchill), type host, Woods Hole Massachusetts; Rhode Island Sound off Sakonnet Pt., Rhode Island (41°31′N, 71°15′W); new host, *Dasyatis americana* Hildebrand and Schroeder, Chesapeake Bay, Virginia.

LOCATION: Spiral valve.

TYPE SPECIMENS: USNM Helm. Coll. No. 7731 (types); voucher specimens deposited, Nos. 74907 and 74908.

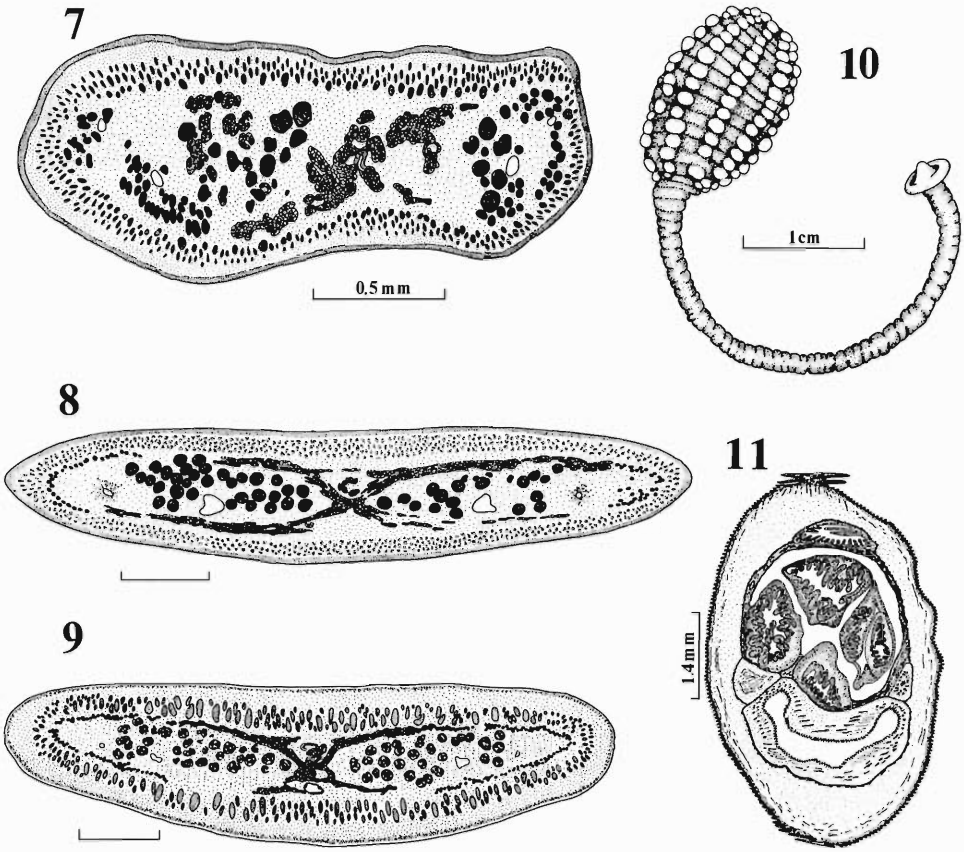
Remarks

This redescription is given to affirm Riser's (1955) description and includes details not given by either Linton or Riser. Ranges are indicative of populations found in both *D. centroura* and *D. americana*. Measurements are based upon Linton's type (USNM 7731) specimens, one of which was sectioned, and collection of specimens from the type host in the type locality, and comparison with specimens obtained from *D. americana* in Chesapeake Bay, Virginia.

Rhodobothrium mesodesmatum comb. n. (Figs. 2, 4, 6, 9)

SYNONYMS: *Anthobothrium peruanum* Rego, Vicente and Herrera, 1968, *Proboscidosaccus mesodesmatis* Bahamonde and Lopez, 1962.

DESCRIPTION (measurements of 12 gravid specimens): Tetraphyllidea; Phyllobothriidae; *Rhodobothrium*. Strobila large, craspedote, apolytic. Total length 21.7 cm (11–33 cm) by 5.2 mm (4–7 mm). Maximum dimensions of scolex, 3.2 mm (3–4 mm) by 4.2 mm (3.3–5 mm); neck short. Bothridia (N = 25) 2.1 mm (1.9–2.4 mm) by 2.2 mm (1.6–3 mm); margins highly frenulated in relaxed specimens, adherent surfaces irregularly folded; contracted bothridia spherical to pear-shaped with margins forming a central opening. Pedicels contractile (N = 15) 1.1 mm (0.7–2 mm) by 1.1 (0.8–1.4 mm). Number of segments 959–1,382. Immature and mature segments much wider than long becoming longer than wide in gravid segments. Mature segments (N = 36) 0.8–2 mm by 2.1–5.5 mm; gravid segments (N = 10) 4.4 mm (3.4–5.5 mm) by 2.3 mm (2–2.6 mm). Cirrus pouch saccate (N = 36) 714 ± 77.5 (600–840) by 157 ± 19.9 (120–250); cirrus long,



Figures 7–11. The genus *Rhodobothrium*. 7–9. Transverse sections through ovarian isthmuses of mature segments. 7. *R. lubeti*. 8. *R. pulvinatum*. 9. *R. mesodesmatum*. 10. Plerocercus, *R. mesodesmatum*. 11. Section of *R. mesodesmatum* plerocercus through scolex and invagination tube. Figures 7–9 to same scale.

armed with a few minute spines. Genital pores marginal, irregularly alternate, equatorial in mature segments, postequatorial in detached gravid segments. Vas deferens expands to form large, coiled, external seminal vesicle in semigravid segments. Testes median to osmoregulatory ducts, medullary, continuous, (N = 36) 150–210 per segment. Testes distribution: prevaginal, 33–55; postvaginal, 43–72; antiporal, 83–92. Testes subspherical, diameter about 50 in immature segments, 110 in mature segments. Vagina voluminous, opening into large genital atrium anterior to cirrus pouch. Ovary posterior, medial, lobes equal (N = 36) 400–510 by 0.53–1.3 mm, consisting of distinct cords of cells radiating from central isthmus; ovary atrophies with age. Vitelline follicles 41–49 in diameter, forming lateral bands arching mediad around lateral testes. Terminal and detached segments triangular, with sacciform uterus, central uterine pore, and anterior, terminal protrusible sucker. Intrauterine eggs 15–18 in diameter. Osmoregulatory ducts small, ventral pair medial to dorsal pair, in the same horizontal plane.

HOST: *Myliobatis chilensis* Philippi, 1892.

LOCATION: Spiral valve.

LOCALITIES: Chilean Pacific coastal waters off San Antonio (type locality), Penuelas, Coquimbo and Antofagasta.

HOLOTYPE AND PARATYPES: USNM Helm. Coll. Nos. 74904 and 74905; 25 additional paratypes in the Museo Nacionale de Historia Natural de Chile, No. 20012, and in the authors' collections.

Remarks

Rhodobothrium mesodesmatum is most similar to *R. pulvinatum* Linton in general appearance but distinct differences separating it from all related species are seen in the anatomy of the segments. Unique characteristics are testes number and their postovarian distribution, persistence of testes in gravid segments, cirrus pouch dimensions, and digitiform nature of the ovary whose radiating lobes resemble a sunburst.

Rhodobothrium mesodesmatum comb. n. plerocerci (Figs. 10, 11)

Numerous plerocerci were taken from the pallial cavity of the clam *Mesodesma donacium* Lamarck. Living larvae are orange with a bipartite body consisting of a bulbous blastocyst with a thick wall of connective tissue and muscle surrounding the scolex and a slender peduncle that terminates in a distinct swelling usually attached to the visceral mass of the clam. The blastocysts (Fig. 10) measure about 1 cm by 7.5 mm and are characterized by eight longitudinal rows of nine to 15 tubercles over their exterior. In section an invagination tube leads into the blastocyst cavity and ends in a muscular thickening near the scolex. The scolex is typical of *R. mesodesmatum* (Fig. 4) as described above. The cylindrical peduncle varies in length with the state of contraction and the longest recovered measured 3.2 cm. Dimensions of these larvae given by Bahamonde and Lopez (1962) are: blastocyst 0.8–2.2 cm by 4–9.3 mm, peduncle 2.1–5.2 cm long. Excysted larvae identical to these were obtained from the stomachs of freshly caught eagle rays, *Myliobatis chilensis,* at Penuelas, Chile (15 km north of Coquimbo) 45 km north of Morrillos where the infected clams were discovered. Adult worms were found in the spiral valves of these same hosts.

HOST AND LOCALITY: *Mesodesma donacium* Lamarck; Morrillos, Chile (30 km south of Coquimbo).

SPECIMENS DEPOSITED: USNM Helm. Coll. No. 74906 and in the authors' collections.

Remarks

Identification of the plerocerci is of particular importance in life history studies and in helping establish the relationships between *Rhodobothrium* (syn. *Inermiphyllidium*) and *Sphaerobothrium*. In France, Gallien (1949) discovered a cestode larva which he named *Proboscidosaccus enigmaticus* from the clam *Mactra solida* Lamarck, 1767. Bahamonde and Lopez (1962) described and figured a similar plerocercus, *P. mesodesmatis,* from the bivalve *Mesodesma donacium* Lamarck, 1818 taken in Chilean coastal waters and realized its similarity to the Phyllobothriidae. Anthouard (1963) and Dollfus (1964) independently asserted that *P. enigmaticus* from European waters was also a phyllobothriid. Euzet recently identified this plerocercus as that of *Sphaerobothrium lubeti* (see Dollfus, 1974).

Proboscidosaccus enigmaticus differs from *P. mesodesmatis* in being smaller, having fewer tubercles per row, host, and in being found in European coastal waters of the North Atlantic. Examination of stomach contents of *Myliobatis chilensis* from the environs of Coquimbo, Chile, revealed that *Mesodesma donacium* is a major food item in the diet of this ray. Excysted plerocerci were found among the stomach contents of several of these rays and both immature and mature strobilate adults in the spiral intestine. Plerocerci of *Rhodobothrium* have been reported as *Inermiphyllidium* taken from the pallial cavity of *Macrocallista nimbosa* (Lightfoot) by Cake (1972) at St. Teresa, Florida. It is likely that these larvae are juvenile *R. pulvinatum* because we have found adults in *Dasyatis americana,* reported herein, a ray common to the Gulf of Mexico. All larvae are referred to the genus *Rhodobothrium* Linton, 1889 according to the law of priority (Art. 24b, ii).

Rhodobothrium lubeti (Euzet 1959) comb. n.
(Fig. 7)

SYNONYM: *Sphaerobothrium lubeti* Euzet 1959.
TYPE HOST AND LOCALITY: *Myliobatis aquila* (L.); Arachon, France.

Remarks

Euzet assigned this species to a new genus on the basis of the nature of its bothridia which he described as subtriangular, bilobed, and pedunculated. He made special note of the fact that when closed (Fig. 39 of Euzet) they are similar to *Scyphophyllidium* Woodland, 1927. However, an inconsistency, we note, exists between his key to the phyllobothriid genera (p. 54) and the description (p. 61) regarding the pedunculated characteristic. In his key to genera they are termed sessile. Examination of three specimens of *R. lubeti* given to us by Dr. H. Harford Williams verifies that the bothridia are pedunculated, subtriangular with ruffled margins, and have highly folded adherent surfaces. The bothridia of *R. pulvinatum* and *R. mesodesmatum* are very round in cross section instead of subtriangular as in *R. lubeti,* and the posterior bothridial margin is not bilobed. The bilobation is not deep in *R. lubeti* but this feature alone would not constitute a generic difference. Similar variations in bothridial morphology are also known in the genus *Phyllobothrium* (see Williams, 1968). The reproductive system and gravid segments figured by Euzet agree with our specimens. Free gravid segments of *R. lubeti* are triangular as are those of *R. pulvinatum* and *R. mesodesmatum.* Only in gravid segments of *R. mesodesmatum* do the testes persist. Internally, we have found several similarities and differences in the musculature, disposition of the vitellaria and the osmoregulatory ducts of the three species (Figs. 7–9). The ovaries in all species are tetralobed and the testes dispersed in the lateral interlobular spaces. Vitelline follicles form lateral bands that arch mediad around the testes. In both *R. pulvinatum* and *R. mesodesmatum* the follicles are small and distinctly peripheral to the testes but in *R. lubeti* some follicles are interspersed among the testes. The medial osmoregulatory ducts are distinctly larger and the smaller ducts lie lateral to them except in *R. lubeti* where they tend to lie more dorsolaterally. The longitudinal musculature is well developed in all species. In both *R. lubeti* and *R. mesodesmatum* large and small muscle bundles are present, however, they randomly intermingle in the latter species and form

a graded series approximately three layers deep in the former. The muscle bundles of *R. pulvinatum* tend to be more uniform in size.

***Rhodobothrium brachyascum* (Riser, 1955) comb. n.**

SYNONYM: *Inermiphyllidium brachyascum* Riser, 1955.

TYPE HOST AND LOCALITY: *Aetobatus californicus* Gill; Monterey Bay, California.

Remarks

Riser (1955) described this species from three mature worms without gravid segments. Upon examining his type specimen (USNM 37409) we found that the bothridia are dissimilar to other members of *Rhodobothrium*. The bothridia of *R. brachyascum* are thin and leaflike having the appearance of members of the genus *Anthobothrium*. Also, Riser noted that the inner and outer muscular rings noted in *R. pulvinatum* are absent in his species. Because there were no gravid segments on his specimens and the type specimen has atypical bothridial morphology, we consider this species questionable as to its generic status until additional material is found.

Discussion

Phyllobothriids are characteristically difficult to identify due to similarities of their internal anatomy and the rather plastic nature of their scolices. When observations are limited to preserved material the true nature of the bothridia may be misleading because of fixation techniques or autolysis. Examples are numerous in early literature of failure to correlate features of external and internal anatomy which resulted in misinterpretation of the correct taxonomic status of many species and the erection or clumping of new taxa. Williams (1968) has done much to clarify the taxonomy of *Phyllobothrium* Beneden, 1859, *Crossobothrium* Linton, 1889, and *Monorygma* Diesing, 1863. He further showed that by careful analysis several other phyllobothriid genera are valid and may have members extant in the literature under old designations. From earlier literature he noted the affinities of several species reported as *Phyllobothrium* or *Anthobothrium* Van Beneden, 1850 to *Sphaerobothrium* Euzet, 1959. Williams (loc. cit.) reported recovering *S. lubeti* Euzet, 1959 commonly from *Myliobatis aquila* off Britain and verified that *Sphaerobothrium* is quite distinct from other phyllobothriid genera. Among the previously reported species Williams suspected might belong in *Sphaerobothrium* was *Anthobothrium pulvinatum* Linton, 1890.

The genesis of *Rhodobothrium* Linton, 1889 arose from the collection of specimens from *Dasyatis centroura* in Massachusetts coastal waters and subsequent use of the name *Rhodobothrium* in an oral presentation at a scientific meeting and publication of an abstract (1889) in which he described the pedicellated and "cushion-like" nature of the bothridia, the most distinctive feature of the genus. Linton (1890) later decided that he had misinterpreted the worms as representing a new genus, for in his description (see plate V) of *Anthobothrium pulvinatum* Linton, 1890 he stated, "I was at first misled by the appearance of the bothridia of this species which in specimens that I had examined when the following description was written were uniformly convex and corrugated, and that too in both living and alcoholic specimens. The specimens were referred to a new genus,

Rhodobothrium, because of the rosette shaped appearance of the bothridia. It would be unnecessary to mention this change in nomenclature were it not for the fact that I used the name *Rhodobothrium* in a communication to the American Journal of Science and Arts, March 1889 . . . ." *Rhodobothrium* is technically valid according to the rules of the International Code of Zoological Nomenclature because: (a) the description, though meager, is recognizable (Art. 16 (a) viii) and available (Arts. 8, 11); (b) Linton's (1890) subsequent views are irrelevant because validity does not depend on use (*nomen oblitum,* Art. 23b) in this case; and (c) *Rhodobothrium* is the oldest available name and has priority (Art. 23).

Riser (1955) realized Linton's error after examining whole mounts and sectioned material of *A. pulvinatum* but created the genus *Inermiphyllidium* instead of resurrecting *Rhodobothrium.* In 1955 Euzet described *Sphaerobothrium,* naming *S. lubeti* as type species, in his doctoral thesis which was published in 1959. Although his description of the open (Fig. 38) and closed (Fig. 39) nature of the bothridia were indicative of *Rhodobothrium,* Euzet apparently was unaware of Linton's or Riser's papers. Euzet separated *Sphaerobothrium* from *Phyllobothrium* by the lack of accessory suckers and from *Anthobothrium* by the highly folded adherent surfaces of the bothridia which he noted resemble *Scyphophyllidium* Woodland, 1927 when closed. In a review of the literature Williams (1968) noted that *S. lubeti* is probably *Phyllobothrium crispatissimum* Monticelli, 1889 of Guiart (1935) from *Leiobatis* (syn. *Myliobatis*) *aquila* and Monticelli's specimens are *Thysanocephalum crispum* Linton, 1890. Yamaguti (1959) gave a detailed description of *Sphaerobothrium* and *Rhodobothrium* using Riser's description of *Inermiphyllidium* for the latter and making *Inermiphyllidium* a synonym of *Rhodobothrium.* Saoud (1963) concluded that both *Rhodobothrium* and *Inermiphyllidium* are synonyms of *Anthobothrium* without examining specimens. He failed to compare the bothridia of *Inermiphyllidium* or *Rhodobothrium,* the most distinctive feature, with *Anthobothrium* and evidently considered the bothridia of *Sphaerobothrium* very distinct from *Anthobothrium* without realizing the similarity of *Sphaerobothrium* to *Rhodobothrium.* Following Williams' (1968) verification of *Sphaerobothrium* and his suggestion that Linton's *A. pulvinatum* is a member of that genus, we collected specimens from the type host and locality and compared them with Linton's (USNM 7731). Our examination of both living and preserved specimens of Linton's species, comparison with specimens of *S. lubeti* from *Myliobatis aquila* furnished by Dr. H. Harford Williams, and the similarity of the plerocerci (described above) clearly indicates that his suspicion was correct. However, we recognize that *Rhodobothrium* Linton, 1889 is valid by the law of priority, as verified by Linton's specimens and description, and that *Inermiphyllidium* Riser, 1955 and *Sphaerobothrium* Euzet, 1959 are junior synonyms.

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The Cysticercus of *Taenia rileyi* Loewen, 1929

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ABSTRACT: The cysticercus larva of *Taenia rileyi* is described and illustrated for the first time. The contradictory information on the form of this larva is also reviewed and evaluated.

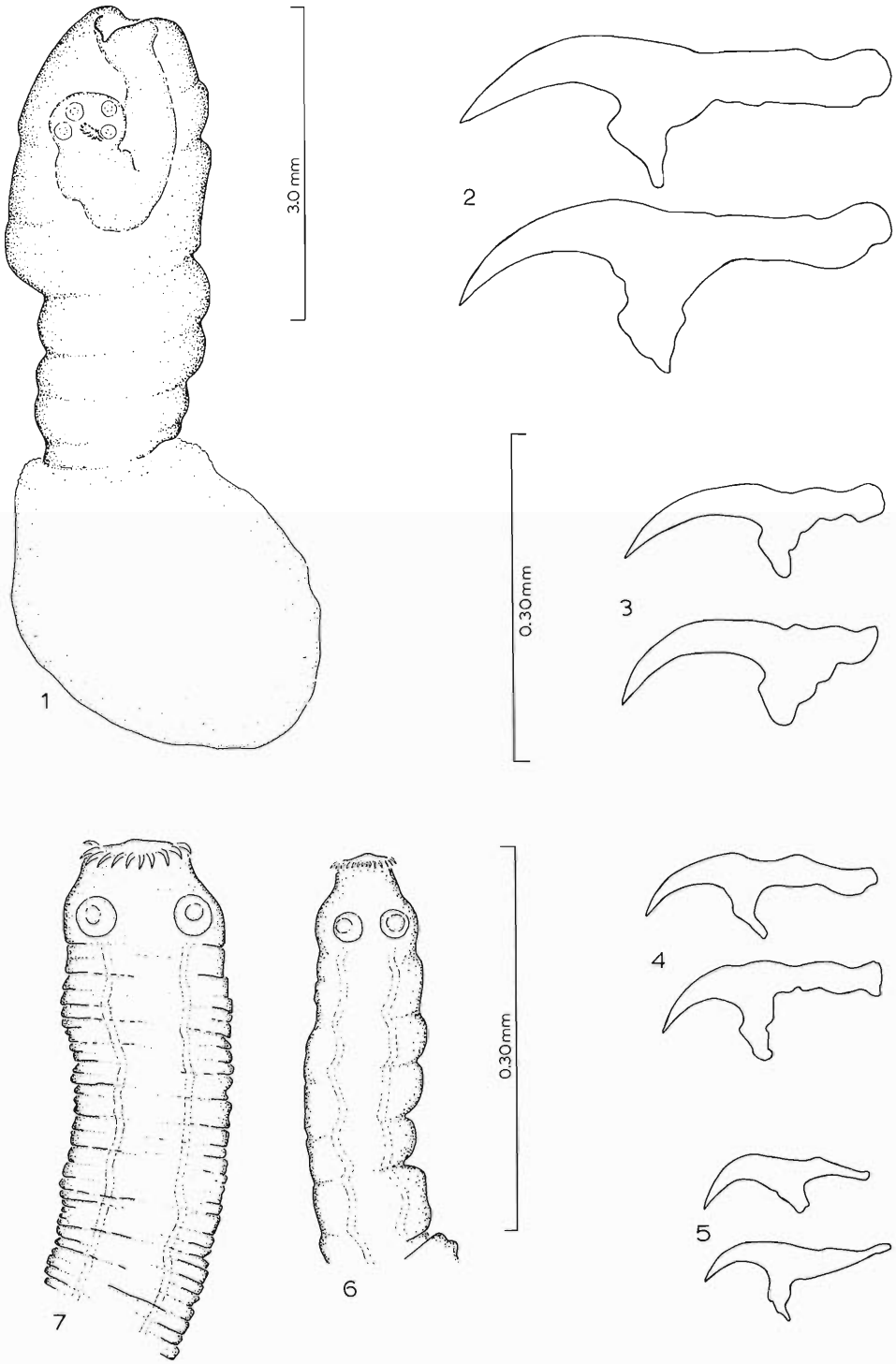
A survey of the helminths of the hispid cotton rat, *Sigmodon hispidus* Say and Ord, in western Texas was recently undertaken. In the course of the study the larvae of two species of *Taenia* were discovered encysted in the livers of this host. Typical examples of *Taenia taeniaeformis* (Batsch, 1786) strobilocerci were encountered in 23% of 129 animals examined. Nine hosts (7%) had what were initially regarded as small, poorly developed strobilocerci of *T. taeniaeformis*. That these latter specimens represent instead unique and undescribed cysticerci of *T. rileyi* Loewen, 1929 is the basis of this report.

Few of the several reports of *T. rileyi* in intermediate hosts provide any information on how the determination was made. The common practice is to compare the size and shape of larval hooks with those of adult tapeworms. Thus, there remains considerable confusion on the form of larval *Taenia rileyi*. Wardle and McLeod (1952) placed this species in the genus *Taenia* (thus implying a cysticercus larval stage), but noted that the larval stage was unknown. *Taenia lyncis* Skinker, 1935 has been synonymized under *T. rileyi* by Verster (1969) largely on evidence presented by Riser (1956). In the original description of the former species Skinker (1935) describes the "larva with large terminal bladder about 8 mm long and 6.5 mm wide, transversely striated (pl. 20, fig. 4); body of larva about 11 mm long and 2.5 mm in maximum width." Despite the suggestion that the bladder is transversely striated, the figure referred to (and its accompanying caption) indicate the striations are instead on the body. Notwithstanding the favorable comparison of these larvae with cysticerci obtained from *Peromyscus maniculatus*, Skinker's description most resembles that of a strobilocercus. Presumably this is the justification for Wardle and McLeod's (1952) placement of this species in the genus *Hydatigera* (species with strobilocercus larvae).

However, Abuladze (1970) proposed the opposite arrangement for these same two species. Based chiefly on a report of a cysticercus in *Cervus unicolor* by Joyeux and Baer (1940), the species *lyncis* was placed in the genus *Taenia*. Grundmann (1958) reported that larval stages of *T. rileyi* recovered from *Ammospermophilus leucurus* and *Neotoma lepida* "were typical strobilocerci." Abuladze (1970) then placed this species among the accounts of *Hydatigera*.

→

Figures 1–7. 1. Whole cysticercus larva of *Taenia rileyi*. Scolex invaginated. 2. The shape of two large hooks from two strobilocerci of *Taenia taeniaeformis*. Figures 2–5 drawn to same scale. 3. The shape of two small hooks from two strobilocerci of *Taenia taeniaeformis*. 4. The shape of two large hooks from two cysticerci of *Taenia rileyi*. 5. The shape of two small hooks from two cysticerci of *Taenia rileyi*. 6. Anterior end of an evaginated cysticercus of *Taenia rileyi* approximately 8.5 mm long. Note the lack of strobilization. Figures 6–7 drawn to same scale. 7. Anterior end of a strobilocercus of *Taenia taeniaeformis* approximately 8.5 mm long.



Subsequent studies of van Zyll de Jong (1966) and Mahrt and Chai (1972) have reported cysticercus larvae for *T. rileyi*.

Materials and Methods

All rats were obtained with snap traps and Sherman live traps in Lubbock and Brewster Counties, Texas, in the period January through March 1977. All animals were frozen before examination. At necropsy cysts of larval *Taenia* were excised from the liver and immediately opened under a dissecting microscope. Larvae were fixed in AFA (alcohol-formalin-acetic acid), stored in 70% ethanol, and stained with Celestine blue B. Head squashes and whole specimens were mounted in Canada balsam. Measurements of the hooks were taken parallel to the handle.

Results

Twenty-nine specimens from 9 hosts were identified as *T. rileyi*. None was encountered in the same host with larval *T. taeniaeformis*. They average 5.51 mm in body length (range 2.86–9.18) while the bladders average 2.61 (2.80–4.48) mm in length. Twenty-one specimens (72%) have a spherical bladder attached to an elongated body with an invaginated scolex (Fig. 1). However, the scolex is evaginated in strobilocercus fashion on eight specimens. That these specimens are not strobilocerci and also not *T. taeniaeformis* was indicated by a comparison of their hooks and bodies with larvae *T. taeniaeformis* of the same size (ca. 8.5 mm). The hooks of the respective larvae are considerably different in size and shape (Figs. 2–5). The number of hooks on *T. taeniaeformis* examined ranged from 32 to 38 (mode = 34) while the hooks of *T. rileyi* numbered 38 to 46 (mode = 44). The large hooks of *T. rileyi* measured 208 to 244 μm; the small hooks measured 150 to 177 μm. Fifteen adult *T. rileyi* from bobcats (*Felis rufus*) collected nearby (Stone and Pence, 1978) have hooks numbering 38 to 46 (mode = 44). The large hooks measure 222 to 249 μm; the small hooks measure 145 to 178. All these values compare well with those of adult and larval *T. rileyi* reported elsewhere (Riser, 1956; Grundmann, 1958; van Zyll de Jong, 1966; Verster, 1969). The anterior body of the respective species is also considerably different. Extreme strobilization is present on even the smallest examples of larval *T. taeniaeformis* (Fig. 7), but lacking on the largest of the *T. rileyi* (Fig. 6). Therefore, by definition, the larvae of *T. rileyi* cannot be the strobilocercus type.

Discussion

It is reasonably certain that the larva of *T. lyncis* from *Odocoileus* spp. illustrated and described by Skinker (1935) is not the same as that described here. The identity of her material is problematical because strobilocercus larvae are unknown in deer. If, however, the larvae are in fact cysticerci and there was an error identifying the figure in question, her specimens may represent *T. omissa* Lühe, 1910. Riser (1956) and van Zyll de Jong (1966) are of the opinion that of the similar species, *T. omissa* and *T. rileyi*, the former utilizes deer as intermediate hosts whereas the latter species develops in rodents. The so-called typical strobilocerci reported by Grundmann (1958) for *T. rileyi* cannot be easily reconciled, except by suggesting that by not considering strobilization as the sole diagnostic criterion, one might easily interpret an evaginated cysticercus of *T. rileyi* as a strobilocercus.

Acknowledgments

I herewith gratefully acknowledge the field assistance of Michael J. Smolen and the field and laboratory assistance of Jacqueline A. Homan. Dr. Danny B. Pence graciously made his laboratory, library, and expertise available throughout the course of the study.

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Abortilepis abortiva (von Linstow, 1904) Yamaguti, 1959 (Cestoda: Hymenolepididae), a Parasite of Ducks[1]

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ABSTRACT: The history of *Hymenolepis abortiva* von Linstow, 1904 is reviewed. The earlier accounts of this rare and minute worm, parasitic in the caeca of ducks, are confirmed by an examination of specimens from the Animal Parasite Collection, U.S. Department of Agriculture.[2] A juvenile specimen from wild ducks taken at Cutty Hunk Island, Massachusetts agrees so completely with the mature specimens that specific identity is apparent.

Historical Survey

Yamaguti (1959) erected a new genus, *Abortilepis,* with *Hymenolepis abortiva* von Linstow, 1904 (syn. *Hymenolepis upsilon* Rosseter, 1911) as type species. In the genus he included *Hymenolepis pauciannulata* Meggitt, 1927 and *Hymenolepis pauciovata* Meggitt, 1927, both species from *Spatula clypeata* taken in the Nile valley, Egypt. The specific name, *pauciovata* Meggitt, 1927, was preoccupied by *pauciovata* Fuhrmann, 1906, and the species was renamed *floreata* by Meggitt (1930). The species *pauciannulata* had been transferred to *Microsomacanthus* López-Neyra, 1942 by López-Neyra (1942).

Von Linstow's account of *H. abortiva* reads, p. 381, "Deutschen Ursprungs ist aus *Anas bosches fera,* Coecum (= *Taenia* ? *microsoma* Crepl., Pagenstecher, Zeitschr. f. wiss. Zool. Bd. IX. 1858. p. 525–528. Tab. XXI).

Diese Art ist entweder höchst selten oder sie ist bisher Übersehen wegen ihrer Kleinheit und ihres verborgenen Aufenthaltes, denn sie ist bisher erst ein einziges Mal, und zwar im Jahre 1858, von Pagenstecher beschrieben, der sie mit einem Fragezeichen zur *Taenia microsoma* Crepl. stellt, mit der sie aber, wie auch Cohn (1901) ausspricht, nichts zu tun hat.

Die hier bescriebenen Exemplare stammen aus einer bei Göttingen geschossenen wilden Ente, und zwar nicht, wie man bei einer Tänie annehmen sollte, aus dem Darme, sondern aus dem hinteren Drittel des mit engem Lumen und dicker Wandung versehenen Coecum, in dem man in der Regel keine Tänien vermutet.

Die länge beträgt bis 2.7 mm, die Breite hinter dem skolex 0.087 mm, am Ende 0.26 mm; hinten werden die Proglottiden länger als breit, die letzte hat eine Länge von 0.31 mm; die Kette besteht aus einer Zahl von 18–20, meistens 19 Proglottiden, von denen in der Regel die letzten 5 Geschlechtsorgane entwickelt haben."

The text and figures describe the morphology of the scolex, proglottids, and the reproductive organs. The account ends with the statement, p. 383, "Die mit 6 Haken bewaffnete Oncosphäre is von einer dünnen Hülle umgeben und ist 0.047 mm lang und 0.040 mm breit."

Hymenolepis abortiva was included by Ransom (1909) in the list of taenioid cestodes of North American birds, but there were no particulars and apparently that is the only record of the species in America. It was redescribed and figured

[1] Investigation supported by NSF DEB-74-14534-A01.

[2] For permission to examine these specimens, I am indebted to Dr. J. Ralph Lichtenfels.

by Lühe (1910) who reported the parasite from *Anas bosches* at Heidelberg and Göttingen, Germany. The description is an almost exact repetition of that by von Linstow.

Specimens, determined subsequently as identical with *H. abortiva,* were described and figured by Rosseter (1911) under the designation *Hymenolepis upsilon.* The worms were found in the feces of a wild duck, *A. bosches,* in England. They were in poor condition, relaxed, extended, but the morphology could be determined. Two cotype specimens were deposited in the U.S. Department of Agriculture, National Animal Parasite collection, and through the kindness of Dr. J. Ralph Lichtenfels, I have examined them. In one specimen the rostellum is folded back and the hooks are disposed in a circle on the scolex. In the other specimen, the scolex is missing. Fixation was poor and morphological details are indistinct but agree with the accounts of Rosseter (1911) and Fuhrmann (1913). A further description of *H. upsilon* was made by Fuhrmann (1913), based on specimens in the collection of avian cestodes in the Göteborg Museum which were sent by Professor L. A. Jägerskiöld to Professor Fuhrmann for study. The worms were from *Anas bosches, Fuligula fuligula,* and *Mergus serrator,* taken in Sweden and on expeditions to Iceland and Greenland. The description by Fuhrmann was more complete and detailed than the original one. Concerning the gonads, Fuhrmann observed, p. 28, "Die Entwicklung der Geschlechtsorgane geht anfangs langsam, dann plötzlich sehr rausch vor sich. So sind *z. B.* in der 11-sten Proglottis die Hoden deutlich angelegt, in der 16-sten alle Drüsen auch die weiblichen voll entwickelt, im 19-ten Glied der Uterus mit Eizellen erfüllt, in der 20-sten schon junge Embryonen." After the description, Fuhrmann noted, p. 28, "Was für diese Art besonders charakteristisch, ist der Umstand, dass bei den zahlreichen von uns untersuchten Exemplaren die weiblichen Drüsen nur in ein bis drei Proglottiden voll entwickelt und dann sofort durch den Uterus verdrängt werden und verschwinden. Dies hat Rosseter zur Ansicht verleitet, dass der Keimstock zum Uterus wird was aber keineswegs zutreffend, indem sich bei dieser Art wie bei der vorigen ein Uterus anlegt, der die seitlichen Exkretionsgefässe nicht uberschreitet."

Mayhew (1925) proposed a new genus, *Weinlandia,* to contain *H. abortiva* and 67 other avian species but the concept was rejected by Fuhrmann (1932). Meggitt (1927) reported *H. abortiva* from *A. bosches* and *Spatula clypeata* in the Nile valley in Egypt. He noted the genital pore at the anterior angle of the proglottid and the central testis slightly posterior to the other two; otherwise agreement with the description of von Linstow. Fuhrmann (1932) revised his earlier (1908) publication, "Die Cestoden der Vögel," and in the later study suppressed *H. upsilon* as a synonym of *H. abortiva.*

The genus *Hymenolepis* Weinland, 1858 was based on *H. flavopuncta* Weinland, 1858, synonym of *Taenia diminuta* Rudolphi, 1819, a cosmopolitan parasite of rats and mice. It is an enormous genus; Hughes (1941) formulated a key to 328 accepted species, parasitic in birds and mammals. Attempts to dismember the unwieldy genus have been made by Fuhrmann (1906, 1932), López-Neyra (1942), and other authors. As noted, Yamaguti (1959) erected the genus *Abortilepis* to receive *H. abortiva* and related species. He reported *A. abortiva* from *Anas, Nyroca, Mergus,* and *Spatula* in Europe and Egypt.

Stunkard (1966) reported on the examination of wild, hybrid ducks, dead on

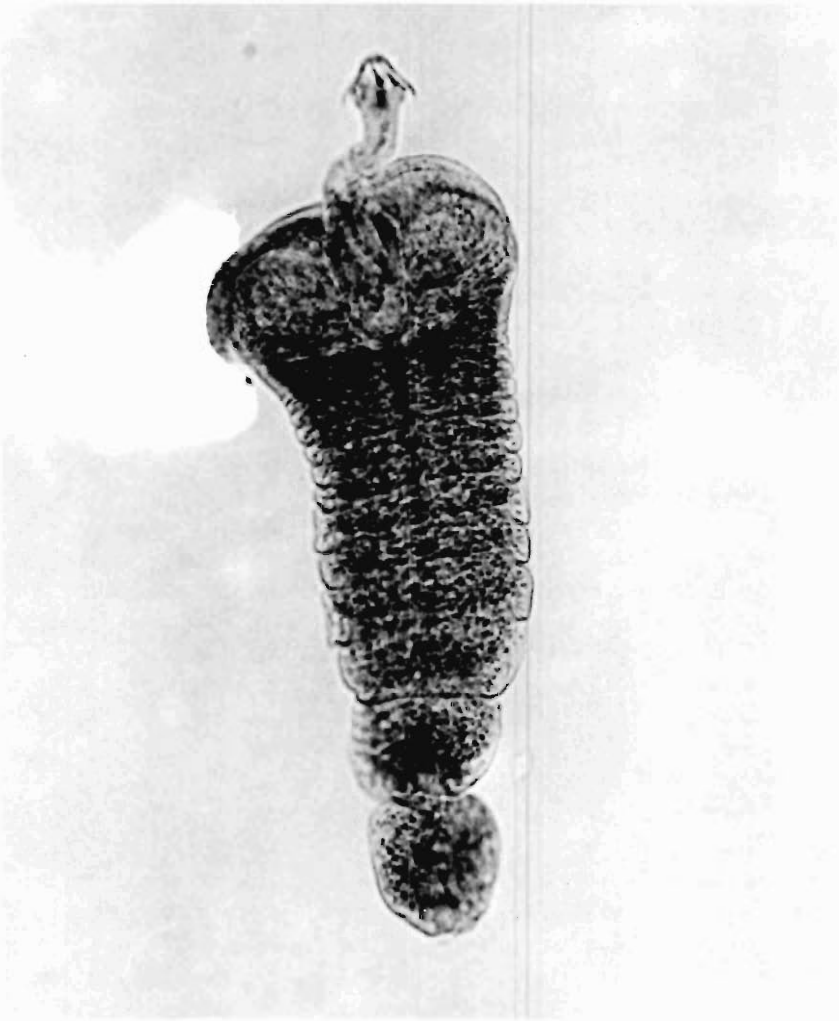

Figure 1

Cutty Hunk Island, Massachusetts, the last of the Elizabethan chain that separates Vineyard Sound from Buzzards Bay. The ducks had been frozen and sent to Woods Hole for autopsy. For examination, the intestines and caeca were slit longitudinally and the contents washed out in half tap, half seawater. *All* worms present were fixed in AFAG (alcohol, formalin, acetic acid, glycerol), stained and mounted. On a slide made from caecal contents there is a small cestode (Stunkard, 1966, Fig. 1) which is identified as *Abortilepis abortiva*. It agrees substantially with the descriptions of von Linstow (1904), Rosseter (1911), and Fuhrmann (1913). The worm is obviously young, because the terminal, sterile proglottid is present. However, it and the three preceding proglottids were separated from the strobila and from each other when the worm was mounted. The strobila is 0.46 mm long and consists of 16 recognizable proglottids. The scolex is 0.16 mm wide,

0.11 mm long; the suckers are unarmed, 0.070 mm in diameter. The rostellum is extruded and the apex, 0.026 mm in diameter, bears the 10 hooks. In form and size the hooks agree with those figured by von Linstow, Rosseter, and Fuhrmann. For identification of *Hymenolepis* species, the size and shape of the rostellar hooks are of cardinal significance since they are constant, whereas other structures manifest variations as a result of muscular contractions. The hooks are 0.033–0.034 mm long; the handle is 0.021–0.022 mm long and the blade is 0.012 mm long. The rostellum extends between the suckers and its posterior end rests at the base of the scolex. Since the species is contracted, there is no neck, but three or four annular constrictions may be recognized. The testes are small, situated along the posterior edge of the proglottid with the median one slightly dorsal and posterior to the Anlagen of the ovary and vitelline gland. The reproductive organs are immature and there are no recognizable spermatozoa. Although juvenile, the specimen agrees so completely with the descriptions of *A. abortiva*, that provisionally, it is assigned to that species. It is deposited in the Helminthological Collection of the American Museum, No. 917.

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Genital Ganglion and Associated Nerves in Male *Macracanthorhynchus hirudinaceus* (Acanthocephala)[1]

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Abstract: The nervous system of *Macracanthorhynchus hirudinaceus* consists of three ganglia, their associated nerves, and receptors. The genital ganglia are reexamined in this study using SEM and light microscopy. The protrusor nerve is the only nerve traversing the distance between the genital ganglion and the posterior terminus of the worm. The posterior depressor nerves are described for the first time. The nerves associated with the bursal muscle are illustrated and the inner and outer bursal nerves described. The presence of a ring commissure is questioned although the dorsal commissure is prominent. A core nerve is described which some investigators may have interpreted as the ventral commissure. Bursal and penis receptors are outlined and a general topography of these and other neural components presented.

Since 1898 the nervous system of Acanthocephala has been represented by the work of Brandes. His illustrations of the nervous system of male *Macracanthorhynchus hirudinaceus* have appeared in most of the reviews of this subject (Hyman, 1951; Bullock and Horridge, 1965; etc.) up to the present. However, previous studies (Kaiser, 1893) as well as more recent ones (Kilian, 1932) provided information which, if accepted, would have made major alterations in Brandes's conclusions.

Our present understanding (Dunagan and Miller, 1977) of the nervous system in male acanthocephala indicates that there may be three accumulations of nerve cells: a cerebral ganglion, a genital ganglion, and a bursal ganglion. The genital ganglion consists of two groups of cells connected by a commissure. Both the cerebral and genital ganglia contain motor and sensory neurons. Kaiser (1893) and Harada (1931) have indicated that these two ganglia are interconnected by units of the lateral posterior nerves originating from the cerebral ganglion. This observation had been made previously by Brandes (1898). Information is currently available regarding the genital ganglion and/or nerves originating therefrom in the following: *Acanthocephalus ranae* (Hamann, 1891; Kaiser, 1893); *Gigantorhynchus echinodiscus* (Hamann, 1895); *M. hirudinaceus* (Kaiser, 1893; Brandes, 1898; Dunagan and Miller, 1975, 1976); *Oligacanthorhynchus microcephala* (Kilian, 1932); *Bolbosoma turbinella* (Harada, 1931); *Moniliformis moniliformis* (Kaiser, 1893; Dunagan and Miller, 1975, 1976). However, only the first four species have been examined extensively.

This study is a reexamination of nerves originating from the genital ganglion as well as other neural elements associated with the male sex apparatus of *M. hirudinaceus*.

Materials and Methods

Macracanthorhynchus hirudinaceus was obtained from Swift Fresh Meats Company in East St. Louis, Illinois. Following removal, the worms were transported to the laboratory in a Dewar flask containing gut contents. Afterwards,

[1] Supported in part by a research grant from the Graduate School of Southern Illinois University and by the National Institutes of Health Grant NB 08583.

the worms were washed and cleaned in a bath of 30% artificial seawater and mounted for either scanning electron microscope studies or wax serial sections. The SEM observations were made on specimens prepared according to the technique of Small and Marszalek (1969) and for the light microscope studies live worms were frozen in liquid nitrogen and then fixed in cold (−20°C) AFA for 1 hr. Following fixation the specimens were handled in a routine manner through dehydration and imbedding in 56°C wax. After sectioning and mounting, the tissue sections were stained with either hematoxylin-eosin, toluidine blue, PAS-alcian blue, or pfloxin.

Results

Figure 1 is a composite drawing reconstructed from serial sections of the posterior end of the male worm. It covers approximately the same area represented by the SEM pictured in Figure 2; however, the specimen in Figure 2 is more highly contracted.

The most obvious feature of the posterior portion of the nervous system is the genital ganglion whose position may change somewhat depending on the state of contraction of those muscles associated with the bursa. Nevertheless, it is always below the insertion of the bursal depressor muscle (BD) and adjacent to the appearance of the ejaculatory duct muscles (E) and Saefftigen's pouch (SP). It consists of two cell accumulations located in the depression between "E" and the bursal cap muscle (B). Each accumulation consists of approximately 20 cells although as many as 23 nuclei and as few as 18 nuclei have been observed. Along the anterior margin a dorsal commissure (DC) arises whose processes are easily distinguished (Fig. 5) from each other. This commissure passes medial to the bursal depressor muscle being difficult to observe in SEM examinations but readily seen in serial sections of wax mounts. It is clear from Figure 2 that no ventral commissure exists on the outer surface of the ejaculatory duct. However, several nerve cell bodies have axons (CN) that pass medial to the ejaculatory duct muscle. These anteriorly located (Fig. 1) prominent processes do not appear to connect the two ganglia.

The anterior depressor nerve (ADN) arises from the ventral lateral margin of each ganglion and proceeds anteriorly to the origin of the bursal depressor (BD) muscle. Here, several axons comprise this nerve branch and follow the bursal depressor muscle posteriorly. Figure 5 (small arrows) shows axons from this nerve in association with the lateral margin of this muscle. Another similar axon grouping also occurs from the opposite ganglion on the lateral margin of the "BD" muscle closest to it. Figure 6 shows one of these axons penetrating to the external surface of the "BD" muscle.

The penis nerve (Pn) arises from the ventral lateral margin of the ganglion (Fig. 1) and innervates receptors in the penis tip. These receptors (Fig. 11, white markers) are readily observed but their three axons are not easily separated. We believe the centralmost receptor receives an axon from each part of the genital ganglion.

The eight receptors (R) located in the posterior margin of the bursal muscle (B) are innervated by three separate nerves from each part of the ganglion. The largest of these nerves, lateral bursal nerve (LBN), is the most lateral. It consists of several (three or more) axons which enter the lateral margins (Figs. 8, 9, white

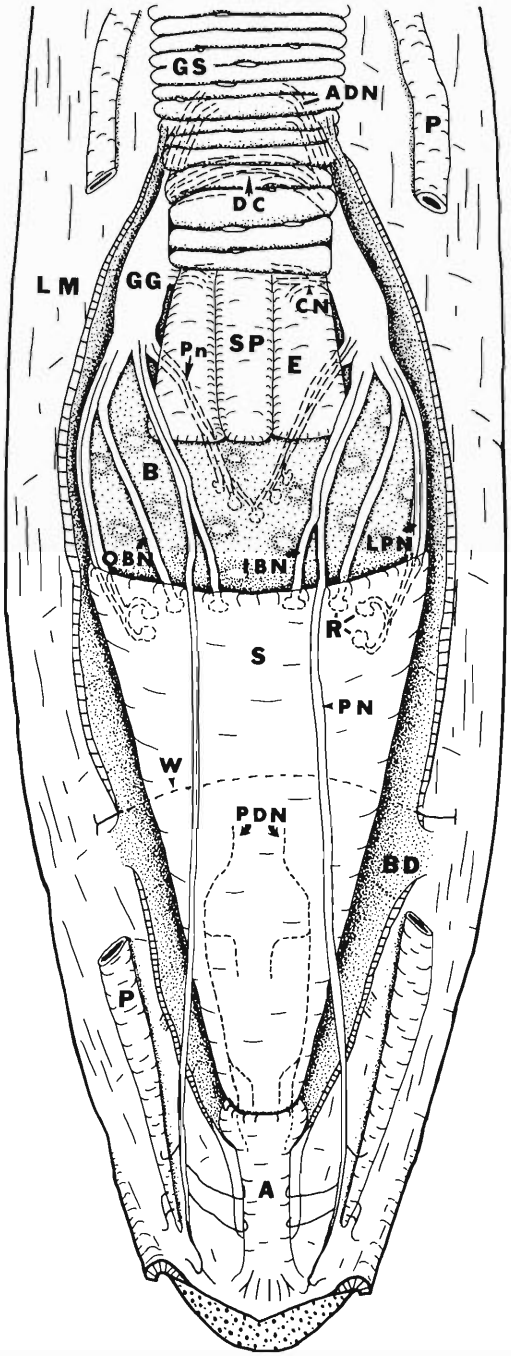

Figure 1. Diagrammatic illustration of the posterior ventral portion of the reproductive system of male *M. hirudinaceus* reconstructed from serial sections. The bursal sac (S) and the posterior bursal accessory muscle (A) have been exposed by removing a portion of the bursal depressor muscle (BD). Note that there is a single protrusor nerve (PN) and no ventral commissure but a core nerve (CN) which does not connect the two ganglia. Abbreviations used: A, posterior bursal accessory muscle; ADN, anterior depressor nerve; B, bursal muscle; BD, bursal depressor muscle; CN, core nerve; DC, dorsal

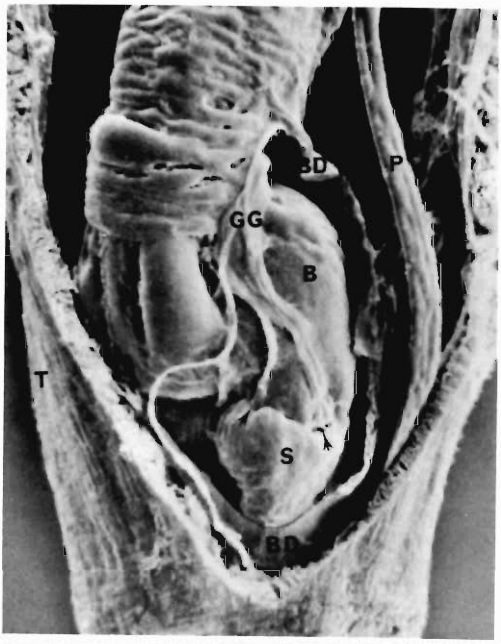

Figure 2. Scanning electron microscopic picture of posterior terminus of male *M. hirudinaceus*. Specimen is more contracted than that shown in Figure 1 but positions of ganglion and nerves are clearly visible. Arrows indicate points of entry of nerves into bursal muscle. Bursal depressor muscle (BD) has been split in order to see the bursal sac (S). Note that there is no ventral commissure visible on the surface. Abbreviations used: B, bursal muscle; BD, bursal depressor muscle; GG, genital ganglion; P, protrusor muscle; S, bursal sac; T, tegument. Genital ganglion measures 675 μm long.

markers) of the bursal muscle where they immediately enlarge and become vesiculated. After penetrating the muscle these axons separate and innervate unusually shaped receptors (Figs. 13, 14) on the external surface of the bursal muscle. Two other nerves, inner and outer bursal nerve, from each cell mass (Fig. 2) are also associated with separate receptors found on the ventral surface of the bursal muscle. These pear-shaped receptors (Figs. 10, 12) are much different from those previously mentioned (Figs. 13, 14). Notice the large number of vesicles present in the receptors as well as in their axons (Fig. 13, nonshafted arrows). Figure 2 shows the relative position of these nerves. Clearly both have a separate existence and enter the muscle at separate points.

The longest of the posterior oriented nerves is the protrusor nerve (PN), so named because it follows the same pattern of passage through the pseudocoel as the protrusor muscle (P). This nerve innervates the protrusor muscle (Fig. 1) and the posterior margins of the "BD" muscle. In addition it probably aids in the

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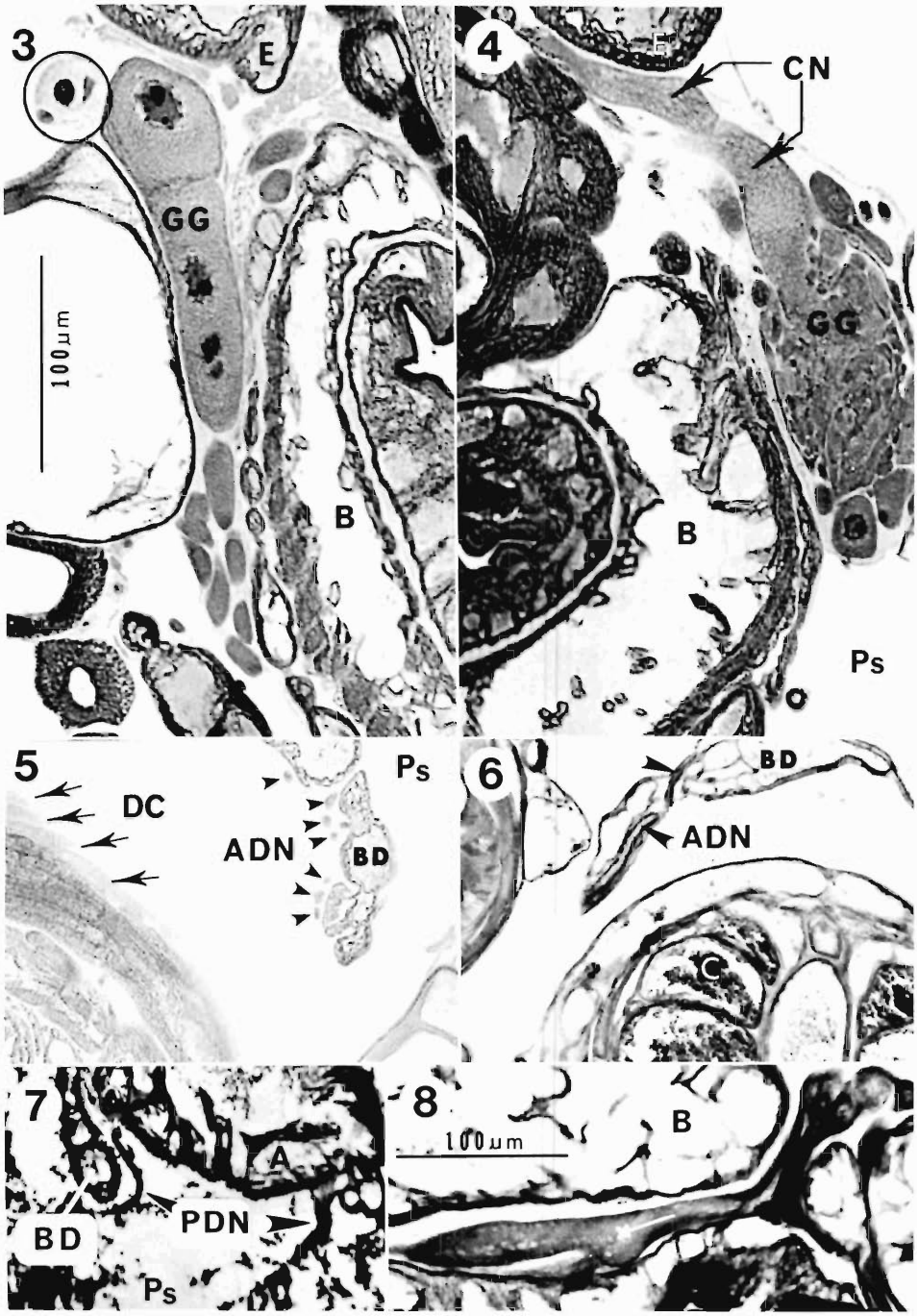
commissure; E, ejaculatory duct muscle; GG, genital ganglion; GS, genital sheath; IBN, inner bursal nerve; LBN, lateral bursal nerve; LM, longitudinal muscle; OBN, outer bursal nerve; P, protrusor muscle; PDN, posterior depressor nerve; PN, protrusor nerve; Pn, penis nerve; R, receptors; S, bursal sac; SP, Saefftigen's pouch; W, nerve from body wall. Genital ganglion measures 700 μm long.



Figures 3–8. 3. Cross section of genital ganglion prior to the entry of protrusor nerve (circled). Note that three axons make up this nerve. 4. Cross section of genital ganglion showing two (arrows) neurons of the core nerve leaving the ganglion and passing medial to the ejaculatory duct muscle. Notice the large size of the cell bodies (arrows). Scale is the same as for Figure 3. 5. Cross section of region immediately anterior to genital ganglion showing some of the axons of the dorsal commissure (DC) as well as axons of the anterior depressor nerve (ADN) on the medial lateral surface of the bursal depressor muscle (BD). 6. Cross section

control of the accessory muscles associated with the genital opening. Although the protrusor nerve enters the body wall and branches several times in the vicinity of the lateral posterior nerve from the cerebral ganglion, we have been unable to follow these axons with sufficient clarity to suggest they go to the cerebral ganglion as did Brandes (1898). Figure 3 (circled axons) shows the protrusor nerve prior to the appearance of its cell bodies indicating there are three axons involved.

Another group of axons from the posterior depressor nerve (PDN) exit the body wall along the posterior dorsal surface (Fig. 1) near the lacunar canal. This pair of nerve processes divide as illustrated and insert into the bursal depressor muscle in two separate areas before disappearing into the accessory muscles associated with the bursal sac. Figure 7 shows two of these axons as they pass between these muscles and the recently appearing posterior bursal accessory muscle.

Occasionally another nerve process (W) appears from the region of the posterior lateral nerve and crosses the pseudocoel dorsal to the bursal sac (Fig. 1). This nerve reenters the body wall in the vicinity of the opposite lateral posterior nerve without having branched or visibly innervated anything associated with the reproductive apparatus. No name has been given to this nerve because it has only been observed twice and it is not clear at this time why the nerve appears in the pseudocoel.

Discussion

Almost any account that discusses the number of cells in the genital ganglion of an acanthocephalan gives a variable number for the total. We previously reported (Dunagan and Miller, 1975) a variation of 19–20 in each ganglion. Since then, we have observed counts of nuclei as high as 23 and as low as 18. Throughout our studies we have had the preconceived belief that the number of cells in the ganglion was fixed. Any variation between cell counts as determined by the number of nuclei was presumed due to staining technique or poor specimen preparation. The conclusion to this approach was to accept the highest number as the correct one. Unfortunately, this thesis has been eroded as a result of observing repeated sets of serial sections in which the number of nuclei varied from set to set and from left to right genital ganglion in the same set. We have reluctantly concluded that some variation in cell number does exist between specimens. This has complicated the problem of explaining ganglion function. One would think that a reduction of just one of these very large cells would have an adverse effect on the organism. These cell counts are similar to those reported by Kaiser (1893) and Kilian (1932).

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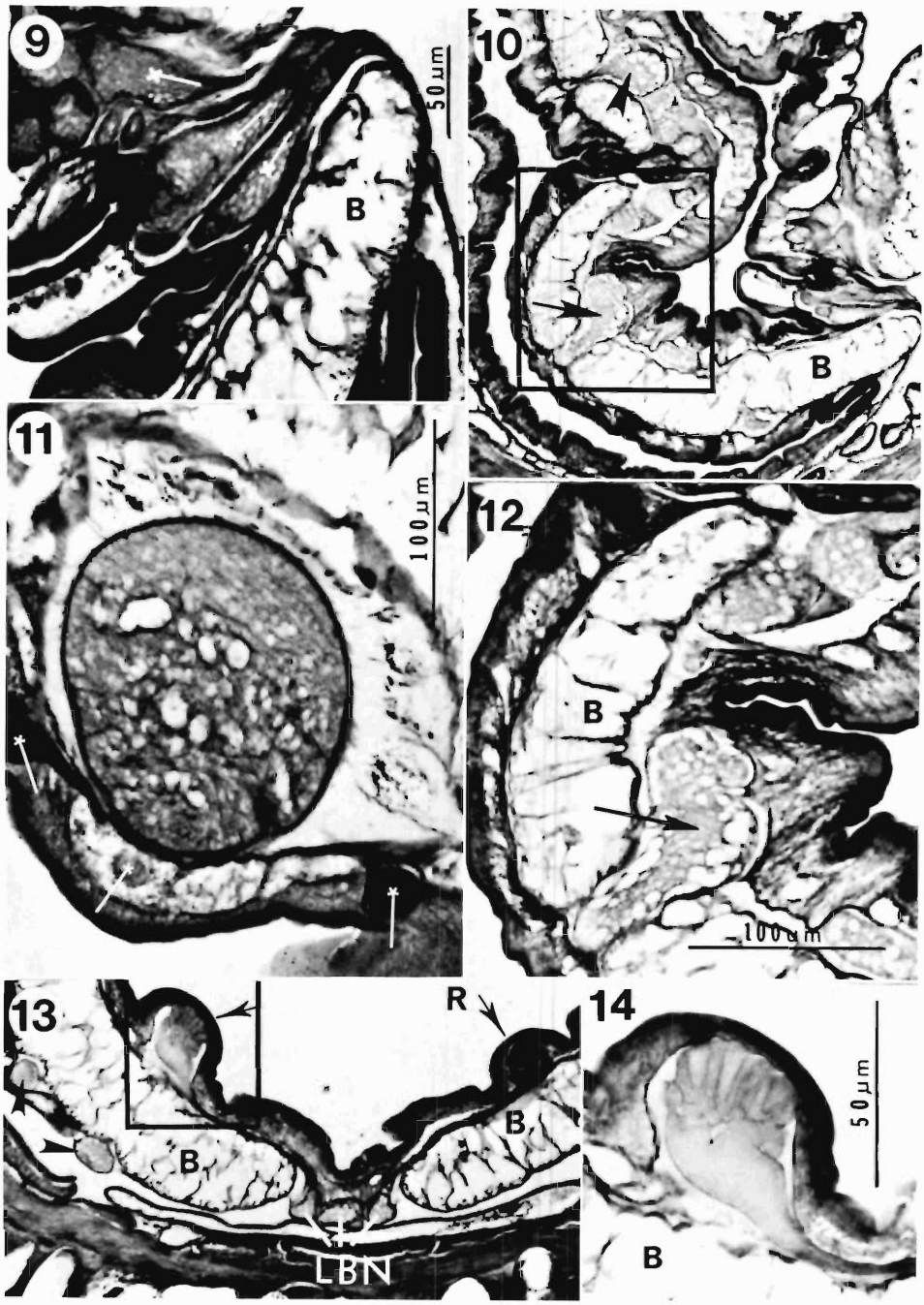
of region anterior to genital ganglion showing movement of an anterior depressor nerve (ADN) axon through an opening in the bursal depressor muscle (BD). 7. Cross section of posterior terminus of bursal depressor muscle (BD) where it joins the posterior bursal accessory muscle (A). Arrow heads show the posterior depressor nerves (PDN) as they move from the pseudocoel (Ps) into these muscles. 8. Cross section of lateral margin of bursal muscle (B) at point of entry of lateral posterior nerve. Note the size (white marker) of an axon of this nerve. Abbreviations used: A, posterior bursal accessory muscle; ADN, anterior depressor nerve; B, bursal muscle; BD, bursal depressor muscle; C, cement gland ducts; CN, core nerve; DC, dorsal commissure; E, ejaculatory duct muscle; GG, genital ganglion; PS, pseudocoel.



Figures 9–14. 9. Cross section of lateral margin of bursal muscle at point of entry of lateral posterior nerve. Note that the large axons (white markers) are highly vesiculate at this point. 10. Cross section through the bursal muscle showing the large vesiculate receptors (arrows) of the inner and outer bursal nerve. 11. Cross section of the penis tip showing three receptors (white markers). See Figure 2 for relative position of these receptors. 12. Enlargement of lower receptor (arrow) shown in Figure 10. 13. Cross section of lateral margin of bursal muscle (B) showing the two receptors (shafted arrows) of the lateral bursal nerve (LBN) and axons (arrow heads) of the inner and outer bursal nerves. The latter are on the dorsal

The genital ganglion organization which has usually been presented (Bullock and Horridge, 1965; Hyman, 1951; etc.) has been that of Brandes (1898) which illustrated this nerve cell complex as consisting of two lateral accumulations of cell bodies connected by a small dorsal and large ventral commissure. This same general design was reported for *Oligacanthorhynchus microcephala* (Kilian, 1932, p. 317) and *Bolbosoma turbinella* (Harada, 1931) although Kilian states that in *O. microcephala* the dorsal commissure is the larger of the two. We are unable to confirm the presence of a ventral commissure in *M. hirudinaceus* although the dorsal commissure is evident. Several prominent axons (Fig. 4) do pass medial to the ejaculatory duct muscle and Saefftigen's pouch. These axons innervate muscles surrounding the vas deferens as well as other structures in the core of the ejaculatory duct. Axons from the opposite genital ganglion can also be followed into the same general area but we have never been able to trace an axon from one ganglion to the other by this route. This is an uncomfortable discrepancy that must be continually studied since Kaiser (1893), Brandes (1898), and Kilian (1932) all reported the presence of a dorsal and ventral commissure. The core nerve (CN, Fig. 1) described in this study may be the previously designated ventral commissure.

The anterior depressor nerve (ADN) was readily observed (Fig. 2) in most preparations. Axons composing this nerve have many separate destinations but most are associated with the bursal depressor muscle (BD). Nine "ADN" axons are clearly observed (Fig. 5) along each lateral margin of this muscle.

The overall general design of genital ganglia must be considerably different from species to species if the few that have been studied are any clue to the group. Harada (1931) described a single posterior nerve process in *B. turbinella* and his Figure 20 showed a much less elongate ganglion with several nerves associated with the anterior margins. Kilian (1932) did not illustrate the genital ganglion in *O. microcephala* and while his description (pp. 317–318) mentioned seven nerves from each ganglion, we have been unable to position them relative to each other. He did state, however, that many of his observations differed from those of Kaiser (1893). The model presented by Brandes (1898) has been reproduced in most reviews as illustrative of the organization of the nervous system in *M. hirudinaceus*. He described the genital ganglion as two lateral balls of cells connected by a ring commissure. Five nerves exit from each ganglion. Two of these nerves arise from the posterior portion of the ganglion and then travel via the pseudocoel to the region of the genital opening where they turn anteriorly and join with the lateral posterior nerve from the cerebral ganglion. Our model (Fig. 1) is much different from that described by Brandes. The ganglion is elongate (Fig. 2) or oblanceolate in form with five posteriorly directed nerves, one anterior medial, and one anterior. However, only one of these posterior nerves, protrusor nerve, traverses the entire remaining length of the body. This nerve is associated with the insertion of the protrusor muscle as well as the bursal accessory muscle (A) and although it inserts into the body wall we have been unable to confirm that it turns anteriorly as an axon in the lateral posterior nerve.

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surface of the bursal muscle. 14. Enlargement of upper left receptor shown in Figure 13. Abbreviations used: B, bursal muscle; LBN, lateral bursal nerve; R, receptor.

The remaining posterior nerves terminate in receptors either in the penis or bursal rim. Kaiser (1893) mentioned the presence of the penis papillae but did not elaborate further, Kilian (1932) stated that there were at least three "Penisnervenpapillen" in *M. hirudinaceus*. We have observed five receptors organized as two pair and a single terminal receptor (Fig. 11). We believe the terminal receptor receives axons from each genital ganglion. According to Kaiser (1893) the rim of the bursal muscle has six receptors. Kilian (1932, p. 317) described eight receptors in this area which is identical to our observations. The four receptors innervated by the lateral bursal nerve (LBN) have fingerlike projections (Fig. 14) oriented toward the bursal lumen whereas the remaining four are pear-shaped highly vesiculate receptors (Fig. 12) individually innervated with separate axons from the genital ganglion. Kilian (1932, p. 318) indicated that these were "Tastorgane."

The posterior depressor nerves (PDN, Fig. 1) may be identical with portions of the nerve complex shown anterior to genital ganglion by Brandes (1898). If not, this description represents a new observation.

A considerable additional amount of work will be needed before we begin to understand how the reproductive apparatus operates. We still know very little about neurotransmitters, membrane potentials, rates of conduction, etc. Indeed, for such a common parasite we know little of its biology beyond its life cycle.

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Parasites of the Woodchuck (*Marmota monax*) in Central New York State

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Abstract: Four hundred and forty-six woodchucks (*Marmota monax*) were examined for parasites; eight nematode, two cestode, four coccidia, and four arthropod species were identified. *Capillaria tamiasstriati* and *Trichostrongylus axei* from woodchucks are new host records and *Strongyloides* from woodchucks is reported for the first time. *Ackertia marmotae*, a filariid parasite of the liver, was the most frequently observed parasite, occurring in 151 of 194 animals. *Ackertia marmotae* was observed in animals as young 7 weeks of age; half of the woodchuck year class was infected by 21.3 ± 15.9 weeks of age. A life history study on *A. marmotae* has previously reported this species as occurring only in adult woodchucks.

Adults of four of seven helminth species survived host hibernation. Seasonal incidences of helminths were related to the species' abilities to survive host hibernation.

A comprehensive review of the literature and tabulation of specimens on deposit in the National Parasite Collection are presented.

Throughout its range, the woodchuck (*Marmota monax*) is one of the most abundant mammals for its size in North America (Hamilton, 1934). In spite of its local abundance, reports on its parasites have been almost entirely limited to species descriptions. The present study was undertaken to explore the host-parasite relationships in a population of woodchucks by determining not only the species composition of parasites, but also parasite incidences and burdens, survival of parasites within the woodchuck during host hibernation, and by examining life histories of some of the parasites encountered.

Four coccidian species have been described from the woodchuck. Dorney (1965) described a heavy-walled species, *Eimeria tuscarorensis* Dorney, 1965, and redescribed three thin-walled species, *E. monacis* Fish, 1930, *E. perforoides* Crouch and Becker, 1931, and *E. os* Crouch and Becker, 1931. He also observed two polysporocystic sporozoans, possibly of the genus *Klossia*, but was unable to count the sporozoites accurately for positive generic diagnosis.

Several ectoparasites have been reported from the woodchuck. Whitaker and Wilson (1974), in a recent literature review of the mites of North American mammals, reported references to five species of mites parasitizing woodchucks. *Androlaelaps fahrenholzi* (Berlese, 1911) was the most frequently cited finding. Lice (Olsen, 1938), fleas (Baker, 1904; Ewing and Fox, 1943), and ticks, predominately of the genus *Ixodes* (Cooley and Kohls, 1938; Twichell, 1939; Ko, 1972a, b) have also been reported. A recent survey of the external parasites of the woodchuck is that of Whitaker and Schmaltz (1973).

Table 1 summarizes previous records of helminth parasitism in woodchucks and reflects contemporary classification. For clarification, a taxonomic review of certain species is in order.

Dikmans (1938) reviewed the genus *Citellinema* and concluded that *C. monacis*

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Table 1. A summary of previous findings of helminth parasites in woodchucks (*Marmota monax*).

Species	Location	Source	Locality
CESTODES			
Taenia crassiceps (Zeder, 1800) (metacestodes)	Intermuscular and thoracic and abdominal cavities	Freeman, 1962	Ontario, Canada
		Beaudoin et al., 1969	Pennsylvania
		Albert et al., 1972	Maryland
		USNM*	Maryland, New York
Taenia mustelae Gmelin, 1790 (metacestodes)	Liver	Freeman, 1956	Ontario, Canada
TREMATODES			
Dicrocoelium dendriticum (Rudolphi, 1819)	Bile ducts and gall bladder	Mapes, 1950	New York
Quinqueserialis hassalli (McIntosh and McIntosh, 1934)	Caecum	Rausch and Tiner, 1948	Wisconsin
NEMATODES			
Strongyloids			
Strongyloides sp.	Small intestine	USNM*	Maryland
Capillaria hepatica (Bancroft, 1894) (ova)	Liver	Georgi, 1974	New York
		Reynolds and Gavutis, 1975	New Jersey
Capillaria sp. (ova)		USNM*	
Ascarids			
Baylisascaris laevis (Leidy,1856)	Small intestine	Leidy, 1856	Pennsylvania
		Tiner, 1951	Pennsylvania, Virginia
		USNM*	
Baylisascaris columnaris (Leidy, 1856) (larval migrants)		Richter and Kradel, 1964	Pennsylvania
Oxyurids			
Citellina triradiata (Hall, 1916)	Caecum	Manter, 1930	Maine
		Rausch and Tiner, 1948	Michigan, Minnesota
		Read, 1957	Connecticut, Maryland, Pennsylvania, Wisconsin
		USNM*	Connecticut, Iowa, Maryland, Michigan, North Carolina
Passalurus ambiguus (Rudolphi, 1819)	Caecum	USNM*	New York
Trichostrongylids			
Citellinema bifurcatum Hall, 1916	Small intestine	Manter, 1930	Maine
		Rausch and Tiner, 1946	
		USNM*	New York
Graphidium sp.	Stomach	USNM*	New York
Obeliscoides cuniculi (Graybill, 1923)	Stomach	Hamilton, 1930†	Kentucky
		Twichell, 1939	Missouri
		Wallace, 1942	Minnesota
		Rausch and Tiner, 1946	Michigan, Minnesota, Missouri, Ohio

Table 1. Continued.

Species	Location	Source	Locality
		Grizzell, 1955	Maryland
		USNM*	Maryland, Missouri, New Jersey, New York, Tennessee, Washington, D.C.‡
Trichostrongylus calcaratus Ranson, 1911	Small intestine	Yamaguti, 1961	
		USNM*	
Trichostrongylids			
Heligmostomum sp.		USNM*	New York
Spiurids			
Physaloptera sp.		USNM*	
Filarids			
Ackertia marmotae Webster, 1967	Connective tissue and lymphatics of liver	Webster, 1967	Ontario, Canada
		Ko, 1972	Ontario, Canada
		Anteson, 1968	Connecticut
		USNM*	

* Specimens on deposit in the National Parasite Collection (U.S.D.A., Beltsville, Maryland) and not reported in the literature.
† Not identified but descriptions and location suggest this species.
‡ National Zoological Park.

Manter, 1930, as described from the woodchuck, was a synonym for *C. bifurcatum* Hall, 1916. Hall (1916) had apparently confused the dorsal and ventral surfaces of *C. bifurcatum* in his original description of this species. Therefore Manter's observations on the sizes of the asymmetrical bursal lobes of *C. monacis* were exactly the reverse of Hall's description of the bursa lobes for *C. bifurcatum*. Dikmans (1938) considered spicule size of the two species similar enough to synonymize *C. monacis* and *C. bifurcatum,* but Manter (1930) thought that differences in spicule size alone was a basis for species separation. Skrjabin et al. (1954) recognized *C. monacis* and *C. bifurcatum* as two distinct species, the distinction being made on the basis of longitudinal striations and cephalic alae. Since the disagreement is not centered on whether there are one or two species of *Citellinema* parasitizing the woodchuck, the name *C. bifurcatum* is used in the present study.

Manter (1930) described *Citellina marmotae* Manter, 1930 from the woodchuck as being different from *C. triradiata* (Hall, 1916) on the basis of a fivefold larger spicule in *C. marmotae*. Read (1957) considered *C. triradiata* and *C. marmotae* to be conspecific and stated that Hall (1916) had apparently considered the gubernaculum to be the main body of the spicule and therefore had described a short, stout spicule and no gubernaculum. Manter (1930) had recognized the spicule but had failed to observe a gubernaculum (Read, 1957).

Sprent (1968) revised the genus *Ascaris* and placed *Ascaris columnaris* Leidy, 1856 and *Ascaris laevis* Leidy, 1856 in the new genus *Baylisascaris*. Anteson (1968) placed *Ackertia marmotae* Webster, 1967 in the genus *Mononema*; Anteson's work was never published and Webster's designation thus prevails.

To complete our review of previous findings of woodchuck helminths, we examined the collection of woodchuck helminths in the National Parasite Collection of the United States Department of Agriculture, Beltsville, Maryland. Our study

of these specimens resulted in a reevaluation of USDA 49366. Specimens cataloged under this entry were previously listed as *Multiceps* sp. The description of the gross lesion accompanying these metacestodes, and our observation of exogenous budding in one of the specimens, lead us to conclude that the metacestodes were *Taenia crassiceps* (Zeder, 1800) rather than *Multiceps* sp. A listing of woodchuck helminths that previously have been deposited in the National Parasite Collection, but that have not been mentioned in the literature is presented in Table 1.

Study Area

This study was conducted in Tompkins County, located in the Finger Lakes region of central New York State. The topography and soils of the county have been strongly influenced by glaciation. The area is characterized by flat to gently rolling valleys and hilltops and steep slopes. The 10 soil associations occurring in the county range from coarse glacial till and outwashings to clay and sand of glacial lake and river sediments. Approximately half of Tompkins County is farmed. Dairy farming is the predominant type of agriculture (Neeley, 1965).

Woodchucks are abundant throughout the county, being limited in local distribution by soil drainage and land use. Hamilton's (1934) classic study of the woodchuck was conducted in Tompkins County and provides a background of life history information on the woodchuck in this area.

Materials and Methods

Woodchucks were collected by shooting or live-trapping at numerous locations in Tompkins County. Collections were made during the months of February through October, beginning in June 1975 and continuing through July 1977. Ages of young-of-the-year woodchucks were determined on the basis of age-weight relationships as described by Snyder et al. (1961).

Woodchucks for experimental use were individually housed in hardware cloth cages. Water and commercial rabbit and/or rat ration were supplied ad libitum. Diets were occasionally supplemented with fresh fruits and vegetables. During winter, cages were provided with straw in which woodchucks could burrow for hibernation. Ambient temperatures in the buildings housing hibernating woodchucks fluctuated between 2 and 10°C while animals were in hibernation.

Parasite examinations included gross necropsy observations, fecal examinations for parasite eggs and larvae (Georgi, 1974), and examination of intestines and intestinal washings. Nematodes observed in 1975 were correlated with reproductive forms found during fecal examinations. During 1976 and 1977, fecal examinations were used to diagnose parasitism and were supplemented by examinations of intestinal washings only as necessary. Ectoparasites were found by combing through the animals' hair and examining the hair and hide during this process.

Nematodes were fixed in hot 70% ethyl alcohol and prepared for study in either phenol-alcohol or glycerine jelly. Larval tapeworms were examined when fresh and stored in ethyl alcohol. Arthropods were mounted in Berlese solution for study.

Additional parasitologic techniques were used to supplement the standard techniques and procedures mentioned above. Blood and cutaneous tissue were ex-

Table 2. Incidence of coccidia in woodchucks (*Marmota monax*) from Tompkins County, New York, 1975–1977.

	Occurrence	Percent positive
Eimeria monacis	190/232	82
Eimeria os	27/232	12
Eimeria perforoides	164/232	71
Eimeria tuscarorensis	39/232	17

amined for microfilaria by the methods of Knott (1939) and Supperer (1953). At the onset of the study, coccidian oocysts from fecal examinations were allowed to sporulate in 2% potassium dichromate. After species diagnosis of coccidia were made and oocysts could be identified without examination of sporocysts, coccidia were identified during fecal examinations without subsequent sporulation. Nematode eggs were cultured in either petri plates (Little, 1966) or jars (Georgi, 1974).

For helminth life history and host specificity studies, woodchucks, domestic rabbits, rats, and mice were inoculated with one or more species of infective larvae or eggs. Depending on the nematode species in the inoculum, infective stages were administered per os or were applied cutaneously or subcutaneously in the axillary region as noted in the results.

Results

Coccidia

All four species of coccidia previously described from the woodchuck were observed (Table 2). No gross lesions were associated with the infections.

Helminths

Two larval cestode and eight nematode species were recovered and identified (Table 3). Representative specimens were placed in the National Parasite Collection (Nos. 67092–67108).

CESTODES: *Taenia crassiceps* metacestodes when present, occurred in one to several 1 × 1 × 2-cm cysts. In one woodchuck, a cyst extended under the dorsal attachment of the diaphragm to the body wall and protruded into both the abdominal and thoracic cavities. Another woodchuck had multiple cysts in the right hind leg. This leg had a circumference approximately twice that of the left hind leg. Histologically, the muscle bundles adjacent to the cysts in this leg were laterally compressed and were undergoing degeneration, apparently due to pressure atrophy. Limited observations of these animals prior to euthanization did not indicate any noticeable loss of muscular function.

No cysticerci were found in two white rats injected intraperitoneally with 10 *T. crassiceps* metacestodes collected from woodchucks. Examination for development of cysticerci in these rats was made 6 weeks after injection.

Taenia mustelae Gmelin, 1790 were encased in 4 to 6 mm, yellowish cysts, on the liver surface and in the parenchyma. Three to five cysticerci were observed per cyst. Some of the cysts contained hard, yellow material, presumably calcified pus, in addition to the metacestodes.

Table 3. Helminth parasites of woodchucks (*Marmota monax*) from Tompkins County, New York, 1975–1977.

	Location	Frequency	No. helminths			Reference collection number*
			Mean ± SD	Range	N	
CESTODES						
Taenia crassiceps (metacestodes)	Musculature, abdominal and thoracic cavities	4/281 (1%)	ND	ND		67094
Taenia mustelae (metacestodes)	Liver	5/281 (2%)	ND	ND		67095
NEMATODES						
Ackertia marmotae	Liver	151/194 (78%)	ND	1–50†	50	67100–67104
Baylisascaris laevis	S. intestine	3/246 (1%)	3 ± 1.4	2–4	2	67099
Capillaria tamiasstriati	S. intestine	9/246 (4%)	4 ± 2.1	2–7	4	67106
Citellina triradiata	Caecum	123/229 (54%)	236 ± 480	3–2,730	26	67107
Citellinema bifurcatum	S. intestine	81/246 (33%)	4.5 ± 5.0	1–19	12	67097–67098
Obeliscoides cuniculi	Stomach	83/248 (34%)	26.2 ± 26.8	1–270	21	67096
Strongyloides sp.	S. intestine	130/246 (53%)	14.9 ± 23.3	1–92	14	67092–67093
Trichostrongylus axei	S. intestine	17/246 (7%)	ND	1–10†	10	67108

ND—Not determined.
* National Parasite Collection, U.S.D.A., Beltsville, Maryland.
† Estimate.

NEMATODES: The species of *Strongyloides* found in the woodchuck was not determined. Parasitic *Strongyloides* females were 2.5–4.6 mm in length, with an esophagus 20–28% of their body length. Eggs containing larvae were passed unhatched from the host. Egg cultures hatched in 24–48 hr at room temperature and 24–48 hr later yielded predominantly infective larvae; free-living adults were rarely observed. The prepatent period was 10–14 days in two woodchucks subcutaneously inoculated with 750–1,000 larvae. Host specificity of *Strongyloides* from the woodchuck was tested by inoculating two mice and two rats subcutaneously with 500–700 larvae. In addition, one rabbit and two mice were subcutaneously inoculated with 200 and 500–700 larvae, respectively. Pooled fecal pellets from the two mice inoculated subcutaneously showed a few *Strongyloides* eggs at 7 days but none were found in subsequent examinations. On the basis of fecal examinations, *Strongyloides* infection was not apparent for the other animals.

The intestinal *Capillaria* found in the woodchuck resembled *Capillaria tamiasstriati* Read, 1949 as originally described from the chipmunk (*Tamias striatus*). Spicule lengths, however, differed slightly, being 0.653–0.685 mm in woodchucks compared to 0.490–0.502 mm as described from chipmunks. This difference was considered insignificant and we therefore believe the intestinal capillarid from the woodchuck is *C. tamiasstriati*.

At room temperature, *C. tamiasstriati* eggs from the woodchuck took approximately 1 month to develop to the larval stage. A woodchuck fed eggs containing *Capillaria* larvae escaped 10 days postinoculation; the infection was not patent at that time.

The distribution of *Trichostrongylus axei* was localized to a farm on which horses and cattle were raised. *Trichostrongylus axei* occurred in 16 of 30 wood-

Table 4. Arthropod parasites of woodchucks (*Marmota monax*) from Tompkins County, New York, 1975–1977.

Parasites	Occurrence	Percent positive
Androlaelaps fahrenholzi	28/213	13
Enderleinelus marmotae	2/213	1
Ixodes cookei	71/213	33
Oropsylla arctomys	110/213	52

chucks from this farm; only one woodchuck that was not from this area was infected.

We examined *C. bifurcatum* specimens (USDA 66295) from the grey squirrel (*Sciurus carolinensis*) and found no morphological differences between *C. bifurcatum* from the grey squirrel and from the woodchuck. At room temperature, *C. bifurcatum* eggs from the woodchuck developed to infective larvae in 14 days. Prepatent period was 14 days in a woodchuck inoculated per os with 50–100 of these larvae.

Ackertia marmotae was the most frequently encountered nematode. The youngest woodchuck infected with *A. marmotae* was 7 weeks of age. Half of the year class was infected by 21.3 ± 15.9 (determined by probit analysis). *Ackertia marmotae* was found primarily in the lymphatics at the hilus of the liver and in the lymphatics of the gall bladder. Lymphatics around the portal veins within the liver parenchyma were also frequently infected. One female was recovered from the lymphatics of the greater omentum and one woodchuck had two of these parasites in one kidney and four in the other. Two woodchucks had *A. marmotae* in their lung parenchyma. All specimens contained eggs and were therefore considered sexually mature.

In addition to the woodchucks randomly collected, five woodchucks exhibiting central nervous system disorders were obtained for necropsy. Brain tissue from each of these animals was treated by the Baerman technique and yielded ascarid larvae believed to be *Baylisascaris columnaris* (Leidy, 1856) or *Baylisascaris procyonis* (Stefanski and Zarnowski, 1951).

Arthropods

Four species of arthropod parasites were encountered (Table 4). The attachment of the tick *Ixodes cookei* Packard, 1869 stimulated an inflammatory reaction and is believed to be responsible for small nodules of connective tissue frequently observed on the skin of woodchucks. The other arthropods were not observed to cause gross lesions on this host.

Effect of hibernation on parasite populations

Trapping success and field sightings of woodchucks began to diminish during September. By mid-October, aboveground woodchuck activity had ceased. Emergence from hibernation started in mid-February; by the middle of March there were signs of woodchuck activity around most burrows believed to have been used for hibernation.

Comparison of fall and spring adult parasite incidence was used, in part, to evaluate the effect of host hibernation on parasite populations (Fig. 1). The in-

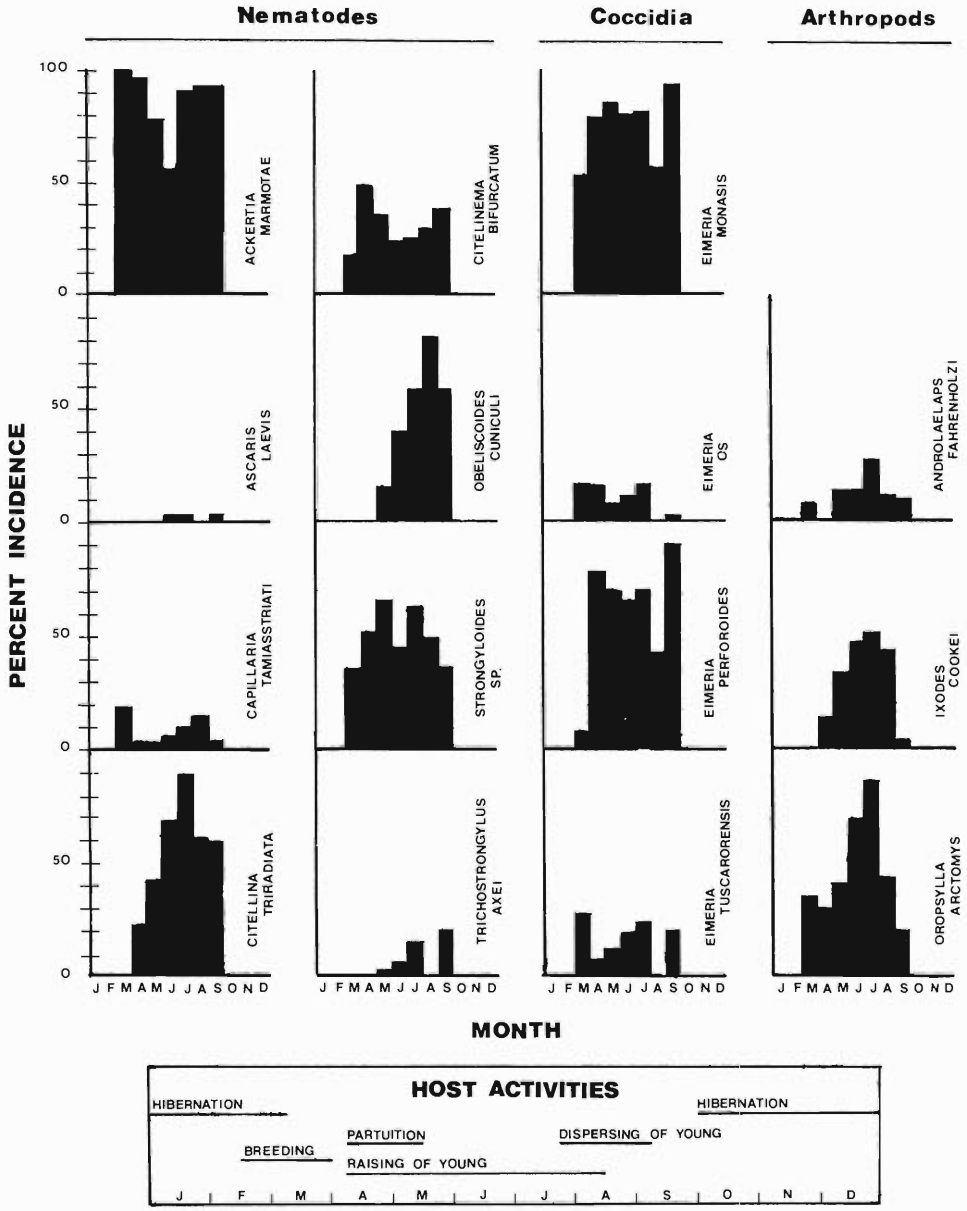

Figure 1. Monthly parasite incidence in woodchucks (*Marmota monax*) from Tompkins County, New York, 1975–1977. Woodchucks hibernated from October through mid-February and were not available in sufficient numbers to be included.

cidence of *A. marmotae, C. tamiasstriati, Strongyloides* sp., and all coccidian species did not change from fall to spring. *Citellinema bifurcatum* exhibited a 50% decrease in incidence while adult *Obeliscoides cuniculi* (Graybill, 1923) and *C. triradiata* apparently failed to survive hibernation.

During February 1976, several woodchuck hibernation burrows were examined every 3 to 5 days for signs of woodchuck activity. Snow cover provided excellent

tracking and enabled observation of signs of animal activity. Woodchucks were collected from some of these burrows within 3 to 5 days after signs of woodchuck activity were first detected. Adult *A. marmotae*, *C. tamiasstriati*, *Strongyloides* sp., and *C. bifurcatum* were recovered from these recently emerged animals. Helminths were alive and eggs were present in their uteri.

Adult *C. bifurcatum* and *A. marmotae* were recovered from a captive woodchuck that died after 2 months of hibernation at 2–10°C. Microfilariae of *A. marmotae* were present in the cardiac blood and/or cutaneous tissue from all of eight captive hibernating woodchucks 1–3 months after the animals entered hibernation.

An attempt was made to examine the temporal element of hibernation by maintaining a colony of nonhibernating woodchucks to serve as controls to hibernators. These attempts failed due to the escape of captive animals and our inability to prevent woodchucks from hibernating.

Monthly incidence of parasites

Except for the month following emergence of woodchucks from hibernation, the incidence of coccidian species remained fairly constant. The incidence of coccidia in young-of-the-year woodchucks in May and June, the time when young woodchucks first began to leave their burrows, was similar to that of adults.

The monthly incidence of helminths was strongly influenced by whether adults of each species could survive host hibernation. Species with adults that survived host hibernation either maintained or reached their maximum incidence earlier in the year than did species that failed to survive host hibernation (Fig. 1).

The influx of young-of-the-year woodchucks into the host population caused an overall reduction of 18 to 40% in the incidence of *A. marmotae* during May and June. The effect of host recruitment was not as apparent for other helminths since young woodchucks seemed to acquire infections at about the same rate as did adults.

Discussion

Capillaria tamiasstriati and *T. axei* from woodchucks are new host records. *Capillaria tamiasstriati* has previously been reported only from the chipmunk (Read, 1949). *Trichostrongylus axei* is cosmopolitan in distribution and has been reported from horses, domestic ruminants, wild ungulates, and some species of ground squirrels (Skrjabin et al., 1954). Neither of these parasites was observed to cause grossly visible lesions in woodchucks, although *T. axei* may provoke a hypertrophic gastritis in horses (Soulsby, 1965). The restricted distribution of *T. axei* to farms with domestic stock suggests that domestic stock may be the source of *T. axei* infection for woodchucks.

The high incidence of *Strongyloides* in woodchucks indicates that this genus is a normal component of the helminth fauna of woodchucks in Tompkins County. *Strongyloides* has not been reported previously from woodchucks, although specimens collected from woodchucks from Maryland were in the National Parasite Collection (USDA 66283).

Because of the large number of species in the genus *Strongyloides*, many of which have been inadequately described (Little, 1966), we were unable to identify the species parasitizing the woodchuck. We did, however, demonstrate that the

Strongyloides sp. from the woodchuck has a high degree of host specificity, producing only a transient experimental infection in one group of mice and no infection in rats, rabbits, or another group of mice. Host specificity has been suggested as an important species criterion for *Strongyloides* (Augustine, 1940; Melvin and Chandler, 1950). If Chandler's (1925) division of *Strongyloides* into two groups is followed, the species from woodchucks must be placed in the *S. papillosis* group. Chandler (1925) characterized the *S. papillosus* group as being more than 3 mm in length, having eggs that seldom hatch before leaving the host's body, and occurring in herbivorous animals.

Webster (1967) reported *A. marmotae* to occur in the connective tissue in the liver of woodchucks. Ko (1972b) found the parasite primarily to inhabit the lymphatics of the liver and gall bladder. We concur with Ko's observations that *A. marmotae* primarily occurs in the lymphatics of the liver and gall bladder. We also found the parasite in the lungs, kidneys, and greater omentum of a few woodchucks, but these sites probably represent sites of normal larval migration (in the case of the greater omentum) or sites of abnormal larval migration with subsequent maturation (in the cases of kidney and lung infections).

The ecology of *A. marmotae* in woodchucks from Tompkins County is quite different from that described by Ko (1972a, b) for *A. marmotae* in Ontario, Canada. Ko observed a much smaller incidence of *A. marmotae* in woodchucks than we did (28[4] vs. 78[5]%, respectively), but the incidence of *I. cookei,* the intermediate host for *A. marmotae,* was about the same (29 vs. 33%, respectively, for all ages) for both study areas. Ko (1972b) also found *A. marmotae* to occur only in woodchucks older than 12 months of age; he reported that 0/135 woodchucks 1–12 months of age had either microfilariae or adult *A. marmotae*. Based on experimental infections and observations from wild woodchucks, Ko (1972b) estimated a prepatent time of 1 yr for *A. marmotae* in woodchucks. In contrast, we found woodchucks as young as 7 weeks of age were infected with *A. marmotae*; the majority of the woodchuck year class was infected with this parasite by 21.3 ± 15.9 weeks of age.

Several authors have reported on the success or failure of helminths to survive hibernation of their host. Blanchard (1903) and Blanchard and Blatin (1907) reported the failure of helminths to survive hibernation in the European marmot (*Arctomys marmota*). Barkow (1846) found *Physaloptera* sp. was retained throughout hibernation by the European hedgehog (*Erinaceus europeaus*). The length of uninterrupted hibernation was shown to influence survival of helminths in the Yugoslavian ground squirrel (*Citellus citellus*) (Simitch and Petrovitch, 1954). Schmidt (1967) stated that naturally occurring parasites of hibernators have usually adapted themselves to the host in such a way that they are not adversely affected by hibernation. However, adaptation of parasites in a host-parasite system may occur at any stage of ontogeny and is not restricted to the adult form (Chute, 1964).

We found adult *A. marmotae, C. bifurcatum, C. tamiasstriati,* and *Strongyloides* are capable of surviving host hibernation within the host. Survival of larval forms of these four species was not specifically demonstrated, but it seems almost

[4] Incidence in adult woodchucks.

[5] Incidence in adult and young-of-the-year woodchucks combined.

certain that *A. marmotae* is capable of surviving hibernation as 4th-stage larvae. Chute (1960, 1964) has also reported *C. bifurcatum* from recently emerged woodchucks.

Obeliscoides cuniculi, T. axei, and *C. triradiata* did not survive as adults within the hibernating host. The rate at which populations of these species reestablished themselves in woodchucks emerging from hibernation indicates that larval forms, like adults, did not survive hibernation within the host. In the case of *O. cuniculi,* it is likely that woodchucks become reinfected from overwintering populations of *O. cuniculi* that are present in cottontail rabbits (*Sylvilagus floridanus*). Rabbits are nonhibernating animals and are generally considered to be the normal host for *O. cuniculi.*

The effects of parasitism on the woodchuck population remain largely unknown. Only those parasites for which the woodchuck serves as an intermediate or paratenic host were observed to produce significant pathological lesions or clinical signs. The occurrence of this type of parasitism was low and was probably insignificant in terms of the effects upon the host population. Parasites for which the woodchuck was the definitive host were not observed to be pathogenic. However, intrinsic to an overdispersed distribution of parasites (Table 4) as described by Crofton (1971a, b), is the assumption that host diathesis varies, and therefore, certain parasites may act as agents of natural selection.

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Parasites of Fish from the Missouri, James, Sheyenne, and Wild Rice Rivers in North Dakota[1,2]

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ABSTRACT: Results of a survey in 1975 of the parasite fauna of fish from four North Dakota rivers are presented. Over 270 fish representing 24 species were examined, and 44 parasite species, mostly helminths, recorded. Of the fish examined, 34% carried ectoparasites. Endoparasites occurred in 76% of the fish. Four forms are reported from new hosts and 22 parasites are reported for the first time from North Dakota. The parasites are systematically arranged showing hosts, location within hosts, incidence and geographic location. The pathogenic and epizootic significance of *Myxobolus* sp., *Diplostomulum spathaceum*, and *Hysteromorpha triloba*, is discussed. Observations on other parasites are recorded.

An extensive survey of the fish parasite fauna in North Dakota was initiated in 1975. As part of this survey, intensive fish sampling was undertaken within a 55-km stretch of the Missouri River below Garrison Dam, James River from the headwaters to Jamestown Reservoir, Sheyenne River from the headwaters to Lake Ashtabula, and the entire Wild Rice River. The Missouri River and its tributary, the James River, are in the Mississippi River Drainage while the Sheyenne and Wild Rice rivers, tributaries of the Red River of the North, are in the Hudson Bay Drainage.

No earlier literature exists on fish parasites of the James, Sheyenne, and Wild Rice rivers. No published study exists on fish parasites of the Red River but three of its North Dakota tributaries have been surveyed by Hoffman (1953), Voth and Larson (1968), and Woods (1971). Missouri River fish parasites have been more extensively studied and numerous species have been described by Kritsky and Leiby (1971), Leiby et al. (1972), Kritsky et al. (1972), Leiby et al. (1973), and Schmidt et al. (1974).

Materials and Methods

Over 270 fish representing nine orders, 13 families, and 24 species were collected between June 28 and November 2, 1975 from 19 sites along the four rivers. Scientific and common names utilized for fish are those recognized by the American Fisheries Society (1970). Hosts were collected by fyke net, variable mesh gill net, seine, dip net, and hook and line. The type of aquatic habitat at each station usually dictated the use of specific collecting gear; however, 1/4-in mesh minnow seines and 3 × 4-ft fyke nets were most frequently used. Fish were placed immediately on ice for transport to the laboratory and were usually necropsied within 24 hr. A few specimens representing less available species could not be examined within 48 hr. They were frozen or preserved in isopropyl alcohol

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and necropsied at a later date. The external surface, mouth, nasal cavities, gills, eyes, musculature, viscera, and mesenteries were examined for parasites. Standard microtechniques were utilized in preparing parasites for identification. Ecotypes of most specimens have been deposited in the United States National Museum Helminthological Collection. Accession numbers are listed in Table 1. Remaining specimens have been retained in the collections of the authors.

Results

Two hundred and seventy-seven fish were examined for ectoparasites. Of these, 251 were examined for endoparasites. Of the fish examined, 34% harbored ectoparasites. Endoparasites infected 76% of the fish. Seven species of parasites were the most taken from a single fish and 80% of the 277 fish harbored at least one parasite. Forty-four species in 35 genera were identified (Table 1). These included 8 species of monogeneans, 12 digeneans, 6 cestodes, 7 nematodes, 3 acanthocephalans, 6 crustaceans, and 2 species of leeches. Ten parasitic forms were identified only to genus. Several parasites could not be placed in any taxon below class. Cyprinids and catostomids often harbored blackspot metacercariae in the integument and nonpigment producing metacercariae in the musculature, viscera, and mesenteries. Species identification in these forms is difficult with preserved material. Since living material was not critically observed, these forms were identified only as *Neascus* spp. Metacercariae from the stomach and intestine of piscivorous fish are probably parasites of prey fish but are still listed in Table 1. Four parasites are reported from new hosts and 22 parasites are reported for the first time from North Dakota.

Discussion

No mortalities of fish populations, attributable to the effects of parasites, were recorded during the study. However, several parasites reported have been of pathogenic and epizootic significance in natural, hatchery, or culture conditions elsewhere and therefore merit brief discussion. Observations on parasites not causing discernible injury to the host are also discussed.

The pathogenic and epizootic potential of *Myxobolus* sp., *Dactylogyrus extensus, Diplostomulum spathaceum, Hysteromorpha triloba, Ornithodiplostomum ptychocheilus, Clinostomum marginatum, Proteocephalus ambloplitis, Pomphorhynchus bulbocolli, Argulus* spp., *Lernaea cyprinacaea,* and *Actinobdella* sp. is well documented in parasitological literature. Of these parasites, only *Myxobolus* sp. and *H. triloba* were implicated in eliciting pathogenic conditions in or on fish. The low incidence and low intensity of other potentially injurious parasites did not result in noticeable effects to fish.

Myxobolus sp. was associated with a pathogenic condition on the gills of a heavily infected fathead minnow. Spores were contained in white, opaque, spherical cysts of the interlamellar type (0.5 mm in diameter). As many as 12 cysts occurred on a single gill arch and numerous gill filaments were disrupted and bleeding.

Metacercariae of *D. spathaceum* and *H. triloba* frequently infected black bullhead in large numbers. The lenses of *Ictalurus melas* often had herniations containing *D. spathaceum* similar to those described by Larson (1965). A maximum of 115 metacercariae was recovered from the lenses of a single black bullhead.

Table 1. Parasites, piscine hosts, anatomic location, incidence and riverine distribution in North Dakota.

Parasite	USNM no.	Host and location	Incidence	River
Protozoa				
Myxobolus sp.		*Pimephales promelas* (g)*	36:2†	M,W
Monogenea				
Anonchohaptor muelleri	74738	*Carpiodes carpio* (g)	11:5	M
¶*Cleidodiscus aculeatus*	74739	*Stizostedion vitreum* (g)	10:2	M
¶*Cleidodiscus adspectus*	74740	*Perca flavescens* (g)	11:1	M
¶*Cleidodiscus floridanus*	74741	*Ictalurus punctatus* (g)	1:1	M
¶*Cleidodiscus pricei*	74742	*Ictalurus melas* (g)	70:20	M,J,W,S
¶*Dactylogyrus extensus*	74743	*Cyprinus carpio* (g)	20:3	W
Dactylogyrus spp.		*Pimephales promelas* (g)	37:6	W,J,S
Icelanonchohaptor microcotyle	74744	*Carpiodes carpio* (x)	11:1	M
¶*Tetraonchus monenteron*	74745	*Esox lucius* (g)	14:2	M,S
Digenea				
Alloglossidium corti	74746	*Ictalurus melas* (i)	55:2	M,W
¶*Bucephalopsis pusilla*	74747	*Stizostedion vitreum* (i)	10:1	M
‡*Bucephalopsis pusilla*		*Pimephales promelas* (m)	36:1	W
‡*Centrovarium lobotes*	74748	*Notropis cornutus* (f)	10:10	S
‡*Clinostomum marginatum*	74749	*Ictalurus melas* (f)	55:2	W,S
		Lota lota (s)	5:1	M
		Unidentified cyprinid (f)	1:1	M
Crepidostomum ictaluri	74750	*Ictalurus melas* (i)	55:1	W
¶*Crepidostomum illinoiense*	74751	*Hiodon alosoides* (i)	10:1	M
‡*Diplostomulum spathaceum*		*Aplodinotus grunniens* (e)	1:1	W
		Catostomus commersoni (e)	30:1	W
		Cyprinus carpio (e)	20:2	W
		Esox lucius (e)	14:1	J
	74752	*Ictalurus melas* (e)	55:25	J,S,W
		Pimephales promelas (e)	36:4	J,S
		Pomoxis nigromaculatus (e)	5:2	W
‡*Hysteromorpha triloba*		*Catostomus commersoni* (f)	30:5	M
	74753	*Ictalurus melas* (f)	55:15	M,J,W,S
Lissorchis gullaris	74754	*Ictiobus cyprinellus* (i)	1:1	M
Lissorchis sp.	74755	*Carpiodes carpio* (i)	10:2	M
‡ *Neascus* spp.		*Catostomus commersoni* (f,m,v,x)	30:16	M,J,S,W
		Culaea inconstans (f,m,v)	7:3	S
		Esox lucius (x)	14:1	J
		Notropis cornutus (f,m,v,x)	10:10	S
		Pimephales promelas (f,m,v,x)	37:27	M,J,W,S
		Unidentified cyprinid (f,m,v,x)	1:1	M
Phyllodistomum staffordi	74756	*Ictalurus melas* (u)	55:8	W,S
§*Phyllodistomum staffordi*		*Ictalurus melas* (u)	55:2	S
‡*Posthodiplostomum minimum centrarchi*	74757	*Lepomis macrochirus* (l)	10:6	M
		Pomoxis annularis (l)	2:2	M
‡*Ornithodiplostomum ptychocheilus*	74758	*Pimephales promelas* (b)	36:19	J,W
Cestoda				
Bothriocephalus cuspidatus		*Hiodon alosoides* (i)	10:9	M
	74759	*Stizostedion vitreum* (i)	10:9	M

Table 1. Continued.

Parasite	USNM no.	Host and location	Incidence	River
§*Bothriocephalus cuspidatus*		*Aplodinotus grunniens* (i)	1:1	W
		Esox lucius (i)	14:1	M
		Ictalurus melas (i)	55:1	M
		Perca flavescens (i)	11:5	M
		Pomoxis annularis (i)	2:1	M
		Salmo gairdneri (i)	1:1	M
		Stizostedion canadense (i)	9:1	M
§Caryophyllaeid		*Catostomus commersoni* (i)	30:2	M,W
‡Cysticerci		*Ictalurus melas* (m)	55:4	W
¶*Corallotaenia minutia*	74760	*Ictalurus melas* (i)	55:8	M,J,W
§Corallobothriin		*Ictalurus melas* (i)	55:10	M,J,W,S
¶*Khawia iowensis*	74761	*Cyprinus carpio* (i)	20:3	M,W
§*Khawia iowensis*		*Cyprinus carpio* (i)	20:2	M,W
¶*Proteocephalus ambloplitis*	74762	*Lepisosteus platostomus* (i)	1:1	M
‡*Proteocephalus ambloplitis*		*Stizostedion vitreum* (m)	10:1	M
¶*Proteocephalus pearsei*	74763	*Perca flavescens* (i)	11:2	M
Proteocephalus pinguis	74764	*Esox lucius* (i)	14:9	M,J,W,S
§*Proteocephalus* spp.		*Esox lucius* (i)	14:2	W
		Hiodon alosoides (i)	10:2	M
		Ictalurus melas (i)	55:3	M
		Ictalurus punctatus (i)	1:1	M
		Lota lota (i)	5:2	M
		Notropis cornutus (i)	10:4	S
		Perca flavescens (i)	11:5	M,S
		Pimephales promelas (i)	36:3	M,J,S
		Pomoxis annularis (i)	2:2	M
		Pomoxis nigromaculatus (i)	5:2	W
		Salmo gairdneri (i)	1:1	M
Nematoda				
Camallanus ancylodirus		*Ictiobus cyprinellus* (i)	1:1	M
	74768	#*Stizostedion vitreum* (i)	10:2	M
§*Camallanus oxycephalus*		*Aplodinotus grunniens* (i)	1:1	W
		Esox lucius (i)	14:1	W
		Ictalurus melas (i)	55:1	W
	74769	*Pomoxis nigromaculatus* (i)	5:1	W
¶‡*Contracaecum spiculigerum*		*Aplodinotus grunniens* (m)	1:1	W
	74770	*Esox lucius* (m)	14:1	J
		Ictalurus melas (m)	55:9	J,W,S
		Ictalurus punctatus (m)	1:1	M
		Lepomis macrochirus (m)	10:2	M
		Perca flavescens (m)	11:1	M
		Pomoxis nigromaculatus (m)	5:2	W
‡*Contracaecum* sp.		*Catostomus commersoni* (m)	30:1	M
		Esox lucius (i)	14:1	J
		Hiodon alosoides (i)	10:1	M
		Ictalurus melas (m)	55:1	J
		Perca flavescens (m)	11:7	M
		Pimephales promelas (m)	36:1	S
		Stizostedion canadense (i)	9:1	M
¶*Dacnitoides robusta*	74771	*Ictalurus melas* (i)	55:1	W
¶*Metabronema salvelini*	74772	#*Hiodon alosoides* (s,i)	10:6	M
		Ictalurus melas (i)	55:1	M
‡*Raphidascaris* sp.		#*Ictalurus melas* (m)	55:2	M,W
		Unidentified cyprinid (m)	1:1	M

Table 1. Continued.

Parasite	USNM no.	Host and location	Incidence	River
Rhabdochona cascadilla	74773	*Notropis cornutus* (i)	10:9	S
¶§*Spinitectus gracilis*	74774	*Ictalurus melas* (i)	55:1	S
¶‡*Spiroxys* sp.		*Ictalurus melas* (m)	55:1	S
Acanthocephala				
‡Acanthocephalan		*Ictalurus melas* (m)	55:1	J
Octospinifer macilentus	74765	*Catostomus commersoni* (i)	30:13	M,J,S
Neoechinorhynchus prolixus		*Carpiodes carpio* (i)	10:1	M
Pomphorhynchus bulbocolli	74766	*Catostomus commersoni* (i)	30:8	S
‡*Pomphorhynchus bulbocolli*		*Ictalurus melas* (m)	55:2	W
Hirudinea				
¶*Actinobdella* sp.		*Catostomus commersoni* (y)	30:1	M
¶*Myzobdella moorei*		*Ictalurus melas* (z)	70:7	J,W,S
	74767	*Ictalurus punctatus* (z)	1:1	M
		Stizostedion canadense (o)	9:2	M
		Stizostedion vitreum (o)	17:10	M
¶*Placobdella montifera*	74775	*Ictalurus melas* (z)	70:1	S
Piscicolids		*Ictalurus melas* (z)	70:11	M,J,S,W
		Perca flavescens (z)	11:2	M
Crustacea				
Achtheres ambloplitis	74776	*Ictalurus melas* (g)	70:1	W
§*Achtheres ambloplitis*		*Ictalurus melas* (g)	70:1	M
¶*Argulus appendiculosus*	74777	*Catostomus commersoni* (g,x)	30:4	W,S
¶*Argulus catostomi*	74778	*Catostomus commersoni* (x)	30:1	S
Ergasilus cyprinaceus		#*Catostomus commersoni*(g)	30:1	S
	74779	*Pimephales promelas* (g)	36:4	J
§*Ergasilus cyprinaceus*		*Pimephales promelas* (g)	36:5	J
Ergasilus versicolor		*Catostomus commersoni* (g)	30:2	M,S
	74780	*Ictalurus melas* (g)	70:4	S
		Ictalurus punctatus (g)	1:1	M
§*Ergasilus* sp.		*Ictalurus melas* (g)	70:2	S
Lernaea cyprinacaea	74781	*Catostomus commersoni* (x)	30:1	M
		Cyprinus carpio (x)	20:1	W
		Esox lucius (x)	14:1	W
		Ictalurus melas (x)	70:2	W,S
		Lepomis macrochirus (x)	10:1	M
		Pomoxis nigromaculatus (x)	5:2	W
Lernaea sp.		*Ictalurus melas* (x)	70:1	S
		Pimephales promelas (v)	36:1	W
		Partially digested fish (v)	1:1	W

* (b) brain, (e) lens of eye, (f) musculature, (g) gills, (i) intestine, (l) liver, (m) mesenteries, (o) oral cavity, (s) stomach, (u) urinary bladder, (v) viscera, (x) body surface, (y) inner side of operculum, and (z) fins.
† First number denotes number of fish examined; second denotes number infected.
‡ Larval.
§ Immature.
No prescript—Adult.
¶ New state record.
# New host record.

Herniations were not observed in the lenses of the six other fish species infected with *D. spathaceum*. Hendrickson (1978) estimated 25–40% of the brook and rainbow trout of a Wyoming lake and a large percentage of the suckers from the same area to have partial loss of sight because of *D. spathaceum* infections.

Both large and small *I. melas* often had heavy infections of *H. triloba*. An estimated 1,500 metacercariae were recovered from the flesh of a Sheyenne River

black bullhead. Small *I. melas* occasionally carried such heavy infections of *H. triloba* in the musculature of the caudal peduncle that the individual myomeres were no longer evident. Meyer (1958) observed a similar condition in bullhead from Iowa.

Metacercariae of *O. ptychocheilus* were found encysted in the cranial cavity of 19 of 36 fathead minnows. Though infections ranged from one to 70 worms, no gross anomalies in brain topography were evident.

Hoffman (1967) reported progenetic metacercariae of *C. lobotes* and *Bucephaloides* sp. from North Dakota cyprinids. In the present study, 60% of the *C. lobotes* (79 of 131) were progenetic. None of seven *B. pusilla* contained eggs.

New host records were established for *M. salvelini, C. ancylodirus, Raphidascaris* sp., and *E. cyprinaceus. Metabronema salvelini* were abundant in the alimentary tract of Missouri River goldeye and especially common in the stomach. Infections of *M. salvelini* ranged from one to 192 worms.

The leech *M. moorei* frequently infected black bullhead and walleye and less frequently sauger. Infections of black bullhead and sauger were light; however, walleye from the Missouri River often had five to 11 large piscicolids (2.5–3.0 cm in length) attached to the roof of the mouth. Fishermen in the Lake Sakakawea area often report large numbers of leeches in the oral cavities of walleye towards mid-July and August (Berard, North Dakota Game and Fish Department, personal communication).

Unusual attachment sites of *I. microcotyle* and *Lernaea* sp. were observed. Kritsky et al. (1972) described *I. microcotyle* from the gills of river carpsucker from the Missouri River in North and South Dakota. Both specimens collected in the present study were attached just posterior to the anus. Barnhart et al. (1976) found two *I. microcotyle* attached to the pectoral fins of the host.

A single specimen of *Lernaea* sp. was found attached entirely within the coelomic cavity of a Wild Rice River fathead minnow. The anterior end of the worm lay between a fold in the intestine with the horns deeply anchored in the liver. The posterior portion of the worm lay free in the coelom along the posterior portion of the intestine. The specimen lacked egg sacks. Another *Lernaea* was removed from the coelom of a small partly digested fish found in the stomach of a Wild Rice River bullhead.

Acknowledgments

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Rediscovery and Redescription of *Eimeria miyairii* Ohira, 1912 from the Norway Rat[1]

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ABSTRACT: The second American finding of *Eimeria miyairii* is reported from Illinois 45 years after the first one. The oocysts are described in detail. They are subspherical, 21–26 × 20–24 (mean 24 × 22) μm, and contain four ovoid sporocysts 11–14 × 7–9 (mean 12 × 8) μm.

The Norway rat (*Rattus norvegicus*) coccidium *Eimeria miyairii* was found in Japan by Ohira (1912) and then in São Paulo, Brazil, by Pinto (1928). Andreassen and Behnke (1968) found it by chance in a laboratory rat in Denmark and described the fine structure of its endogenous stages. It was also reported by Mullin et al. (1972) and Mullin et al. (1975) in the Malaysian woodrat *R. tiomanicus* and Whitehead's rat *R. whiteheadi* in Malaysia. It has apparently been found only once before in the United States; Becker and Burroughs (1933) found it in material from a rat sent to them by A. C. Chandler from Houston, Texas. This was the strain used by Roudabush (1937) to study the endogenous stages.

It was thought for many years that the species now known as *E. nieschulzi* was *E. miyairii*. Ohira's paper was in Japanese and hence could not be read by western workers. Roudabush (1937) finally had it translated and established the correct name; his interpretation was confirmed by Levine and Ivens (1965), who also had Ohira's paper translated. Pinto (1928) thought that the organism he found was new and named it *E. carinii* (now a synonym of *E. miyairii*) and this was the name that Becker and Burroughs (1933) used.

Forty-five years after the first American report by Becker and Burroughs (1933), we found this species in two wild Norway rats (*Rattus norvegicus*) trapped on a farm near Danville in east central Illinois. Neither Roudabush (1937) nor Andreassen and Behnke (1968) described or illustrated the oocysts (and the latter probably did not even see them); the descriptions by Ohira (1912), Pinto (1928), and Becker and Burroughs (1933) were incomplete, and the illustrations by Ohira and Pinto were unsatisfactory. It is therefore appropriate to redescribe and illustrate the oocysts from *R. norvegicus* at this time. Dimensions are in μm unless otherwise stated.

Eimeria miyairii Ohira, 1912

Oocysts (Fig. 1) subspherical, 21–26 × 20–24 (mean 24 × 22) (50 oocysts measured), with moderately rough, 2-layered wall, outer layer yellowish, radially striated, about 1.3 thick, inner layer brownish, about 0.4 thick, without micropyle or residuum, with polar granule. Sporocysts ovoid, 11–14 × 7–9 (mean 12 × 8) (50 sporocysts measured), with wall about 0.2 thick, without Stieda body or rarely with a tiny one, without substiedal body, with coarsely granular residuum. Sporozoites comma-shaped, lying lengthwise head to tail in sporocysts, with clear globule in broad end.

[1] Aided by U.S. Department of Agriculture Research Agreement 12-14-1001-805.

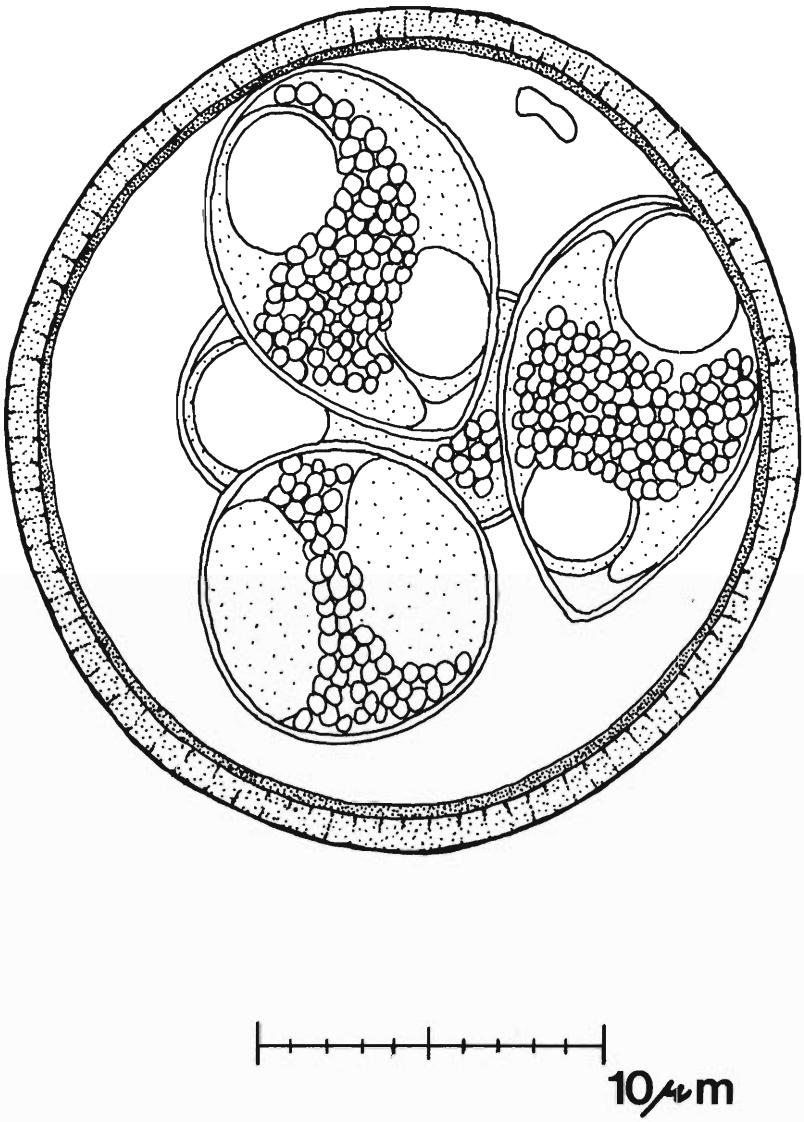

Figure 1. Oocyst of *Eimeria miyairii* from the Norway rat, *Rattus norvegicus*, ×2,300.

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Do not be disturbed by the partially blank pages. Efficient use of the new technology dictates that each paper start at the top of a new page. But despite these spaces the overall cost of printing the *Proceedings* will be significantly less than with the old double column format. This has enabled us to reduce page contributions from $15.00 to $12.50, effective with Volume 46 (1979).

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The Editor

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Loss of Amprolium Resistance in *Eimeria tenella* by Admixture of Sensitive and Resistant Strains

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ABSTRACT: A suspension of equal numbers of oocysts from amprolium-resistant and amprolium-sensitive strains of *Eimeria tenella* was given to a group of unmedicated chickens. The resultant mixture was serially passed through nine additional groups of unmedicated chickens concomitantly given an equivalent number of sensitive strain oocysts. After 10 dilutions, the response of the mixed strain to 125 ppm amprolium was approximately the same as that of the sensitive strain. Results were similar when the resistant strain was manually diluted with sensitive oocysts before administration to medicated chickens.

Resistance to anticoccidials in strains of *Eimeria tenella* persists virtually unchanged after passage through unmedicated chickens (Gardiner and McLoughlin, 1963; Ball, 1968; McLoughlin and Chute, 1968). In contrast, Ball (1966) found that the percentage of resistant oocysts recovered at each passage progressively declined when a small number of glycarbylamide-resistant oocysts were mixed with a larger number of sensitive oocysts and the combination was serially passed through groups of unmedicated birds. McLoughlin (1970) briefly mentioned a loss of resistance occasioned by progressive dilution of an amprolium-resistant strain. More recently, Jeffers (1976b) found that massive introductions of attenuated, sensitive oocysts by the drinking water markedly reduced the number of decoquinate-resistant oocysts subsequently recovered in samples of the litter on which unmedicated birds were run. His attenuated strain did not cause clinical coccidiosis in the experimental birds.

The present study was biphasic. In the first phase, a mixture of amprolium-resistant and -sensitive oocysts was serially propagated in groups of unmedicated birds with additional sensitive oocysts introduced at each passage. In the second phase, mixtures of resistant and sensitive oocysts calculated to approximate the theoretical biological dilution of the first phase were used as inocula for amprolium-medicated birds, providing a basis for judging whether the effects observed in the first phase were simply the results of dilution.

Materials and Methods

Three-week-old White Leghorn cockerels were used. They were grouped by weight (Gardiner and Wehr, 1950) and each group of 10 birds was started on the appropriate mash 24 hr before the infected groups were inoculated with 100,000 sporulated *E. tenella* oocysts/bird.

The birds were weighed and necropsied on the eighth day after inoculation. Cecal lesions were evaluated, and oocyst cultures were made from the ceca and cecal contents. Subsequently, the number of oocysts recovered per bird was estimated for each group. Mortality rate, weight gain, cecal lesion scores, and oocyst production were used to calculate the Anticoccidial Index for each group (McManus et al., 1968). The Indices formed the basis for comparisons; less than 160 was considered poor, 160–179 moderate, and above 180 good.

In vivo dilution: For each passage, medicated (125 ppm of amprolium) and

Table 1. Sensitivity to 125 ppm amprolium (expressed as Anticoccidial Indices) of mixed (MIX), amprolium-resistant (RES), and amprolium-sensitive (SEN) strains.

	Anticoccidial Index					
	Trial I			Trial II		
Passage	MIX	RES	SEN	MIX	RES	SEN
1	—	114	200	—	129	204
2	78	51	194	157	114	196
3	97	96	202	163	114	190
4	167	81	208	160	129	202
5	152	151	201	151	126	194
6	160	101	195	195	159	218
7	178	133	199	213	161	209
8	169	109	207	200	116	192
9	203	78	206	220	100	213
10	188	144	207	199	138	200
11	196	137	198	204	142	206

unmedicated groups of birds (SEN) were inoculated with oocysts from a strain of *E. tenella* that had never been exposed to drugs. Similar groups (RES) were given oocysts from an amprolium-resistant strain (McLoughlin and Gardiner, 1968). For the first passage, an additional group of unmedicated chicks was inoculated with a mixture consisting of 50,000 sporulated oocysts/bird from each of the above strains. For each subsequent passage, oocysts recovered from this last group were (1) again mixed in a 1:1 ratio with amprolium-sensitive oocysts from the unmedicated SEN group of the preceding passage and used to inoculate a group of unmedicated birds and (2) assayed for resistance to amprolium by inoculation into respective groups of amprolium medicated and unmedicated birds. These last two groups were designated MIX.

IN VITRO DILUTION: The stock strains of *E. tenella* were the same as those used in the in vivo trials. Ten inocula were prepared in an ascending ratio of sensitive to resistant oocysts (Table 2). The first was a 1:1 and the tenth a 1,029:1 mixture. These were adjusted so that each inoculation dose contained a total of 100,000 sporulated oocysts in the prescribed proportions.

The first two trials consisted of 10 groups of amprolium-medicated birds each inoculated with one of the aforementioned mixtures plus an unmedicated, uninoculated control. The third trial which was run concomitantly with the second in vivo mixture trial had two additional groups of amprolium-medicated birds. One group was inoculated with the resistant-strain and the other with sensitive-strain oocysts. Similarly inoculated groups of unmedicated birds also served as controls.

Results

IN VIVO DILUTION: The data for the medicated groups inoculated with the mixed strain and with the progenitor strains are given as Anticoccidial Indices in Table 1.

Anticoccidial Indices for the medicated groups inoculated with the resultant mixed strain were not consistently 160 or more until the resistant strain had undergone five dilutions in birds. The Anticoccidial Indices for these groups usually were between those of the medicated groups inoculated with either the re-

Table 2. Sensitivity to 125 ppm amprolium (expressed as Anticoccidial Index) of an amprolium-resistant strain diluted with an amprolium-sensitive strain.

Dilution: sensitive/ resistant	Anticoccidial Index		
	Trial I	Trial II	Trial III
1:1	147	144	153
3:1	165	145	145
7:1	179	160	160
15:1	173	167	174
31:1	188	162	159
63:1	185	184	180
131:1	200	201	201
256:1	202	188	187
514:1	215	190	217
1,029:1	217	183	202

sistant or the sensitive strains of oocysts. The two trials were made many months apart and involved the use of different strains of birds which may account for some of the observed variations. In both trials, for the last three passages, the Anticoccidial Indices for the medicated groups inoculated with the mixed strain were approximately the same as those for the group inoculated with the sensitive strain and consistently exceeded those for the medicated group inoculated with the resistant strain. Amprolium afforded good protection throughout for infections initiated with the sensitive strain.

IN VITRO DILUTION: The data for the medicated groups of the three trials are given as Anticoccidial Indices in Table 2. Essentially the same pattern was observed as for the in vivo dilution trials. Dilutions greater than 31:1 (sensitive to resistant) when used to inoculate medicated groups resulted in Anticoccidial Indices of 180 or more. Moreover, in all tests of the third trial, the infections initiated with the dilution strain were better controlled by amprolium medication than were those initiated with the resistant strain. Also, for this trial, the response of medicated groups to the dilution strain, in general, was intermediate between those of the parental strains.

Discussion

Results from the in vivo portion of these studies indicate that a progressive biological dilution of a resistant strain of *E. tenella* eventually results in a loss of detectable resistance. This effect is presumably due to dilution and is not a spontaneous loss of resistance inasmuch as the undiluted resistant strain simultaneously passed under similar conditions retained its tolerance for amprolium. These results are complemented by those of the in vitro phase of the studies in which the resistant strain was manually diluted with the sensitive strain.

Our results, in general, agreed with those of Ball (1966) in which a mixture of oocysts from a glycarbylamide resistant and from a sensitive strain was serially passed without further mechanical dilution through unmedicated birds. Our results also agreed with those of Jeffers (1976b) for floor pen trials in which massive doses of sensitive strain oocysts were administered twice in the drinking water of birds reared on litter contaminated with a buquinolate-resistant strain. He

found a marked reduction in proportion of resistant oocysts in litter samples taken at 4- and 6-week intervals.

The observations of Ball (1966), Jeffers (1976b), and McLoughlin (1970) and those in the present study all indicate that an infusion of drug-sensitive oocysts into a drug-resistant population of *E. tenella* causes a decrease in resistance within the mixed population. This loss of resistance was great enough in the present studies so that resistance to amprolium was not detectable in either instance at the end of the study. Moreover, in none of the studies just discussed was there any suggestion of drug resistance transfer that has been reported under certain experimental conditions in *E. tenella* (Jeffers, 1974, 1976a) and in *E. maxima* (Joyner and Norton, 1975).

Acknowledgment

We appreciate the technical assistance of Mr. L. M. Spriggs.

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Differential Characters of *Filaroides milksi* Whitlock, 1956 and *Filaroides hirthi* Georgi and Anderson, 1975

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ABSTRACT: Recently, Pence (1978) placed the validity of *Filaroides hirthi* Georgi and Anderson, 1975 in question, claiming that "both the spicules and range of measurements are probably within the range of intraspecific variation of *F. milksi*." *Filaroides hirthi* possesses considerable economic importance as a parasite of commercially reared research Beagle dogs and commands academic interest because, like *F. osleri* (Cobbold, 1789), this species is infective in the first larval stage and requires no period of development outside of the host (Georgi, 1976). Therefore, it is imperative that the validity of *F. hirthi* be established beyond cavil as a species distinct from *F. milksi*.

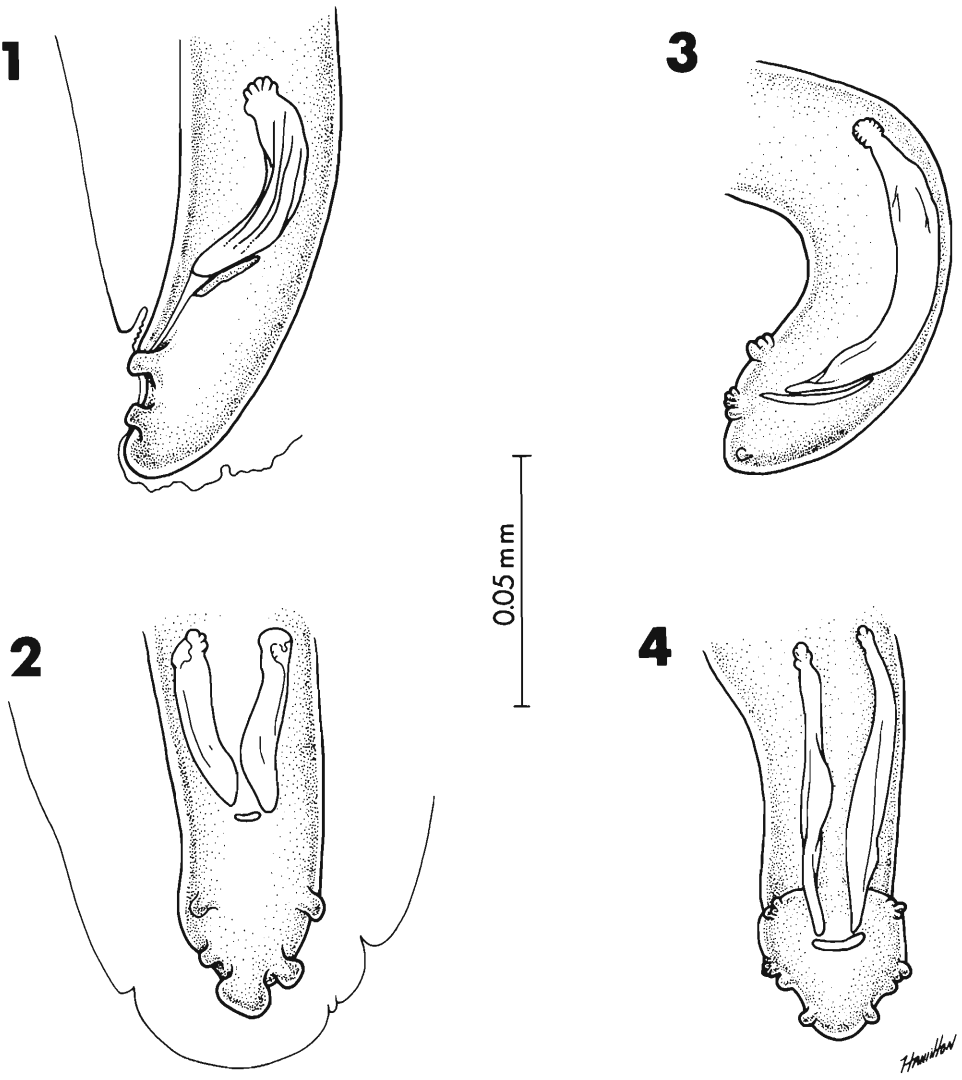
Materials and Methods

Original camera lucida drawings of the type specimen of *F. hirthi* were used in the preparation of Figures 1 and 2. The formalin-preserved canine lung tissue from which Whitlock obtained his *F. milksi* type specimens served as a source of material for Figures 3 and 4. Specimens were studied with bright-field, phase contrast and Nomarski contrast optics; drawings were made with the aid of a Zeiss drawing tube (camera lucida).

Observations and Discussion

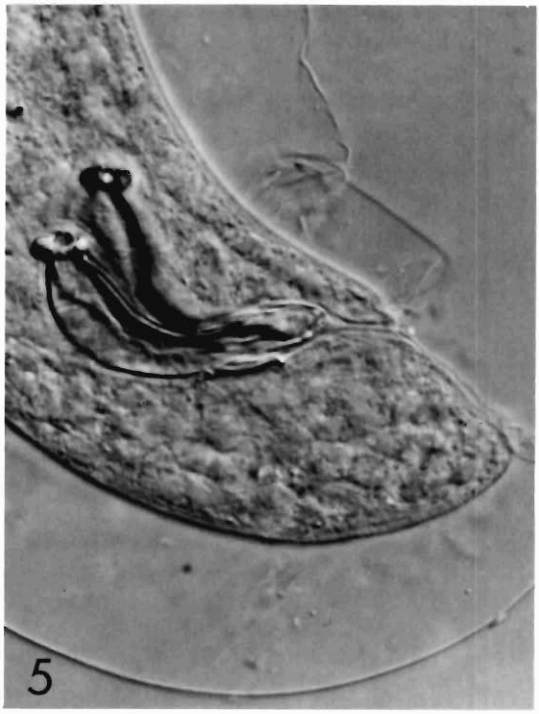
Whitlock (1956) described the caudal extremity of the male *F. milksi* as follows: "Five flap-like structures surrounded the tail of the male. The most caudal we interpreted as the dorsal lobe of the bursa. One pair of flaps was lateral to the cloaca (ventral lobes); a second pair was posterior and lateral (lateral lobes). Careful examination of these flaps indicated some ray structure within them but it was not sufficiently distinct to be of much utility. The tail had to be rolled about in order to demonstrate the bursa and it showed more distinctly with phase microscopy." Nomarski contrast optics render Whitlock's "ray structure" sufficiently distinct to be observed and drawn, allowing for a fair measure of patience and perserverence on the part of the microscopist (Figs. 3, 4). The relatively simple "2 pairs of ventrolateral papillae and terminally expanded lobe" on the caudal extremity of *F. hirthi* differ qualitatively from their probable homologues on *F. milksi* and so we need not rely only on bodily dimensions in distinguishing these two species.

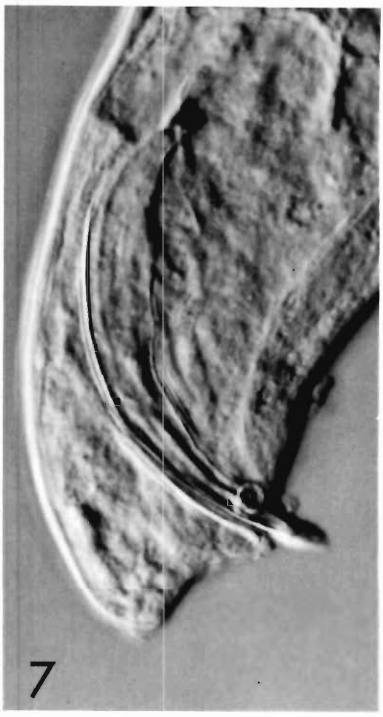
The spicules of *F. hirthi* are broader in relation to their length and have broader knobs for attachment of retractor muscles in addition to being shorter than the spicules of *F. milksi* (Figs. 5–7). We have found, in the case of *F. hirthi*, that the spicules are fully developed by the fourth week of infection and, as comparison of Figures 6 and 7 show, the spicules of *F. milksi* from a dog fully resemble those from a skunk. Therefore, spicule length and shape does not appear to be influenced by the age of the worms or by the species of host animal. This is fortunate because differentiation of *F. hirthi* and *F. milksi* will, in practice, more likely be based on spicule morphology, which is easy to visualize microscopically, than on the more objective but microscopically elusive differences in bursal structure.

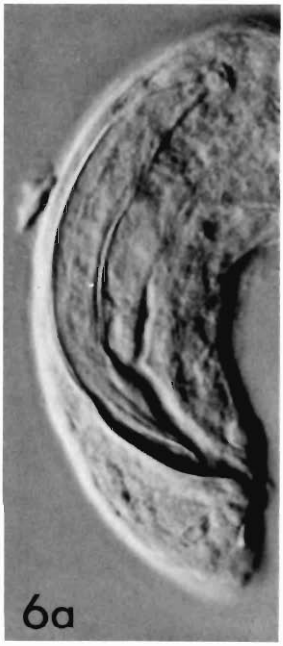


Figures 1–4. Lateral and ventral aspects of caudal extremities of *Filaroides* spp. 1, 2. *F. hirthi* Georgi and Anderson, 1975. 3, 4. *F. milksi* Whitlock, 1956. The teguminal sheath of the formalin-fixed *F. milksi* specimens studied was indistinct and therefore deleted from these drawings.

Body dimensions are, at best, capricious differential characters. For example, Pence (1978) cited body length and width measurements recorded for *F. hirthi* by Hirth and Hottendorf (1973) as "probably within the range of intraspecific variation of *F. milksi*." However, the data of Hirth and Hottendorf (1973) included the voluminous and variable teguminal sheath (R. S. Hirth; personal communication, 23 March 1978) whereas the data of Georgi and Anderson (1975) excluded the teguminal sheath. Therefore, these data are in no way comparable with respect to width. In addition, living *F. hirthi* worms are capable of remarkable extension and shortening and when killed may remain the same or almost







Figures 5–7. Caudal extremities of *Filaroides* spp. males in optical section (ventrolateral papillae/ "ray structure" not in focus). 5. *F. hirthi*. 6a, 6b. Right and left aspects of *F. milksi* from Whitlock's canine type material. 7. *F. milksi* from a striped skunk (*Mephitis mephitis*) collected in the vicinity of Ithaca, New York.

double in length depending on the technique of relaxation (e.g., heat, cold, immersion in various fixatives). Therefore, comparison of body measurements of the smaller, more delicate species of *Filaroides* must be approached with considerable caution.

Based on the evidence presented here, *F. hirthi* should be considered a valid species. In order to provide interested taxonomists with adequate material, I have deposited two specimens of canine lung tissue in the USNM Helm. Coll. as follows: *F. milksi*; lung tissue from which Whitlock's types were obtained (No. 74734) and *F. hirthi*; lung tissue from an experimentally induced infection (No. 74735). Many worms or portions thereof can be teased from a very small portion of either specimen of lung tissue and the balance returned to the collection. Unfortunately, neither species stands up well under the sort of manipulation necessary to demonstrate the male caudal structures and therefore, adequate microscopic study tends to destroy the specimen.

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Research Note

Helminths of the Lesser Prairie Chicken, *Tympanuchus pallidicintus* (Ridgway) (Tetraonidae), from the Texas Panhandle

The Lesser Prairie Chicken, *Tympanuchus pallidicintus* (Ridgway), is an endemic gamebird of the sandy semiarid western rangelands dominated by sand shinnery oak (*Quercus havardi*), sand sagebrush (*Artemisia filifolia*) and little bluestem (*Schizachyrium soparium*). Its range presently extends very locally from southeastern Colorado and western Kansas into the Oklahoma and Texas Panhandles and south-central New Mexico. Although the species sharply declined after 1900 to a population of only about 3,000 birds in 1963, populations have increased in recent years to levels sufficient to allow very limited hunting seasons (Oberholser, 1974, The bird life of Texas. Vol. 1. Univ. Texas Press, Austin. 530 pp.).

Although there are several helminth species reported from the Greater Prairie Chicken, *Tympanuchus cupido* (Linnaeus), (Cram, 1928, U.S. Dep. Agric. Tech. Bull. 49:1–9; Gross, 1930, Progress report of the Wisconsin Prairie Chicken investigations. Wis. Conserv. Comm. Madison, Wis. 1–112; Harper et al., 1967, J. Wildl. Manage. 31:265–269; Leigh, 1940, Ill. Nat. Hist. Surv. Bull. 21:185–194; Leigh, 1941, J. Parasitol. 27:97–106; Morgan and Hamerstrom, 1941, J. Wildl. Manage. 5:194–198; Wehr, 1940, Vet. Med. 35:52–58), there is apparently only a single helminth, *Oxyspirura petrowi* Skrjabin, 1929, reported from the Lesser Prairie Chicken (Addison and Anderson, 1969, Can. J. Zool. 47:1223–1227). The Greater Prairie Chicken is restricted in range to the more humid mixed and long grass prairies of the eastern and central Great Plains (Oberholser, 1974, loc. cit.). Because of the differences in habitat of these two species, possible differences in their helminth parasite faunas could be predicted. Consequently, the present study was initiated to determine the composition and intensity of helminth parasitism in the Lesser Prairie Chicken and to compare the helminth fauna of this host with that of its eastern counterpart, the Greater Prairie Chicken.

Seven specimens of *T. pallidicintus* were collected in Yokam Co., Texas, during the 1977 hunting season (October 15–16). An additional three birds from the same locality examined in the summers of 1976 and 1977 were provided by Dr. K. Stromberg. These were stress mortalities resulting from capturing and collaring. Attempts to collect additional hosts in December 1977 from Lea Co., New Mexico, were unsuccessful. Collected birds were frozen and later necropsied and examined for helminths. Nematodes were fixed briefly in glacial acetic acid, stored in a mixture of 70% ethyl alcohol with 5% glycerine and examined in glycerine wet mounts. Cestodes were fixed in AFA, stained with Celestine blue B, and mounted in Canada balsam. Simpson's index of diversity (Holmes and Podesta, 1968, Can. J. Zool. 46:1193–1204) was computed to indicate the concentration of dominance of the helminth faunas in this and previous studies involving the Greater Prairie Chicken. Sorenson's index of similarity (Greig-Smith, 1964, Quantative plant ecology. Butterworth & Co., London. 256 pp.) was used to compare the helminth faunas of prairie chickens from different geographic

Table 1. Helminths of the Lesser Prairie Chicken from the Texas Panhandle.

Helminth species	No. infected/ No. examined	%	Intensity	
			Range	$\bar{X}$
Oxyspirura petrowi	4/7	57	1–9	4
Heterakis isolonche	6/10	60	7–267	125
Rhabdometra odiosa	3/10	30	1–5	3

regions. These data were arranged in a trellis diagram. Representative specimens of helminth species recovered in this study are deposited in the USNM Helm. Coll. (Nos. 74690–74692).

Two nematode and one cestode species were recovered (Table 1). Eight of 10 birds examined were infected with one to three species of helminths. *Heterakis isolonche* von Linstow, 1906 (=*H. bonasae*) and *Rhabdometra odiosa* (Leidy, 1887) Jones, 1929 are reported for the first time from *T. pallidicintus*.

The taxonomy and host-parasite relationships of the eyeworm *Oxyspirura petrowi* have been reviewed by Pence (1975, Proc. Helminthol. Soc. Wash. 42:181–183). This is apparently a widespread parasite of numerous ground-dwelling and/or ground-feeding avian species in North America. It has been previously reported from the Lesser Prairie Chicken in the Oklahoma Panhandle (Addison and Anderson, 1969, loc. cit.) and the Greater Prairie Chicken in Michigan (Cram, 1937, A review of the genus *Oxyspirura* with a morphological study of *O. petrowi* Skrjabin, 1929, recently discovered in galliform birds of the northern United States. Pages 89–98 *in* Papers Helminthol. Publ. Comm. 30 yr. Jubilee K. I. Skrjabin. Moscow), Nebraska (McClure, 1941, J. Wildl. Manage. 13:394–397) and Ontario (Addison and Anderson, 1969, loc. cit.). In West Texas it occurs in the Harlequin and Scaled Quail (Pence, 1975, loc. cit.) and Ring-necked Pheasant (Pence, unpublished data). The present study indicates a relatively high incidence of infection (57%) in the Lesser Prairie Chicken from the Texas Panhandle.

Although previous studies (Leigh, 1940, loc. cit.; Morgan and Hamerstrom, 1941, loc. cit.; Harper et al., 1967, loc. cit.) indicate that the Greater Prairie Chicken is commonly infected with the cecal worm *Heterakis gallinarum* (Schrank, 1788) Madsen, 1949, specimens collected in the present study from the Lesser Prairie Chicken most closely conform to the description of a related species, *H. isolonche* (Levine, 1968, Nematode parasites of domestic animals and man. Burgess Publ. Co., Minneapolis. 600 pp.). The distinct curvature and sharp tip of the terminal end of the right spicule characteristic of *H. gallinarum* is distinctly absent in specimens recovered in this study. *Heterakis isolonche* is frequently reported from the bobwhite in the United States (Kellogg and Calpin, 1971, Avian Dis. 15:704–715). Although two of the birds in the present study had heavy infections (>200 worms), both were in good condition and apparently suffered no ill effects from these levels of infection. *Heterakis isolonche* is the most common helminth parasite of the Lesser Prairie Chicken in the Texas Panhandle.

The cestode, *Rhabdometra odiosa*, has been previously reported from the bobwhite (Kellogg and Calpin, 1971, loc. cit.) and Plain Chachalaca (Christensen

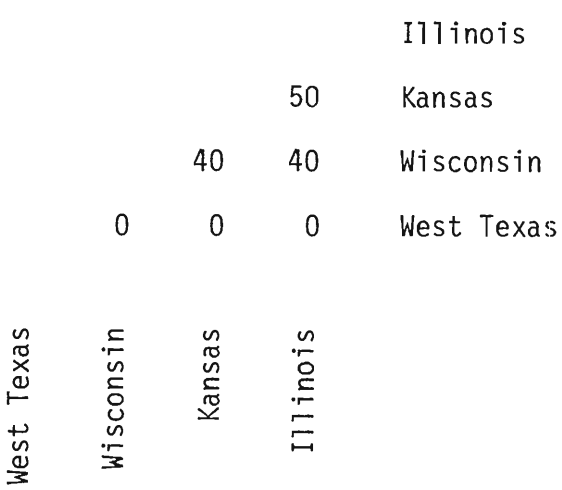

Figure 1. Trellis diagram of values for Sorenson's index of similarity for the helminth faunas of Greater and Lesser Prairie Chickens from different geographic regions in North America.

and Pence, 1977, J. Parasitol. 63:830) in Texas. A related species, *Rhabdometra nullicollis* Ransom, 1909, is reported from the Greater Prairie Chicken in Wisconsin (Morgan and Hamerstrom, 1941, loc. cit.).

Of the helminths infecting the Lesser Prairie Chicken, two of the three species, *O. petrowi* and *R. odiosa,* require arthropod intermediate hosts. These are undoubtedly transmitted during the spring and summer months when insects constitute an important part of this host's diet (Oberholser, 1974, loc. cit.). It is also of interest that all three helminths reported in this study are also important parasites of quail. Undoubtedly, the Scaled Quail and Bobwhite serve in part as a reservoir for these infections.

Simpson's index computed for the Lesser Prairie Chicken from the Texas Panhandle was 0.35 indicating a lack of dominance (in terms of frequency of occurrence) of any particular helminth species in the population. Likewise, Simpson's indices for the helminth faunas of the Greater Prairie Chicken in Illinois (Leigh, 1940, loc. cit.), Wisconsin (Morgan and Hamerstrom, 1941, loc. cit.), and Kansas (Harper et al., 1967, loc. cit.) were 0.33, 0.31, and 0.48, respectively. These low values indicate a similar equability of dispersion among the helminth species in this host.

Comparison of the helminth fauna of the Lesser Prairie Chicken from West Texas and that of the Greater Prairie Chicken in Illinois, Wisconsin, and Kansas using Sorenson's index of similarity revealed a basic dissimilarity between Greater Prairie Chicken helminth faunas in different geographic regions and between the helminth faunas of the Greater and Lesser Prairie Chickens (Fig. 1). Although at least two species, *Heterakis gallarinum* and *Cyrnea colini* (Cram, 1927) Chabaud 1959, are found in the Greater Prairie Chicken from the above three areas, the other species comprising the total helminth composition from each area are sufficiently variable to indicate a basic dissimilarity between different geographic regions.

Although our sample size is small resulting from the difficulty in obtaining host

specimens, the helminth fauna of the Lesser Prairie Chicken in the Texas Panhandle appears to consist principally of three species: *O. petrowi, H. isolonche,* and *R. odiosa.* The conspicuous absence of certain helminth species such as *H. gallinarum, Ascaridia galli* (Schrank, 1788) Travassos, 1913, *C. colini,* and *Raillietina variabilia* Leigh, 1941 in Lesser Prairie Chickens commonly encountered in the Greater Prairie Chicken probably results from the latter hosts' preference for a much more arid, sandy-soiled habitat. Such an environment undoubtedly suppresses transmission of many parasite species whose egg or larval stages require higher levels of moisture and a different soil type for development (Levine, 1968, loc. cit.). There is a basic dissimilarity in the helminth fauna of this host and its eastern counterpart, the Greater Prairie Chicken. There appears to be an equability of dispersion (lack of dominance) of helminth species in both hosts.

We wish to thank Dr. K. Stromborg and Mr. M. Rhodes for assistance in collecting some of the birds examined. Funds for this study were provided in part by the Institute for Museum Research, The Museum of Texas Tech University.

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Research Note

Some Helminth Parasites of the Common Grackle of Southern Texas

Quiscalus quiscula, Vieillot, 1819 (common grackle) ranges from southern Canada east of the Rocky Mountains, south to the Gulf of Mexico. Studies of the parasites of this host have been primarily limited to midwestern populations (Welker, 1962, Ph.D. Thesis, Ohio State Univ.—Indiana; Stanely and Rabalais, 1971, Ohio J. Sci. 71:302–303; Cooper and Crites, 1974, Proc. Helminthol. Soc. Wash. 41:233–237—Ohio). Greiner et al. (1975, Can. J. Zool. 53:1762–1768) report on the hematozoa of the grackle throughout its range. Only two endohelminths, *Conspicuum icteridorum* Denton and Byrd, 1951 (Denton and Byrd, 1951, Proc. U.S. Nat. Mus. 101(3274):157–202) and *Tanaisia bragai* dos Santos, 1934 (Byrd and Denton, 1950, Am. Midl. Nat. 43:32–57) have been reported from grackles in Texas.

Fifteen adult common grackles were live-trapped by Dr. K. A. Arnold, Department of Wildlife and Fisheries Sciences, Texas A&M University, between February 1 and April 19, 1977 in Brazos County, Texas. Six additional specimens

were collected March 7, 1978 from the same location. Birds were killed by constriction and examined immediately. Helminths were recovered by dissection of the intestine and all other internal organs, and were fixed and stained by standard techniques.

Two female specimens of *Splendofilaria* sp. (Nematoda: Filariidae) not previously reported from grackles, were removed from the right auricle of one host. Other species recovered included: *Conspicuum icteridorum* (Trematoda: Dicrocoeliidae) from the gall bladder of 17 (1–14, 5.8, 80%), one acanthocephalan, *Mediorhynchus* sp. (Gigantorhynchidea: Gigantorhynchidae) from the upper intestine of 1 (1,1, 4.7%), *Capillaria ovopunctata* (Nematoda: Trichuridae) from the intestine of 9 (1–13, 3.5, 42.8%), *Diplotriaena* sp(?) (Nematoda; Filariidae) from the body cavity of 3 (1–2, 1.6, 14.2%) and *Chandlerella quiscali* (Nematoda: Filariidae) from the brain of 12 (2–approx. 50, 57.1%).

Although Odetoyinbo (Diss. Abstr. 21:2836–2837) reported no evidence of cerebral abnormalities in birds infected with up to 61 *C. quiscali,* one heavily infected host in our sample had accumulated a large amount of cerebral fluid, separating the brain from the skull by about a millimeter. Odetoyinbo and Ulmer (1960, J. Parasitol. 46:18) placed *C. quiscali* in the genus *Splendofilaria,* while Robinson (1971, J. Parasitol. 57:772–776) and Cooper and Crites (loc. cit.) retained the designation *Chandlerella* on the basis of esophageal morphology and absence of cuticular bosses. We also feel that these differences are sufficient to retain the genus *Chandlerella* Yorke and Maplestone, 1926.

Specimens of *C. quiscali* and *C. icteridorum* have been deposited in the USNM Helm. Coll., Nos. 73953 and 73954, respectively. Specimens of *Capillaria* and *Splendofilaria,* No. 77A-23, *Diplotriaena,* No. 77A-37, and *Mediorhynchus,* No. 78A-32 have been deposited with the Texas A&M University Invertebrate Collection.

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Research Note

Lissorchis hypentelii (Trematoda: Lissorchiidae) from Red Cedar River, Wisconsin, Catostomid Fishes

Lissorchis hypentelii (Fischthal, 1942) has been reported parasitizing *Hypentelium nigricans* (LeSueur) in Michigan (Fischthal, 1942, J. Parasitol. 28:389–393) and *Moxostoma aureolum* (LeSueur) in West Virginia (Hoffman, 1967, Parasites of North American freshwater fishes. Univ. Calif. Press). This communication reports the species from *H. nigricans* and *M. macrolepidotum* (LeSueur) in Wisconsin and constitutes an additional host and distribution record.

Three species of catostomid fishes were collected from the Red Cedar River,

southern Barron County, Wisconsin, intermittently from May 1967 to August 1976 and monthly from June 1977 through May 1978. No *M. macrolepidotum* were collected in September 1977. Trematodes were fixed in cold AFA and stained in Mayer's paracarmine. One specimen (from *M. macrolepidotum*) was deposited in the USNM Helm. Coll. (No. 74727).

Nine (4%) of 223 *H. nigricans*, six (5%) of 118 *M. macrolepidotum*, and none of 203 *Catostomus commersoni* were parasitized by *L. hypentelii*. Worm burdens for *H. nigricans* and *M. macrolepidotum* were 3.6 (1–9) and 6.8 (1–12), respectively. Parasitism occurred during the summer (July through September).

Lissorchis hypentelli from Wisconsin hosts were larger than those reported by Fischthal (loc. cit.). Sixteen specimens from *H. nigricans* averaged 2.42 (2.12–2.93) mm in length by 0.49 (0.42–0.54) mm wide, whereas 19 specimens from *M. macrolepidotum* averaged 2.83 (2.28–3.46) mm in length by 0.79 (0.51–0.98) mm wide. Also, in specimens from *M. macrolepidotum*, the posterior testis, ellipsoidal in shape, was always larger than the subcircular to circular-shaped anterior testis and, in 68% of the worms, the anterior extent of the vitellaria was at the posterior margin of the acetabulum. Although these latter differences may be caused by fixation, they may also represent host induced variation.

Dr. Ronald A. Campbell, Southeastern Massachusetts University, aided in collecting fishes during September 1968 and Mr. Grant L. Williams aided in collecting fishes since 1974.

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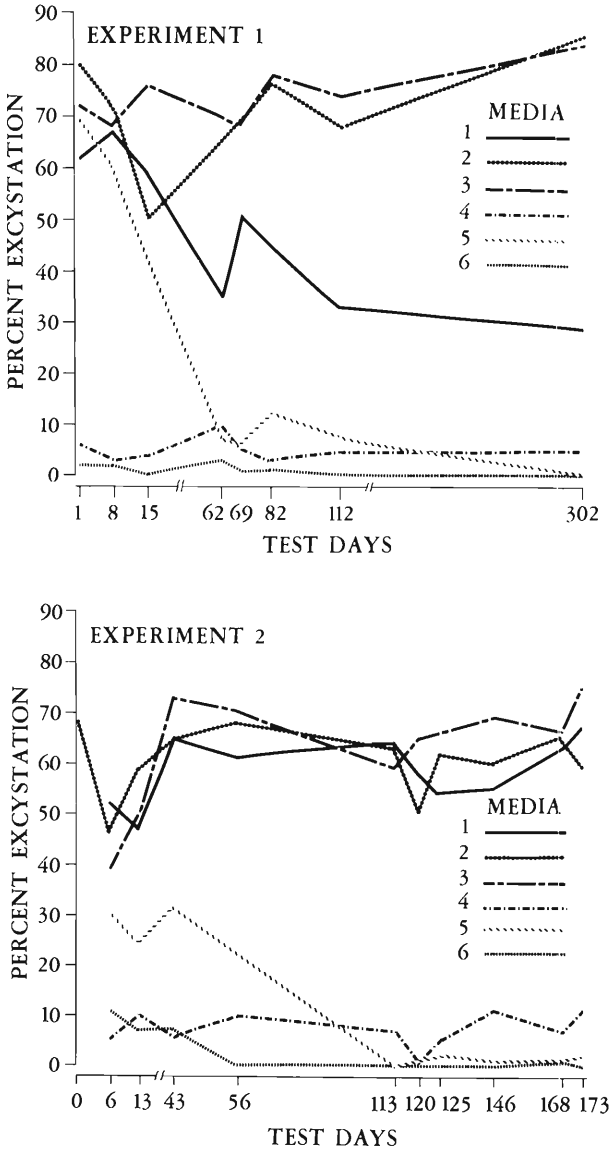
Research Note

Survival of Sporocysts of *Sarcocystis* in Various Media

Studies on *Sarcocystis* often require the use of oocysts or sporocysts that have been stored for several weeks or months after collection. Normally, when oocysts or sporocysts are collected in feces from the final host, parasites are separated from the fecal materials, and the clean parasites are stored under refrigeration in water alone or in aqueous solutions of 2.5% potassium dichromate, 1% sulfuric acid, or other solutions that retard growth of bacteria, fungi, and protozoa. That the viability of sporocysts may be affected by the medium in which they are stored was first suggested when a stock culture of *Sarcocystis cruzi* stored in 2.5% potassium dichromate was excysted in vitro (Fayer and Leek, 1973, Proc. Helminthol. Soc. Wash. 40:294–296) and yielded a much smaller number of sporozoites than was expected. This finding was reinforced when freshly obtained sporocysts received in various media from other investigators had extremely poor rates of excystation with our excystation technique. The present study was undertaken to determine which storage medium would be best for prolonged survival of sporocysts and for control of bacterial and fungal contaminants.



Figures 1 and 2. Experiments 1 and 2. Percentage of excystation of *Sarcocystis cruzi* sporocysts at various storage time intervals in: 1. Distilled H_2O at room temperature. The following under refrigeration: 2. Distilled H_2O; 3. Hanks' Balanced Salt Solution with penicillin, streptomycin, Fungizone, and Mycostatin; 4. 2% sulfuric acid; 5. 2.5% potassium dichromate; 6. 1% sodium hypochlorite.

Two experiments were begun with cleaned sporocysts collected from dogs that had been fed *S. cruzi*-infected beef. The duration of these experiments was 302 and 173 days; samples were examined for excystation on those days shown in Figures 1 and 2. At the onset of the study (day 0) sporocysts were 6 weeks old in Experiment 1, and 4 weeks old in Experiment 2, and had been stored in tap water. In each experiment, six screw-top, 50-ml centrifuge tubes, each containing 10–15 ml of sporocyst-bearing residue, were filled with test liquids. These liquids

Table 1. Sequential listing of storage media based on survival of *Sarcocystis cruzi* as indicated by excystation of sporocysts.

Medium	Medium number*	Average percent excystation	
		Experiment 1 (302 days)	Experiment 2 (173 days)
Hanks' balanced salt solution with antibiotics	3	73.8	63.2
Distilled water (refrigerated)	2	70.2	59.7
Distilled water (room temperature)	1	47.0	58.6
2.5% potassium dichromate	5	25.5	11.4
2% sulfuric acid	4	5.1	7.3
1% sodium hypochlorite	6	1.1	2.6

* As listed in text and in Figures 1 and 2.

were: (1) distilled water; (2) distilled water; (3) Hanks' Balanced Salt Solution (HBSS) pH 7.0–7.4, containing 10,000 units of penicillin/ml, 0.01 g of streptomycin/ml, 0.05 mg of Fungizone/ml, and 500 units of Mycostatin/ml (PSFM);[1] (4) 2% sulfuric acid in water; (5) 2.5% potassium dichromate in water; and (6) 1% sodium hypochlorite in water. Tube 1 was stored at room temperature (18–24°C); all others were refrigerated (7–10°C).

Sporocysts stored in each of the liquids were tested periodically for viability by in vitro excystation as follows: for each test, 2 to 5 ml of each sporocyst suspension was pipetted into a 50-ml (conical) screw-top centrifuge tube, centrifuged (225 g for 10 min in this and in all subsequent centrifugations), and the supernatant fluid decanted, leaving a pellet of approximately 0.25 ml. Each pellet was rinsed twice by suspending it in 2 ml of 0.02 M cysteine hydrochloride, centrifuging it, and decanting the supernatant fluid. The pellet was finally resuspended in 2 ml of cysteine hydrochloride. The air in each tube was displaced with a 1:1 mixture of CO_2 and air delivered at 600 ml/min for 2 min. Each tube was capped immediately and incubated at 37–39°C overnight (about 18 hr). Fresh excystation medium was prepared immediately before use as follows: 0.005 g of 4× alpha-chymotrypsin (60 units/mg) and 10 ml of bovine bile were added to 5 ml of Ringer's solution containing 0.75% taurocholic acid. The pH was adjusted to 7.4–7.8 with $NaHCO_3$. After centrifuging and decanting the cysteine hydrochloride supernatant fluid, each pellet of sporocysts was resuspended in 1.0 ml of excystation medium. This suspension was centrifuged, the supernatant fluid discarded, and the pellet resuspended in approximately 2.0 ml of excystation medium and incubated a second time at 37–39°C with gentle agitation at 30-min intervals. Beginning 3 hr later, a drop of the sporocyst suspension was placed on a microscope slide, covered with a coverslip, and examined microscopically. The first 100 sporocysts observed (or all of those on the slide) were recorded as excysted or nonexcysted. These counts were made quickly, following the same sequence of examinations and times in excystation media.

[1] Mention of a trademark or proprietary product does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture, and does not imply its approval to the exclusion of other products that may be suitable.

Sporocyst survival in various liquids for 302 and 173 days, in Experiments 1 and 2, respectively, is expressed in Figures 1 and 2 as percentage of excystation. As early as 1 and 6 days and continuing to the conclusion of both experiments, the excystation of sporocysts in 2% sulfuric acid and in 1% sodium hypochlorite was at or near 10%. The excystation rate of sporocysts stored in 2.5% potassium dichromate declined less rapidly, falling to 10% or lower at 62 days (Experiment 1) and 113 days (Experiment 2) and continuing at a low rate for the duration of testing. The excystation rate of sporocysts stored in distilled water at room temperature declined from 60–70% to 30% in Experiment 1 but remained between 47 and 67% in Experiment 2. Sporocysts stored in refrigerated distilled water and in HBSS-PSFM had excystation rates that remained between 40 and 86% in both experiments. The sequential listing of the average excystation rates for the sporocysts stored in each of the test liquids is the same for both experiments (Table 1).

The data must be interpreted in general terms because of the large within-group variations in each experiment. Although we have equated excystation rate with viability, obviously, an increase in percentage of excystation from one testing period to the next (Experiment 2, medium 3) does not mean that viability has increased; e.g., more organisms cannot be alive at 43 days than were alive at 6 days. These differences in excystation rates may reflect both the use of different bile samples in the excysting medium from one test day to another and sample variation. However, the trends are clear. Sporocysts stored in sulfuric acid, sodium hypochlorite, or potassium dichromate had low excystation rates. Sporocysts stored in distilled water at either room or refrigeration temperature and those stored in HBSS-PSFM had the highest excystation rates. Sporocysts stored in water, however, had fungal, bacterial, and protozoal growths. Thus, the best storage medium to maintain previously cleaned *Sarcocystis* sporocysts free of bacterial, fungal, and protozoal contaminants was HBSS-PSFM.

These data may also be interpreted to suggest that, unlike those eimerian or isosporan sporocysts that are protected by the oocyst wall, *Sarcocystis* sporocysts that are not surrounded by such a wall may be vulnerable to chemical disinfectants.

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Research Note

Observations on "Large" *Trichuris* eggs in man

During the period September 1975 through April 1976, 10 stool specimens of each of 10 children who had trichuriasis were examined for the presence of the eggs of *Trichuris trichiura*. These persons were inpatients at a children's clinic in Nassau, Bahamas. One of the children had, in addition to typical eggs of *T. trichiura*, larger eggs which were partially flattened throughout the length of the shell.

The patient (#202EW) was a male, age 9 years, who received a single dose of two 100-mg tablets of levamisole in a drug evaluation study. This drug is highly active against *Ascaris lumbricoides*, but not against *T. trichiura*. Two days prior to the administration of the drug, a pretherapy stool specimen was obtained, which had an egg count, by the Stoll method, of 4,400 *T. trichiura* eggs per gram feces, and 165,600 *A. lumbricoides* eggs. This pretherapy specimen contained approximately 18% large eggs, along with the typical *T. trichiura* eggs. During the 5-day follow-up study, the *Trichuris* egg counts remained at approximately the same level. The *A. lumbricoides* egg count went to zero on follow-up day 4. On follow-up day 1, the patient had an anal bolus of impacted ascarids, which were passed (5 females, 2 males), and on follow-up day 2, 6 additional worms were passed (3 females, 1 male, and 2 immature ascarids). There were three follow-up studies done in the drug evaluation test. The first one, already mentioned, was started 1 day after levamisole was given, and was continued for 5 consecutive days. Each day a stool specimen was collected, egg counts were done, and any worms that were passed were collected and preserved. The second follow-up was done 3 months later for 3 consecutive days, and the third follow-up consisting of a single stool specimen was done 6 months posttherapy. Large *Trichuris* eggs were found in all 10 pre- and posttherapy stool specimens, and constituted 2.9 to 20.0 (avg. = 12.5) percent of *Trichuris* eggs present.

The lowest level was seen at the 3-month follow-up; at 6 months posttreatment the percentage of eggs was 11.1. Unfortunately, the adult worms were not recovered from the patient who moved away from the area. The patient's first recorded parasitic infection was at the age of 15 months when he had ascariasis and amebiasis. Environmental conditions providing exposure opportunities to human and animal excrement existed prior to, and throughout the period of this study. The patient lived in a crowded area where outhouses were used, as there were no indoor sanitary facilities. There were present large numbers of stray dogs and also rats, but few cats and no pigs. Creeping eruption caused by dog and or cat hookworm larvae is frequently seen in the child population.

Plotkowiak (1970, Ann. Acad. Med. Stetinensis Roczniki Pomor. Medy. w Szczecinie 25–26:147–150) reported on observations in Poland of 140 Poles, 114 Vietnamese, and eight foreigners who passed eggs of *T. trichiura*. Five of the Vietnamese excreted, besides typical eggs, also "big" eggs (Table 1). The large eggs observed in the Bahamian child and in the five Vietnamese, are approximately the same size as those of the egg of the dog whipworm, *T. vulpis*. Hall

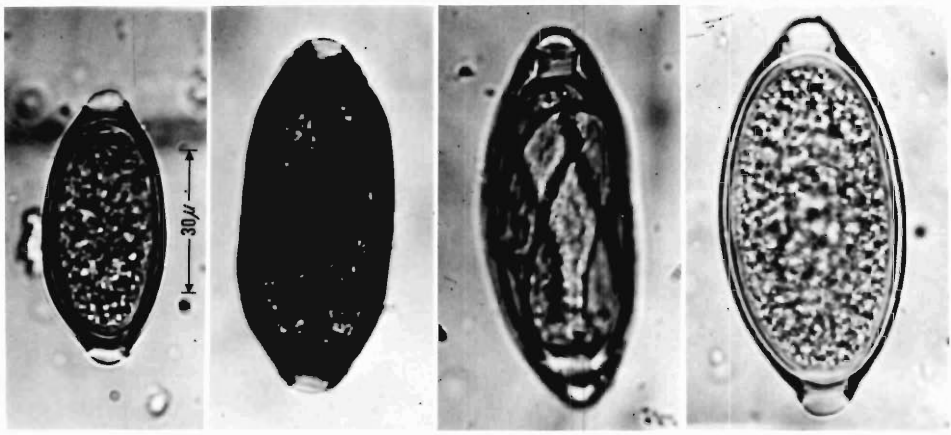

Figure 1. Left to right, typical egg of *Trichuris trichiura*; a large egg from patient of Nassau, Bahamas; large egg from same patient cultured to embryo stage to show egg viability; and the egg of *T. vulpis*. All egg stages photographed at 450× magnification.

and Sonnenberg (1956, J. Parasitol. 42:197–199) reported on an apparent case of human infection with the whipworm, *T. vulpis*, of the dog. The tentative identification was based on the size of the eggs and the character of the vulva and vagina. In Figure 1 are shown a typical egg of *T. trichiura*, a large egg (Bahamian), and another large egg from the same source which was cultured to the larval stage, and an egg of *T. vulpis*. Measurements of typical and large whipworm eggs from human feces are presented in Table 1, along with measurements of eggs of

Table 1. Measurements in micrometers (L × W) of *Trichuris* sp. representing possible human infections. Listed are typical and large eggs (Bahamas), "big" eggs of Vietnamese children (Poland), and those of various suspected hosts.

Species	Host	No. eggs counted	Egg measurements		
			Mean	Range	Mode
T. trichiura, typical (#202, Bahamas)	man	110	56.0 × 25.3	50.0–62.5 × 25.0–35.0	55.0 × 25.0
T. sp. "large" eggs (#202, Bahamas)	man	53	74.5 × 34.1	67.5–87.5 × 30.0–37.5	75.0 × 32.5
T. sp. "big" eggs (Vietnamese)	man	73	72.0 × 31.2	65.0–82.0 × 26.6–34.8	70.0 × 32.0
*T. vulpis** (Human infection)	man	103	82.0 × 38.0	75.0–90.0 × 33.0–46.0	—
T. vulpis (Literature)	dog	—	—	72.0–90.0 × 32.0–40.0	—
T. vulpis (Local)	dog	10	82.7 × 39.7	80.0–85.0 × 37.5–45.0	82.5 × 38.7
T. campanula	cat	25	63.0 × 34.0†	—	—
		—	—	72.0–81.0 × 31.0–36.0‡	—
T. suis	pig	—	—	50.0–56.0 × 21.0–25.0‡	—
T. muris	rat	—	—	57.0–62.0 × 30.0–35.0§	—

* Apparent human infection reported by Hall and Sonnenberg, 1956.
† Mean sizes of 25 eggs of *T. campanula* in cats in the Bahamas.
‡ As reported by Levine, 1968, in "Nematode Parasites of Domestic Animals and of Man."
§ As listed in Morgan and Hawkins, 1960, "Veterinary Helminthology."

Trichuris species from dogs, cats, pigs, and rats which fall within or overlap one of the two size ranges.

Clarkson and Owen (1960, J. Helminthol. 34:319–322) identified *T. campanula* from cats in the Bahamas. Twenty-five eggs were counted and their mean size was 63 μm × 34 μm. They also examined the type specimen of *T. campanula* from Brazil, described in 1889 by von Linstow. The egg measurements, probably not mean sizes, given by Linstow are 72 μm × 46 μm. The authors concluded that the whipworm seen in the Bahamian cats is *T. campanula*.

Thus, on an ecological basis, cats might be considered to be a possible source of human *Trichuris* infection in the Bahamas. It is also of interest to note that cross infections of man with *T. suis* eggs and of pigs with the eggs of *T. trichiura* was recently accomplished by Beer (1976, Res. Vet. Sci. 20:47–54).

Since *Trichuris* adults from this patient were not observed, one can only speculate on the source of the large *Trichuris* eggs. These eggs are slightly smaller on the average than eggs of *T. vulpis* and have a more flattened appearance, yet they are considerably larger than eggs of *T. trichiura, T. suis, T. muris,* and eggs of *T. campanula* from Bahamian cats. Though they most clearly resemble *T. vulpis* eggs it is also possible that they represent atypical eggs of *T. trichiura*.

I am indebted to Julie M. Wershing, M.D., who supplied the stool specimens for the study from the patients of the Hardecke Children's Clinic, Nassau, Bahamas, and clinical and epidemiological information.

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JESSE ROY CHRISTIE

(17 September 1889–21 April 1978)

The long and illustrious career of Jesse Christie was ended by death on April 21, 1978. For almost 50 years he was active as a scientist, teacher, friend, and colleague in the scientific communities of nematology, parasitology, and plant pathology. Over the years his advice and counsel were sought by students and colleagues alike, and he always gave freely of his time for this. By nature he was a quiet, gentle man but his rather frequent dry wit reflected a strong incisive mind. His research, written with unusual clarity and conciseness, knew no compromise and was always of the highest standard and quality.

He was born September 17, 1889 in New Boston, New Hampshire, attended the University of New Hampshire 1909–1913, and obtained the B.S. degree from the University of Kentucky in 1914. He then taught zoology at the University of Maryland 1915–1916, served in the U.S. Army 1917–1919, and also earned the M.S. (Parasitology) in 1918 from the University of Illinois. He then taught zoology at Fairmount College 1919–1920 and at Millikin University from 1920–1922.

In 1922 Christie joined the USDA where he remained for 31 years. Initially he was stationed in Falls Church, Virginia, and from his outstanding research on nematode parasites of insects came his classic and unparalleled studies on the biology and life cycle of mermithid parasites of grasshoppers. Some of these studies were conducted while he held a Research Table at the Marine Biological Laboratory, Woods Hole, Massachusetts. During this time, he also earned his Ph.D. (Parasitology) in 1934 from George Washington University. In the mid-1930's he was transferred to the new consolidated facilities at Beltsville, Maryland and for the next few years made outstanding contributions on plant-parasitic nematodes. Among his major accomplishments there were unraveling the biology and host relations of foliar nematodes and root-knot nematodes. During his years in the Washington, D.C. area, he was closely associated with N. A. Cobb, G. Steiner, and other colleagues, including A. L. Taylor, Edna Buhrer, and Benjamin and May Belle Chitwood.

In 1948, Christie was transferred to Sanford, Florida, to investigate a serious problem of unknown cause on vegetables and other important crops. In typical fashion he (and with his assistant, Vernon Perry) soon had an answer by revealing the pathology and pathogenicity in plants caused by the soil-inhabitating nematode, *Trichodorus christiei* Allen, 1957. With this species he discovered and established ectoparasitic nematodes to be of major economic importance on crops, thus opening a new area of research in nematology.

Christie retired from USDA in 1953 and then, with FAO, spent a year in Indonesia on plant nematode problems. In 1954 he joined the University of Florida to establish and develop a nematology program, retiring a second time in 1960 and accepting Emeritus Professor status.

Included in his more than 100 publications is a classic book, "Plant Nematodes—Their Bionomics and Control," published in 1959 and translated into Spanish in 1970. Many students of today know Christie by this book.

Many honors and awards were given Jesse Christie in recognition and appreciation for his outstanding service as scientist and teacher. He became a member

Christie in his laboratory in Florida in the 1950's

of the Helminthological Society of Washington in 1922; was elected Recording Secretary in 1926–1927 and again in 1929–1930, President in 1930–1931, first Editor of its Proceedings 1934–1947, and Life Member in 1956. He was a Charter Member of the American Society of Parasitologists and was elected a Fellow in the American Phytopathological Society in 1972. He was elected to Honorary Membership in the Society of Nematologists in 1968, in the Florida Nematology Forum in 1970, and in the Soil and Crop Science Society of Florida in 1974. The Florida Fruit and Vegetable Association's Research Award was given him in 1957 and the Gamma Sigma Delta Senior Faculty Award in 1961.

After retirement Christie lived alternately, with the seasons, in Florida and Nova Scotia, and for several years on his north–south trips always visited in Beltsville. For those who had the privilege of knowing him personally, Jesse Christie's sterling character and delightful personality will be a treasured memory; and for everyone, his scientific contributions will serve as an inspiring monument to strive for the standards of excellence so common in our departed friend and colleague.

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KONSTANTIN IVANOVICH SKRJABIN

(7 December 1878–17 October 1972)

In this centennial year of the birth of Academician K. I. Skrjabin, The Helminthological Society of Washington joins with innumerable parasitological and other scientific societies throughout the world in celebrating the life and work of one who must truly be called the founder and father of helminthology in the Soviet Union.

Inasmuch as members of our Society recognized many years ago the enormous impact of the work of this man on the development of world parasitological knowledge and thought by fostering his election as Honorary Member of the American Society of Parasitologists in 1932, and also largely because of the surprising fact that Academician Skrjabin was apparently never a member of any category in the Helminthological Society, it is somehow especially fitting that this Society now pay special tribute to this man. This is especially indicated because Skrjabin was, from the beginning, recognized as a great leader by nearly all those who have been identified with "Helm Soc," probably the oldest parasitological society in the world!

So far as I know, what I have said thus far is true, yet it is based on a limited review of the record (and "commonplace" data with respect to the early history and proceedings of the Helminthological Society, are at best somewhat casual) and imperfect personal recollections. Among the latter, three points with reference to Skrjabin, none published, seem worthy of mention: (1) In a *quasi*-seminar course that I was privileged to attend in 1932–1934, a small group of some 11 graduate students at the Johns Hopkins University elected after many months, simply as an exercise, to vote on the 10 outstanding parasitologists of the world and the 15 "runners up"; Skrjabin was one of four or five who were named on the first list of every student, (2) I remember well a statement by Dr. W. W. Cort to his students (1930–1934) to the effect that the Russians knew much more parasitologically about their vast country than we did about ours. He was thinking, I am sure, of the many scientific, mainly helminthological, expeditions that Skrjabin led, organized, or approved, and of his particular interest in relations of climate to parasitism. I think, in retrospect, that Cort's own enthusiasm for expeditions may have had some origins in his exceptional familiarity with, and interest in, those of Skrjabin, and (3) as early as 1930, which may or should be the year when I joined the Helminthological Society, the researches of Skrjabin were regularly and prominently mentioned, always, so it seemed, with special regard, almost reverence, for this prodigious producer of parasitological and other scientific information.

I never met Professor Skrjabin although I often felt close to him, especially when I was associated with Dr. Cort. I can add little if anything to the numerous articles that have been written.

Skrjabin began publishing in 1908 at the age of 30 and authored more than 700 articles during the next 60 years. This number includes 62 comprehensive monographs—26 on trematodes, 8 on cestodes, and 28 on nematodes. He and his colleagues and students conducted more than 300 expeditions to gather data on

parasites of man, animals, and plants in all parts of the Union. He founded the All-Union Helminthological Society and was its permanent president. He stimulated the foundation of the international journal *Helminthologia* in 1959 and was its Editor for more than 10 years.

Honors, awards, and recognitions happily came to Skrjabin during his lifetime. At least a dozen foreign countries bestowed high honors or titles.

Many biographical articles have been written about Skrjabin and several are being published in honor of his centenary. It is to be hoped that parasitologists who see these articles will derive solid inspiration from a fuller understanding and appreciation of the life and work of this remarkable man.

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PRESENTATION

1978 Anniversary Award of the Helminthological Society of Washington
517th Meeting, 19 October 1978
Dr. Kenneth Casper Kates

Mr. President, Honored Guests, and Members of the Helminthological Society of Washington:

Dr. K. C. Kates, whom we honor at this meeting with the Anniversary Award of the Helminthological Society of Washington, has had a long and full career in research which has contributed significantly to the field of parasitology.

Dr. Kates was born at Millville, New Jersey, April 29, 1910, where he attended public schools. He received his A.B. degree in 1932 from Columbia University, St. Stephen's-Bard College, majoring in Zoology and minoring in Chemistry; his M.A. in 1934 and Ph.D. in 1937 from Duke University with a major in Cytology and a minor in Physiology. His awards and honors include: Biology Prize, St. Stephen's-Bard College, Columbia University, 1932; Graduate Assistant, Zoology, Duke University, 1932–1934; University Fellow, Zoology, Duke University, 1934–1935; member of Sigma Xi, 1934; Fellow, AAAS, 1949; and member Washington Academy of Sciences, 1951. His career spans 37 years of federal service: 28 years as a Zoologist/Parasitologist with research organizations in the U.S. Department of Agriculture, 3 years with the Army in World War II as a Medical Parasitologist and Hospital Laboratory Officer, and 6 years with the Food and Drug Administration as Veterinary Parasitologist. He has gained national and international recognition in Veterinary Parasitology.

Dr. Kates has about 80 scientific publications, and has numerous presentations at scientific meetings to his credit. He has written many confidential opinions on new and supplemental antiparasitic drug applications, and upon request has prepared numerous reviews of technical books. In 1942 he served as Secretary to this Society, as its Vice-President in 1943, and as its President in 1947. He now serves on the Editorial Board of the Proceedings, and since 1956 he has been a Trustee of the Ransom Memorial Trust Fund. From 1949–1953 he was a Council Member, American Association for the Advancement of Science; 1961–1971 a member of the Editorial Board, Journal of Parasitology; 1962, Chairman, Awards Committee, Helminthological Society of Washington; 1962–1966 Chairman, Translations Committee, American Society of Parasitologists; 1966, Chairman, Tellers Committee; 1966–1975 Translation Committee; 1968–1970, Associate Chairman, General Program Committee, Second International Congress of Parasitology, Washington, D.C.; and 1972–1975, Editorial Consultant, Journal of Parasitology. Over the years he has written many manuscript reviews for the Journal of Parasitology, Proceedings of The Helminthological Society and other technical journals, and served on a number of Ph.D. candidate committees.

Dr. Kates' major endeavors were investigations with sheep and swine parasites and in anthelmintic treatment of animal parasites. A few of his many accomplish-

The Anniversary Award is presented to Dr. Kenneth C. Kates by Merle L. Colglazier

ments include: studies of the life cycle and biology of the swine thorny-headed worm, *Macracanthorhynchus hirudinaceus*; the discovery of several new oribatid mite vectors of the broad tapeworm of ruminants, *Moniezia expansa*, and a report on the only work on experimental infections in sheep with this parasite; the characterization and description of the interrelationships between climatic conditions and the epizootiology of helminth parasites in sheep—which are generally applicable to other ruminant parasitisms and very important in management practices. Furthermore, he demonstrated the life history and pathogenicity of the intestinal nematode parasite of sheep, *Nematodirus spathiger*, and documented for the first time the importance of immature stages of this parasite in causing damage to the intestinal lining—an important contribution toward determining those species of nematodes truly harmful to ruminants.

He demonstrated that the Mongolian gerbil–*Trichostrongylus* spp. host-parasite system could be used effectively as a primary screen for candidate anthelmintic chemicals. He contributed to the identification and experimental characterization of two naturally occurring isolates of *Haemonchus contortus* of sheep and other ruminants which are resistant to some benzimidazole anthelmintics; he also was involved in the first experimental development, in the laboratory, of an anthelmintic-resistant strain of *H. contortus* from a drug-sensitive strain, and the demonstration that this cambendazole-resistant strain was cross-resistant to other chemically related anthelmintics. These results are important to the continuing evaluation of modern anthelmintics for livestock and emphasize the need for

constant vigilance to avoid breakdown in therapeutic control of helmintic diseases resulting from drug-resistant strains of parasites. He has also contributed substantially to the evaluation of numerous old and new anthelmintics in domestic animals including studies with turkeys and equids and many other studies too numerous to mention here.

Dr. Kates is always the teacher: from 1935–1938 he was head of the Biology Department, Dickinson Junior College, Williamsport, Pennsylvania. Since 1946 he has been Lecturer and Professorial Lecturer in Zoology (Parasitology), George Washington University, Washington, D.C. and in 1951, 1960, and 1963 was Lecturer in Zoology, University of Maryland, College Park. These and other significant assignments were readily accepted by Dr. Kates during his career.

My personal association with Dr. Kates has covered more than 30 years and I would like to add an expression of my high regard for the man and for his scientific acumen, his unselfish willingness to assist others, his forthrightness, and his unrelenting pursuit of excellence. To me he is a man without peer.

It is my great honor to present to this gentlest of men, Dr. Kates—Leader, Colleague, Scientist, Critic, Teacher, Advisor, and Friend—this Anniversary Award from the members of the Helminthological Society of Washington "In recognition of distinguished contributions and services toward achievement of Society's aims and objectives." (Awards Committee: Richard L. Beaudoin, Sherman S. Hendrix, and Louis S. Diamond.) Dr. Kates retired from the USDA in July 1975 and has recently changed his residence; his new address is 2601 Imperial Court, Dunkirk, Maryland 20754.—MERLE L. COLGLAZIER

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