Volume 43 January 1976 Number 1

PROCEEDINGS

of

The Helminthological Society of Washington

A semiannual journal of research devoted to Helminthology and all branches of Parasitology

Supported in part by the
Brayton H. Ransom Memorial Trust Fund

Subscription $15.00 a Volume; Foreign, $15.50

CONTENTS

(Continued on Back Cover)

THE HELMINTHOLOGICAL SOCIETY OF WASHINGTON

THE SOCIETY meets once a month from October through May for the presentation and discussion of papers in any and all branches of parasitology or related sciences. All interested persons are invited to attend.

Persons interested in membership in the Helminthological Society of Washington may obtain application blanks from the Corresponding Secretary-Treasurer, Dr. William R. Nickle, Nematology Laboratory, Plant Protection Institute, ARS-USDA, Beltsville, Maryland 20705. A year's subscription to the Proceedings is included in the annual dues ($8.00).

OFFICERS OF THE SOCIETY FOR 1976

President: A. MORGAN GOLDEN
Vice President: KENDALL G. POWERS
Corresponding Secretary-Treasurer: WILLIAM R. NICKLE
Assistant Corresponding Secretary-Treasurer: HARLEY G. SHEFFIELD
Recording Secretary: J. RALPH LICHTENFELS
Librarian: JUDITH M. SHAW (1962–)
Archivist: JUDITH M. SHAW (1970–)
Representative to the Washington Academy of Sciences: ROBERT S. ISENSTEIN (1976–)
Representative to the American Society of Parasitologists: HARRY HERLICH (1975–)
Executive Committee Members-at-Large: JAMES C. BURKE, 1977
RONALD FAYER, 1977
MILFORD LUNDE, 1976
EDGAR A. STECK, 1976

THE PROCEEDINGS OF THE HELMINTHOLOGICAL SOCIETY OF WASHINGTON

THE PROCEEDINGS are published semiannually at Lawrence, Kansas by the Helminthological Society of Washington. Papers need not be presented at a meeting to be published in the Proceedings. However, non-members may publish in the Proceedings only if they contribute the full cost of publication. Members will be requested to pay a standard charge of $10.00 per page.

MANUSCRIPTS should be sent to the EDITOR, A. James Haley, Department of Zoology, University of Maryland, College Park, Maryland 20742. Manuscripts must be typewritten, double spaced, and in finished form. The original and two copies are required. Photocopies of figures and drawings may be submitted for review purposes; originals will be requested after acceptance of the manuscript. Papers are accepted with the understanding that they will be published only in the Proceedings.

REPRINTS may be ordered from the PRINTER at the same time the corrected proof is returned to the EDITOR.

BACK VOLUMES of the Proceedings are available. Inquiries concerning back volumes and current subscriptions should be directed to: Helminthological Society of Washington, c/o Allen Press, Inc., 1041 New Hampshire St., Lawrence, Kansas 66044, U.S.A.

BUSINESS OFFICE. The Society's business office is at Lawrence, Kansas. All inquiries concerning subscriptions or back issues and all payments for dues, subscriptions, and back issues should be addressed to: Helminthological Society of Washington, c/o Allen Press, Inc., 1041 New Hampshire St., Lawrence, Kansas 66044, U.S.A.

EDITORIAL BOARD

A. JAMES HALEY, Editor

1976	1977	1978
WILBUR L. BULLOCK	MURRAY D. DAILEY	NEWTON KINGSTON
JACOB H. FISCHTHAL	JOHN E. HALL	RALPH J. LICHTENFELS
WILLIAM R. NICKLE	BETTY JUNE MYERS	JOHN S. MACKIEWICZ
GILBERT F. OTTO	STEWART C. SCHELL	ROBIN M. OVERSTREET
EVERETT L. SCHILLER	GENE B. SOLOMON	GERALD D. SCHMIDT

PROCEEDINGS OF THE
HELMINTHOLOGICAL SOCIETY OF WASHINGTON

VOLUME 43 JANUARY 1976 NUMBER 1

Three New Lissorchiid Cercariaea of the Mutabile Group from *Laevapex fuscus* (Adams, 1841) and *Ferrissia rivularis* (Say, 1917)[1]

BRYAN L. DUNCAN[2] AND DOMINIC L. DEGIUSTI[3]

ABSTRACT: Three new lissorchiid cercariaea are described from southeastern Michigan. They are placed in the provisional genus *Cercariaeum* Luhe, 1919, Mutabile group as defined by Sewell (1922). Until the adult trematode for each is known, these cercariaea are designated *Cercariaeum* types I, II, and III. *Cercariaeum* types I and II utilize the ancylid snail *Laevapex fuscus* (Adams, 1841) and *Cercariaeum* type III utilizes the ancylid *Ferrissia rivularis* (Say, 1917) as the first intermediate host. *Cercariaeum* type I utilizes *Chaetogaster limnaei* as its second intermediate host. *Cercariaeum* types II and III utilize *C. limnaei*, *Dugesia tigrina*, and *D. dorotocephala* as second intermediate hosts. The cercariaea differ in distribution and arrangement of tegumental spines and papillae, body dimensions, intermediate host utilization, mode of infection of second intermediate hosts, and ability to penetrate and encyst within *D. dorotocephala*. Rediae in which they develop differ in size, ratio of gut to body dimensions, and number of embryos.

Cort (1918) described *Cercariaeum mutabile* from *Helisoma campanulatum smithii* Baker from Douglas Lake, Michigan. Sewell (1922) established and defined the Mutabile group based upon *C. mutabile*, with the primary feature being development in rediae. Wallace (1939, 1941) claimed to have found *C. mutabile* in *Helisoma trivolvis*, and metacercariae in *Planaria* sp. and *Chaetogaster limnaei*, a commensal on *H. trivolvis*. He experimentally obtained adults in the intestine of the lake chubsucker, *Erimyzon sucetta kennerlii* Girard, which is also a natural host. He named the adult *Triganodistomum mutabile*. Smith (1967, 1968) claimed to have found *C. mutabile* in *Ferrissia rivularis*, *Laevapex fuscus*, and *Helisoma trivolvis*, and to have confirmed his observation by experimental studies.

The present study describes three new mutabilous, lissorchiid cercariaea from the ancylid snails *Laevapex fuscus* and *Ferrissia rivularis*, bringing to four the number of these cercariaea described.

Materials and Methods

Ferrissia rivularis (Say, 1917) (Gastropoda: Pulmonata: Ancylidae) was collected from rocks in rapids of tributary streams of Looking Glass River, Ingham Co., Michigan. *Laevapex fuscus* (Adams, 1841) (Gastropoda: Pulmonata: Ancylidae) was collected from stems of emergent rooted aquatic plants, *Peltandra virginica* (L.) Kunth and *Saururus cernuus* L., in the littoral fringes of Looking Glass River. Both snails were also collected from bottom debris. Snails were brought into the laboratory, individually isolated and observed for the emergence of cercariaea, or dissected and examined for parasite stages. Infected snails were also sectioned.

Newly emerged cercariaea were placed in an aqueous menthol solution until immobilized and fully extended, then fixed with 10% neutral formalin at 80 C. Twenty of these cercariaea were placed on a slide under a floating cover slip to prevent distortion and

[1] Contribution from the Department of Biology, Wayne State University, Detroit, Michigan 48201.
[2] Present address: Department of Fisheries & Allied Aquaculture, Auburn University, Auburn, Alabama 36830.
[3] Department of Biology and Department of Comparative Medicine, Wayne State University, Detroit, Michigan 48201.

measured with an ocular micrometer. Twenty rediae containing mature cercariaea were fixed in 10% formalin at 80 C, without prior relaxation, for measurement. Coverslip pressure was prevented by mounting rediae within a vaseline ring. All measurements are expressed in micrometers.

Cercariaea were studied extensively in the living condition, using both phase contrast and bright field microscopy because certain morphological features were not easily observed in killed, fixed specimens. Due to the thickness and curvature of the body, the excretory system and tegumental spines were best observed by flattening living cercariaea under cover slips. Neutral red and nile blue sulphate stains were used for observation of the internal structure of living cercariaea. Papillae were studied on formalin-fixed, unstained material.

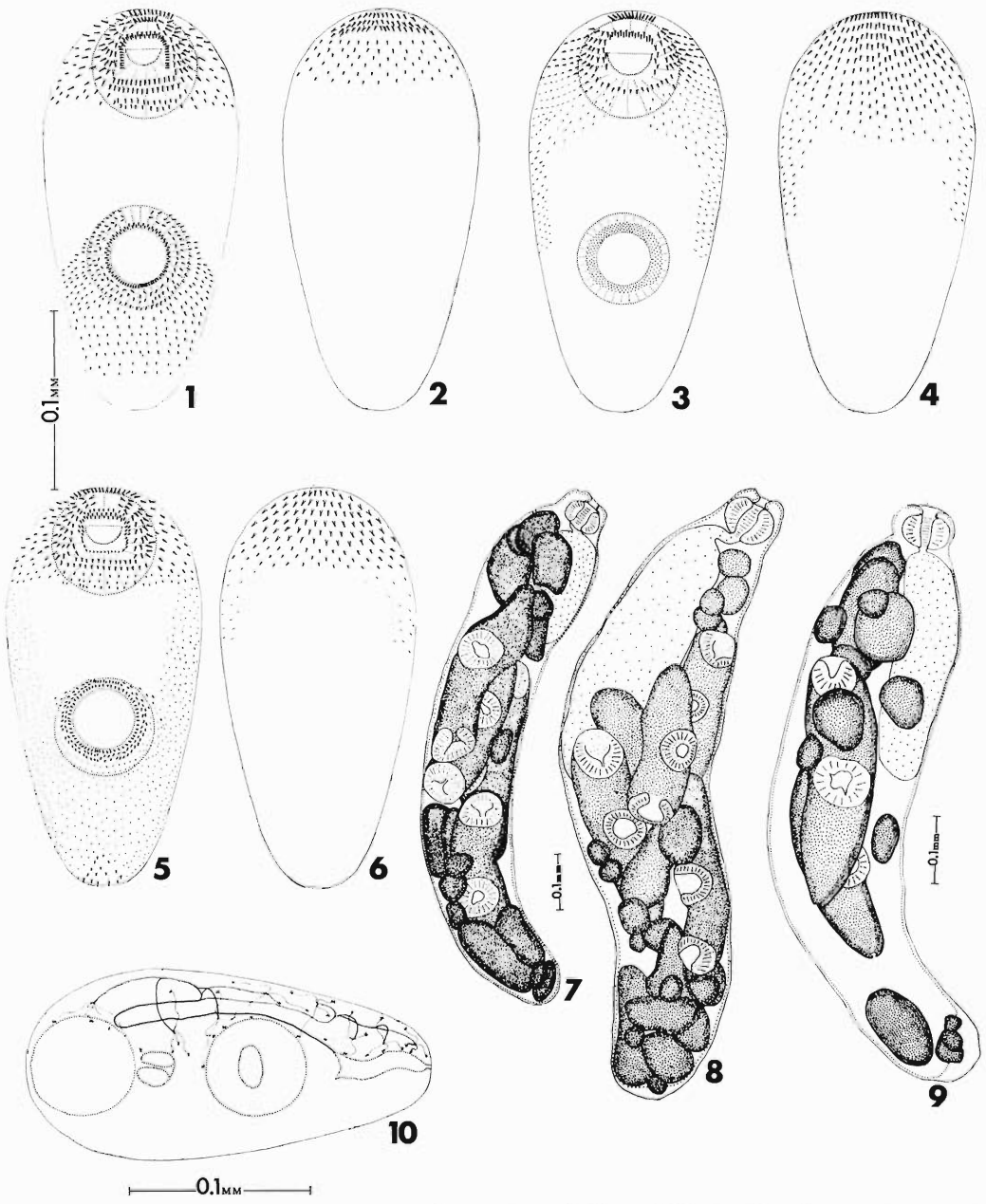
Living rediae were dissected from infected snails in 0.2% saline solution and mounted within a vaseline ring under a cover slip for observation. Rediae containing mature cercariaea were sectioned and stained with hematoxylin, eosin, and mucicarmine to facilitate study of the glands and reproductive system.

Laboratory-raised *Dugesia dorotocephala* was used for most experimental infections because it is easily cultured in the laboratory and can be easily manipulated. *D. tigrina*, collected from natural sources, was used for some experimental infections, but was not always available when needed. This species was difficult to maintain in the laboratory, and when manipulated exuded copious amounts of mucous, thereby interfering with the experimental procedure. Metacercariae are visible as round, refractile spheres in the parenchyma of *Dugesia* spp. when they are compressed on a slide beneath a cover slip and viewed with a dissecting microscope.

Cercariaeum type I (Figs. 1, 2, 10, 11, 15)

Description

DIMENSIONS: Body length 268–368 (303), width 60–83 (73); pharynx length 19–25 (21), width 22–25 (25); oral sucker length 51–60 (55), width 54–64 (58); acetabulum length 54–64 (60), width 57–71 (62). Tegumental spines: Inner part of oral sucker rim with series of spines surrounding mouth opening and divided into two alternating rows in anterior quadrant, and a single row in each lateral quadrant, with all spines radially oriented and points directed inward; eight rows of obliquely directed spines in lateral quadrants of outer part of oral sucker rim extending into anterior quadrant; four transverse rows of posteriorly directed spines on posterior quadrant of outer part of oral sucker rim; two transverse rows of large spines with anteriorly directed points on outer part of anterior quadrant of oral sucker rim; two alternating rows of spines with inwardly directed points in anterior and lateral quadrants of inner part of acetabular rim with a single row in posterior quadrant; three rows of spines on outer part of acetabular rim; ventral tegument in area of oral sucker with 10 rows of obliquely directed spines which decrease in size as they approach lateral margins of body and terminate level with posterior margin of oral sucker, appearing continuous with spines of lateral quadrants of outer part of oral sucker rim; spination of posterior ventral tegument begins posterior to anterior one-third of acetabulum and radiates laterally and posteriorly from acetabulum, appearing continuous with acetabular spination and terminating two-thirds of distance beyond acetabulum; three transverse rows of oblique, large spines and six rows of small, backward-pointing spines on anterior one-fifth of dorsal tegument. Tegumental papillae: Four symmetrically arranged groups of papillae with three to four papillae per group on posterior hemisphere of oral sucker rim; nine small, or slightly elevated, setaceous papillae present around posterior margin of mouth openings; one pair small setaceous papillae on anterior margin of mouth opening and a second pair on lining in midregion of buccal cavity; three large papillae on acetabular rim and nine large setaceous papillae on wall of acetabular cavity; seven to eight large setaceous papillae, 6 μm in height, on each of extreme lateral margins; four setae that appear to rise directly from tegument and three small setaceous papillae at extreme anterior margin of body; 15 large setaceous papillae, 12 of which are symmetrically arranged in lateral regions between oral sucker and acetabulum; a folding of the body appears just



Figures 1–6. Tegumental spines of *Cercariaeum* types I, II, and III. 1. Type I, ventral aspect. 2. Type I, dorsal aspect. 3. Type II, ventral aspect. 4. Type II, dorsal aspect. 5. Type III, ventral aspect. 6. Type III, dorsal aspect. 7. Type I, redia. 8. Type III, redia. 9. Type II, redia. 10. Type I, excretory system.

anterior to acetabulum on relaxed, fixed cercariaea, and four large setaceous papillae appear in side view on tegument of folded region; seven small papillae on midventral region of body between oral sucker and acetabulum with one papilla on lateral margin of body, level with center of oral sucker; three large, lateral setaceous papillae on ventrum posterior to acetabulum; 16 large setaceous papillae, 12 of which are symmetrically arranged and 11 small papillae, eight of which are symmetrically arranged on lateral regions of dorsal tegument on anterior one-half of body; two large setaceous papillae and two small papillae near midline of posterior one-half of dorsal tegument. Twenty-three penetration gland duct openings present in two rows on anterior quadrant of oral sucker rim. Excretory system: Excretory bladder cylindrical in shape with thick muscular walls, located posterior to acetabulum, extending anteriorly from excretory pore, occupying central portion of posterior one-fifth of body; two primary collecting tubules arise from anterolateral margins of bladder and extend anteriorly to posterolateral margin of oral sucker where they double back to region level with anterior margin of acetabulum, and bifurcate forming two secondary collecting tubules; one of these tubules extends anteriorly, branching into four tertiary collecting tubules distributed to the anterior one-half of the body; the other secondary collecting tubule extends posteriorly and branches into four tertiary collecting tubules distributed to the posterior one-half of the body; each tertiary collecting tubule branches into four capillaries and each capillary terminates in a flame cell. Thus, eight groups of four flame cells each are distributed to each lateral side of the cercariaeum; the flame cell pattern formula is $2[(4 + 4 + 4 + 4) + (4 + 4 + 4 + 4)] = 64$ flame cells. Digestive system: Ventrally subterminal mouth surrounded by oral sucker, followed by buccal cavity, prepharynx, muscular pharynx, and esophagus which bifurcates at level of anterior border of acetabulum into two thin-walled crura that terminate two-thirds of distance beyond acetabulum. Reproductive system: Testes lie in tandem posterior to genital primordium and ventral to excretory bladder, and a row of elongated cells with spindle-shaped nuclei connects each testis to the genital primordium; a row of cells extends obliquely from genital primordium to near lateral margin of body where gonopore of adult worm is located; female organs and associated structures not clearly differentiated from genital primordium, though posteriorly directed dorsal and ventral extensions of genital primordium probably represent primordium of uterus. Penetration gland cells: Arranged in two groups, each containing six to 10 tightly adhering cells located dorsal to and on either side of the pharynx; each gland cell contains acidophilic, mucicarmine-positive, granular substance; two bundles of ducts extend anteriorly from each group and pass dorsally to oral sucker where they open to outside on outer part of anterior quadrant of oral sucker rim. Subtegumental gland cells: Large cells with large nuclei and basophilic, mucicarmine-positive cytoplasmic granules, located in parenchyma surrounding excretory bladder; small cells, deeply basophilic with no discernible granules, scattered beneath tegument, especially numerous at level of acetabulum. Redia (Fig. 7): Sausage-shaped, active, lacking locomotor processes. Dimensions: Body length 308–535 (428), width 101–158 (131); gut length 86–206 (145); ratio of body to gut length 1:3.4–1:7.8 (1:5.4); ratio of body to gut width 1:1.5–1:2.1 (1:1.7); pharynx width 35–41 (38); number of embryos and cercariaea 6–15 (11).

HOST: *Laevapex fuscus* (Adams, 1841).

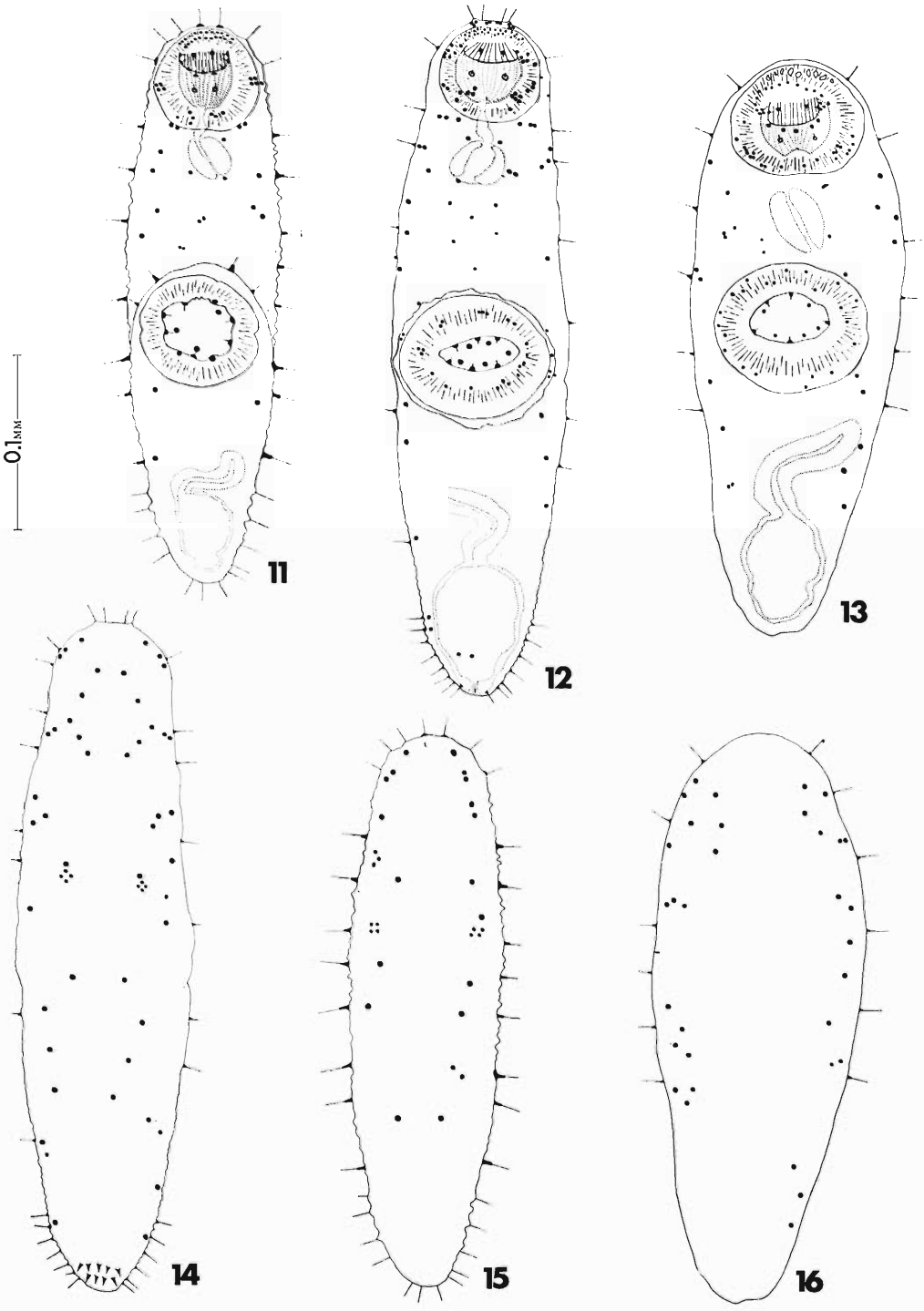
HABITAT AND LOCALITY: Looking Glass River, Ingham Co., Michigan.

HOLOTYPES: United States National Museum Helm. Coll. No. 73948.

PARATYPES: Authors' collection.

→

Figures 11–16. Tegumental papillae of *Cercariaeum* types I, II, and III. 11. Type I, ventral aspect. 12. Type II, ventral aspect. 13. Type III, ventral aspect. 14. Type II, dorsal aspect. 15. Type I, dorsal aspect. 16. Type III, dorsal aspect.



Cercariaeum type II (Figs. 3, 4, 12, 14)

Description

DIMENSIONS: Body length 308–328 (317), width 76–89 (81); pharynx length 19–25 (22), width 22–25 (24); oral sucker length 44–51 (48), width 51–56 (53); acetabulum length 56–82 (63), width 57–67 (62). Tegumental spines: Series of backward-directed spines on inner part of oral sucker rim surrounding mouth and divided into two alternating rows in anterior quadrant and one row in lateral quadrants; five oblique rows of spines on lateral quadrants outer part of oral sucker rim and one transverse row on posterior quadrant; five alternating rows of minute, radially oriented spines in anterior and lateral quadrants of inner part of acetabular rim with three alternating rows in posterior quadrant. Fifteen to 17 oblique rows of spines on ventral tegument in area of oral sucker, which radiate laterally and posteriorly terminating halfway between oral sucker and acetabulum; continuous with these and terminating level with middle of acetabulum are three longitudinal rows of minute oblique spines confined to lateral regions of body; a single row of spines is present on anterior margin of ventral tegument; dorsal tegument has 21 longitudinal rows of spines radiating posteriorly from anterior margin of body and extending over anterior one-third of body; continuous with these are three longitudinal rows of oblique spines limited to lateral regions of body and extending to middle of body. Tegumental papillae: Four symmetrically arranged groups with six to nine small papillae per group on oral sucker rim; buccal cavity with two pairs small setaceous papillae on lining; 21 small papillae scattered around central part of acetabular rim; 11 large setaceous papillae on wall of acetabular cavity; five small papillae on tegumental fold surrounding base of acetabulum; 13 to 15 large setaceous papillae 3 μm in height on each of extreme lateral margins of body; four setae appear to arise directly from tegument at extreme anterior tip of body; 15 marginally located setaceous papillae, intermediate in size between large and small papillae, at extreme posterior end; 20 large setaceous papillae in lateral and midventral regions of ventral tegument in anterior one-half of body, with 10 at anterior tip of body, seven in midventral region between oral sucker and acetabulum, and two near anterolateral margins of acetabulum; 10 large setaceous papillae on ventral tegument in posterior one-half of body, with two in midventral region and eight in lateral margins; dorsal tegument on anterior one-half of body has 31 large setaceous papillae, of which 30 are symmetrically arranged, and nine small papillae, eight of which are symmetrically arranged; dorsal tegument on posterior one-half of body has 22 large setaceous papillae arranged in lateral and midventral regions, and in two transverse rows of five and four papillae at posterior tip of body and two small papillae in lateral regions. On anterior quadrant of oral sucker rim are two rows of penetration gland duct openings with 12 openings in each row. Excretory system: Arrangement of tubules and distribution of flame cells similar to *Cercariaeum* type I with flame cell formula $2[(4 + 4 + 4 + 4)] + [(4 + 4 + 4 + 4)] =$ 64 flame cells. Digestive system, reproductive system, and arrangement, morphology, and number of glands similar to *Cercariaeum* type I. Redia (Fig. 9): Sausage-shaped, active, lacking locomotor processes. Dimensions: Body length 282–805 (517), width 95–139 (114); gut length 127–335 (259); ratio of body to gut length 1:1.9–1:4 (1:2.8); ratio of body to gut width 1:1.8–1:3.7 (1:2.7); pharynx width 38–51 (42); number of embryos and cercariaea 14–42 (27).

HOST: *Laevapex fuscus* (Adams, 1841).

HABITAT AND LOCALITY: Looking Glass River, Ingham Co., Michigan.

HOLOTYPES: United States National Museum Helm. Coll. No. 73949.

PARATYPES: Authors' collection.

Cercariaeum type III (Figs. 5, 6, 13, 16)

Description

DIMENSIONS: Body length 295–322 (312), width 86–101 (94); pharynx length 25–32 (30), width 25–32 (29); oral sucker length 57–63 (60), width 60–67 (65); acetabulum length 63–73 (68), width 63–73 (68). Tegumental spines: Series of spines surrounding mouth opening divided into three alternating rows in anterior quadrant, two alternating rows in anterior one-half of lateral quadrants which

are reduced to a single row in posterior one-half of lateral quadrants and a single row of minute spines in posterior quadrant; nine oblique rows of large spines in lateral quadrants of outer part of oral sucker rim extending just into anterior quadrant; five transverse rows of spines in posterior quadrant of outer part of oral sucker rim; single transverse row of spines on outer part of anterior quadrant of oral sucker rim; three rows of large spines on acetabular rim in lateral and posterior quadrants, with two rows in anterior quadrants; scattered small spines present on outer part of acetabular rim in lateral quadrants, and arranged in two rows in posterior quadrant; 10 rows oblique spines on ventral tegument in region of oral sucker; four to five longitudinal rows present in lateral regions of body terminate level with anterior one-fifth of acetabulum; ventral tegumental spination in area of acetabulum begins level to anterior one-fifth of acetabulum and radiates laterally and posteriorly to lateral margins of body; a triangular-shaped group of large spines is located near posterior tip of body; nine transverse rows of spines on anterior one-fifth of dorsum; two rows minute spines in lateral regions which terminate two-fifths of distance from anterior end of body. Tegumental papillae: 22 small papillae scattered on posterior hemisphere of oral sucker rim; semicircular row of 11 small papillae terminating at each end in a group of four small papillae, on anterior hemisphere of oral sucker rim; semicircular row of five small setaceous papillae near posterior margin of mouth; three pairs of symmetrically arranged, small setaceous papillae on lining of buccal cavity; 22 small papillae scattered on acetabular rim; 10 large setaceous papillae on wall of acetabular cavity; eight large setaceous papillae and seven small papillae in midventral and ventrolateral regions of tegument between oral sucker and acetabulum; seven large setaceous papillae and two small papillae present in ventrolateral regions of tegument of posterior one-half of body; 20 large setaceous papillae on lateral regions of anterior one-half of dorsal tegument; 13 large setaceous papillae present on posterior one-half of dorsum; nine penetration gland duct openings on anterior quadrant of oral sucker rim. Arrangement of excretory tubules and distribution of flame cells similar to *Cercariaeum* types I and II with flame cell formula $2[(4 + 4 + 4 + 4) + (4 + 4 + 4 + 4)] = 64$ flame cells. Digestive system, reproductive system, and arrangement, morphology, and number of glands similar to that of *Cercariaeum* types I and II. Redia (Fig. 8): Sausage-shaped, active, lacking locomotor processes. Dimensions: Body length 496–1,058 (817), width 201–348 (257); gut length 86–206 (145); ratio of body to gut length 1 : 1.8–1 : 3 (1 : 2.3); ratio of body to gut width 1 : 1.1–1 : 2.2 (1 : 1.6); pharynx width 44–76 (59); number of embryos and cercariaea 14–42 (27).

HOST: *Ferrissia rivularis* (Say, 1917).

HABITAT AND LOCALITY: Tributary streams of Looking Glass River, Ingham Co., Michigan.

HOLOTYPES: United States National Museum Helm. Coll. No. 73950.

PARATYPES: Authors' collection.

Cercariaea are unable to swim and their movements are limited to the substrate onto which they emerge from the snail and adhere by their posterior end. When active they extend and contract their bodies vigorously. Occasionally they exhibit a random, nondirectional, inchwormlike movement. Wallace (1941) reported that light stimulated *Cercariaeum mutabile* to activity. In the present study this could not be demonstrated, though it was observed that activity could be induced by agitation of the water. During periods of rest they roll into spheres with the acetabulum pulled against the oral sucker.

Cercariaeum types I and II emerge from *L. fuscus* in early summer and fall when adult snails are most numerous. In the intervening months immature snails with immature infections predominate. *Cercariaeum* type III begin to emerge from *F. rivularis* in April and continue emerging throughout the summer and fall.

A second intermediate host of *Cercariaeum* types I, II, and III is *Chaetogaster limnaei*, a commensal on *L. fuscus* and *F. rivularis* which when recovered from infected snails has metacercariae encysted within its body cavity. *C. limnaei* is not penetrated by *Cercariaeum* type I, but was observed to ingest this cercariaeum. Penetration through the gut wall into the body cavity was not observed. *Cercariaeum* types II and III readily attach to and penetrate into the body cavity of *C. limnaei* where encystment occurs.

Dugesia tigrina and *D. dorotocephala* serve as additional second intermediate hosts of *Cercariaeum* types II and III. Initial attachment to the epidermis is made with the oral sucker; the acetabulum is pulled into position and attachment to the cuticle occurs. The anterior end of the cercariaeum probes the epidermis and penetrates into the parenchyma. *Cercariaeum* type II is vigorously active within the parenchyma before encystment. Study of sectioned material shows encystment occurs 10–15 min after penetration. Eleven experiments were conducted in which 25–100 *D. dorotocephala* were exposed to 25–138 newly emerged cercariaea for 11–25 hr. Forty to 87% of *D. dorotocephala* exposed in each experiment became infected with cercariaea. In the field and laboratory it was observed that *D. tigrina* and *D. dorotocephala* were frequently located on the base of the shell of *L. fuscus*, probably facilitating contact of the cercariaea with this intermediate host. *Cercariaeum* type III moves sluggishly within the parenchyma of *D. dorotocephala* and frequently escapes from its host after failing to encyst. Twelve experiments were conducted in which 25–50 *D. dorotocephala* were exposed to 25–61 newly emerged cercariaea for a period of 11–25 hr. In one experiment no infections occurred; in 11 experiments 2–24% of the *D. dorotocephala* exposed became infected with cercariaea.

L. fuscus may also serve as a second intermediate host for *Cercariaeum* type II. Metacercariae were found in the interlobular hemocoel, tentacles, pseudobranch, and foot musculature of *L. fuscus*. In the hemocoel of one snail, large numbers of metacercariae were observed distorting the digestive gland tubules and an eosinophilic hyaline degeneration of the digestive gland epithelium was present, characterized by a shrunken, glassy, strongly acidophilic appearance and pycnotic nuclei.

The adult forms of *Cercariaeum* types I, II, and III are unknown. There are similarities in the distribution of tegumental spines of *Cercariaeum* type I with *Lissorchis hypentelii* recovered from *Hypentelium nigricans* at the same site where infected snails were collected. The circumoral spination of *Cercariaeum* type III resembles that of juvenile *Lissorchis attenuatum*, which was recovered from *Catostomus commersoni*, from the same site where infected snails were collected.

Discussion

More than 100 specimens of each type of cercariaeum were examined. The three types of cercariaea were found to differ in body size, number, and distribution of tegumental spines and papillae and redial morphology. Patterns of tegumental spines were found to be constant, demonstrating they are of taxonomic value. Tegumental papillae vary in number and are often irregularly and asymmetrically arranged. They do, however, exhibit distinct groupings that appear to be characteristic for each type. Considerable caution should be exercised in assigning specific taxonomic value to the papillae.

The three types of cercariaea differ in their specificity and mode of infection of second intermediate hosts. *C. limnaei* was the only second intermediate host naturally and experimentally infected with *Cercariaeum* type I. The process of infection was not observed, but evidence suggests that it may occur by ingestion of the cercariaeum which then penetrates the stomach wall into the body cavity where it encysts. This mode of infection was observed by Wallace (1941) for *Cercariaeum mutabile*. *Cercariaeum* type II has the broadest second intermediate host range, utilizing *C. limnaei*, *D. tigrina*, *D. dorotocephala*, and *L. fuscus*. These hosts were not observed to ingest *Cercariaeum* type II. Penetration and encystment of cercariaea in all but *L. fuscus* was observed. *Cercariaeum* type III is intermediate in its second intermediate host utilization. *C. limnaei* is a good host, whereas *D. dorotocephala* and *D. tigrina* do not appear to be suitable on the basis of experimental infections.

There is considerable confusion regarding the species of mutabilous cercariaea. Cort (1918) briefly described the cuticular spination of *Cercariaeum mutabile*, but was unable to clearly define the outlines of reproductive structures other than the ovary and testes. He described the testes as ventral to the excretory bladder and illustrated the excretory pore as terminal in position. He does not describe glands or a prepharynx. Wallace (1941), in redescribing *C. mutabile*, describes the cuticular spination which differs in distribution from that of Cort (1918). He also describes a well-developed metraterm and cirrus complex, stating that only the second testis lies ventral to

the excretory bladder. Further, he describes penetration and cystogenous glands, a prepharynx, "adhesive" glands surrounding the excretory pore, a dorsally subterminal excretory pore, and tegumental papillae. Wallace (1941) does not adequately compare his cercariaeum with that of Cort (1918) and does not account for discrepancies in their respective descriptions. It is thus questionable that they worked with the same species of cercariaeum. Smith (1967, 1968) studied a cercariaeum he identified as *C. mutabile*. He offers no description or basis for his identification, thus making proper comparison with the present proposed species and the previous descriptions of Cort and Wallace impossible.

It is concluded that the three cercariaea in the present study are the larval stages of three distinct species of the genus *Lissorchis* and are distinct from *C. mutabile* as described by Cort (1918) and added to by Wallace (1941). Inasmuch as these cercariaea may be the larval stages of previously described adult *Lissorchis*, they are given the temporary designations *Cercariaeum* type I, *Cercariaeum* type II, and *Cercariaeum* type III, until the life cycles and adult stages are known. Evidence that *Cercariaeum* types I and III are larval forms of *Lissorchis hypentelii* and *L. attenuatum*, respectively, is morphological and ecological; experimental evidence is as yet lacking.

Literature Cited

Cort, W. W. 1918. A new cercariaeum from North America. J. Parasitol. 5: 86–91.

Sewell, R. B. S. 1922. Cercariae Indicae. Indian J. Med. Res. 10 (Suppl.): 1–370.

Smith, R. J. 1967. Ancylid snails as intermediate hosts of *Megalodiscus temperatus* and other digenetic trematodes. J. Parasitol. 53: 287–291.

———. 1968. Ancylid snails as first intermediate hosts of *Lissorchis mutabile* comb. n. (Trematoda: Lissorchiidae). J. Parasitol. 54: 283–285.

Wallace, H. E. 1939. Life history of *Triganodistomum mutabile* (Cort): Trematoda. J. Parasitol. 25 (Suppl.): 26–27.

———. 1941. Life history and embryology of *Triganodistomum mutabile* (Cort), (Lissorchiidae: Trematoda). Trans. Am. Microscop. Soc. 60: 309–326.

Rowardleus and *Janiszewskella*, New Caryophyllid Genera (Cestoidea: Caryophyllidea) from *Carpiodes cyprinus* (Catostomidae) in Eastern North America

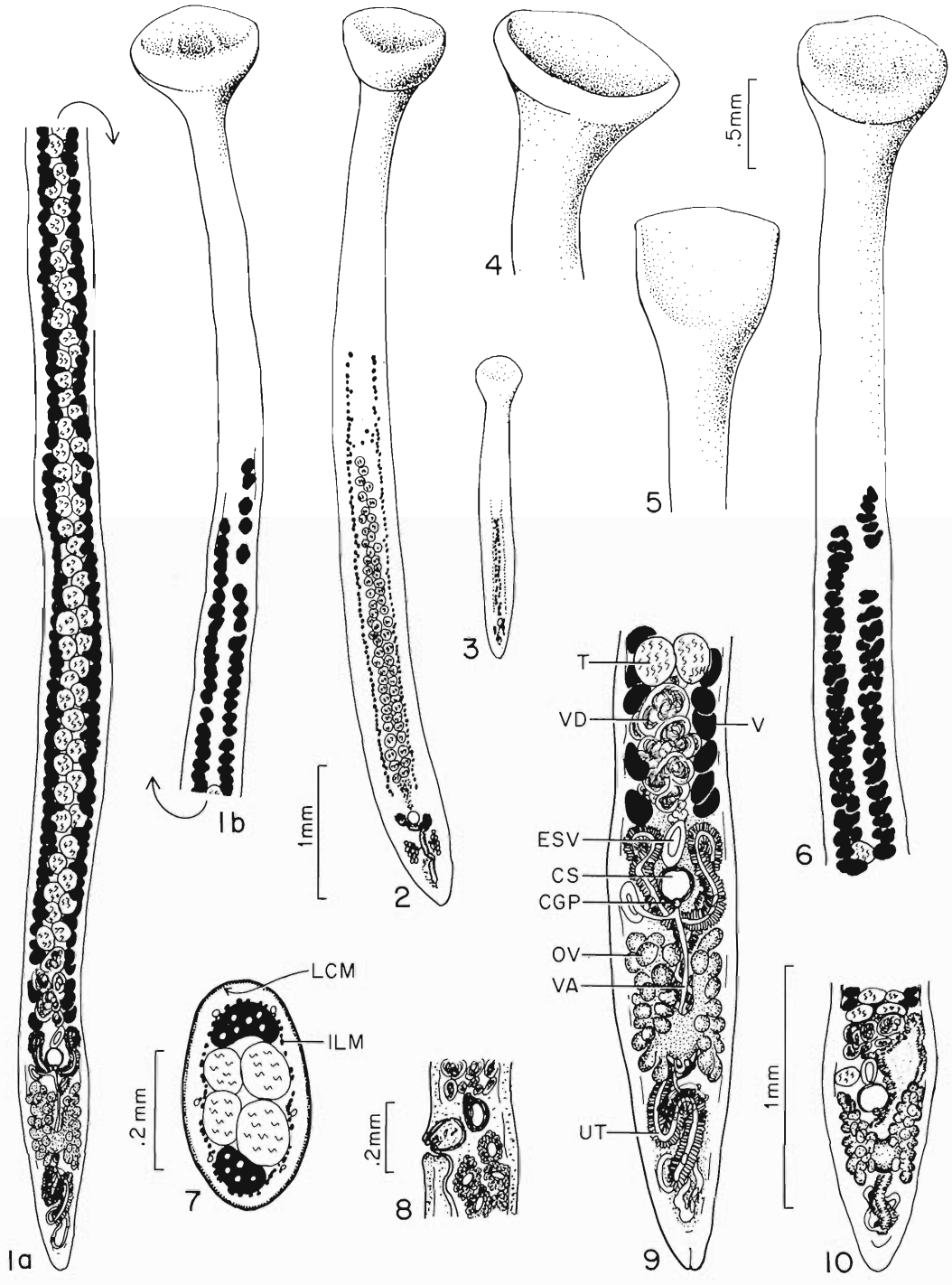
JOHN S. MACKIEWICZ AND WILLIAM G. DEUTSCH[1]

Biological Sciences, State University of New York at Albany, New York 12222; and
Biological Sciences, State University of New York at Binghamton, New York 13901

ABSTRACT: *Rowardleus pennensis* gen. et sp. n. and *Janiszewskella fortobothria* gen. et sp. n., of the family Caryophyllaeidae, are described from the host in the Susquehanna River of Pennsylvania. *Rowardleus* has a cuneiformoloculate scolex, single gonopore, lateral vitellaria, and uterus anterior of cirrus sac; *Janiszewskella* has a bothrioloculodiscate scolex, single gonopore, lateral vitellaria, and uterus posterior of cirrus sac. Illustrations and brief notes on incidence and seasonal occurrence complement the descriptions.

As part of an ecological study of the Susquehanna River by the junior author (Deutsch, 1974) 64 *Carpiodes cyprinus* (Lesueur) were examined for intestinal parasites from June through November of 1973. Fish were from the vicinity of the Susquehanna Steam Electric Station, east of Berwick, Luzerne Co., Pennsylvania, and consisted of the following collections (number examined in parentheses): June (5), July (8), August (6), September

[1] Present address: Ichthyological Associates, Inc., R.D. #1, Berwick, Pennsylvania 18603.



(18), October (16), and November (11). Fish ranged in size from 307 to 467 mm and were approximately divided with respect to sex. This paper concerns the new caryophyllid species found; parasites recovered from other hosts will be presented elsewhere.

Worms were recovered by decanting the intestinal contents of fish that were killed or had been dead (refrigerated) for no more than 6 hr. These techniques prevented obtaining information on the exact position of cestodes in the intestine. Most worms were killed in hot water and fixed in FAA; all were stained with Semichon's carmine and mounted, thus preventing measurement of ova. Sections were prepared from demounted worms that were subsequently overstained in the same stain. Measurements are in microns unless otherwise indicated; drawings were made with the aid of a microprojector.

Order Caryophyllidea Van Beneden (in Carus, 1863)
Family Caryophyllaeidae Leuckart (in Lühe, 1910)
Rowardleus gen. n.

GENERIC DIAGNOSIS: Caryophyllaeidae. Scolex cuneiformoloculate. Cirrus and uterovaginal canal open together forming single large gonopore. Ovary H-shaped. Uterus extending anterior of cirrus. Preovarian vitellaria in two lateral rows. Postovarian vitellaria absent. External seminal vesicle present. Type species: *Rowardleus pennensis* sp. n.

Remarks

Rowardleus belongs to the group of Caryophyllaeidae having a single gonopore and lateral vitellaria and includes the genera *Archigetes* Leuckart, 1878, *Bialovarium* Fischthal, 1953, *Penarchigetes* Mackiewicz, 1969, and *Isoglaridacris* Mackiewicz, 1965. It can be separated from the first three as follows: from *Archigetes* and *Penarchigetes* that have a discate scolex and postovarian vitellaria, *Penarchigetes* also lacks an external seminal vesicle; and from *Bialovarium* that has a clavoloculate scolex and V-shaped ovary. The new genus is most similar to *Isoglaridacris* with which it shares a similar type scolex, external seminal vesicle, and as found on two species of *Isoglaridacris*, absence of postovarian vitellaria. It differs from *Isoglaridacris*, however, by having a distinctly H-shaped ovary with short posterior arms that do not join or closely approach each other, and a uterus that extends anterior of the cirrus sac.

This new genus is named in honor of the late Dr. Robert A. Wardle of the University of Manitoba (Canada) as a tribute to his scholarly volumes on the biology, systematics, and biology of the Cestoidea (Wardle and McLeod, 1952; Wardle et al., 1974). The generic name, derived from *Robert Wardle*, is masculine in gender.

Rowardleus pennensis gen. et sp. n. Pennsylvania caryophyllid (Figs. 1–9)

SPECIFIC DIAGNOSIS (means are based on 11 mature worms from four fish; ranges in parentheses): Worms 12.3 (8.9–18.4) mm long by 0.56 (0.48–0.70) mm wide at gonopore. Scolex cuneiform with six loculi (cuneiformoloculate). Neck long, constricted. Inner longitudinal muscles (ILM) large fascicles. Outer longitudinal muscles (OLM) small fascicles, one-fourth distance from tegument to ILM. Longitudinal cuticular muscles prominent. Testes begin behind anterior vitellaria, 5.2 (4–7.3) mm from scolex apex, extend to vas deferens, occasionally to cirrus sac, number 73 (53–86), larger than vitellaria; posterior ones

←

Figures 1–10. ***Rowardleus pennensis*** **n. sp. (1–9). 1a, b. Mature worm, holotype. 2, 3. Immature worms. 4, 5. Scolex variations. 6. Anterior end. 7. Cross section through middle of body. 8. Mid-sagittal section through gonopore. 9. Posterior end. 10.** ***Hypocaryophyllaeus paratarius*** **from** ***Carpiodes carpio,*** **Tennessee, posterior end. Abbreviations (Figs. 1–24): CGP, common gonopore; CS, cirrus sac; ESV, external seminal vesicle; ILM, inner longitudinal muscles; LCM, longitudinal circular muscles; MG, Mehlis' gland; OV, ovary; POV, postovarian vitellaria; T, testis; UT, uterus; V, vitellarium; VA, vagina; and VD, vas deferens.**

larger than cirrus sac. External seminal vesicle large, from 140–180 long by 75–100 wide, wall 20–25 thick ($N = 5$). Vas deferens conspicuous, large mass between cirrus sac and testes. Cirrus sac small with well-defined muscular walls, round, 0.13 (0.12–0.15) mm wide; from 3.8–5 times into body width at gonopore. Preovarian vitellaria in lateral rows, begin 3.4 (2.7–5.1) mm from scolex apex, extend to uterus, seldom to ovary. Previtelline distance contained in length of worm 3.2 (2.6–4.8) times, represents 28 (21–39) per cent of worm length. Postovarian vitellaria absent. Postgonopore distance 1.2 (0.8–1.7) mm, contained in length of worm 10.3 (9.2–12.4) times, represents 10 (8–10.8) per cent of worm length. Ovary strongly follicular, 610 (530–800) long, H-shaped. Seminal receptacle absent.

SPECIMENS STUDIED: 25 mature (2 sectioned), 15 immature.

HOST: Quillback, *Carpiodes cyprinus* (Lesueur), type host (Cypriniformes: Catostomidae).

LOCATION: Intestine.

LOCALITIES: Pennsylvania: Luzerne Co., Susquehanna River at Susquehanna Steam Electric Station, 8 km east of Berwick (type locality); Wyoming Co., Susquehanna River, town of Falls.

TYPE SPECIMENS: Holotype, USNM Helm. Coll. No. 73428; paratypes (2) USNM Helm. Coll. No. 73429, (1) British Museum (Natural History) Helm. Coll. No. 1975.8.20.1.

Supplementary material includes sagittal and cross sections, and whole mounts: USNM Helm. Coll. No. 73430 (3 slides); British Museum Helm. Coll. No. 1975.8.20.2–3 (2 slides).

The species is named after the state of Pennsylvania (Penn., *ensis* L., belonging to), where it was collected.

Remarks

The scolex loculi are shallow and so poorly developed that they cannot be seen on most of the mounted worms (Figs. 2–6). The gonopore is actually the deep depression (atrium) formed from the opening of ejaculatory duct and uterovaginal duct entering from opposite directions; neither opening is on the ventral surface of the worm as in *Hypocaryophyllaeus* Hunter, 1927, or *Spartoides* Hunter, 1929. From study of sections (Fig. 8), and several specimens mounted in order to view the cirrus laterally, there is no doubt that a single large gonopore is present. Longitudinal cuticular muscles (Fig. 7) are especially prominent. Unlike *Biacetabulum* or other genera in which the uterus loops from side to side as it passes anterior of the cirrus sac, there is usually a single loop on each side of the cirrus sac (Fig. 9). These loops are evident in immature worms (Fig. 2) indicating that they are not simply displaced anteriorly as the uterus fills with eggs. Ovarian follicles are in the medullary parenchyma. No anomalies were found.

Intensity varied from 1 to 50 ($\bar{x} = 6.8$) in 22 of 64 fish and was highest in June and July, with a pronounced drop in September, and subsequent rise in November. This seasonal pattern is like that reported for many other caryophyllids (Mackiewicz, 1972). There were six concurrent infections with the second new species described below. There was no difference in the size or sex between infected and uninfected fish.

Discussion

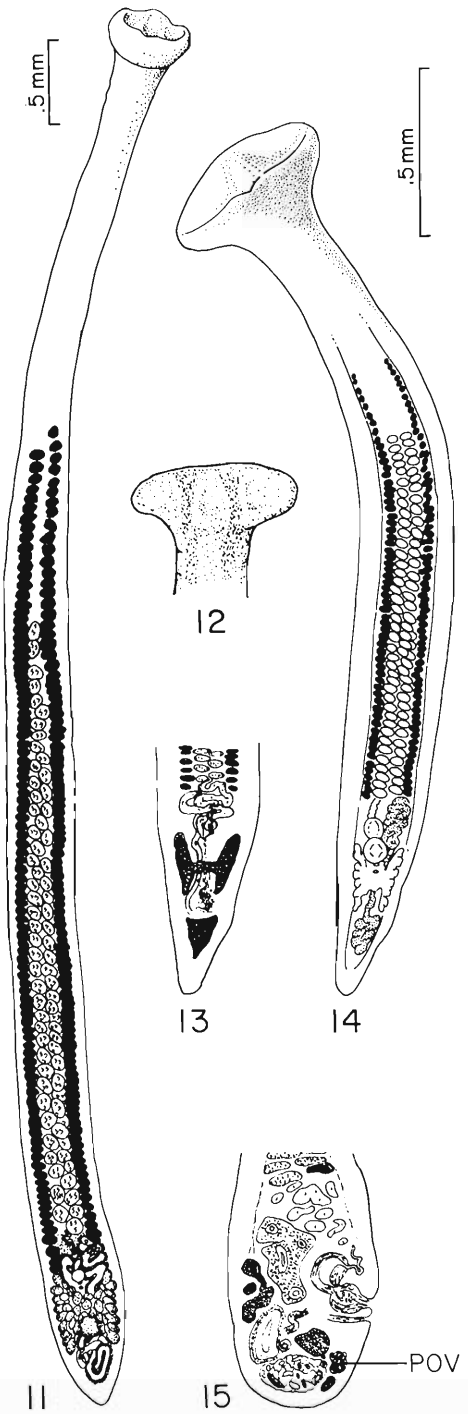
While reexamining and comparing the *Hypocaryophyllaeus paratarius* specimens in the Hunter collection, consisting of 29 slides: whole mounts, 14 immature, 1 mature; longitudinal and cross sections of 11 and 4 immature worms, respectively, a whole mount (immature) marked "Co-type, G-40-13" from the University of Minnesota Collection, and the type, USNM Helm. Coll. No. 51150 (two slides of longitudinal serial sections of a strongly contracted mature worm), with the description and illustrations in Hunter (1930), certain inconsistencies were discovered that have a bearing on the identity of *Rowardleus* and the diagnosis of the genus *Hypocaryophyllaeus*. Those inconsistencies of concern involve the postovarian vitellaria and position of the cirrus sac.

The genus *Hypocaryophyllaeus* Hunter, 1927 is characterized as having postovarian vitellaria (POV), as shown in figure 37 and 38 of Hunter (1930). Careful study of all of the above 32 slides indicates that POV are absent in *H. paratarius*. It appears that either the uterine glands, prominent in this species, or, more likely, the ovarian follicles, may have been mistaken for POV by Hunter. Indeed

the position of the POV in Figure 15 would suggest the latter because of their position near the ovarian commissure. Furthermore, the uterus of the cotype (Fig. 14) forms a mass that could be readily mistaken for POV on a whole mount preparation.

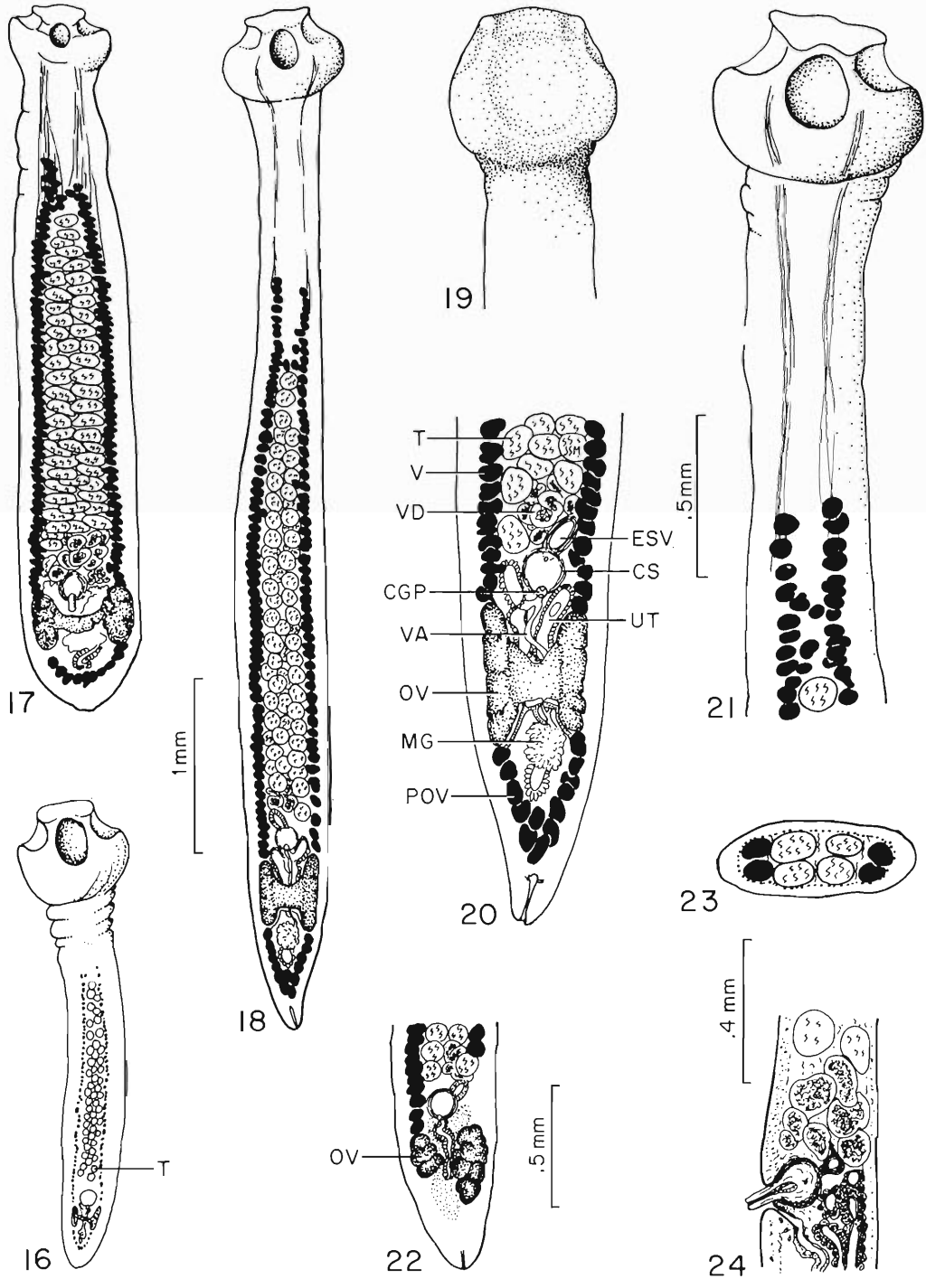
On the other hand, it may be that a mixed infection of one species with another without POV was initially involved in the original description of *H. paratarius*. A comparison of Figures 13 and 15 strengthens this possibility. In figure 13 one finds a small external seminal vesicle (ESV) about one-half the size of the cirrus that is anterior of a nonfollicular ovary. In Figure 15, on the other hand, one finds that the ESV is larger than the cirrus that is posterior to the anterior edge of a follicular ovary. Except for the presence of POV, all specimens examined have a large ESV and a cirrus that is included between the wings of a follicular ovary; other features such as the two gonopores and extensive cortical region agree with Hunter's description.

As a result of a reexamination of 30 specimens used in the original description of *H. paratarius* we conclude that in the Hunter (1930) monograph figure 37 (our Fig. 13) represents an unknown species in an undescribed genus and that figure 38 (our Fig. 15) is *H. paratarius* except that ovarian follicles were probably mistaken for POV. Unfortunately Figure 37 has been reproduced in Wardle and McLeod (1952: fig. 339B), Yamaguti (1959: fig. 69a), Hoffman (1967: fig. 173b), and Schmidt (1970: fig. 45b). Additional specimens of *H. paratarius* that agree with Hunter's description and material, except for the absence of POV (Figs. 10, 11),



→

Figures 11–15. *Hypocaryophyllaeus paratarius* (Figs. 12–15, same scale). 11. Mature worm from *Carpiodes carpio*, Tennessee. 12. Scolex, adapted from Hunter (1930: fig. 5). 13. Posterior end, adapted from Hunter (1930: fig. 37). See text for discussion of the identity of this figure. 14. Immature worm, "Co-type, G-40-13" Univ. Minnesota Collection, Hunter slide No. 274. 15. "Sagittal section, through reproductive systems," adapted from Hunter (1930: fig. 38), POV label by authors, see text for interpretation of section.



have been found in *Carpiodes cyprinus* and *C. carpio* of the Clinch River (Anderson Co.), Tennessee, by the senior author.

Rowardleus pennensis n. sp. and *H. paratarius* basically have the same type scolex (Figs. 6, 12), number of testes, and body shape; however, the former has a single gonopore, cirrus anterior of ovary, less anterior extension of uterus, ovarian follicles in medullary rather than cortical parenchyma, and is a consistently larger worm. While the phenotypic expression of some of these characteristics may vary with the degree of contraction or maturity, the single gonopore and cirrus position remains the same on all specimens, regardless of age or degree of contraction. Because of the discoveries herein described, the genus *Hypocaryophyllaeus*, especially with respect to its relationship to *Rowardleus* and *Spartoides* Hunter, 1929, is now in the process of revision.

Janiszewskella gen. n.

GENERIC DIAGNOSIS: Caryophyllaeidae. Scolex bothrioloculodiscate. Ejaculatory duct joins uterovaginal canal. Ovary H-shaped. Uterus not extending anterior of cirrus. Preovarian vitellaria in two lateral rows. Postovarian vitellaria present. External seminal vesicle present. Type species: *Janiszewskella fortobothria* sp. n.

Remarks

Janiszewskella belongs to the group of Caryophyllaeidae having a single gonopore and lateral vitellaria and includes the genera *Rowardleus* gen. n., *Bialovarium* Fischthal, 1953, *Isoglaridacris* Mackiewicz, 1965, *Penarchigetes* Mackiewicz, 1969, and *Archigetes* Leuckart, 1878. It can be separated easily from the first four genera as follows: from *Rowardleus* which has a cuneiformoloculate scolex and lacks postovarian vitellaria; from *Bialovarium* which has a clavoloculate scolex and a V-shaped ovary; from *Isoglaridacris* which has a cuneiformoloculate scolex and ovary with posterior arms joined or nearly so; and from *Penarchigetes* which lacks an external seminal vesicle. The new genus is most similar to *Archigetes* with which it shares the following characters: single gonopore, bothriolоculodiscate scolex, external seminal vesicle, and lateral vitellaria (some species, e.g., *A. sieboldi*, have lateral and medial vitellaria). It differs from *Archigetes* by not having the uterus extending anterior the cirrus. Other morphological differences, perhaps less significant, include separate pre- and postovarian vitellaria groups and the large size of gravid worms. Size itself can hardly be regarded as a generic character, but with respect to *Archigetes*, where small size (i.e., less than 3 mm long) is an absolute prerequisite for neotenic development in the tubificid intermediate host, the large size of worms in this new genus precludes an *Archigetes*-type development. Kennedy (1965) includes neotenic development as part of the generic diagnosis of *Archigetes*. A final difference concerns hosts: *Archigetes* may mature in an invertebrate (Annelida) as well as cyprinid and cobitid fishes while *Janiszewskella* is a parasite of catostomid fish. This combination of morphological, lifecycle, and host characteristics serves to readily distinguish the new genus from *Archigetes*.

This new genus is named in honor of Dr. Janina Janiszewska, University of Wroclaw (Poland), as a tribute to her contributions to caryophyllid systematics and her thorough review of the European fauna (Janiszewska, 1954). The generic name is feminine in gender.

Janiszewskella fortobothria gen. et sp. n. Quillback caryophyllid (Figs. 17–24)

SPECIFIC DIAGNOSIS (means are based on 20 mature worms from 7 fish; ranges in parentheses): Mature worms 5.8 (3.7–8.7) mm

←

Figures 16–24. ***Janiszewskella fortobothria*** **n. sp. 16. Immature worm. 17. Mature worm, contracted. 18. Mature worm, holotype. 19. Scolex variation, bothrium indistinct. 20. Posterior end. 21. Anterior end. 22. Anomaly. 23. Cross section through middle of body. 24. Midsagittal section through gonopore and everted cirrus.**

long by 0.55 (0.38–0.70) mm wide at gonopore. Scolex with two median bothria, four lateral loculi, and a terminal disc (bothrioloculodiscate), bothria large, strongly developed. Neck constricted, short. Inner longitudinal muscles (ILM) large fascicles. Outer longitudinal muscles (OLM) apparently absent. Testes begin behind anterior vitellaria, 1.8 (1–2.9) mm from scolex apex, extend to vas deferens, occasionally to cirrus sac, number 83 (65–92), larger than vitellaria, posterior ones larger than or about same size as cirrus sac. External seminal vesicle large, from 140–250 long by 70–100 wide, wall 15–20 thick ($N = 5$). Vas deferens conspicuous, large mass between cirrus and testes. Cirrus sac large with well-defined muscular walls, round, 0.165 (0.140–0.200) mm wide; from 2.5 to 4.8 times into body width at gonopore. Preovarian vitellaria in lateral rows but with a few scattered median follicles anteriorly, begin 1.3 (0.8–2.13) mm from scolex apex, extend to ovary; not continuous with postovarian vitellaria. Previtelline distance contained in length of worm 4.4 (3.7–5.1) times, represents 23 (19.7–26.6) per cent of worm length. Postgonopore distance 0.87 (0.55–1.2) mm, contained in length of worm 6.7 (5.4–8.8) times, represents 15 (13.2–18.3) per cent of worm length. Postovarian vitellaria present, usually touching ovary and forming a V or U. Ovary lobulate, 380 (280–530) long, H-shaped. Seminal receptacle absent.

SPECIMENS STUDIED: 103 mature (2 sectioned), 107 immature.

HOSTS: Quillback, *Carpiodes cyprinus* (Lesueur), type host.

LOCATION: Intestine.

LOCALITIES: Pennsylvania: Luzerne Co., Susquehanna River at Susquehanna Steam Electric Station, 8 km east of Berwick (type locality).

TYPE SPECIMENS: Holotype, USNM Helm. Coll. No. 73431, paratypes (1) USNM Helm. Coll. No. 73432, (1) British Museum (Natural History) Helm. Coll. No. 1975.8.20.4.

Supplementary material includes sagittal and cross sections, and whole mounts: USNM Helm. Coll. No. 73433 (7 slides); British Museum Helm. Coll. No. 1975.8.20.5-9 (5 slides).

The species name is derived from *forto* L., strong and *bothria* referring to the exceptionally strongly developed bothria.

Remarks

As verified by study of sections the two median holdfasts of the scolex are exceptionally well-developed bothria (Figs. 16, 21) rather than acetabular suckers having a characteristic basement membrane. These bothria become obscured in relaxed worms (Fig. 19). The presence of a few median vitelaria in the anterior part of the preovarian vitelline field of most worms (Figs. 17, 18) is a distinctive feature of this species; generally such vitellaria are absent when lateral rows are so well developed. As in *Glaridacris confusus* Hunter, 1929, a single row of postovarian vitelline follicles are arranged in a V pattern (Fig. 20). The only anomaly observed (Fig. 22) lacked part of the ovary, postovarian vitellaria, uterus, and some preovarian vitellaria; fine granules (microsporidia?), absent from other worms, were conspicuous in the posterior part of this immature worm.

Superficially this species resembles *Biacetabulum carpiodi* Mackiewicz, 1969, from which it can best be distinguished by not having the uterus anterior the cirrus sac and lacking median vitellaria over the whole testes field. It also resembles *Glaridacris laruei* (Lamont, 1921); however, the narrow neck with a few median vitellaria, single large gonopore, and V-shaped cluster of postovarian vitellaria readily serve to separate it from that species which is usually found in *Catostomus* sp.

Intensity varied from one to 48 ($\bar{x} = 11$) in 19 of 64 fish; infections were absent from June through August but rose sharply in October.

Acknowledgments

Supported in part by grant 20-A022-A from the Research Foundation, State University of New York, to the senior author and in part by Ichthyological Associates, Inc. through grants from the Pennsylvania Power and Light Company for the Susquehanna River Study. The junior author thanks Dr. Jacob H. Fischthal, SUNY, Binghamton, New York, for his direction in thesis research. We thank Dr. F. G. Wallace for loan of the cotype slide of

H. paratarius from the University of Minnesota collection.

Literature Cited

Deutsch, W. G. 1974. An ecological survey of the parasites of fishes of the North Branch Susequehanna River near Berwick, Pennsylvania. Master's thesis, State Univ. New York at Binghamton, 111 p.

Hoffman, G. 1967. Parasites of North American freshwater fishes. Univ. Calif. Press, Berkeley, 486 p.

Hunter, G. W. III. 1930. Studies on the Caryophyllaeidae of North America. Ill. Biol. Monog. 11 (1927), 182 p.

Janiszewska, J. 1954. Caryophyllaeidae europejeskie ze szczególnym uwzględnieniem Polski. Trav. Soc. Sci. des Lettres de Wroclaw, Seria B, Nr. 66, 73 p.

Kennedy, C. R. 1965. Taxonomic studies on *Archigetes* Leuckart, 1878 (Cestoda: Caryophyllaeidae). Parasitology 55: 439–451.

Mackiewicz, J. S. 1972. Caryophyllidea (Cestoidea): a review. Exp. Parasit. 31: 417–512.

Schmidt, G. D. 1970. How to Know the Tapeworms. Wm. C. Brown Co., Dubuque, 266 p.

Wardle, R. A., and J. A. McLeod. 1952. The Zoology of Tapeworms. Univ. Minn. Press, Minneapolis, 780 p.

———, ———, **and S. Radinovsky.** 1974. Advances in the zoology of tapeworms, 1950–1970. Univ. Minn. Press, Minneapolis, 274 p.

Yamaguti, S. 1959. Systema Helminthum, Vol. II. The Cestodes of Vertebrates. Interscience, New York, 860 p.

Helminths of the White Ibis in Florida[1]

ALBERT O. BUSH[2] AND DONALD J. FORRESTER
College of Veterinary Medicine, University of Florida, Gainesville, Florida 32610

ABSTRACT: Forty-two species of helminths were recovered from 140 white ibises (*Eudocimus albus* L.) collected in fresh- and saltwater habitats in Florida. These included 22 species of trematodes, 2 species of cestodes, 17 species of nematodes, and one acanthocephalan. Thirty-five of these are new host records. Based on maturity and prevalence of infections only 23 of the species are considered to be normal parasites of the white ibis. Birds collected from freshwater marshes had more nematode species than birds from saltwater islands. The converse was true with trematodes. Adult birds from both areas were infected with four parasites which were not recovered from juveniles of either area.

The white ibis (*Eudocimus albus* L.) is common locally along southern coastal areas in the United States (Bent, 1926). In addition, it is found through coastal Central America to northern South America and most of the Caribbean Islands. The white ibis is considered resident throughout its range although, in addition to postbreeding dispersal, some migration has been recorded (Palmer, 1962).

During the breeding season in Florida, white ibises segregate into two groups, one of which nests on saltwater islands, the other nesting in freshwater marshes. Although nesting on saltwater islands, the saltwater group flies regularly to feed in mainland estuarine systems and marshes while the freshwater group continues to fly from the nesting site to marshes and prairies. At other times of the year both groups of birds are found predominantly in freshwater marshes and prairies in central and southern Florida.

Previously, nine trematodes: *Ascocotyle mcintoshi* by Price (1936), *Mesostephanus* sp. by Hutton and Sogandares-Bernal (1959), *Stomylotrema* sp. by Hutton and Sogandares-Bernal (1960), *Fibricola cratera* by Lumsden (1961), *Patagifer vioscai* by Lumsden (1962),

[1] From a thesis submitted by the senior author to the Graduate School of the University of Florida in partial fulfillment of the requirements for the degree of Master of Science. Supported in part by grants number 977-G and 1270 from the Florida Game and Fresh Water Fish Commission. A contribution of Federal Aid to Wildlife Restoration, Florida Pittman–Robertson Project W-41. Florida Agricultural Experiment Stations Journal Series No. 5938.

[2] Present address: Department of Zoology, University of Alberta, Edmonton, Alberta, Canada T6G 2E1. Address reprint requests to: Dr. D. J. Forrester, College of Veterinary Medicine, University of Florida, Gainesville, Florida 32610.

Posthodiplostomum minimum and *Zonorchis petiolatum* by Lumsden and Zischke (1963), *Parastrigea diovadena* by Dubois and Macko (1972), and *Polycyclorchis eudocimi* by Pence and Bush (1973) have been reported. One cestode, *Parvitaenia ibisae*, by Schmidt and Bush (1972) has been reported as well as two nematodes: *Tetrameres* sp. by Bârus (1966) and *Tetrameres williamsi* by Bush et al. (1973) and two Acanthocephala: *Corynosoma* sp. by Hutton (1964) and *Southwellina dimorpha* by Schmidt (1973).

The following report deals with the helminth parasites from white ibises collected from peninsular Florida.

Materials and Methods

One hundred and forty white ibises were collected by shotgun, .22 caliber rifle, or manually (nestling birds) from October 1970 through August 1972 from the following localities: Paynes Prairie, Alachua County (35 adults); Bivens Arm, Alachua County (20 immatures); Sea Horse Key, Levy County (10 adults and 20 immatures); Palmdale, Glades County (35 adults); and Terra Ceia Bay, Manatee County (20 adults). The study areas were chosen so that both adult and immature birds would be collected in saltwater systems (Levy and Manatee counties) as well as freshwater systems (Alachua and Glades counties).

Techniques for recovering, killing, fixing, preserving, and staining helminths were those described by Kinsella and Forrester (1972) with the exception that many microphallid trematodes were examined both alive and stained to aid in taxonomy, and the intestinal tracts of birds collected in saltwater areas were baermannized to aid in the recovery of small flukes.

Results and Discussion

Forty-two species of helminths were recovered from 140 white ibises examined, none of which was free of helminths. These included 22 species of trematodes, 2 species of cestodes, 17 species of nematodes, and 1 acanthocephalan. Thirty-five are new host records. Table 1 lists the helminths recovered, their prevalence, intensity of infection, and location in the host.

Trematoda

The family Microphallidae was represented by 5 species, the Echinostomatidae by 4 species, the Heterophyidae and Cyclocoelidae by 2 species each. The remaining 9 families all contained a single species and, in 5 families, only a single individual of the species was recovered.

The Stomylotrematidae infected the greatest number of hosts while the Microphallidae had the greatest intensity of infection.

One of the most interesting trematodes recovered was *Patagifer vioscai* (Lumsden, 1962). Although the life cycle of this species is unknown, immature *P. vioscai*, in various stages of development, were found in many birds. In what appears to be a uniquue situation, the smallest flukes (nongravid) were found under the gizzard lining. Eighteen birds harbored from 1–40 immature specimens in this site. The size of the flukes was correlated with the distance from the gizzard, fully mature adults being found in the jejunum.

Stomylotrema vicarium Braun, 1901, was first reported in the United States by Lumsden and Zischke (1963) from the yellow-crowned night heron (*Nyctanassa violacea*). Recently, it has been reported from Florida scrub jays (*Aphelocoma c. coerulescens*), Florida sandhill cranes (*Grus canadensis pratensis*), and Florida wild turkeys (*Meleagris gallopavo osceola*) (Kinsella, 1974; Forrester et al., 1975; Hon et al., 1975). In all of these reports, *S. vicarium* was rare, but in the present study it was the most prevalent trematode.

Stomylotrema vicarium has been reported from a number of avian hosts in South America (Travassos et al., 1969) and, since the white ibis is common to both South America and North America, it may be the host responsible for the presence of *S. vicarium* in the coastal United States.

Although found in the majority of the birds from Manatee County, *Parorchis acanthus* (Nicoll, 1907) was not found concurrently with the other cloacal-inhabiting fluke, *S. vicarium*, even though *S. vicarium* was recovered from the remaining 25% of the ibises examined from this county. This may well indicate some form of competitive interaction between the two species.

Table 1. Helminths of 140 white ibises from Florida.

Helminths	Per cent infection	Number of worms per infected bird		Status
		Mean	Range	
Trematoda				
Stomylotrema vicarium (7)*	68	52	1–243	**
Parastrigea diovadena (5)	61	123	1–2,900	**
Patagifer vioscai (4, 5)	36	5	1–40	
Posthodiplostomum minimum (5)	26	162	1–1,014	
Ascocotyle mcintoshi (5)	16	174	1–3,276	
Parorchis acanthus (7)	11	3	1–8	**
Lyperosomum sinuosum (10)	9	5	1–24	**
Tanaisia fedtschenkoi (6)	7	7	4–12	**
Polycyclorchis eudocimi (8)	6	1	1–3	
Gynaecotyla adunca (5)	6	258	1–899	**
Carneophallus turgidus (5)	4	590	2–1,078	**
Probolocoryphe glandulosa (5)	4	2,230	1–6,200	**
Ascocotyle ampullacea (5)	3	363	5–1,324	**
Parvatrema sp. (5)	1	8	2–14	**
Acanthoparyphium sp. (5)	1	5	3–6	**
Levinseniella sp. (5)	1	605	31–1,170	**
Maritrema sp. (5)	<1	11	—	**
Stephanoprora denticulata (5)	<1	2	—	**
Microparyphium facetum (7)†	<1	1	—	**
Ophthalmophagus sp. (2)†	<1	1	—	**
Clinostomum marginatum (1)†	<1	1	—	**
Ornithobilharzia sp. (11)	<1	1	—	**
Cestoda				
Parvitaenia ibisae (5)	75	49	1–436	
Microsomacanthus sp. (5)	18	8	1–35	**
Nematoda				
Tetrameres williamsi (3)	50	14	1–101	
Capillaria contorta (2)	21	3	1–8	**
Strongyloides sp. (5)	13	17	1–111	**
Larval spirurids (4)†	9	2	1–10	**
Sciadiocara umbellifera (4)	7	11	1–26	**
Skrjabinoclava thapari (3)	5	2	2–7	**
Ancyracanthopsis coronata (4)	4	6	2–15	**
Syncuaria sp. (4)	4	3	1–5	**
Cyathostoma sp. 1 (8, 9)	4	6	1–26	**
Contracaecum sp. (2)†	2	2	1–3	**
Synhimantus sp. (2)	1	2	1–2	**
Syngamus trachea (8)	<1	2	—	**
Capillaria sp. (5)	<1	1	—	**
Viktorocara sp. (4)	<1	1	—	**
Cyathostoma sp. 2 (8, 9)	<1	1	—	**
Sciadiocara chabaudi (4)	<1	1	—	**
Gnathostoma procyonis (5)†	<1	1	—	**
Acanthocephala				
Southwellina dimorpha (5)	69	10	1–35	

* Numbers in parentheses indicate location in host: (1)—mouth cavity; (2)—esophagus; (3)—proventriculus; (4)—gizzard lining; (5)—small intestine; (6)—kidney; (7)—cloaca; (8)—trachea; (9)—lungs; (10)—pancreas; (11)—blood vessels.

** New host records.

† Only immature specimens recovered.

Ascocotyle ampullacea is reported for the first time in the white ibis. It was originally described from raccoons (*Procyon lotor*) by Miller and Harkema (1962).

Nine specimens of a previously undescribed species of the genus *Acanthoparyphium* were recovered from two birds from Manatee County. Heard (pers. comm.) recovered the same species from clapper rails (*Rallus longirostris*) collected in neighboring Pinellas County. This species differs from existing *Acanthoparyphium* spp. by having a complete ring of fairly large papillae on the outer margin of the acetabulum.

Undescribed species of *Maritrema* and *Parvatrema* were found infrequently in birds collected in Manatee County. Both species were recovered by Heard (1970) in clapper rails and by Kinsella (pers. comm.) in rice rats (*Oryzomys palustris*).

A species of *Levinseniella* was recovered from birds in both Manatee and Levy counties.

All specimens were poorly relaxed and further identification could not be made.

Cestoda

Parvitaenia ibisae Schmidt and Bush, 1972, was the most prevalent cestode and was recovered from all study areas. Kinsella (1972) and Courtney and Forrester (1974) recovered immature specimens of this species in the black skimmer (*Rynchops nigra*) and the brown pelican (*Pelecanus occidentalis*), respectively.

An undescribed species of *Microsomacanthus*, characterized by 10 wrench-shaped hooks (24 μ long), one poral and two antiporal testes, a convoluted vas deferens anterolateral to the poral testis, and a chitinous lining for a portion of the vagina, occurred sporadically in birds from all study areas.

Nematoda

The Schistorophidae included 4 species followed by the Acuariidae and the Syngamidae with 3 species each, and the Trichuridae with 2 species. The remaining families each contained a single species.

Skrjabinoclava thapari Teixeira de Freitas, 1953, occurred at low levels of infection in birds from all study areas. This is the first report of this species from an avian host.

A single, immature specimen of *Gnathostoma procyonis* Chandler, 1942, was recovered, and this too is a new record from an avian host.

A species of *Strongyloides*, metrically and morphologically similar to *S. avium* Cram, 1929, was encountered frequently in birds collected from freshwater localities. Free-living males were not cultured, therefore specific determination could not be made. This appears to be the same species recovered from wild turkeys by Hon et al. (1975) on one of the same study areas.

A low-level infection of *Capillaria contorta* Travassos, 1915, was encountered in all four study areas. The already abundant host list for this parasite must now be extended to include Ciconiiformes.

A single male specimen of *Capillaria* (similar to *C. mergi*) was recovered from the lower small intestine of an adult bird from Alachua County.

Two new species of *Cyathostoma* were encountered. The first had spicules almost equal (0.74 to 0.84 mm long), a lightly chitinized gubernaculum, and a dorsal ray with two lateral branches which further subdivided near the distal tip. Although slightly larger in all dimensions, this species appears close to *C. coscorobae* Chapin, 1925. The major difference lies in the morphology of the dorsal ray. The second species of *Cyathostoma* was similar to the first with the exception of spicule length, which ranged from 0.62 to 0.65 mm. The two species of *Cyathostoma* were never encountered in the same host.

The species of *Synhimantus* recovered was the same found by Hon et al. (1975) in wild turkeys and by Forrester et al. (1974, 1975) from sandhill cranes (*Grus canadensis*) and represents an undescribed species.

Acanthocephala

A single species of acanthocephalan, *Southwellina dimorpha* Schmidt, 1973, was found frequently in birds from all study areas. Immature *S. dimorpha* have been recovered from crayfish, *Procambarus clarkii* (Schmidt, 1973), a common food item for white ibises (Bent, 1926; Palmer, 1962).

Host–Parasite Relationships

When examining the extensive parasite list from the white ibis, it is obvious that a number of infections are of such low prevalence that they cannot be considered as "normal" white ibis parasites. We consider those parasites which reach sexual maturity and occur in 5% or more of the respective host population (i.e., salt or freshwater) to be "normal" for the white ibis parasite fauna. Applying these criteria to the present survey, the parasite list is reduced to 23 species, all of which find the white ibis a suitable host in which to grow and reproduce. The remaining 19 species are considered to represent spurious infections falling into two categories.

The first category includes six species which, regardless of the prevalence of infection, did not mature and were not recognizable as larval forms of any adult specimens recovered. Of those that could be identified, and for which the life cycle is known, evidence suggests that their presence in the white ibis is strictly pas-

Table 2. Prevalence and intensity of helminth infections in white ibises from freshwater and saltwater areas in Florida.

Helminths	Fresh water (90 birds)		Salt water (50 birds)	
	Per cent infection	Mean No. worms per inf. bird	Per cent infection	Mean No. worms per inf. bird
Trematoda				
Stomylotrema vicarium	71	36	62	84
Parastrigea diovadena	59	25	64	288
Patagifer vioscai	25	3	56	5
Posthodiplostomum minimum	18	12	40‡	282
Ascocotyle mcintoshi	0	0	44	174
Parorchis acanthus	0	0	30†	3
Lyperosomum sinuosum	6	4	14†	6
Tanaisia fedtschenkoi	8	8	6	7
Polycyclorchis cudocimi	7	2	6	1
Gynaecotyla adunca	0	0	16	258
Carneophallus turgidus	0	0	12	590
Probolocoryphe glandulosa	0	0	10†	2,230
Ascocotyle ampullacea	0	0	8‡	363
Parvatrema sp.	0	0	4†	8
Acanthoparyphium sp.	0	0	4†	5
Levinseniella sp.	0	0	4	605
Maritrema sp.	0	0	2†	11
Stephanoprora denticulata	0	0	2‡	2
Microparyphium facetum	0	0	2‡	1
Ophthalmophagus sp.	1*	1	0	0
Clinostomum marginatum	0	0	2‡	1
Ornithobilharzia sp.	0	0	2†	1
Cestoda				
Parvitaenia ibisae	74	22	76	95
Microsomacanthus sp.	21	8	12	5
Nematoda				
Tetrameres williamsi	58	15	44	10
Capillaria contorta	28	3	8	3
Strongyloides sp.	20	17	0	0
Larval spirurids	13**	2	0	0
Sciadiocara umbellifera	0	0	20†	11
Skrjabinoclava thapari	4	3	6	2
Ancyracanthopsis coronata	0	0	12†	6
Syncuaria sp.	0	0	4	3
Cyathostoma sp. 1	7**	6	0	0
Contracaecum sp.	0	0	6‡	2
Synhimantus sp.	1**	2	2‡	1
Syngamus trachea	1**	2	0	0
Capillaria sp.	1*	1	0	0
Viktorocara sp.	1**	1	0	0
Cyathostoma sp. 2	1	1	0	0
Sciadiocara chabaudi	1**	1	0	0
Gnathostoma procyonis	1*	1	0	0
Acanthocephala				
Southwellina dimorpha	82	11	46	8

* Restricted to Glades Co. (freshwater birds).
**Restricted to Alachua Co. (freshwater birds).
† Restricted to Manatee Co. (saltwater birds).
‡ Restricted to Levy Co. (saltwater birds).

sive. These parasites develop in intermediate hosts utilized relatively infrequently as a food source by the white ibis.

The second category was represented by 11 species which, although mature and presumably viable, occurred so infrequently (eight species were found in only one host, the remaining three species infected two hosts each) that they were considered as rare members of the parasite fauna in the white ibis. With one exception, those parasites assigned to the second category and which could be identified at the species level occurred more frequently in at least one other avian and/or mammalian host known to have overlapping food or habitat preferences with the white ibis. This ap-

pears to indicate low host specificity as the white ibis is either not inhibitory or only mildly inhibitory towards these species.

The exception is *Sciadiocara chabaudi* Schmidt and Kinsella, 1972, described on the basis of a single male from a common gallinule, *Gallinula chloropus*, and a single female from a purple gallinule, *Porphyrula mortinica*. Thus, to date, only three specimens, from three different hosts, have been recovered. It seems reasonable to conclude that the normal host for this species is yet to be found.

Comparison of Ibises from Fresh- versus Saltwater Habitats

Of the 42 species of helminths recovered, only 24 occurred in birds from fresh water, while 32 species were found in ibises from salt water (Table 2). Both species of cestodes and the acanthocephalan were common to both habitats. Eight species of trematodes were recovered from freshwater ibises, while 21 species were recovered from saltwater birds; 7 species were common to both. Thirteen species of nematodes were recovered from freshwater ibises with 8 species being recovered from saltwater birds; 4 species were common to both. Those parasites that were shared between the two populations were thought to be relatively long-lived compared to the once/year breeding cycle of white ibises. This resulted in species which cycle in estuarine systems being recovered several months postbreeding (when the birds disperse to freshwater marshes), at which time the host was collected in a freshwater system. The converse was true also.

The species which were exclusive to either fresh- or saltwater birds are thought to be short-lived, requiring continual recruiting to maintain their infections in the host.

Comparison of Adults versus Juveniles

Considering only those parasites defined as normal for white ibises, there was a striking similarity in the differences between the adults and juveniles of freshwater birds and the adults and juveniles of saltwater birds. Four parasites (*Polycyclorchis eudocimi*, *Lyperosomum sinuosum*, *Tanaisia fedtschenkoi*, and *Skrjabinoclava thapari*) were found in adult hosts from both fresh and salt water, yet were absent from juvenile hosts in fresh and salt water.

In only one instance were juvenile birds infected with a normal parasite when the corresponding adults were not. This occurred in salt water where four juvenile white ibises were infected with *Ascocotyle ampullacea*.

In general, considering that white ibises are altricial and regurgitative feeders, one would suspect that juvenile birds are exposed to the same parasites as adults. The absence of *L. sinuosum* and *S. thapari* (both of which cycle in estuarine systems) in juveniles from saltwater areas may indicate one of the following: (1) these parasites require the physiological and/or morphological conditions of an adult bird; (2) these parasites are not found in intermediate hosts at that time of the year when the white ibis breeds; (3) during the breeding season the white ibis does not feed on the intermediate host through which these parasites cycle; or (4) the parasite level of infection is very low in the intermediate host.

Hypothesis number 3 is probably false, since *Uca pugilator*, which acts as the intermediate host for *S. thapari* (Kinsella, pers. comm.), was frequently found in the food contents of the ibises collected in salt water during the breeding season.

The complete life cycles of *P. eudocimi*, *T. fedtschenkoi*, and *L. sinuosum* are unknown.

Acknowledgments

The authors wish to thank J. M. Kinsella for advice and criticism throughout the study. L. E. Williams, Jr., and other personnel of the Florida Game and Fresh Water Fish Commission assisted in collecting some of the hosts. The taxonomical assistance of the following is gratefully acknowledged: J. F. Denton, G. Dubois, R. W. Heard, J. C. Holmes, L. T. Hon, H. Madsen, J. C. Pearson, D. B. Pence, and G. D. Schmidt.

Literature Cited

Bârus, V. 1966. Nematodos de la familia Tropisuridae Yamaguti, 1961, parasites de Aves de Cuba. Poeyana, Series A, No. 20: 1–22.

Bent, A. C. 1926. Life histories of North American marsh birds (Orders Odontoglossae, Herodiones, and Paludicolae). U. S. Nat. Mus. Bull. 135.

Bush, A. O., D. B. Pence, and D. J. Forrester. 1973. *Tetrameres* (*Gynaecophila*) *williamsi* sp. n. (Nematoda: Tetrameridae) from the white ibis, *Eudocimus albus*, with notes on *Tetrameres* (*Tetrameres*) *grusi* Shumakovich, from the sandhill crane, *Grus canadensis*. J. Parasit. 59: 788–792.

Courtney, C. H., and D. J. Forrester. 1974. Helminth parasites of the brown pelican in Florida and Louisiana. Proc. Helm. Soc. Wash. 41: 89–93.

Dubois, G., and J. K. Macko. 1972. Contribution à l'étude des Strigeata La Rue, 1926 (Trematoda: Strigeida) de Cuba. Ann. Parasit. 47: 51–75.

Forrester, D. J., A. O. Bush, L. E. Williams, Jr., and D. J. Weiner. 1974. Parasites of greater sandhill cranes (*Grus canadensis tabida*) on their wintering grounds in Florida. Proc. Helm. Soc. Wash. 41: 55–59.

———, ———, **and** ———. 1975. Parasites of Florida sandhill cranes, *Grus canadensis pratensis*. J. Parasit. 61: 547–548.

Heard, R. W. 1970. Parasites of the clapper rail, *Rallus longirostris* Boddaert. II. Some trematodes and cestodes from *Spartina* marshes of the eastern United States. Proc. Helm. Soc. Wash. 37: 147–153.

Hon, L. T., D. J. Forrester, and L. E. Williams, Jr. 1975. Helminths of wild turkeys in Florida. Proc. Helm. Soc. Wash. 42: 119–127.

Hutton, R. F. 1964. A second list of parasites from marine and coastal animals of Florida. Trans. Am. Micros. Soc. 83: 439–447.

———, **and F. Sogandares-Bernal.** 1959. Studies on the trematode parasites encysted in Florida mullets. Special Scientific Report No. 1. Fla. State Board of Conserv. Marine Lab. No. 59-12.

———, **and** ———. 1960. A list of parasites from marine and coastal animals of Florida. Trans. Am. Micros. Soc. 79: 287–292.

Kinsella, J. M. 1972. Helminth parasites of the black skimmer, *Rynchops nigra* from Lake Okeechobee, Florida. J. Parasit. 58: 780.

———. 1974. Helminth fauna of the Florida scrub jay: host and ecological relationships. Proc. Helm. Soc. Wash. 41: 127–130.

———, **and D. J. Forrester.** 1972. Helminths of the Florida duck, *Anas platyrhynchos fulvigula*. Proc. Helm. Soc. Wash. 39: 173–176.

Lumsden, R. D. 1961. The white ibis, *Eudocimus albus* (Linn.), host for the diplostomatic trematode *Fibricola cratera* (Barker and Noll, 1915) Dubois, 1932, in Louisiana. J. Parasit. 47: 897.

———. 1962. Four echinostome trematodes from Louisiana birds including the description of a new species. Tul. Stud. Zool. 9: 301–308.

———, **and J. A. Zischke.** 1963. Studies on the trematodes of Louisiana birds. Z. Parasit. 22: 316–366.

Miller, G. C., and R. Harkema. 1962. Studies on helminths of North Carolina vertebrates. II. *Ascocotyle ampullacea* sp. n. (Trematoda: Heterophyidae) from raccoons. J. Parasit. 48: 427–428.

Palmer, R. S. (ed.). 1962. Handbook of North American Birds. Vol. 1. Yale Univ. Press, New Haven and London.

Pence, D. B., and A. O. Bush. 1973. *Polycyclorchis eudocimi* gen. et sp. n. (Trematoda: Cyclocoelidae) from the trachea of the white ibis, *Eudocimus albus* L. J. Parasit. 59: 85–89.

Price, E. W. 1936. A new heterophyid trematode of the genus *Ascocotyle* (Centrocestinae). Proc. Helm. Soc. Wash. 3: 31–32.

Schmidt, G. D. 1973. Resurrection of *Southwellina* Witenberg, 1932, with a description of *Southwellina dimorpha* sp. n. and a key to genera in Polymorphidae (Acanthocephala). J. Parasit. 59: 299–305.

———, **and A. O. Bush.** 1972. *Parvitaenia ibisae* sp. n. (Cestoidea: Dilepididae), from birds in Florida. J. Parasit. 58: 1095–1097.

———, **and J. M. Kinsella.** 1972. Two new species of *Sciadiocara* Skrjabin, 1915 (Nematoda: Schistorophidae) from birds in Florida. J. Parasit. 58: 271–274.

Travassos, L., J. F. Teixeira de Freitas, and A. Kohn. 1969. Trematodeos do Brasil. Mem. Inst. Oswaldo Cruz 67: 1–886.

Torquatoides crotophaga Williams, 1929 (Nematoda: Spiruridae: Habronematinae), from Cuculiform Birds in Texas

DANNY B. PENCE AND STANLEY CASTO
Department of Veterinary and Zoological Medicine,
Texas Tech University School of Medicine, Lubbock, Texas 79409

ABSTRACT: New host and geographic records are established for *Torquatoides crotophaga* Williams from the gizzard of the roadrunner, *Geococcyx californianus*, and the groove-billed ani, *Crotophaga sulcirostris*, from Texas. A redescription of this species from North American hosts is provided and the affinities of *Torquatoides* with related genera of the Habronematinae are discussed.

Nematodes were recovered from under the koilon of the gizzard of the roadrunner and groove-billed ani collected in South Texas. These were identified as *Torquatoides crotophaga Williams*, 1929. Since the only previous records for this nematode are from the smooth-billed ani, *Crotophaga ani*, in Panama (Williams, 1929) both the above avian species represent new host records. Additionally, this is the first report of the genus *Torquatoides* outside the tropics. Because the original description by Williams (1929) is based on very few specimens (one male and four females) and the recent referral of this and the closely allied genus *Viguiera* to the Spiuridae (Habronematinae) from the Acuariidae (Chabaud, 1960; Inglis, 1965), the following redescription is presented in order to better elucidate the range of morphometrical variation and to clarify certain morphological features of the cephalic extremity.

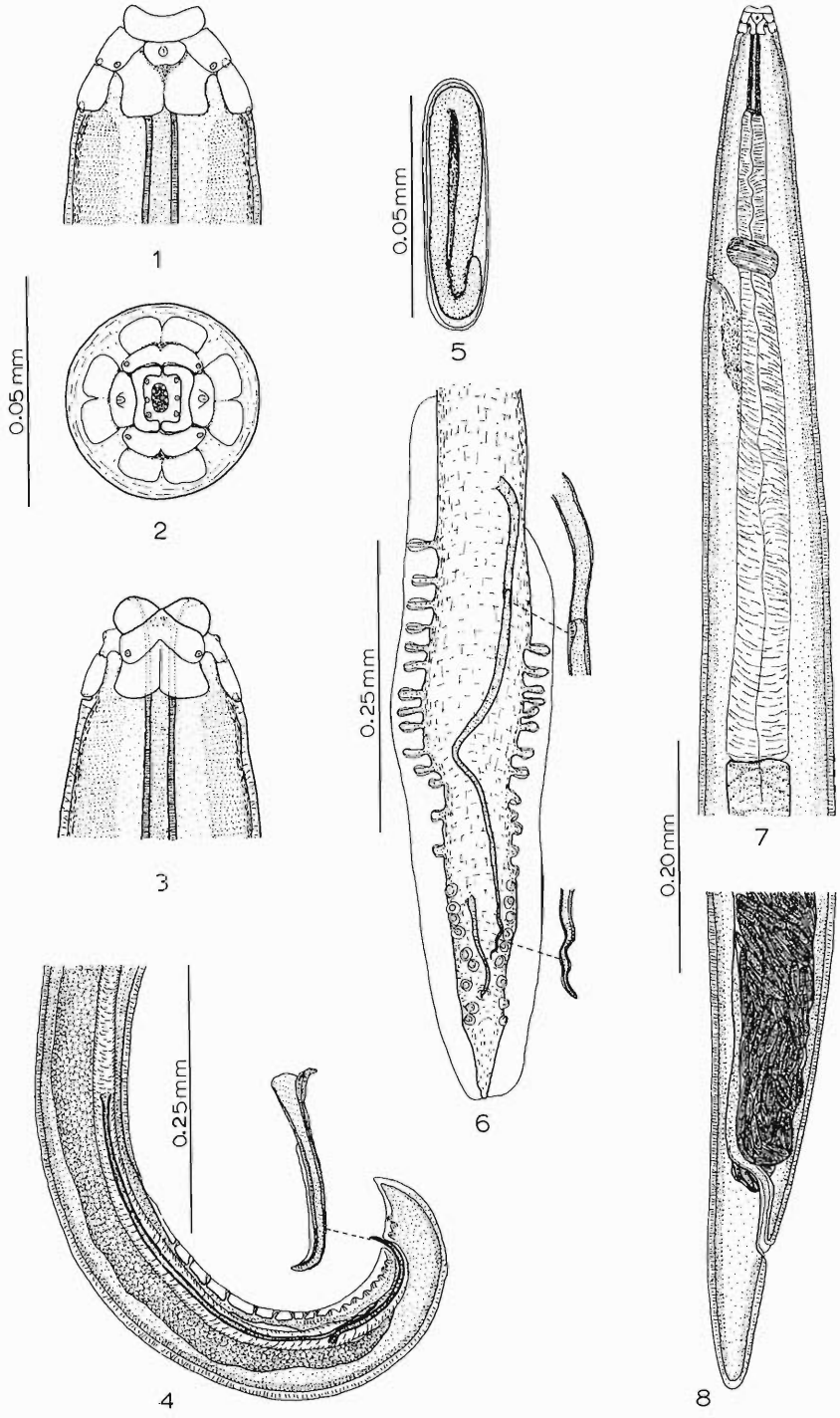
Nematodes were fixed in glacial acetic acid, stored in a mixture of 70% ethyl alcohol containing 5% glycerin by volume, and studied in glycerin mounts after evaporation of the alcohol. Drawings were made with the aid of a Leitz drawing tube. In the following description all measurements are in microns unless otherwise indicated. The means follow in parentheses the range of values of measurements.

Torquatoides crotophaga Williams, 1929 (Figs. 1–8)

DESCRIPTION: Spiruridae Oerley, 1885, Habronematinae Chitwood and Wehr, 1932, *Torquatoides* Williams, 1929 (= *Torquatella* York and Maplestone, 1926). With characters of the genus. Long, slender white nematodes slightly tapering toward anterior and posterior extremities (Figs. 7, 8). Cuticle thick, very lightly striated transversely, transparent, with lateral alae arising a short distance posterior to cephalic extremity. Oral opening dorsoventrally elongate, with five pairs of teeth on anterior border of each pseudolabium. Two lateral concave trilobed pseudolabia delimit oral opening anteriorly. Three pairs small papillae in inner circle surrounding oral opening (Fig. 2). More posteriorly, pseudolabia give rise to a series of plates which form a shieldlike covering over cephalic extremity. Two small platelets each bearing an amphid located laterally to pseudolabia (Figs. 1–3). Labia located dorsoventrally, each consisting of a plate with two lobes (Fig. 3). Four papillae in inner circle, one papilla located submedially on each of two lobes of labium (Fig. 2). Pharynx long, cuticularized. Esophagus with muscular and glandular portions. Deirids lateral just below level of nerve ring. Excretory pore ventral at level of or just below nerve

→

Figures 1–8. ***Torquatoides crotophaga*** **Williams. 1. Female anterior extremity, lateral view. 2. Female *en face* view. 3. Female anterior extremity, dorsal view. 4. Male posterior extremity, lateral view. 5. Egg. 6. Male posterior extremity, ventral view. 7. Female anterior extremity. 8. Female posterior extremity.**



ring (Fig. 7). Vulva near middle of body displaced to left of medioventral line. Ovejector short, muscular near vagina becoming more glandular distally and ultimately divided into uterine branches. No caudal papillae in female, tail short and blunt-tipped (Fig. 8). Posterior extremity of male slightly twisted but not spirally coiled, with asymetrical caudal alae (Figs. 4, 6). Nineteen to 20 pairs of preanal papillae varying in size and structure, from anus anteriorly, as small and sessile to large and pedunculate. Two pairs sessile postanal papillae (Fig. 6). Spicules unequal and dissimilar; right spicule shorter and stouter slightly alate in proximal portion, left spicule longer and more slender without alate portion, both spicules sharp-tipped (Figs. 4, 6). Gubernaculum absent. Tail of male short, with pointed tip. Eggs elongate, flattened, oval in cross section, containing a well-developed larva (Fig. 5).

MALE (based on 5 specimens): 5.95 to 7.07 (6.49) mm long, 72 to 101 (91) wide (maximum). Pharynx 65 to 75 (70) long. Esophagus 1.43 to 1.83 (1.69) mm long. Nerve ring, excretory pore, and deirids 128 to 165 (147), 128 to 160 (148), and 145 to 195 (170) from anterior extremity, respectively. Right and left spicules 115 to 154 (143) and 410 to 508 (447) long, respectively. Ratio of right to left spicules 1:2.9 to 1:3.8 (1:3.2). Tail 48 to 53 (51) long.

FEMALE (based on 10 specimens): 18.41 to 20.63 (19.39) mm long, 149 to 174 (161) wide (maximum). Pharynx 75 to 99 (88) long. Esophagus 2.33 to 2.91 (2.63) mm long. Nerve ring, excretory pore, and deirids 150 to 212 (180), 149 to 228 (193), 120 to 224 (186) from anterior extremity, respectively. Vulva 4.26 to 6.45 (5.68) mm from anterior extremity. Tail 112 to 124 (120) from posterior extremity. Eggs 48 to 64 (56) long, 9 to 16 (14) wide.

HOSTS: Roadrunner, *Geococcyx californianus*, and groove-billed ani, *Crotophaga sulcirostris*.

LOCATION: Under koilon of gizzard.

LOCALITY: Millett, LaSalle County, Texas. 4 ♂♂, 6 ♀♀, and 3 ♀♀ worms from two of six roadrunners collected 29 May 1974 by D. B. Pence and 1 ♂ and 2 ♀♀ nematodes from one of one groove-billed ani collected 30 May 1974 by S. D. Casto.

DISPOSITION OF SPECIMENS: 1 ♂ and 1 ♀ USNM Helm. Coll. No. 73814. Remaining specimens in collection of authors.

PATHOLOGY: There was no observed gross pathology.

Remarks

Yamaguti (1961) proposed the name *Cathematella* for *Torquatella* York and Maplestone, 1926, since the latter is preoccupied. However, as correctly pointed out by Inglis (1965), Williams (1929) proposed the name *Torquatoides* for a subgenus of *Torguatella* with *Spiroptera balanocephala* Gendre, 1922, as the type species. Since this species is referred to the genus *Torquatella* (Chabaud, Brygoo, and Durette, 1963) and is included by Yamaguti (1961) in *Cathematella* the latter must fall as a synonym for *Torquatoides* Williams, 1929. Thus, in the present work the above conclusions of Inglis (1965) are followed and the name *Torquatoides* is used as the only available replacement for *Torquatella* York and Maplestone, 1926.

The genus *Torquatella* (= *Torquatoides*) was divided by Williams (1929) into the subgenera *Torquatella* with *T.* (*T.*) *torquata* Gendre, 1922, as the type species and *Torquatoides* with *T.* (*T.*) *balanocephala* Gendre, 1922, as the type species. The subgenera were differentiated by the presence of lateral alae and only four cephalic papillae in *Torquatella* while there were not lateral alae and eight head papillae in *Torquatoides*. However, Chabaud et al. (1963) demonstrated that the ventral papillae of Gendre (1922) on the submedian axis of the lateral angles of the labia were small plates rather than papillae. The only remaining character for separation of the genus into subgenera is the presence of lateral alae. Thus, until more fully understood it seems premature to divide this genus past the species level on the basis of a single character.

As pointed out by Willams (1929) *Torquatoides crotophaga* is most closely related to *T. torquata*. The two species differ in (1) there are only 13 pairs of preanal papillae in *T. torquata* (17–20 in *T. crotophaga*), (2) there are three pairs of postanal papillae in *T. torquata* (two pairs in *T. crotophaga*), (3) there is a gubernaculum in *T. torquata* (absent

in *T. crotophaga*), and (4) the spicules are larger in *T. crotophaga*. *Torquatoides torquata* as well as *T. balanocephala* are described from birds in Central Africa (Gendre, 1922a, b; Chabaud, 1960). *Torquatoides conocephala* described from Brazil by Molin (1860) is so poorly known that Williams (1929) placed it in *species inquirenda*.

Discussion

That the affinities of the several genera of gizzard worms of the families Spiruridae (Habronematinae) and Acuariidae (Schistorophorinae) are difficult to determine because of morphologically grossly similar structures in the cephalic region has long been recognized. The recent review by Inglis (1965) contributed significantly toward a better understanding of the interrelationships of these two groups of spiruroids. It was Chabaud (1960) who first noted that the head of *Viguiera* was typical of the Habronematinae rather than the Schistorophorinae in which it was previously placed. It was later demonstrated after a careful study of *Torquatoides balanocephala* that this genus was closely allied to *Viguiera* and that its cephalic extremity was typical of the Habronematinae as well (Chabaud et al., 1963). The present study confirms these observations and demonstrates that the cephalic extremity of *T. crotophaga* is typical of the Habronematinae in that the four papillae of the outer circle are on the labia which are large single dorsal and ventral plates. This is in contrast to the Schistorophorinae (Acuariidae) in which the cephalic papillae are on the pseudolabia and all the cephalic elaborations are modifications of the pseudolabia. Thus, with more critical studies of the cephalic extremities, particularly utilizing *en face* views, resolution of the affinities of the numerous allied genera in the Schistorophorinae and Habronematinae will undoubtedly be forthcoming.

The genus *Torquatoides* has thus far been reported only from the host orders Cuculiformes (Cuculidae) and Coraciiformes (Meropidae). Host records include *Torquatoides conocephala* Molin from *Cuculus cayanus* in Brazil (Molin, 1860), *T. torquata* Gendre from *Centropus monachus* in Central Africa (Gendre, 1922), *T. crotophaga* Williams from *Crotophaga ani* in Panama (Williams, 1929) and *Geococcyx californianus* and *Crotophaga subcirostris* from Texas (present study), and *T. balanocephala* Gendre from *Merops malimbicus* from Central Africa (Gendre, 1922b) and *Merops superciliosus* from Madagascar (Chabaud et al., 1963). Although this appears to be the predominant genus of gizzard worms in cuculiform birds, it is interesting to note that there is a single species of the allied genus *Viguiera*, *V. coccyzae* Pence, reported from the yellow-billed cuckoo, *Coccyzus americanus*, in Louisiana (Pence, 1973).

Host specificity in this genus (limited to cuculiform and coraciiform birds) may be a predominant factor in its limited distribution since the number of species in both host families greatly increase in the tropical areas of the world. However, the assumption of Williams (1929) that *Torquatoides* is purely tropical in distribution is disproven by the present study in which *T. crotophaga* is reported from two hosts endemic in the subtropics of North America.

Acknowledgments

The authors express sincere appreciation to Mr. John Casto for assistance in collection of the birds examined in this study.

Literature Cited

Chabaud, A. G. 1960. Quatre spirurides parasites d'oiseaux malgaches. Mem. Inst. Sci. Madagascar 14: 105–124.

———, **E. R. Brygoo, and M. C. Durette.** 1963. Spirurides parasites d'oiseaux malgaches. Ann. Parasit. 38: 93–108.

Gendre, E. 1922a. Sur un helminthe peu connu *Spiroptera conocephala* Molin. Soc. Linn. Bordeaux 73: 92–98.

———. 1922b. Sur deux spiropteres nouveaux, voisins de *Spiroptera conocephala* Molin. Soc. Linn. Bordeaux 73: 132–136.

Inglis, W. G. 1965. The nematodes parasitic in the gizzard of birds: A study in morphological convergence. J. Helminth. 39: 207–224.

Molin, R. 1860. Una monografia del genere Spiroptera. Sitzungsch. Akad. Wissensch., math-naturu. cl. 38: 911–1005.

Pence, D. B. 1973. Two new gizzard worms from Louisiana birds, *Viguiera coccyzae* sp. n.

from *Coccyzus americanus* and *Viguiera pari* sp. n. from *Parus carolinensis* and *Parus bicolor* (Nematoda: Spiruridae). Proc. Helm. Soc. Wash. 40: 102–107.

Williams, O. O. 1929. Revision of the nematode genus *Torquatella* with a description of *Torquatella crotophaga* sp. nov. Univ. Cal. Pub. Zool. 33: 169–178.

Occurrence of *Ascarophis* (Nematoda: Spiruridea) in *Callianassa californiensis* Dana and Other Decapod Crustaceans

GEORGE O. POINAR, JR. AND GERARD M. THOMAS

Division of Entomology and Parasitology, University of California, Berkeley, California, 94720; and The Bodega Marine Laboratory, University of California, Bodega Bay, California 94923

ABSTRACT: Four species of *Ascarophis* were collected from the hemocoel of decapod crustaceans in California and Washington. Two species were found in the hemocoel of *Callianassa californiensis* Dana. One species was recovered from the body cavity of *Pagurus samuelis* (Stimpson) and *P. granosimanus* (Stimpson), and a fourth species was found in *Pachycheles pubescens* Holmes and *Pugettia producta* (Randall). The infective stage juveniles of the first three species are described. The nematodes occurred in capsules produced by the crustacean host.

Adults of the spirurid genus *Ascarophis* occur in the alimentary tract of marine fish or elasmobranchs. Except for the following reports, the intermediate hosts of the majority of *Ascarophis* species are unknown. Uspenskaya (1953) recovered *A. filiformis* Poljansky and *A. morrhuae* Beneden from decapod crustacea, and Petter (1970) found the latter nematode in the crab, *Carcinus maenas* Penn. Uzmann (1967) described an *Ascarophis* sp. from *Homarus americanus* and Feigenbaum (1973) recorded this genus of parasites from *penaeus* shrimp. Tsimbalyuk et al. (1970) found *A. pacificus* in crustacea on the shores of the Sea of Okhotsk, while Poinar and Kuris (1975) discussed the effect of an *Ascarophis* infection on the shore crab, *Hemigrapsus oregonensis* (Dana), in California.

The following paper discusses the incidence of *Ascarophis* infection in *Callianassa californiensis* and other decapod crustacea in California and Washington and describes the infective-stage juveniles of three *Ascarophis* species encountered.

Materials and Methods

The majority of decapod crustaceans sampled for *Ascarophis* infections were collected from the region of Bodega Bay, California, from 1972–75. A list of these crustaceans is presented in Table 1. Representatives from this list were also collected from Hood Canal, Washington.

The hosts were carefully dissected in seawater and examined for nematodes. Host capsules containing parasites were removed, opened, and the nematodes killed in hot (80C) seawater. The specimens were then fixed in TAF and processed to glycerin for examination.

Because of the abundance of *Callianassa californiensis* Dana and the high incidence of *Ascarophis* in this host, additional data were obtained from host populations collected near Gaffney Point at Bodega Bay.

Results

All nematodes found in the decapod crustaceans sampled belonged to the genus *Ascarophis*. The incidence of infection for the various hosts is given to Table 1. All nematodes were in the infective stage and four separate species could be distinguished on the basis of morphology.

Two species of *Ascarophis* occurred in *Callianassa californiensis* (Table 1). Both species

A and B were located in granular capsules attached to the wall of the pyloric stomach (Figs. 1, 2). Since adult nematodes were not available, identification was not possible, and the juveniles were distinguished on morphological features. The smaller species (B) was more abundant than the larger (A), and the incidence of infection for both ranged from 0–75%. The factors determining the rate of infection were not clear; however, larger adult hosts were more commonly infected than the smaller juveniles. Up to 20 specimens of species B were collected from a single host, whereas usually only one or two specimens of species A occurred in infected *Callianassa*. Rarely both species occupied the same capsule. The capsules varied from spherical to elliptical in shape and ranged from 0.3–1.8 mm to 1.0–3.6 mm in size. Most capsules were of sufficient thickness to prevent the nematode from escaping, although the parasite moved about easily in the central cavity. Electron microscopic studies showed that the capsules were formed by muscle cells responding to the parasite. Further details on this host reaction are reported elsewhere (Poinar and Hess, in press).

A description of the two species of juvenile *Ascarophis* recovered from *C. californiensis* is given below. In the quantitative portion of the description, the number following the character represents the average value for that character while the numbers in parentheses show the range. All measurements are given in microns unless otherwise specified.

Table 1. Incidence of *Ascarophis* infections in decapod crustaceans collected from Bodega Bay, California.

Crustacean	No. examined	No. infected with *Ascarophis*	Mean % infected
Callianassa californiensis Dana	77	26	33.8
Cancer antennarius Stimpson	2	0	0
Cancer gracilis Dana	4	0	0
Cancer magister Dana	11	0	0
Cancer productus Randall	10	0	0
Emerita analoga (Stimpson)	6	0	0
Hemigrapsus nudus (Dana)	25	0	0
Pachycheles pubescens Holmes	11	2	18.2
Pachygrapsus crassipes Randall	14	0	0
Pagurus granosimanus (Stimpson)	19	1	5.3
Pagurus hirsutiusculus (Dana)	67	0	0
Pagurus samuelis (Stimpson)	81	7	8.6
Petrolisthes cinctipes (Randall)	9	0	0
Petrolisthes eriomerus Stimpson	7	0	0
Pugettia producta (Randall)	11	1	9.1
Upogebia pugettensis (Dana)	24	0	0

Description of *Ascarophis* species A. *Ascarophis* Beneden (Hedruridae: Spirurida) (Figs. 2, 3–5)

The nematodes occur in granular capsules attached to the pyloric stomach; cuticle with yellowish tinge, smooth or with fine annules; head containing four papillae and two amphids; lateral lips project up and inward; mouth opening elliptical; rectal cells distinct; caudal mucron indistinct. Quantitative data ($n = 8$): Length, 8 (6–10) mm; greatest width, 156 (123–192); width at head, 28 (23–31); length of stoma, 78 (52–87); length of muscular portion of pharynx, 432 (317–480); length of glandular portion of pharynx, 1,552 (1,200–1,700); distance from head to nerve ring, 140 (108–154); distance from head to excretory pore, 198 (169–216); length of tail, 104 (78–130); length of indistinct mucron at tip of tail, 3.5 (2–5); width of mucron, 6 (5–7).

Description of *Ascarophis* species B (Figs. 1, 6–8)

Cuticle with whitish tinge, smooth or with fine annulations; head containing four papillae and two amphids; lateral lips project up and inward; mouth opening elliptical; rectal cells distinct; caudal mucron not pronounced. Quantitative data ($n = 10$): Length, 3.7 (3.5–4.0) mm; greatest width, 78 (65–92); width at head, 15; length of stoma, 96 (90–102); length of muscular portion of pharynx, 374 (347–400); length of glandular portion of pharynx, 947 (847–1,078); distance from head to nerve ring, 142 (123–171); distance from head to excretory pore, 194 (162–244); length

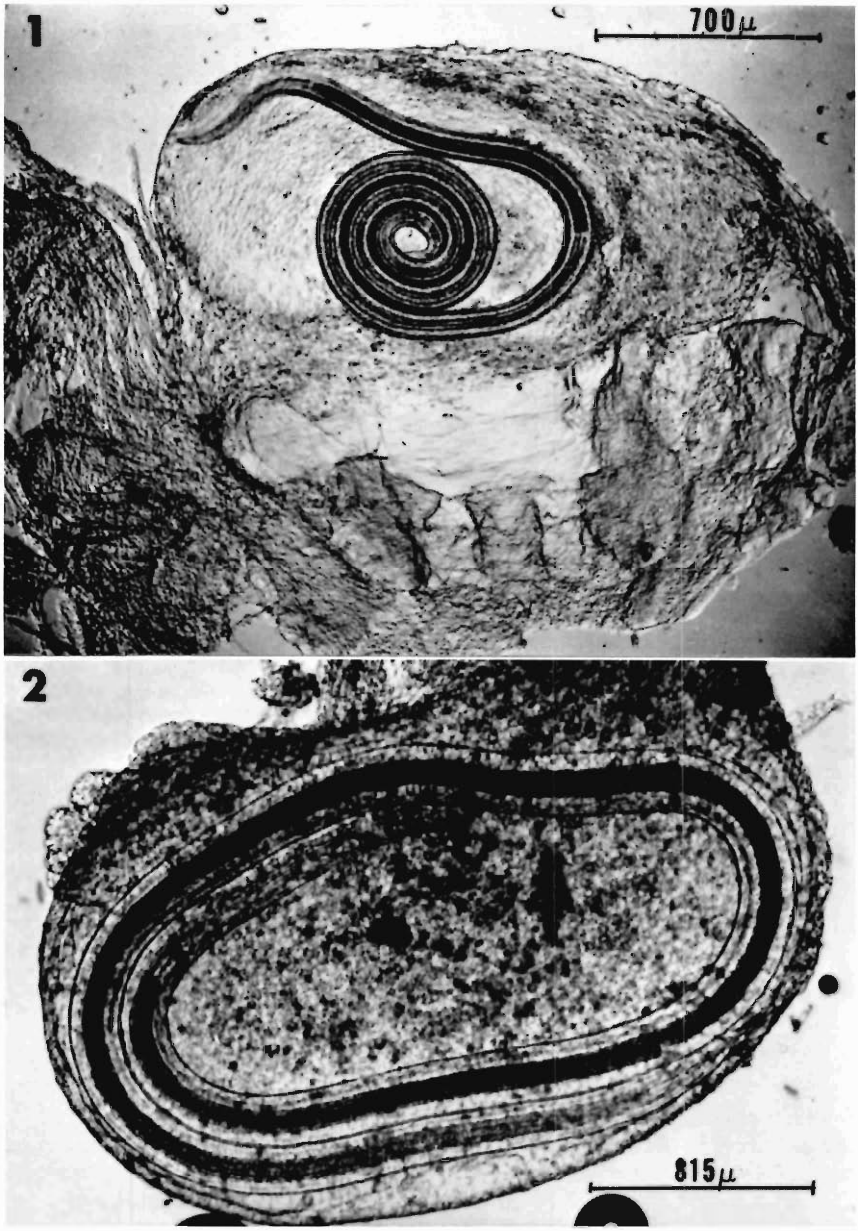


Figure 1. *Ascarophis* species B enclosed in a host capsule attached to the pyloric stomach of *Callianassa californiensis.*

Figure 2. *Ascarophis* species A enclosed in a host capsule connected to the pyloric stomach of *C. californiensis.*

of tail, 83 (53–110); length of mucron at tip of tail, 7 (3–13); width of mucron, 7 (6–13).

DIAGNOSIS: The two above-described juveniles differ from those of *A. morrhuae* Beneden and *A. pacificus* Zhukov by lacking a zone of cuticular serrations. They differ from the *Ascarophis* that occus in *H. oregonensis* and other crabs by their shorter length, shorter muscular and glandular portions of the pharynx, and shorter distances from their head to nerve ring and excretory pore. They differ from the juveniles of *A. filiformis* by their shorter stoma length. The *Ascarophis* sp. described by Uzmann (1967) in the American lobster has a longer glandular portion of the pharynx and a greater distance from the head to nerve ring and excretory pore than the *Callianassa* juveniles. Specimens studied here all came from infected *Callianassa* at Bodega Bay. The same hosts ($n = 28$) sampled at Hood Canal, Washington, were free from nematode infection.

A third species of *Ascarophis* occurred in specimens of *Pagurus samuelis* and *P. granosimanus* (Table 1). These nematodes occurred in fine capsules generally attached to the dorsal wall of the abdomen near the junction of the cephalothorax.

Some capsules were located next to the dorsal wall of the abdominal muscle. The incidence of infection was low, and although *P. hirsutiusculus* occurred in the same habitat as the other two species, it was never found infected with *Ascarophis*.

DESCRIPTION: Third-stage *Ascarophis* juveniles from *Pagurus* spp. (Figs. 9–11). White nematodes coiled in membranous capsules of their host; cuticle smooth except for a zone of serrations starting shortly behind the excretory pore and continuing to about one-half the length of the glandular pharynx; head with four papillae and two amphids; lateral lips projected up and inward; rectal cells and caudal mucron distinct. Quantitative data ($n = 10$): Length, 8.5 (6.9–10.6) mm; greatest width, 74 (69–77); width at head, 15 (11–15); length of stoma, 154, (143–169); length of muscular portion of pharynx, 704 (639–770); length of glandular portion of pharynx, 3,025 (2,541–3,388); distance from head to nerve ring, 182 (146–200); distance from head to excretory pore, 234 (216–254); length of tail, 104 (84–115); length of mucron at tip of tail, 14 (11–16); width of mucron, 7 (6–9).

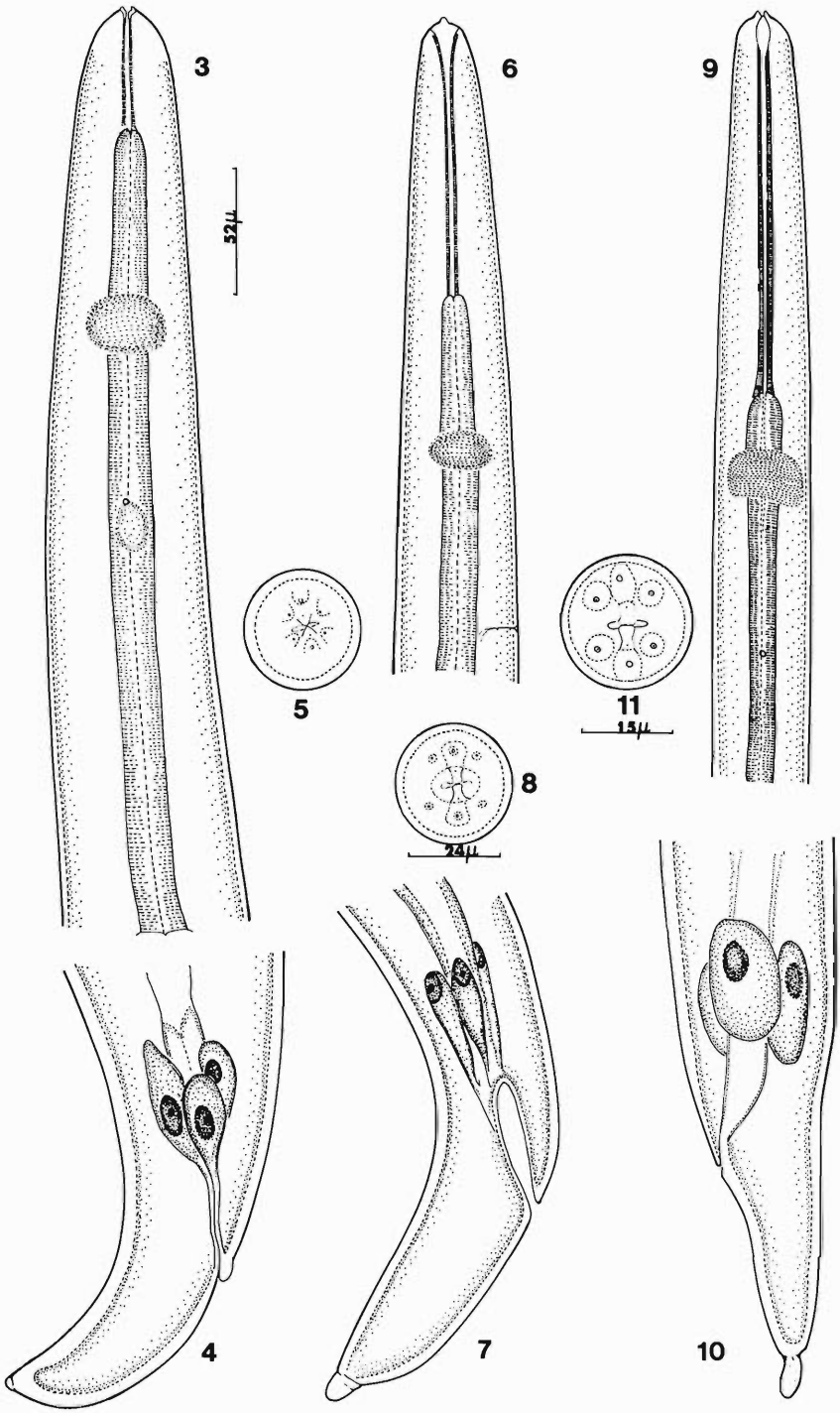
DIAGNOSIS: The presence of a zone of cuticular serrations separates this species from all other described *Ascarophis* juveniles except *A. pacificus* and *A. morrhuae*. However, the present species possesses a longer muscular and glandular pharynx than the above two species. It is closest in morphology to *A. pacificus*.

A fourth species of *Ascarophis* was recovered from *Pugettia producta* and *Pachycheles pubescens* (Table 1). This species was identical to the previously described juveniles collected from *Hemigrapsus oregonensis* and *Pachycheles rudis* (Poinar and Kuris, in press). The nematodes were enclosed in host capsules that were associated with the hepatopancreas in *P. pubescens*. In *P. producta*, the capsules occurred on the pyloric stomach, mouthparts, and under the carapace. This species was also collected from *P. producta* at Hood Canal, Washington (three infected out of 28).

Discussion

The findings reported here represent new host records in relation to *Ascarophis* infections. Previous authors reporting *Ascarophis* infections in decapods (Tsimbalyuk et al., 1970; Petter, 1970; Uspenskaya, 1953; Feigenbaum, 1973) did not mention finding the nematodes in host capsules. In fact host reactions by crustaceans to spirurid nematodes are considered rare, although Uzmann (1967) found an *Ascarophis* coiled in "lenticular cysts" in the American lobster. In the present study, all nematodes recovered from the hemocoel of decapods were contained in granular host capsules, similar in part to responses produced by insects to spirurid nematodes (Poinar, 1969). The two instances in *C. californiensis* when *Ascarophis* was not in these typical granular, thick capsules resulted in encapsulation by host blood cells. These nematodes were moribund and may have been eventually killed by the reaction (Poinar and Hess, in press).

Such effective hemocytic host reactions may explain the apparent host specificity of these *Ascarophis* infections. Although the range of the crustacean hosts overlaps geographically and ecologically, thus allowing various decapods equal access to *Ascarophis* eggs, a definite



infection pattern occurs. Thus, the two nematode species in *C. californiensis* were found only in this host whereas the species in *Pagurus* spp. was found only in hermit crabs. Only the fourth species shows a wider host distribution. Although the "habitual" or preferred invertebrate host of the latter is *H. oregonensis*, the nematodes also develop to the infective stage in *Pachycheles* spp. and *P. producta*. Again, however, other decapods sharing the same habitat (even under the same rock) as *H. oregonensis*, such as *H. nudus*, *P. crassipes*, *P. cinctipes*, and *P. eriomerus* were never found to be infected. A second possible explanation for this infection pattern could be different food preferences of the decapods under question. However, this explanation seems less plausible. Perhaps further information on this point will become available when the definitive hosts are collected and their habits revealed.

There was no sign of physical damage to any of the infected crustaceans investigated here. However, detailed data of the effect on the crustaceans were not taken. Only Poinar and Kuris (in press) presented results indicating that *Ascarophis* infections decrease the rate of growth and possibly increase the mortality among older, larger individuals of *H. oregonensis*. It is possible that heavily infected decapods, in general, are more susceptible to predation by potential vertebrate hosts.

Acknowledgments

The authors thank Armand M. Kuris and John Cornell of the Bodega Bay Marine Laboratory for calling their attention to *Ascarophis* infections in decapod crustaceans they were studying and to Dennis Sullivan for help in collecting infected specimens. Grateful appreciation also is given to Dr. Annie J. Petter, Museum National d'Histoire Naturelle, Paris, for confirming the identifications of *Ascarophis*.

Literature Cited

Feigenbaum, D. L. 1973. Parasites of the commercial shrimp, *Penaeus vannamei* Boone and *Penaeus brasiliensis* Latreille. M.S. thesis, The University of Miami, Coral Gables, Florida, 84 p.

Petter, A. J. 1970. Quelques spirurides de poissons de la région nantaise. Ann. Parasit. Hum. Comp. 45: 31–46.

Poinar, Jr., George O. 1969. Arthropod immunity to worms. *In* "Immunity to Parasitic Animals," Vol. 1, p. 173 (G. Jackson, R. Herman, and I. Singer, eds.). Appleton-Century-Crofts, New York.

———, **and Roberta Hess.** (In press.) Cellular responses in decapod crustaceans to *Ascarophis* spp. (Spirurida: Nematoda). Comparative Pathobiol.

———, **and Armand M. Kuris.** (In press.) Juvenile *Ascarpohis* (Spirurida: Nematoda) parasitizing intertidal decapod crustacea in California with notes on prevalence and effects on host growth and survival. J. Invertebr. Pathol.

Tsimbalyuk, E. M., V. V. Kulikov, and A. K. Tsimbalyuk. 1970. A contribution to the biology of *Ascarophis pacificus* (Nematoda, Ascarophididae). Zool. Zh. 49: 1874–1875 (in Russian).

Uspenskaya, A. V. 1953. Life cycle of nematodes of the genus *Ascarophis* van Beneden (Nematodes-Spirurata). Zool. Zh. 32: 828–832 (in Russian).

Uzmann, J. R. 1967. Juvenile *Ascarophis* (Nematoda: Spiruroidea) in the American lobster, *Homarus americanus*. J. Parasit. 53: 218.

←

Figure 3. Ventral view of the anterior portion of *Ascarophis* species A from *C. californiensis*.

Figure 4. Lateral view of the tail of *Ascarophis* species A from *C. californiensis*. Mag. same as Fig. 3.

Figure 5. *En face* view of *Ascarophis* species A from *C. californiensis*. Mag. same as Fig. 3.

Figure 6. Lateral view of the anterior portion of *Ascarophis* species B from *C. californiensis*. Mag. same as Fig. 3.

Figure 7. Lateral view of the tail of *Ascarophis* species B from *C. californiensis*. Mag. same as Fig. 3.

Figure 8. *En face* view of *Ascarophis* species B from *C. californiensis*.

Figure 9. Ventral view of the anterior portion of *Ascarophis* from *Pagurus* spp. Mag. same as Fig. 3.

Figure 10. Lateral view of the tail of *Ascarophis* from *Pagurus* spp. Mag. same as Fig. 3.

Figure 11. *En face* view of *Ascarophis* from *Pagurus* spp.

Proteocephalus buplanensis sp. n. (Cestoda: Proteocephalidae) from the Creek Chub, *Semotilus atromaculatus* (Mitchill), in Nebraska[1]

MONTE A. MAYES

School of Life Sciences, University of Nebraska–Lincoln, and Division of Parasitology, Harold W. Manter Laboratory, University of Nebraska State Museum, Lincoln, Nebraska 68588

ABSTRACT: *Proteocephalus buplanensis* sp. n. differs from *P. ptychocheilus*, *P. cobraeformis*, and *P. torulosus* by the presence of a vestigial apical sucker; from *P. percae* and *P. pearsei* by having larger suckers and testes distributed in two layers.

There are numerous reports of *Proteocephalus* spp. from the creek chub, *Semotilus atromaculatus* (Mitchill), but none has been identified to species (Amin, 1975; Anthony, 1963; Fischthal, 1950; Hoffman, 1953; Voth and Larson, 1968). Species of *Proteocephalus* which have been reported from other cyprinid fishes (Dechtiar, 1972; Kennedy, 1974; Freze, 1965) include *P. cobraeformis* Haderlie, 1953; *P. osculatus* (Goeze, 1782) Nybelin, 1942; *P. pearsei* LaRue, 1919; *P. ptychocheilus* Faust, 1920; *P. sagittus* (Grimm, 1872) LaRue, 1911; *P. torulosus* (Batsch, 1786) Nufer, 1905. The following species of *Proteocephalus*, which was found in four of 57 creek chubs, is the first proteocephalid tapeworm to be reported from the fishes of Nebraska.

Materials and Methods

Hosts were collected by seine and dissected soon thereafter. Tapeworms were removed, relaxed in iced creek water, fixed in AFA for 24 hr, and stored in 70% ethanol. Whole mounts were stained with Meyer's hematoxylin; others were sectioned at 10 μ and stained with hematoxylin and eosin; all material was dehydrated in ethanol, cleared, and mounted in Canada balsam. Measurements, based on 25 examples except for 125 testes and six scolices, are in microns unless otherwise indicated; the range is followed by the average in parentheses. Figures were prepared with the use of a camera lucida.

[1] Supported in part by a contribution of Federal Aid in sport fish restoration, Project F-4-R, Nebraska and the Nebraska Game and Parks Commission.

Proteocephalus buplanensis sp. n. (Figs. 1–5)

HOST: *Semotilus atromaculatus* (Mitchill).

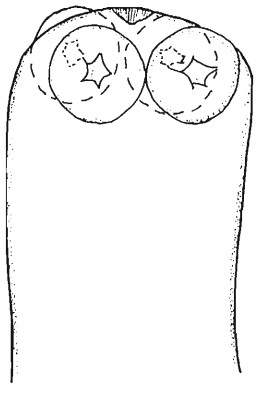
TYPE LOCALITY: Niobrara River, one-half mile east of Box Butte Reservoir, Dawes County. Other locality: Minnechaduza Creek, 1 mile east of Crookston, Cherry County.

TYPE SPECIMENS: USNM Helm. Coll. No. 73294 (holotype) and No. 73295 (paratype); other paratypes, University of Nebraska State Mus. Manter Lab. Nos. 20263 and 20264 and in the author's collection.

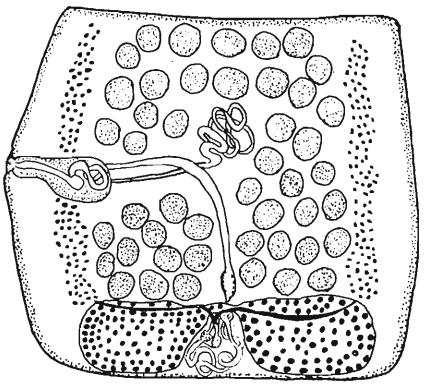
DESCRIPTION (based on six nearly complete worms): Body unspined, length of most complete strobila 140 mm, maximum width 1.26 mm. Scolex slightly wider than neck, width 405–632 (554); lateral suckers well developed, diameter 212–280 (246); apical sucker vestigial, diameter 76–88 (81). Neck short, length 450–745 (560). Immature and mature proglottids wider than long; latter, length 520–800 (669), width 880–1,060 (977), ratio of length to width 1 : 1.18–1.35 (1 : 1.27); gravid proglottids longer than wide, length 900–1,360 (1,187), width 840–1,260 (1,030), ratio of length to width 1 : 0.91–1.08 (1 : 0.96). Genital pores marginal, slightly anterior to middle of proglottid, irregularly alternate. Cirrus pouch

→

Figures 1–5. ***P. buplanensis*: 1. Scolex. 2. Mature proglottid. 3. Gravid proglottid. 4. Cross section of mature proglottid. 5. Details of region of ovary and oviduct. Abbreviations: O, ovary; OD, oviduct; SR, seminal receptacle; VR, vitelline reservoir.**

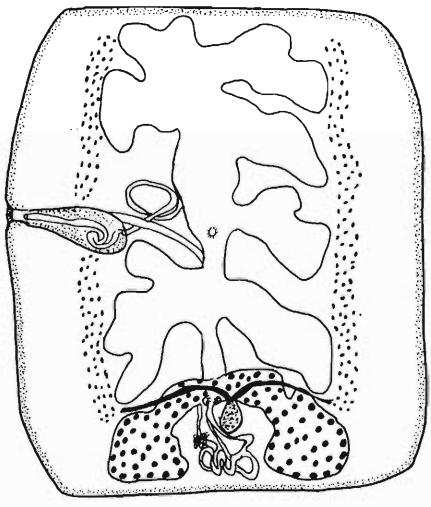


1

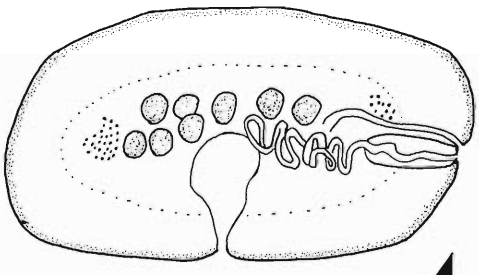


400μ

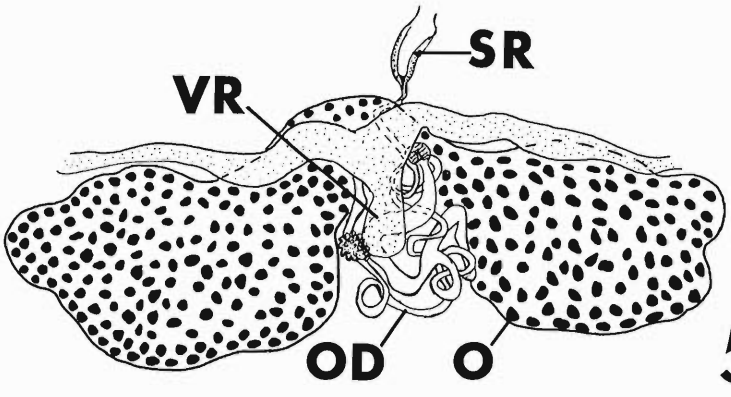
2



3



4



5

200μ

pyriform, 227–259 (247) long, extending transversely about ¼ width of mature proglottid, containing coiled ejaculatory duct and short, unspined cirrus. Testes numbering 67–101 (83) in mature proglottids, subspherical, medullary, in two layers within intervitelline field, extending from anterior border to ovary, diameter 56–90 (70). Vas deferens median, somewhat anterior to level of cirrus pouch, coiled proximally. Vaginal pore opening immediately dorsal to male pore, surrounded by small sphincter; vagina extending medianly dorsal to cirrus pouch then curving posteriorly toward ovary. Seminal receptacle small, immediately preovarian. Ovary in posterior quarter of proglottid, bilobed with anterior isthmus; oocapt prominent; oviduct convoluted, between ovarian lobes, receiving duct from seminal receptacle before reaching small, indistinct Mehlis' gland. Vitelline follicles small, medullary, in lateral fields from anterior border of proglottid to ovary; ducts large, passing ventral to ovary; reservoir median. Uterus extending anteriorly dorsal to isthmus; inconspicuous in mature proglottids; forming two to seven branches per side in gravid proglottids, normally fewer on poral side; uterine pore single, ventral, median, at level of cirrus pouch. Eggs uniformly 22 in diameter.

Discussion

Of the species of *Proteocephalus* with a functional or vestigial apical sucker, *P. buplanensis* most closely resembles *P. percae* (Mueller, 1780) Railliet, 1899, and *P. pearsei*. *Proteocephalus buplanensis* differs from *P. percae* in having larger suckers and testes distributed in layers, and in lacking body spines; from *P. pearsei* in having larger suckers, a longer strobila, testes in two layers, and fewer uterine branches.

Proteocephalus cobraeformis and *P. ptychocheilus* lack an apical sucker but are otherwise similar to *P. buplanensis*. Comparisons with type material show that *P. buplanensis* differs further from *P. cobraeformis* (USNM Helm. Coll. No. 37196) in having a longer strobila, more testes, and a globose rather than a spatulate scolex; from *P. ptychocheilus* (USNM Helm. Coll. No. 61066) in having 67–101 (83) testes 56–90 (70) in diameter, not 60 testes 80–100 in diameter, a vas deferens not extending posteriorly toward the ovary, and a smaller Mehlis' gland.

LaRue (1914), in a detailed study of *Proteocephalus torulosus*, stated, "In sections of the head the writer was unable to find even a trace of a vestigal fifth sucker." Wagner (1917) independently reached the same conclusion. Other workers, including Joyeux and Baer (1936), Wardle and McLeod (1952), and Dubinina (1962), all agree that *P. torulosus* lacks an apical sucker. Freze (1965), however, published a composite description of *P. torulosus* based on LaRue (1914), Wagner (1917), Dubinina (1962), and original material, in which he describes and figures a scolex with "an apical organ, which is seen with difficulty and consists of an accumulation of darker staining cells . . . with a diameter of 0.070–0.100 mm." In light of previous work on this species, it seems apparent that Freze's original material represented a species other than *P. torulosus*, and Freze's description will not be used in the following comparison.

Proteocephalus buplanensis differs from *P. torulosus* in having a vestigial apical sucker and proglottids more nearly equal in length and width (the ratio of length to width in *P. buplanensis* being 1:1.27 for mature proglottids and 1:0.96 for gravid proglottids; the same ratio being 1:2.5 and up to 1:4.5 for *P. torulosus*). The cirrus pouch is consistently ¼ the width of the mature proglottid in *P. buplanensis*; in *P. torulosus* it is ¼–⅙, again illustrating the variability of the proglottid width in *P. torulosus*. Both *P. buplanensis* and *P. torulosus* are parasites of cyprinid fishes, but the latter has never been reported from North America.

The name *buplanensis* is from Latin *bu* = great and *planus* = plains, and refers to the Great Plains Region of which Nebraska is a part.

Acknowledgments

I would like to thank Professor Mary Hanson Pritchard, under whose direction this research was completed, and Dr. J. Ralph Lichtenfels for the loan of specimens from the U. S. National Museum Helminthological Collection.

Literature Cited

Amin, O. M. 1975. Intestinal helminths of some southeastern Wisconsin fishes. Proc. Helm. Soc. Wash. 42: 43–46.

Anthony, J. D. 1963. Parasites of eastern Wisconsin fishes. Tr. Wisconsin Acad. Sci., Arts and Lett. 52: 83–95.

Dechtiar, A. O. 1972. Parasites of fish from Lake of the Woods, Ontario. J. Fish. Res. Bd. Canada 29: 275–283.

Dubinina, M. N. 1962. Cestoidea Rud., 1808 Tapeworms. *In* B. E. Bychowsky (ed.), Key to Parasites of Freshwater Fish of the U.S.S.R. Zool. Inst., Acad. Sci. USSR, Moscow–Leningrad 80: 384–438. (In Russian. English transl. IPST Ltd., 1964.)

Fischthal, J. H. 1950. Parasites of northwest Wisconsin fishes. II. The 1945 survey. Tr. Wisconsin Acad. Sci., Arts and Lett. 40: 87–113.

Freze, I. 1965. Proteocephalata in fish, amphibians, and reptiles. *In* K. I. Skrjabin (ed.), Essentials of Cestodology Vol. 5. Acad. Sci. USSR, Moscow, 538 p. (In Russian. English transl. IPST Ltd. 1969.)

Hoffman, G. L. 1953. Parasites of fish of Turtle River, North Dakota. Proc. North Dakota Acad. Sci. 7: 12–19.

Joyeux, C., and J. G. Baer. 1936. Cestodes. Faune de France 30: 1–613.

Kennedy, C. R. 1974. A checklist of British and Irish freshwater fish parasites with notes on their distribution. J. Fish Biol. 6: 613–644.

LaRue, G. R. 1914. A revision of the cestode family Proteocephalidae. Illinois Biol. Monogr. 1: 1–350.

Voth, D. R., and O. R. Larson. 1968. Metazoan parasites of some fishes from Goose River, North Dakota. Amer. Midl. Nat. 79: 216–224.

Wagner, O. 1917. Über den Entwicklungsgang und Bau einer Fischtaenie (*Ichthyotaenia torulosa* Batsch). Jena Z. Naturw. 55: 1–66.

Wardle, R. A., and J. A. McLeod. 1952. The Zoology of Tapeworms. Univ. Minnesota Press, Minneapolis, 780 p.

Parasites of Channel Catfish, *Ictalurus punctatus* Rafinesque, from the Island Region of Western Lake Erie

JOHN C. BAKER AND JOHN L. CRITES

Center for Lake Erie Area Research, Department of Zoology,
The Ohio State University, Columbus, Ohio 43210

ABSTRACT: Twenty species of parasites were recovered from 178 *Ictalurus punctatus* from the island region of western Lake Erie. *Allacanthocasmus varius* Van Cleave, 1922, and *Neoechinorhynchus rutili* Mueller, 1790, represent new host records. *Achtheres micropteri* Wright, 1882, and *Illinoibdella alba* Meyer, 1940, are reported from channel catfish in Lake Erie for the first time.

Parasites of *Ictalurus punctatus*, along with other species of fish, were previously surveyed in Lake Erie by Bangham and Hunter (1939) and Bangham (1972). Dechtiar (1972) reports new parasite records for Lake Erie fish. Bangham and Hunter's survey was conducted from 1927–29; 36 channel catfish were examined and 14 species of parasites were reported. Bangham's survey was conducted in 1957; 39 channel catfish were examined and 19 species of parasites were reported. Dechtiar collected data on new parasite records for Lake Erie fish from 1961–69; 35 channel catfish were examined and the study confirmed the same species of parasites reported by Bangham and Hunter (1939) and added six new records.

This study represents the first extensive study devoted only to the parasites of *Ictalurus punctatus* in Lake Erie.

Address reprint requests to John L. Crites

Materials and Methods

Fish were collected in the island region of western Lake Erie by otter trawl, trap net,

Table 1. Parasites recovered from 178 channel catfish, *Ictalurus punctatus* Rafinesque, in Lake Erie.

Parasite	USNM No.	Developmental stage (site of infestation)	Incidence	Range	Mean worm burden (standard deviation)
Protozoans					
Icthyophthirius multifiliis Fourquet, 1876		(gills)	0.6%		
Henneguya exilis Kudo, 1929		(gills)	18.5%		
Monogenetic trematodes					
Cleidodiscus pricei Mueller, 1936	73747	Adults (gills)	12.0%		
Cleidodiscus floridanus Mueller, 1926	73746	Adults (gills)	22.0%		
Digenetic trematodes					
Allocreadium ictaluri Pearse, 1924	73749	Adults (intestines)	5.6%	1–2	1.30 (0.67)
Alloglossidium corti (Lamont, 1921)	73753	Adults (intestines)	20.8%	1–303	49.17 (75.37)
Diplostomum spathaceum Rudolphi, 1819	73750	Metcercariae (lens of eye)	28.1%	1–12	2.00 (1.99)
Acetodextra amiuri (Stafford, 1904)	73748	Adults (ovaries and swim bladder)	14.0%	1–18	7.00 (10.31)
Allacanthacasmus varius Van Cleave, 1922	73751	Adults (intestines)	2.2%	1–4	2.00 (1.99)
Phyllodistomum lacustri Loewen, 1929	73752	Adults (urinary bladder)	45.5%	1–21	2.82 (2.29)
Cestodes					
Corallobothrium fimbriatum Essex, 1927	73755	Adults (intestines)	77.0%	1–379	22.47 (41.83)
Corallobothrium giganteum Essex, 1927	73754	Adults (intestines)	4.0%	1	1.00 (0)
Nematodes					
Dichelyne robusta (Van Cleave and Mueller, 1932)	73757	Adults (intestines)	1.7%	1	1.00 (0)
Spinitectus gracilis (Ward and Magath, 1916)		Adults (intestines)	0.6%	1	1.00 (0)
Camallanus oxycephalus Ward and Magath, 1916	73756	Larval and adult (intestines)	16.9%	1–4	1.50 (0.86)
Eustrongylides tubifex Jagerskiold, 1909	73758	Larvae encapsulated (mesenteries)	14.6%	1–22	3.15 (5.08)
Acanthocephalans					
Neoechinorhynchus rutili (Mueller, 1790)	73759	Adults (intestines)	3.4%	1–24	5.67 (9.05)
Crustaceans					
Ergasilus versicolor Wilson, 1911	73760	Adult females (gills)	48.3%	1–37	5.03 (6.78)
Achtheres micropteri Wright, 1882	73761	Second copepodid and adults (gills)	5.6%	1–6	2.20 (1.04)
Annelids					
Illinoibdella alba Meyer, 1940	73762	Pectoral, anal, caudal fin	2.8%	1–5	1.80 (1.79)

and hook and line from June through September of 1973 and 1974. Channel catfish were sacrificed by a blow to the cranium and the body and organs were examined with the aid of a dissection scope. Preparation of parasites for identification followed standard technique.

Results and Discussion

During the course of the study 178 channel catfish were examined and all were infected. A total of 20 species of parasites were found. Results are summarized in Table 1.

Achtheres micropteri and *Illinoibdella alba* are reported from channel catfish for the first

time in Lake Erie. *Neoechinorhynchus rutili* and *Allacanthocasmus varius* are reported from channel catfish for the first time. *Corallobothrium fimbriatum* was found to be the predominant species occurring at an incidence of 77.0%.

Acknowledgments

The authors wish to express thanks to Dr. Wilbur Bullock for confirming the identification of *Neoechinorhynchus rutili*.

Literature Cited

Bangham, R. V. 1972. A resurvey of the fish parasites of western Lake Erie. Ohio Biol. Sur., New Series 4 (2): 32 p.

———, **and G. W. Hunter.** 1939. Studies on the fish parasites of Lake Erie. Distribution Studies. Zoologica 24 (4): 385–448.

Dechtiar, A. O. 1972. New parasite records for Lake Erie fish. Great Lake Fisheries Commission, Ann Arbor, Michigan, 20 p.

Parasitism of the Pika, *Ochotona princeps* Richardson (Mammalia: Lagomorpha), in Utah and Nevada with the Description of *Eugenuris utahensis* sp. n. (Nematoda: Oxyuridae)

ALBERT W. GRUNDMANN AND PAUL S. LOMBARDI

Department of Biology, University of Utah, and Department of Microbiology, College of Medicine, University of Utah

ABSTRACT: Parasitism was studied in the nine subspecies of *Ochotona* now restricted to isolated high mountain masses of Utah and Nevada. Although isolated since the Pleistocene, parasite species recovered showed conformity, lending support to host distribution concepts. Four previously reported species were recorded, the tapeworm, *Schizorchis ochotonae*; nematodes, *Murielus harpespiculus*, *Cephaluris coloradensis*, and *Labiostomum coloradensis*. In addition, three previously unreported nematodes were present belonging to *Trypanoxyuris*, *Strongyloides*, and *Trichuris*, and a new species, *Eugenuris utahensis*, is described. An analysis of host specificity, parasite association, and frequency of occurrence is presented.

The mammalian genus *Ochotona* in North America shows broad subspeciation with restricted distribution to the higher mountain masses of western North America. The pika is narrowly restricted in its niche, being confined to talus slopes surrounded by appropriate vegetation, usually at higher elevations. Two species exist, *O. collaris* Nelson in southeastern Alaska and the Yukon, and *O. princeps* Richardson in the Rocky and Sierra mountain chains. The present study involves discrete populations of *O. princeps* where the species reaches its most southern extension in the mountains of Utah and Nevada. The distribution in Utah is of special interest because populations have been restricted to isolated high mountain masses since the Pleistocene. According to Hubbs and Miller (1948) the flora and fauna of the study region were quite homogeneous and generally interconnected throughout the Great Basin and Colorado River drainage during the Wisconsin or last pluvial period of the Pleistocene. Antevs (1948) indicates that following this period a warming and drying altithermal period ensued isolating pika populations to the higher mountains above 7,000 ft elevation. Nine subspecies are recognized at the southern fringe of distribution in this region, eight in Utah and one in Nevada.

A number of studies on pika helminths have been conducted in western North America with the exception of the area of the Great Basin and Colorado Plateau west of the Rocky Mountains, the focus of the present report. These

Table 1. Parasite distribution in *Ochotona princeps* subspecies from Utah and Nevada.

	Subspecies of host						
	Ochotona princeps cinnemomea	*O. p. wasatchensis*	*O. p. uinta*	*O. p. lasalensis*	*O. p. fuscipes*	*O. p. barnsei*	*O. p. nevadensis*
No. of animals sampled	71	14	12	4	4	10	15
% infected with one or more species	76.0	78.6	100	50	100	100	66.6
Parasite species							
Cestoda:							
Schizorchis ochotonae Hansen	37	6	8	2	3	4	8
Nematoda:							
Cephaluris coloradensis Olsen	23	4	5	2	2	3	8
Labiostomum coloradensis Leiby	8	3	3	0	1	2	4
Eugenuris utahensis	8	0	2	1	2	2	3
Trypanoxyuris sp.	2	0	0	0	0	0	0
Murielus harpespiculus Dikmans	9	3	7	0	4	4	3
Strongyloides sp.	2	0	0	0	0	0	0
Trichuris sp.	0	0	1	0	0	0	0
Protozoa:							
Sarcocystis sp.	0	0	4	0	0	0	0

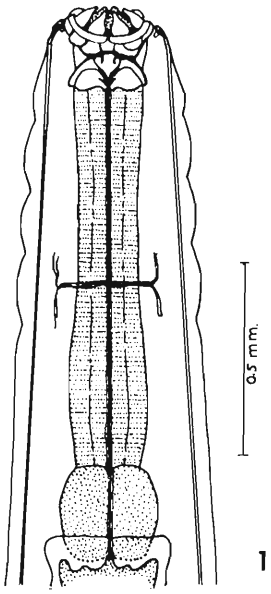
have resulted in the description of a number of the species most of which were recovered in the present study. Dikmans (1939) described *Murielus harpespiculus* from *O. princeps* at Jackson Hole, Wyoming. Jellison (1947) reported an undetermined parasite from the lungs of pika in Montana. Studies in Colorado produced *Schizorchis ochotonae* Hansen 1948, *Graphidiella ochotonae* Olsen 1948, *Cephaluris coloradensis* Olsen 1949, and *Labiostomum coloradensis* Leiby 1961, all from *O. princeps figginsi*. Sevaraid (1955) studied pika parasites in California but did not publish his findings. However, Voge (1955, 1956) lists *Schizorchis ochotonae*, *Cephaluris coloradensis*, *Labiostomum naimi*, and a *Dermatoxys* species from California pika. Roest (1953) reported a *Dermatoxys* species in Oregon as well as an unidentified cestode. Barrett and Worley (1970) reported on parasites of pika in Montana listing as new records a filaroid nematode from the pleural region, a species of *Sarcocystis*, and an *Eimeria* sp. Lubinsky (1957) previously reported a *Sarcocystis* species and *Physaloptera bispiculata* Vas et Pereira from pika in Alberta, Canada.

Other contributions to the parasitology of pika in North America were made from *O. collaris* in Alaska. Phillip (1938) reported a species of *Dermatoxys*, which was later thought by Inglis (1959) to be *Cephaluris*. Akhtar (1956) described *Labiostomum rauschi* and *Eugenuris talkeetnaeuris*, and Rausch (1960) added *Schizorchis caballeroi* from *O. collaris* and in 1962 found *Sarcocystis*.

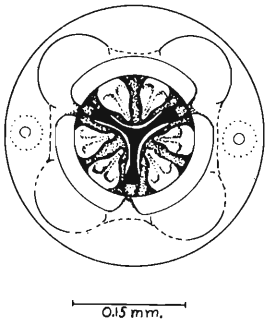
Attempts were made to collect at least some specimens of all the subspecies represented in the region, partly as a parasite survey and partly to determine if parasitism might provide a clue in establishing that all subspecies of the region are part of the same Plesistocene host stock. The host subspecies of the region are distributed as follows (Fig. 6): in Utah, *Ochotona princeps uinta* Hollister from the Uinta Mountains; *O. p. wasatchensis* Durrant and Lee, Wasatch Mountains; *O. p. moorei* Gardner, Wasatch Plateau; *O. p. cinnemomea* Allen, Tushar Mountains; *O. p. barnsei* Durrant and Lee, Fish Lake Mountains; *O. p. lasalensis* Durrant and Lee, La Sal Mountains; *O. p. utahensis* Hall and Hayward, Aquarius Plateau; *O. p. fuscipes* Howell, Markagunt Plateau; and *O. p. nevadensis* Hall, Ruby Mountains, Nevada. Specimens of seven of the nine subspecies were obtained excepting *O. p. utahensis* and *O. p. moorei* (see Table 1)

→

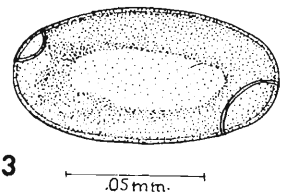
Figures 1–5. *Eugenuris utahensis* sp. n. 1. Head and esophagus of female. 2. Face view of male head. 3. Egg. 4. Section of female showing anteriorly directed vagina. 5. Tail of male showing arrangements of genital papillae and caudal alae.



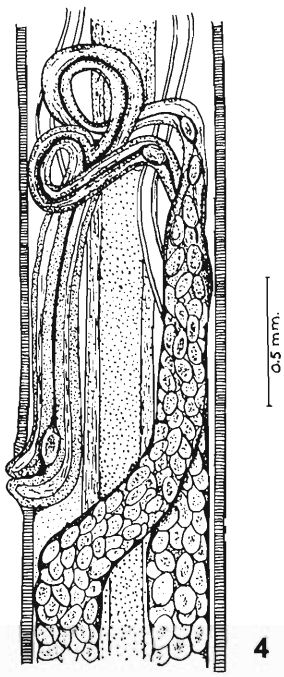
1



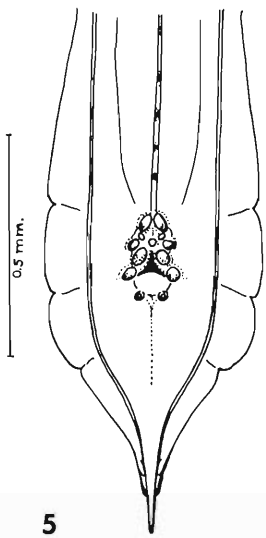
2



3



4



5

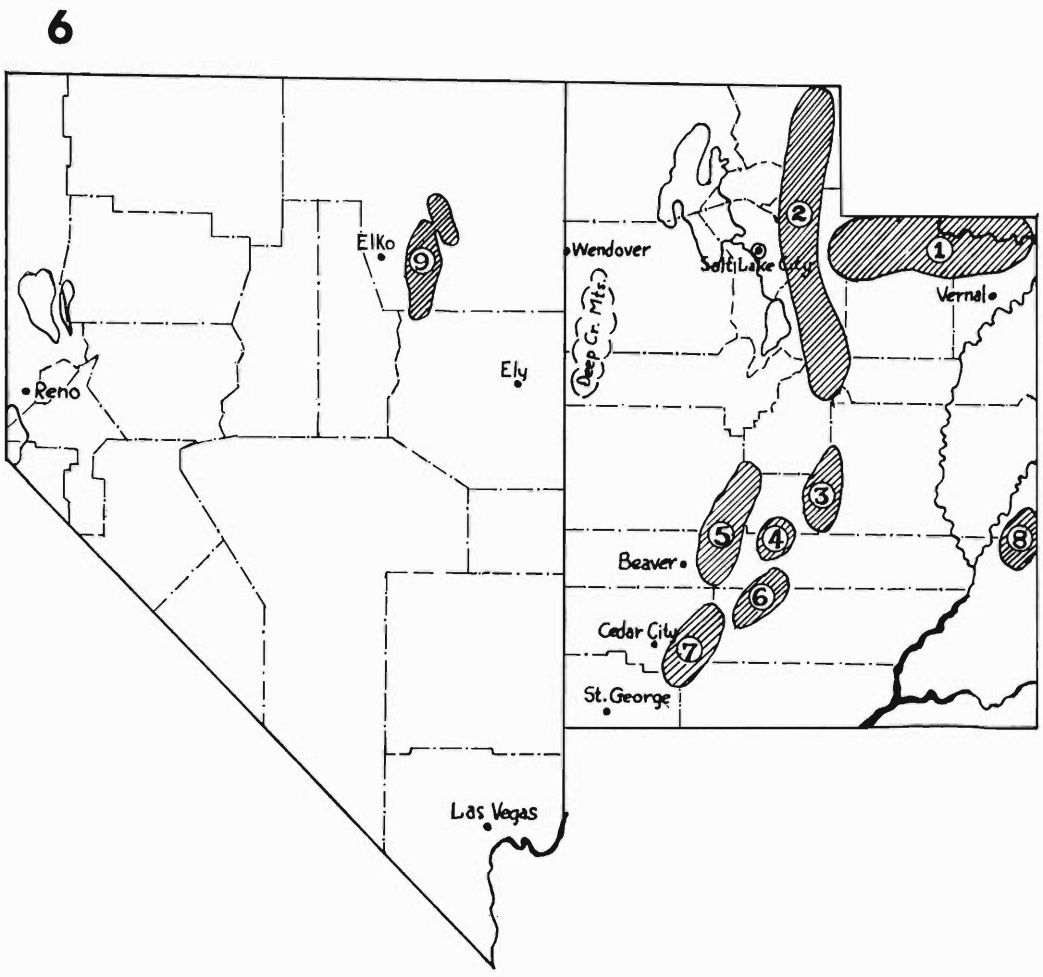


Figure 6. Host subspecies distribution in Utah and Nevada. (1) *Ochotona princeps uinta*, Uinta Mts., Utah. (2) *O. p. wasatchensis*, Wasatch Mts. (3) *O. p. moorei*, Wasatch Plateau. (4) *O. p. barnsei*, Fish Lake Mts. (5) *O. p. cinnemomea*, Tushar Mts. (6) *O. p. utahensis*, Aquarius Plateau. (7) *O. p. fuscipes*, Markagunt Plateau. (8) *O. p. lasalensis*, La Sal Mts. (9) *O. p. nevadensis*, Ruby Mts., Nevada.

although some of the samples were small. The two subspecies not included are located in the general complex of mountains in central Utah and conceivably could be expected to show close affinities and similar parasitism. Of interest are the Deep Creek Mountains located on the Utah–Nevada border between the central mountain chain in Utah and the Ruby Mountains in Nevada. The range is high with peaks near 12,400 ft elevation and good talus slopes abound. The mammals of these mountains were studied by Hansen (1951) and no pika found. Hall (1946) did not report pika at additional sites in the Great Basin portion of Nevada.

Materials and Methods

All animals were obtained with a 410-gauge shotgun or 22 cal. rifle. Dissection in most cases was completed on freshly killed animals. Some were preserved in formalin for later

study. Examination included viscera, body cavities, head, and musculature. Tapeworms were stained with Delafield's hematoxylin and mounted in balsam. Nematodes were temporarily cleared in chlorolactophenol d'Amman and stored in glycerin alcohol.

Results and Discussion

A total of 130 specimens representing seven of the nine host subspecies were examined. The number examined of several of the subspecies was too small to provide conclusive results and was indicative only of species present. Fleas were collected from a representative sample.

Eight species of helminths were recovered consisting of one cestode and seven nematodes (see Table 1). Four species, composed of the cestode *Schizorchis ochotonae* and the nematodes, *Cephaluris coloradensis*, *Labiostomum coloradensis*, and *Murielus harpespiculus*, frequently were present, the first and second in all subspecies examined and the latter two in all but one in each case. An apparently new species of *Eugenuris* occurred in all subspecies other than *O. p. wasatchensis* and is described.

The three remaining nematode species, belonging to *Trypanoxyuris*, *Strongyloides*, and *Trichuris*, are new records for pika in North America. A *Trichuris* sp. (*Trichocephalus*) was previously reported by Gvosdev (1962) from *Ochotona pusilla* and *O. pallasi* in the Kazakh Mountains near Lake Baikal. Gvosdev also reports *Trichostrongylus colubriformis* Giles from *Ochotona rutilla* and *Syphacia obvelata* (Rudolphi) and the acanthocephalan, *Moniliformis moniliformis*, from *Ochotona daurica*. Both of the nematode species occur in most localities of Utah concurrent with pika colonies, with the former being a parasite in sheep and the latter in *Microtus* sp. *Moniliformis clarki* Ward is present in *Peromyscus maniculatus rufinis* in areas occupied by pika colonies.

No cases of cysticercosis or other abnormal pathology were noted in lungs and liver as reported by Jellison (1947). The organism described by Jellison closely resembles the adiospores of a species of *Emmonsia*. These bodies frequently have been encountered in the lungs of rodents collected from drier habitats of the Bonneville Basin.

Table 2. Frequency and compatibility of parasite species in *Ochotona princeps*.

	Schizorchis ochotonae	*Cephalurus coloradensis*	*Labiostomum coloradensis*	*Eugenuris utahensis*	*Murielus harpespiculus*	*Trypanoxyuris*	*Strongyloides*	*Trichuris*
Schizorchis ochotonae		22	8	9	12	1		
Cephalurus coloradensis	22		9	10	13	1	1	1
Labiostomum coloradensis	8	9		3	7	1		1
Eugenuris utahensis	9	10	3		5	1		1
Murielus harpespiculus	12	13	7	5		1		1
Trypanoxyuris	1	1	1	1	1			
Strongyloides		1						
Trichuris		1	1	1	1			
Frequency of occurrence*	32	36	14	13	21	2	1	1

* These numbers represent the times each species appeared in cases of multiple parasitism.

Two species of fleas, *Ctenopsyllus terribilis* (Rothchild) and *Amphalius necopinus* (Jordan), were present with the latter being rare. In addition, an unidentified species of *Sarcocystis* was recovered from *O. p. uinta*.

High multiple-species parasitism with complete host specificity is well developed in pika. There appears to be no exchange of parasites with other mammals of the habitat such as the golden marmot, *Marmota flaviventris eugelharti* Allen, the white-footed deer mouse, *Peromyscus maniculatus rufinis*, the least chipmunk, *Eutamias minimus*, and the snowshoe rabbit, *Lepus americanus bairdii* Hayden, even though it was observed that pika in the Tushar Mountain area [Fig. 6 (5)] commonly collect and incorporate marmot feces in their haystacks.

Multiple parasitism with marked tolerance of one species for another is common. Of the four oxyurid species, three, *Cephaluris*, *Eugenuris*, and *Labiostomum*, were frequently present in a single animal. All four species appear to develop initially in the cecum, where all remain except *Labiostomum*, that as an adult prefers the colic loop. *Cephaluris*, *Eugenuris*, and *Trypanoxyuris* have been taken

Table 3. Average numbers of individuals of each species present in cases of multiple parasitism observed. * Numbers in parentheses are numbers of host animals upon which the average is based.

Species of parasite	One species present	Two species present	Three species present	Four species present	Five species present	Total No. parasites of each species recovered	% of total No. of parasite individuals present
Cestoda:							
Schizorchis ochotonae	(21)* 2.6	(20) 4.2	(8) 3.3	(4) 1.5	(1) 2.0	175	18.0
Nematoda:							
Murielus harpespiculus	(3) 8.6	(9) 17.1	(6) 36.8	(3) 20.3	(2) 25.0	512	52.6
Labiostomum coloradensis		(8) 2.5	(3) 1.6	(3) 1.6	(2) 5.0	40	4.1
Cephaluris coloradensis	(4) 2.0	(19) 5.6	(8) 4.7	(3) 3.6	(2) 23.0	210	21.6
Eugenuris utahensis	(3) 1.3	(2) 1.0	(7) 2.5	(2) 1.0	(2) 6.5	32	3.3
Trypanoxyuris sp.			(1) 1.0	(1) 1.0		2	0.2
Strongyloides sp.		(1) 2.0				2	0.2
Trichuris sp.					(1) 1.0	1	0.1

from the cecum of a single animal. Adults of all four species, some gravid, have been taken from the colic loop.

The percentage of infection is high in all colonies sampled. In the Tushar Mountain area [Fig. 6 (5)] where the largest sample (71) was taken 76.2% were infected. In cases where one or more species were present in a group of 100 animals, 31 exhibited a single species, 29 had 2; 11 had 3, 4 had 4, and 2 had 5. Table 2 presents the frequency of association and occurrence of each species. Lack of antagonism between species can also be observed by looking at average numbers of individuals of each species present when one to five species are involved (Table 3). It should be noted that as multiple species parasitism increases, numbers of individuals of each show a degree of consistency with some always more numerous and prevalent than others. The two cases where five species were present produced the largest total numbers of individuals (122) and the largest number of each of four species indicating that these hosts probably exhibited a reduced ability to resist hyperinfection and cannot be considered as average.

Genus *Eugenuris* Schulz

The taxonomic status of the genus *Eugenuris* is confused. The genus was erected by Schulz in 1948 with the decription of *E. schumakovitchi* from the cecum and large intestine of *O. daurica*. *Eugenuris* resembles the genus *Labiostomum* described by Akhtar in 1941 but lacks the cephalic wings and spicules. Later, Akhtar in 1953 described *Pikaeuris pikaeuris* as a new genus and species from Afghanistan pika. *Pikaeuris* differs from *Labiostomum* mainly in that it lacks a cephalic bulb; however, Akhtar made no comparison with *Eugenuris* previously described by Schulz. Akhtar (1956) attempted to clarify the status of the oxyurids from the pikas of the world. He synonymized *Pikaeuris* Akhtar with *Eugenuris* Schulz into *Eugenuris*. He further described *Eugenuris talkeetnaeuris* from *O. collaris* in Alaska, thus placing three species in the genus. Akhtar also erected the subfamily Labiostominae to include *Labiostomum*, *Cephaluris*, and *Eugenuris*.

Inglis (1959) published a controversial paper on the oxyurids of pika in Iran. In addition to describing *Cephaluris chabaudi* and *Labiostomum akhtari*, Inglis proceeded to synonymize *Eugenuris* with *Labiostomum* listing six species in the latter.

Gvosdev (1962) reviewed the parasites of pika. He did not recognize the systematic arrangement of Inglis, and, based on a series collected from a number of pika species, and on the work of Dubinin and Dubinina (1951) moved *Eugenuris schumakovitchi* into the genus *Dermatoxys*, thereby in effect invalidating the genus *Eugenuris*; however, not having access to the description or specimens of *E. talkeetnaeuris*, described from Alaska by Akhtar, he left this species as valid, although questioned. Gvosdev accepted the genus *Pikaeuris* to include *P. pikaeuris*, and the genera *Cephaluris* and *Labiostomum*. Gvosdev also refused to recognize the earlier reorganiza-

tion of the family Heteroxynematidae proposed by Skrjabin and Shikhobalova (1950) and Skrjabin et al. (1960) that recognized the three genera, *Eugenuris*, *Pikaeuris*, and *Labiostomum*, as separate, with *E. schumakovitchi* as the type species of *Eugenuris*. Yamaguti (1961) has followed the classification of Skrjabin and Shikhobalova placing *Eugenuris* and *Labiostomum* in the subfamily Aspiculurinae and *Dermatoxys*, *Cephaluris*, and *Pikaeuris* in the Heteroxynematinae. Examination of specimens of these genera in our collection, with the exception of *Pikaeuris*, causes us to accept the latter arrangement and consider the genus *Eugenuris* as valid.

The morphological features described by Schulz in his erection of the genus *Eugenuris* and published by Yamaguti are well represented in *E. utahensis* sp. n. and separate the genus readily from *Dermatoxys*. *Eugenuris utahensis* fits this description somewhat better than *E. talkeetnaeuris* since the former has an egg with two opercula and a more typical head structure.

Eugenuris Schulz 1948

GENERIC DIAGNOSIS: Aspiculurinae: Body with two sublateral flanges on each side, united posteriorly to form into a lateral wing. Mouth aperture surrounded by six teeth. A pair of lateral and two pairs of submedian head papillae. Buccal cavity divided into two (anterior and posterior) chambers. Esophageal bulb weakly developed, without chitinous valvular apparatus. Male: Caudal alae present; around cloacal aperture are grouped several pairs of papillae. Spicules and gubernaculum absent. Female: Vulva in anterior half of body. Vagina directed forward, divided into two uteri (Fig. 1). Eggs asymmetrically oval, outer shell with minute tubercles, operculated at each pole. Parasites of pika.

Eugenuris utahensis n. sp.

Fifteen males and 17 females were collected from the cecum and colic loop of six of the subspecies of pika in Utah. These specimens differ in a number of characteristics from other described species in the genus.

DESCRIPTION: Mouth surrounded by six lips with broad somewhat oval base and thin cylindrical apex (Figs. 1, 2). Two pair cephalic papillae present, the dorsal pair well developed, the subventral pair frequently less prominent. Stoma cylindrical, buccal cavity divided into anterior and posterior chambers by three-lobed glottid apparatus. Esophagus muscular with weakly developed posterior bulb (Fig. 1). Two lateral alae extending length of body except tail.

MALE: 8.01 to 11.56 mm long, 0.32–0.57 mm greatest width. Esophagus without bulb, 0.62–0.76 mm; bulb 0.17–0.19 by 0.14–0.16. Tail 0.47–0.62. Long midventral crest beginning 0.57–0.78 anterior to anus extending anteriorly 0.60–1.07 mm. Spicule and gubernaculum lacking. Caudal papillae, 5–6 pairs plus 1 odd (Figs. 5); 3–4 pairs preanal, 1 pair adanal, and 1 pair postanal. Caudal alae well developed.

FEMALE: 15.9–18.53 mm long, 0.75–0.82 greatest width. Cuticular striations present 0.015–0.28 mm in width. Esophagus without bulb 1.16–1.21 mm. Bulb, 0.19–0.24 by 0.21–0.25. Tail, 2.2–2.8 mm, structure and form similar to *E. schumakovitchi*. Vulva to anterior end measuring 6.77–7.69 mm. Vagina directed forward, divided into two uteri (Fig. 1). Eggs 0.10 by 0.05, operculated at each end, outer shell with minute tubercules (Fig. 3).

LOCATION: Mainly the cecum.

TYPE LOCALITY: Mt. Delano—Tushar Mountains—20 miles east of Beaver, Utah.

TYPE SPECIMENS: Holotype: USNM Helminth Coll. No. 73259.

Remarks

E. utahensis may be separated from *E. schumakovitchi* and *E. talkeetnaeuris* by lip structure and arrangement and numbers of anal papillae. The six lips of *utahensis* have oval bases with thin cylindrical apices; those of *schumakovitchi* are more oval with hollowed out apices; and those of *E. talkeetnaeuris* are cylindrical with blunt apices, and covered by a triangular flap. Numbers of caudal papillae in *E. schumakovitchi* 7 pairs; in *E. talkeetnaeuris* 8 pairs, plus 1 odd (3 preanal, 1 adanal, 4 postanal) in *E. utahensis*, 5–6 pairs, 1 odd (3–4 pairs preanal, 1 pair adanal, 1 pair postanal). Also origin and geographical isolation of the host must be considered. *O. princeps* is the southern form and in Utah and Nevada has been isolated as a series of subspecies subsequent to the Pleistocene glaciation. *O. collaris* in Alaska may represent a sub-

sequent invasion of North America. The egg of *E. utahensis* has two opercula while *E. talkeetnaeuris* has one.

Literature Cited

Akhtar, S. A. 1956. On nematodes (family: Oxyuridae Cobb., subfamily Labiostominae n. subf.) parasitic in the pika of Alaska. Part I. Pakistan J. of Sci. Res. 8: 133–139.

Antevs, E. 1948. The Great Basin with emphasis on glacial and post-glacial times. III. Climatic changes and pre-white man. Univ. of Utah Bull. 38: 168–191.

Barrett, R. E., and D. E. Worley. 1970. Parasites of the pika (*Ochotona princeps*) in two counties in south central Montana with new host records. Proc. Helm. Soc. Wash. 37: 179–181.

Dikmans, G. 1939. Two new nematodes (Trichostrongyloidea) from rodents. Proc. Helm. Soc. Wash. 6: 1–4.

Durrant, S. D. 1952. Mammals of Utah. Univ. of Kansas Publ., Mus. of Nat. Hist. 6: 1–549.

———, **and M. R. Lee.** 1955. Three new pikas (genus *Ochotona*) from Utah. Proc. Biol. Soc. Wash. 68: 1–10.

Gvosdev, E. V. 1962. Analysis of the helminth fauna of the pika (Ochotonidae) in relation to the geographic distribution of the host. Trudy Inst. Zool. Akad. Nauk Kazakh. SSR 16: 63–80.

Hall, E. R. 1946. Mammals of Nevada. Univ. Calif. Press, Berkeley, Calif., p. i–xi, 1–710, 11 pls., 485 figs. 1 July 1946.

Hansen, M. F. 1948. *Schizorchis ochotonae*, n. gen., n. sp., an anoplocephalid cestode. Am. Midl. Nat. 39: 754–757.

Hansen, R. M. 1951. A systematic comparison of the mammals of Mount Nebo and the Deep Creek Mountains, Utah. Unpubl. M.S. thesis, Univ. of Utah Lib., 98 p.

Hubbs, C. L., and R. R. Miller. 1948. The Great Basin, with emphasis on glacial and post-glacial times. II. The zoological evidence: Correlation between fish distribution and hydrographic history in the desert basins of western United States. Univ. of Utah Bull. 38: 17–166.

Inglis, W. G. 1959. Some oxyurid parasites (Nematoda) from *Ochotona rufescens vizier* (Mammalia: Lagomorpha). Soc. Zool. de France, Trans. 84: 178–187.

Jellison, W. L. 1947. An undetermined parasite in the lungs of a rock rabbit, *Ochotona princeps* Richardson (Lagomorpha: Ochotonidae). Proc. Helm. Soc. Wash. 14: 75–77.

Leiby, P. D. 1961. *Labiostomum coloradensis* n. sp. (Oxyuridae: Nematoda) from the pika, *Ochotona princeps*. J. Parasit. 47: 733–734.

Lubinsky, G. 1957. List of helminths from Alberta rodents. Can. J. Zool. 35: 623–627.

Olsen, L. S. 1948. A new trichostrongylid nematode from the pika, *Ochotona princeps figginsi*. Amer. Midl. Nat. 39: 748–753.

———. 1949. A new species of oxyurid nematode from a pika, *Ochotona princeps figginsi*. Trans. Am. Microsc. Soc. 68: 337–341.

Phillip, C. B. 1938. A parasitological reconnaissance in Alaska with particular reference to varying hares. II. Parasitological data. J. Parasit. 24: 483–488.

Rausch, R. L. 1960. Studies on the helminth fauna of Alaska XXXVII, description of *Schizorchis caballeroi* n. sp. (Cestoda: Anoplocephalidae), with notes on other parasites of *Ochotona*, Libro. Homenaje al Dr. Eduardo Caballero Y. C. Mexico, D. F., p. 399–405.

———. 1962. Notes on the collared pika, *Ochotona collaris* Nelson, in Alaska. Murrelet 42: 22–24.

Roest, E. S. 1953. Notes on pikas from the Oregon Cascades. J. Mamm. 34: 132–133.

Sevaraid, J. H. 1955. The natural history of the pika (mammalian genus *Ochotona*). Microfilm copy of unpublished doctoral dissertation. Univ. Calif. Lib., Berkeley, Calif., 820 p.

Skrjabin, K. I., and N. P. Shikhobalova. 1950. Reorganization of the nematode family Heteroxynematidae Skrjabin and Shikhobalova 1948. Dokl. Akad. Nauk, SSSR n.s., 71 (3): 589–591.

———, ———, **and E. A. Lagodovskaya.** 1960. Oxyurata of animals and man. Part one: Oxyuroidea. Essentials of Nematodology, Vol. VIII. Acad. Sci. of the USSR, Moscow. (English translation, 1974. Israel Program for Scientific Translations, Jerusalem, 526 p.)

Voge, M. 1955. A list of the cestode parasites from California mammals. Am. Midl. Nat. 54: 413–417.

———. 1956. A list of the nematode parasites from California mammals. Am. Midl. Nat. 56: 423–429.

Yamaguti, S. 1961. Systema Helminthum. Vol. 3, pt. 1, 679 p. Interscience Pub. Inc., New York.

Fine Structure and Development of the Body Wall in the Monogenean, *Gyrodactylus eucaliae* Ikezaki and Hoffman, 1957[1]

DELANE C. KRITSKY[2] AND FRANCIS J. KRUIDENIER

Department of Zoology, University of Illinois, Urbana–Champaign 61801

ABSTRACT: The body wall of *Gyrodactylus eucaliae* comprises a confluent external tegument resting on an underlying basal lamina and three discontinuous layers of myofibers. The adult tegument is a modified cytoplasm bound externally and basally by tripartite membranes and containing mitochondria and three types of vacuolar structures embedded in a dense matrix. The tegument is confluent via tortuous ducts with cell bodies located within the parenchyma. It develops from a cellular embryonic epidermis with typical nuclei. The embryonic epidermis becomes syncytial with subsequent loss of nuclei. The basal lamina consists of two fibrous strata which provide the sites of origin and insertion of the myofibers. The smooth myofibers contain both thick and thin myofilaments which apparently interact in contraction. Thin myofilaments are united to hemidesmosomelike structures (sarcodesmosomes) which connect the contractile elements of the fiber to the apparently nontensible basal lamina and intercellular matrices.

Information on the ultrastructural organization and development of the tegument of Monogenea is increasing rapidly. Lyons (1970a, 1971) demonstrated a confluent cytoplasmic covering connected by processes with parenchymally situated cell units in the monopisthocotyleids *Acanthocotyle elegans*, *Entobdella soleae*, and *Amphibdella flavolineata* and later (1972) in the polyopisthocotyleids *Rajonchocotyle emarginata* and *Plectanocotyle gurnardi*. These reports confirmed Morris and Halton's (1971) study of *Diclidophora merlangi*. In contrast, underlying nucleated units were not observed in adults and embryos of an undescribed species of *Gyrodactylus* (Monopisthocotylea) by Lyons (1970b).

Lyons (1973) found that a nucleate primary epidermis of flat cells in embryonic onchomiracidia of *E. soleae* is either replaced by or develops into a secondary epidermis comprising ciliated cellular regions and a syncytial nucleated interciliary cytoplasmic layer. The latter loses its nuclei and apparently fuses with a discontinuous presumptive adult epidermis which connects to cell bodies in the parenchyma. *Gyrodactylus eucaliae* differs from this as reported herein.

[1] From part of a dissertation submitted to the University of Illinois at Urbana–Champaign by the senior author for the Ph.D. degree in zoology.

[2] Present address: College of Medical Arts, Idaho State University, Pocatello, Idaho 83209.

Materials and Methods

Brook sticklebacks, *Culaea inconstans* (Kirtland), from Cottonwood Lake, 3 miles N of Butte, North Dakota, were transported alive to Butte in 1-gal plastic containers. Vigorous shaking of several fish in a small volume of lake water dislodged the parasites, which were quickly recovered unharmed with a capillary pipette and fixed by two 2-hr immersions in iced 3% glutaraldehyde. The worms were washed and stored in cold 0.3 M sucrose and shipped by air to the Illinois laboratory for postfixation in cold 1% OsO_4 for 1.5 hr. Solutions were buffered (pH 7.4) with s-collidine. The worms were washed in distilled water, dehydrated through ethyl alcohol, and embedded in Epon 812 from propylene oxide. Thin sections were cut with a Sorvall ultratome, placed on 200-mesh copper grids coated with formvar and amorphous carbon, stained with concentrated lead citrate and 1% uranyl acetate, and examined with an Hitachi HU-11A electron microscope.

Observations

Adult body wall

The tegument comprises a confluent surface layer (syntegument) and subsurface elements (cytotegument), both of which differ in fine structure and position (Figs. 1, 5, 6).

SYNTEGUMENT: The syntegument on the body varies in thickness from 1.1 μ in specimens with empty uteri to 0.8 μ in those distended by large embryos. It is thinner over the haptor (0.2–0.3 μ). Similar inclusions occur throughout. Most common are flattened ovoids (V_1), 0.4–0.5 μ in diameter, coarsely granular centrally, electron-light and finely reticulate peripherally, bound by an 82-Å membrane, and generally oriented along the surface (Figs. 1, 5). A second unit (V_2) is randomly distributed, elongate ovate, 0.6–0.7 μ by 0.2–0.3 μ, filled with a delicately reticulate and electron-light material, and bound by a 50-Å membrane. The latter inclusions progressively decrease in density and apparently eventually erupt through the surface as dilute vacuoles (Fig. 4). Small mitochondria are most common in the basal half as double-membrane-bound vesicles with fragmented or poorly developed cristae (Fig. 5). In occasional specimens, rare granules resemble isolated or free ribosomes. Golgi complexes and endoplasmic reticula were not identified.

The external surface has microvilli, 0.4 μ in diameter, more than 2 μ long, and spaced approximately 1 μ apart. A tripartite membrane, 107–113 Å thick and overlain with 90 Å of a fine-grained material, occurs on the surface. The comparable basal membrane is irregularly infolded imparting an interrupted trilayered appearance (Fig. 5). These infolds are rarely perpendicular to the base and do not traverse the syntegument. Surface and basal membranes unite only in oral, excretory pore, head organ, and sensilla areas and are bound to these counterparts by septate desmosomes (Fig. 2). Small hemidesmosomes secure the basal membrane to the basal lamina (Fig. 5).

Exhaustive search revealed only one recognizable nucleus-like structure, 5.8 μ long and obviously deteriorating in an otherwise normal specimen. Intimately associated with a whorled laminate body, it contained a dense central mass or nucleolus about 1.5 μ in diameter embedded in a coarse moderately dense matrix (Figs. 9, 10). Almost as rare were large (4.2–4.5 μ) vacuous bodies, membrane-bound and irregularly laminate (Fig. 3). Intermediates demonstrating a presumed relationship between these structures were not found.

The amorphous basal lamina is 0.3–0.4 μ thick and comprised of two distinct strata: A superficial moderately dense layer which merges with an inner layer that is confluent in turn with adjacent intercellular matrices (Fig. 1). The lamina and intercellular matrices contain nonperiodic, random, variably crossed fibrils which are 130 Å in diameter and circular to ovate in cross section. The fibrils of the superficial layer are appreciably fewer and less distinct. Quantitative variation, apparent in both strata, were not correlated with body regions.

CYTOTEGUMENT: Units of the cytotegument (cytons) were found only beneath the muscle layers in the dorsal half of the posterior trunk in adult worms. Their cytoplasm contains a variably layered rough endoplasmic reticulum (Fig. 6). Free ribosomes are common between reticular membranes and in the general cytoplasm. Golgi complexes are numerous. Nuclei were not observed, probably because the cytons are large, somewhat irregular, and difficult to delimit sharply from surrounding cells. The plasmalemma infolds frequently, is about 90 Å thick, devoid of ribosomes, and in external contact with the fibrous matrix of a narrow intercellular space. The discrete units, V_1 and V_2, develop in the cytons, concentrating where each constricts into its single efferent ductule (Fig. 6).

The duct, 1 μ in diameter, extends tortuously from each cyton to the base of the syntegument and is packed with secretions and few mitochondria. A thin tripartite membrane (125 Å thick) forms the wall, inside which a dense stratum of cytoplasm contains peripheral longitudinal microtubules of about 270 Å in diameter (Figs. 6, 7). The thin intercellular matrix surrounding the proximal duct (Fig. 6) is replaced distally by the heavier matrix investing the muscle fibers. Terminally, the duct is supported by the basal lamina (Fig. 8). The membranous lining diverges along the base of the syntegument and is continuous with the basal membrane. Secretions discharged from the duct appreciably distend the syntegument, with vacuoles (V_1 and V_2) scattered at the margins of the dilation. Such dilations were found only on the dorsolateral surfaces of the parasite (Fig. 8).

BODY WALL MUSCLES: Discontinuous layers of outer circular and inner longitudinal myofibers underlie the basal lamina. Deeper diagonal myofibers are usually restricted to the

cephalic and peduncular regions. Cytoplasmic strands connect these myofibers to myocytes compressed irregularly among body organs (Fig. 15). The nucleus of the myocyte has an eccentric, partly flattened nucleolus, a granular nucleoplasm, and variable masses of chromatin scattered near the nucleolus and the double, porous nucleolemma. Rough endoplasmic reticula with localized dilated cisternae dominate the perinuclear cytoplasm and are confluent with the external nuclear membrane. Mitochondria and loosely organized Golgi complexes are present.

The nonstriated myofibers comprise both thick (240 Å) and thin (100 Å) parallel myofilaments within an electron-light sarcoplasm. Thick filaments are usually distributed evenly in the fiber and appear to consist of five or six dense subunits (each about 95 Å in diameter) situated around a less dense core (Fig. 17). Thin myofilaments are disposed radially around the thick units as well as randomly in the fiber. Satellite thin filaments appear connected to the margins of the thick filaments by delicate bridges (Fig. 17).

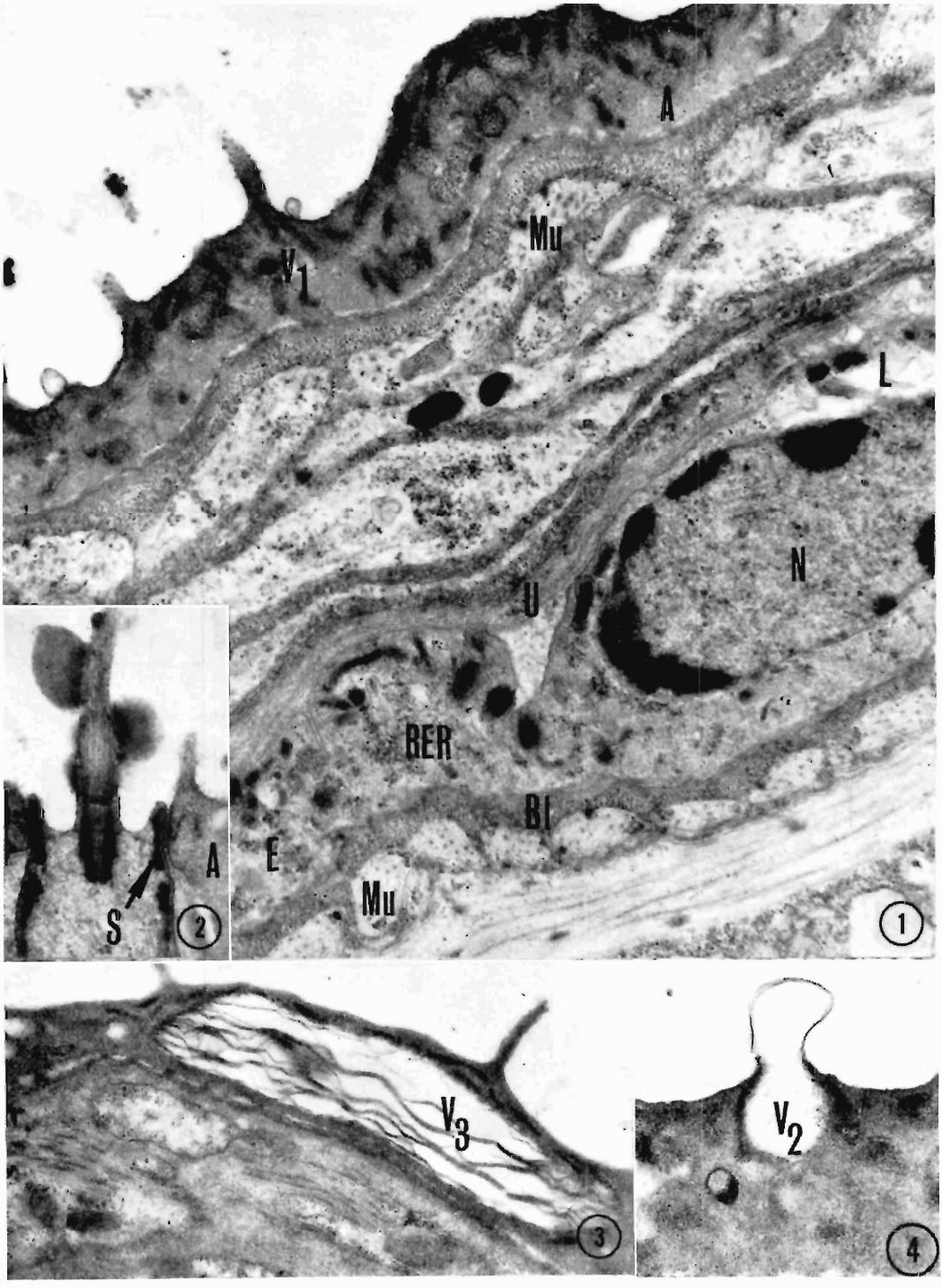
Concentrated systems of dense fibers (sarcodesmosomes) radiate from the sarcolemma into the sarcoplasm (Fig. 16). The 72 Å sarcolemma thickens to 230 Å, indents, and increases in density in the sarcodesmosome. Fibrillar units radiate from the sarcodesmosome into the matrix of the basal lamina or intercellular spaces. Similarly, the dense compact fibrillar units of the sarcodesmosome extend into the sarcoplasm apparently as a zone of longitudinally oriented, nonsatellite thin myofilaments (Figs. 18, 19). Sarcodesmosomes are most numerous at the ends of the myofiber where major sites of origin or insertion occur.

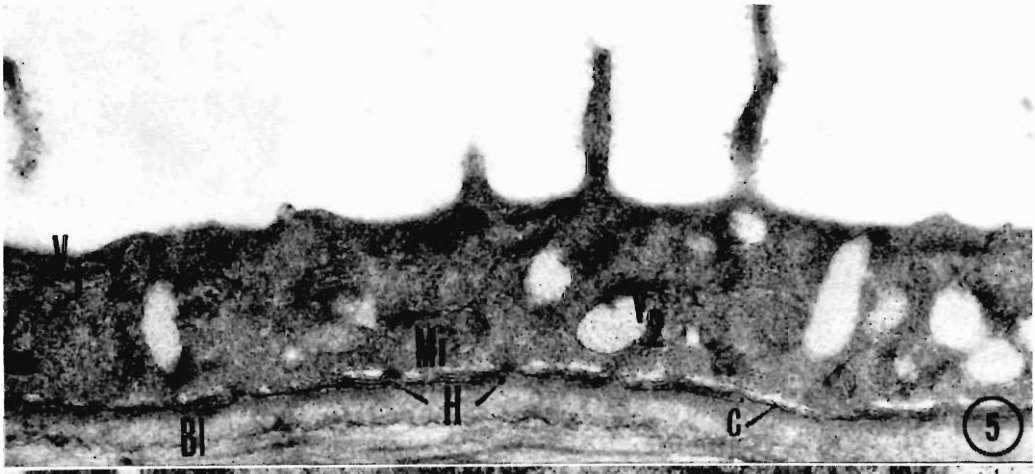
Nonsatellite thin filaments also appear to attach to dense, longitudinally oriented, intramyofiber masses which are difficult to distinguish from bisected sarcodesmosomes (Fig. 15).

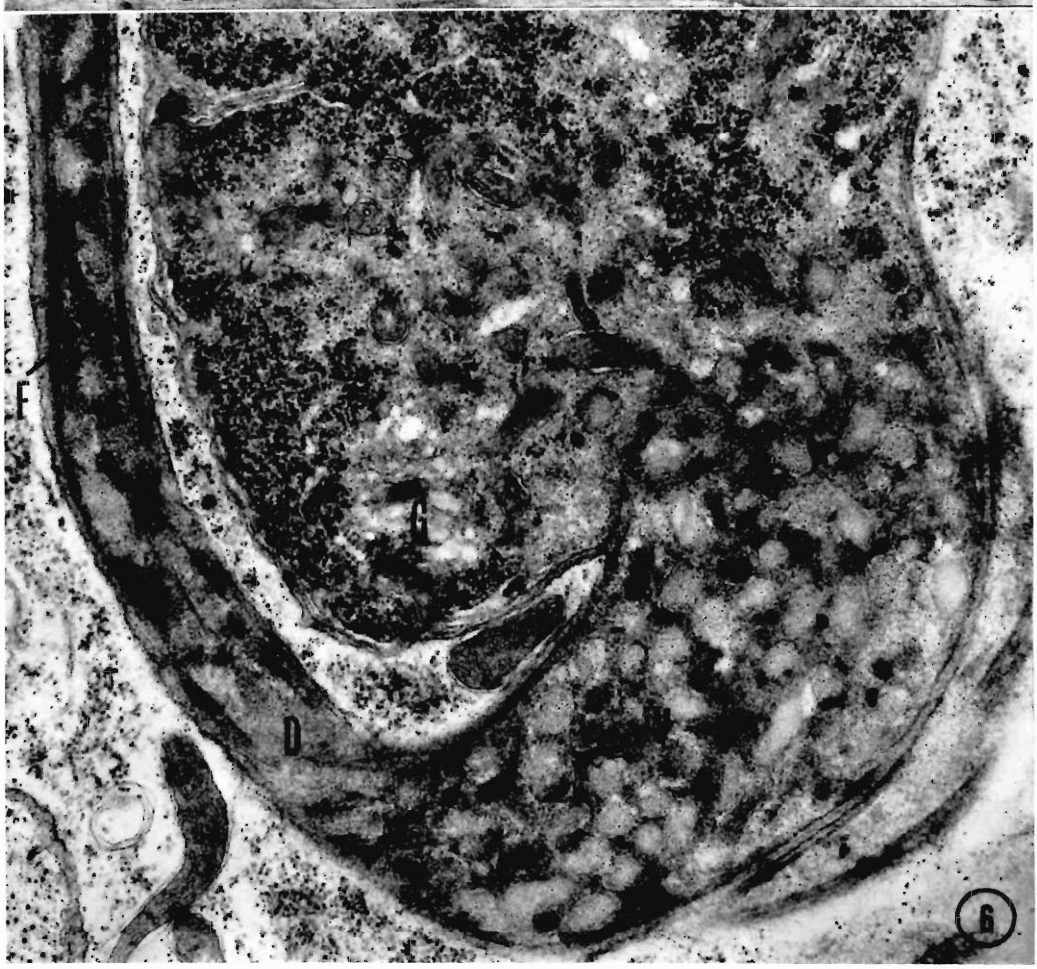
Broad, flat cisternae of the smooth reticulum with dense matrices closely parallel the sarcolemma to which they are attached at undetermined intervals by zones of delicate bridges (Figs. 16, 17). Occasional tubules dilate terminally into relatively large sacs. Sar-

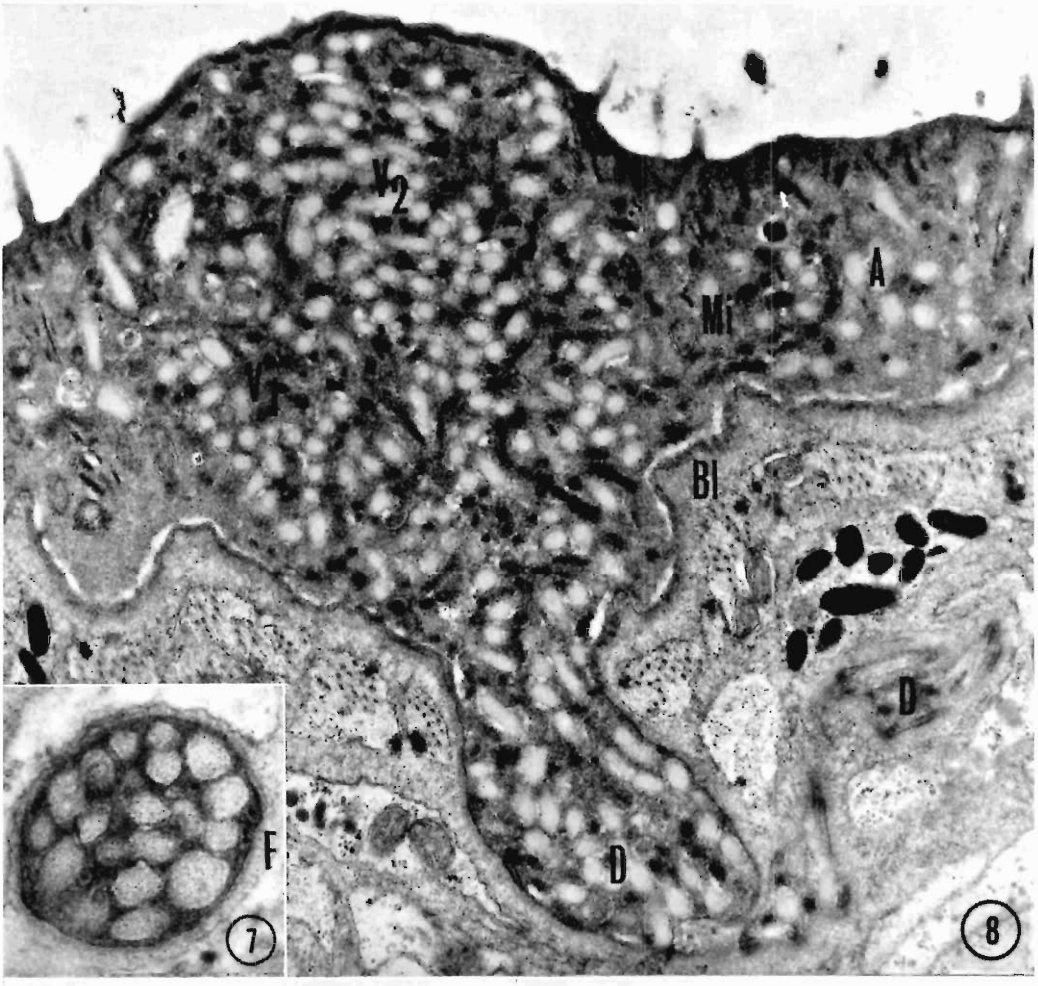
→

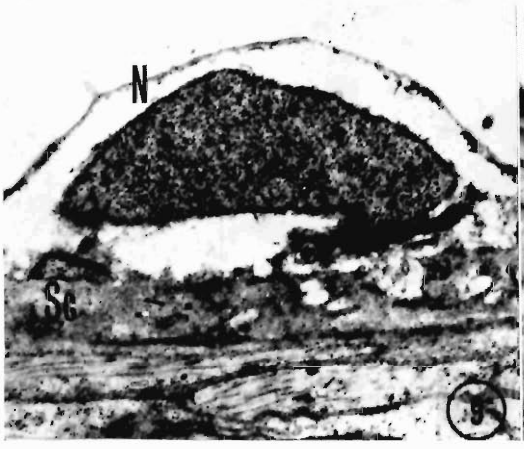
Figures 1–19. Electron micrographs of the body wall of *Gyrodactylus eucaliae*. Abbreviations: A, adult syntegument; Bl, basal lamina; c, unit membrane; D, duct; E, embryonic tegument; F, microtubule; G, Golgi complex; H, hemidesmosome; If, intramyofiber mass; L, laminar body; Mi, mitochondrion; Mu, myofiber; N, nucleus; RER, rough endoplasmic reticulum; S, septate desmosome; Sd, sarcodesmosome; Sl, sarcolemma; St, sarcotubule; U, uterus; Uf, uterine fluid; V, vacuole. Fig. 1. Electron micrograph showing synteguments of the adult and primary embryo. A nucleus (N) is present in the embryonic syntegument. × 25,000. Fig. 2. Association of sensory sensilla and syntegument. × 20,500. Fig. 3. Laminate vacuole in the adult syntegument. × 18,000. Fig. 4. Electron micrograph showing the apparent discharge of a V_2 vacuole. × 25,000. Fig. 5. Syntegument with various inclusions and folded basal membrane. × 33,000. Fig. 6. Portion of a cyton and associated duct. × 26,000. Fig. 7. Transverse section of a duct from a cyton. × 37,000. Fig. 8. The distended syntegument at the site of discharge of a duct (D) from cyton. × 18,600. Figs. 9, 10. Serial electron micrographs of the nucleuslike structure in the adult syntegument. × 15,000 and 10,000, respectively. Fig. 11. Body wall of primary embryo. × 26,000. Fig. 12. A normal nucleus (N) in the synthelium of a young embryo. In *Gyrodactylus* spp., embryos are usually oriented as an inverted U (Mizelle and Kritsky, 1967). This micrograph is from the resulting region of *contiguous* tegument. × 10,900. Fig. 13. Syntegument of primary embryo showing separation of nuclear and cytoplasmic matrices. Serial sections demonstrated the central nucleolus. × 20,000. Fig. 14. Electron micrograph showing the body-wall structure of three generations of parasite. Note that the tegument of the older embryo (E_1) is deeply folded while that of the younger (E_2) is discontinuous (at arrows). × 19,600. Fig. 15. A myocyte. A single myofiber (Mu) is visible in the sarcoplasm. × 19,800. Fig. 16. Transverse section of a sarcodesmosome (Sd) showing its association with the sarcolemma (Sl). × 62,300. Fig. 17. Electron micrograph of a myofiber showing the arrangement of thick and thin myofilaments, the tubular nature of the thick myofilaments, and the fibrous connectives between the sarcotubules (St) and sarcolemma (Sl). × 61,500. Figs. 18, 19. Longitudinal sections of sarcodesmosomes (Sd) showing the apparent origin of thin myofilaments from their terminal surfaces. × 68,800.

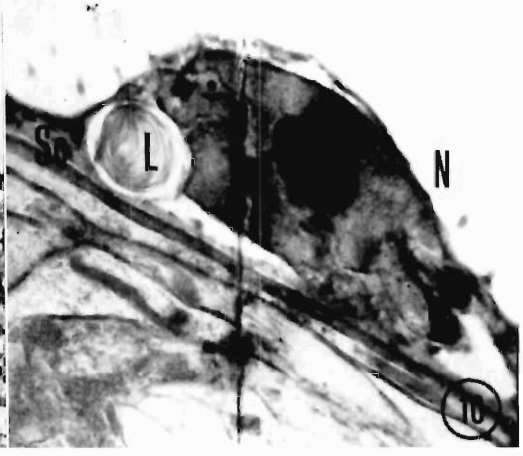


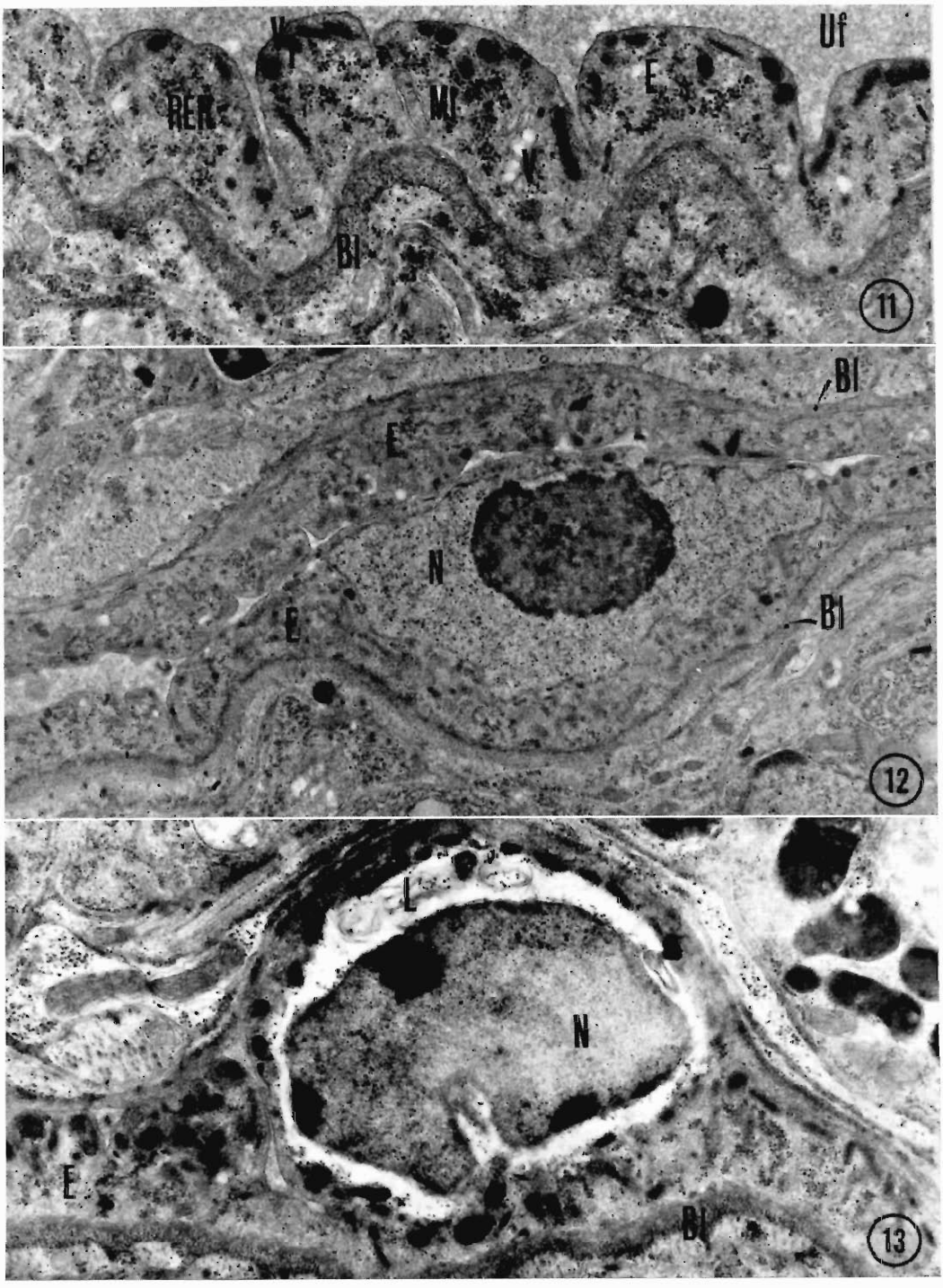


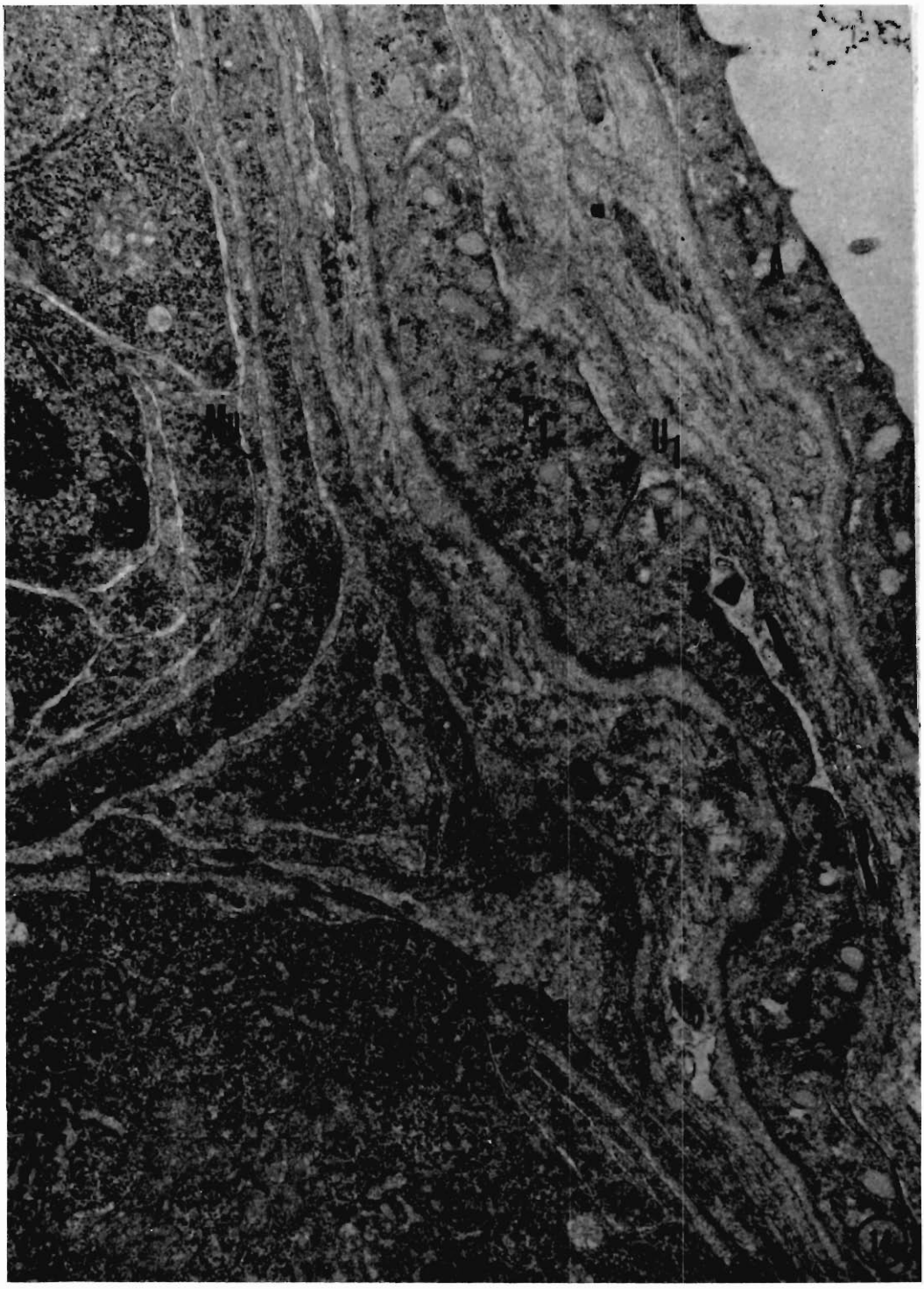


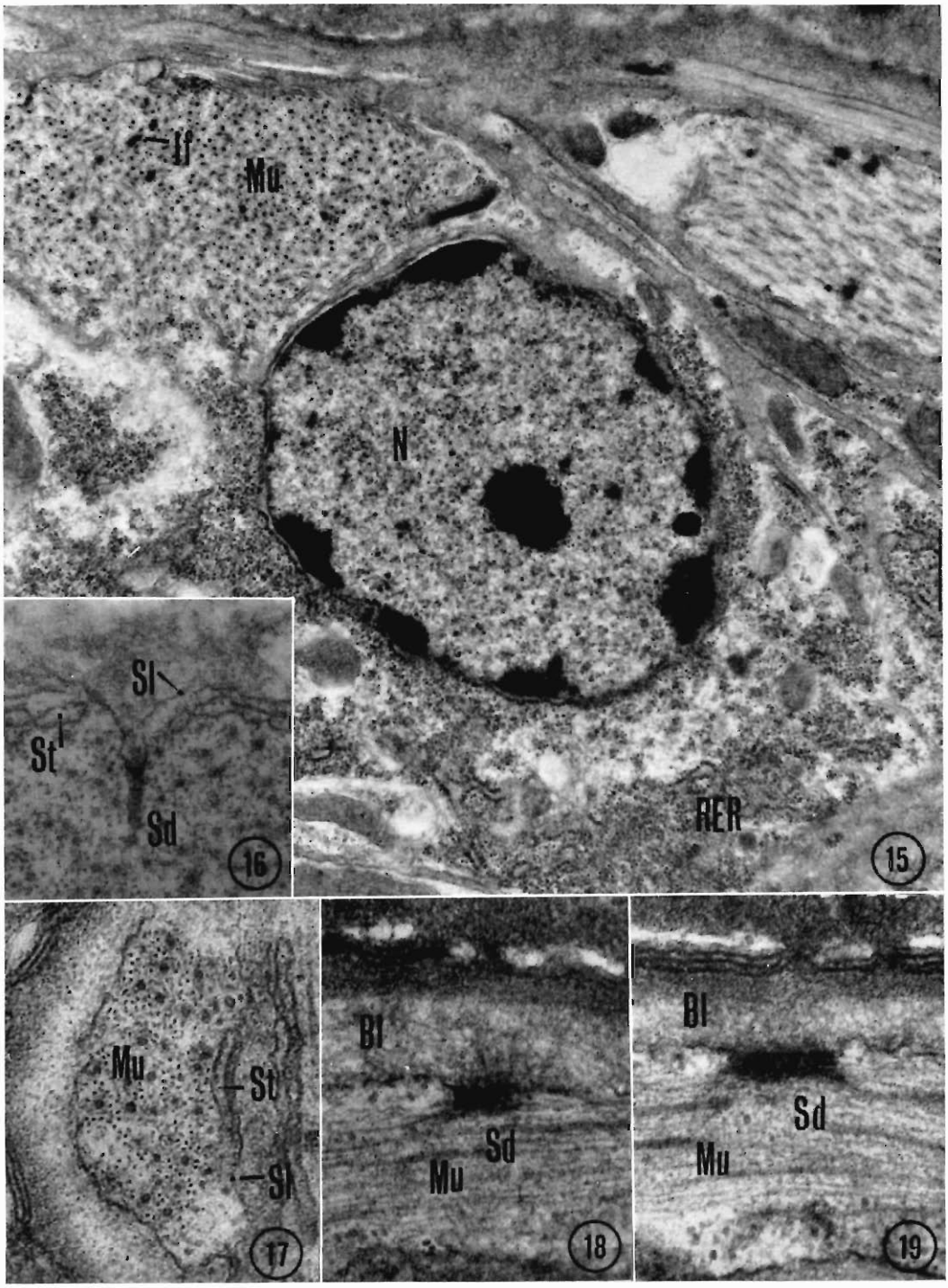












cotubules are numerous along opposed margins of adjacent myofibers, but less numerous in apposition to other visceral entities and rare or absent along sublaminar margins of circular myofibers. Mitochondria usually are peripheral or terminal in the myofiber.

Embryonic body wall

TEGUMENT: The syntegument of embryos nearing term, like that of adults, is a confluent layer, bound on both surfaces by unit membranes and resting on a fibrous basal lamina (Fig. 11). It is approximately as thick as that of the parent but may seem heavier because of the strong contraction evidenced by deep surface infoldings (Figs. 1, 14). A few microvilli appear just before birth. Teguments (cytothelium) of the youngest embryos are thin and interrupted at undetermined intervals (Fig. 14, arrows).

Neither the large laminated nor the small erupting vacuoles of adult synteguments were found in embryos. In contrast to their fate in adults, secretions (V_1 and V_2) from the cytotegument, absent from the youngest embryos (Fig. 14, E_2), become numerous but retain their density and do not vesiculate during embryogenesis. No secretion-caused dilations of the syntegument were seen. Few Golgi or Golgi-like bodies were present. The numerous ribosomes and rough endoplasmic reticula of early stages diminish, with ribosomes appearing to cluster during intrauterine development (Fig. 14).

Most significantly, elongate–ovate to globular nuclei, 3 to 7 μ long, characterize the synteguments of embryos. They contain a fine-grained nucleoplasm, an eccentric and compact nucleolus, and peripheral and perinucleolar chromatin (Fig. 12). In older primary embryos, the nuclear substance separates from the cytoplasm and the resulting space frequently contains irregularly whorled or laminate abnormalities (Figs. 1, 13) which increase with age.

The embryonic cytotegument was not observed.

MUSCLES: In very young secondary embryos, elongate processes from underlying myoblasts extend adjacent to and beneath the nonfibrillar, unstratified basal lamina, which is slightly broader than but otherwise apparently similar to the undifferentiated intercellular matrices with which it appears continuous (Fig. 14). These precursors of myofibers are irregularly flattened to ovoid in cross section, lack myofilaments and sarcodesmosomes, and possess sparse ribosomes. In intermediate embryos characterized by a syncytial epidermis with normal nuclei (synthelium), the myofilaments and sarcodesmosomes are apparent while concurrent stratification and fibril development is advancing in the basal lamina (Figs. 11, 12). In older primary embryos nearing term and characterized by deteriorating nuclei in the syntegument, the myofibers are smaller than, but otherwise similar to, those of postparturitional adults (Fig. 1).

Discussion

The fine structure of the body wall of *Gyrodactylus eucaliae* differs from that reported by Lyons (1970b) for *Gyrodactylus* sp. most conspicuously by the presence of cytotegmental units or cytons which connect through tortuous ducts with the syntegment. Present micrographs demonstrate the secretory nature of the cyton, tracing its discrete products into the syntegument. Mitochondria, also discharged from the cyton, do not accumulate appreciably in the surface layer. No evidence of backflow into the cyton was observed. A mechanism of discharge is suggested in which general contraction of body muscles would increase internal pressures on the cytons and simultaneously draw open the mouth of their ducts. Resilience of the lamina-reinforced walls of the ducts would constrict them when muscles relax.

Gyrodactylid embryogeny in which consecutively younger intrauterine generations develop one within another obviates artifacts of technical variance in the several growth stages that are seen in one ultrathin section. Thus, since uterine environments patently favor cell and organelle formation and development, concurrent decreases in syntegmental ribosomes and endoplasmic reticula and the deterioration of their Golgi complexes during embryogenesis suggest intrinsic, progressive maturational changes which render late embryonic synteguments inherently unsuitable substrates for these organelles. Comparable development of degenerative abnormalities in the syntegmental nuclei substantiates this.

Final disappearance of ribosomes, reticula, and Golgi bodies, and the vesiculation of cytotegmental secretions with presumed syntegmental incorporation of their substance, suggests continued maturational changes in the synteguments of postparturitional adults. Final degradation and the rapid disappearance of nuclei from this layer appear to confirm this.

Studies thus demonstrate that a cytothelium of very young embryos fuses into a nucleate synthelium of young embryos which in turn alters markedly into the adult syntegument. They amplify the report by Katheriner (1904) that a monolayered nucleate epidermis becomes syncytial and enucleate during the development of *G. elegans*. Young's (1935) generalized concept of intracuticular nuclear degeneration and matrix regression also appears partly tenable. Somewhat similar, Lyons (1973) indicated the extrusion of nuclei from a cellular primary epidermis following syncytial fusion in *Entobdella soleae*. Also, Hockley (1972) reported nuclear loss from a syncytial primary tegument of cercarial *Schistosoma mansoni*. Further studies on development are needed to reconcile current conceptual inconsistencies.

Myofibers in the body wall of *G. eucaliae* resemble those of nonstriated muscles of various invertebrates including other platyhelminths (see Lumsden et al., 1967, 1968 for comparative reviews). MacRae (1963) suggests that the delicate linkage of encircling thin myofilaments to a central, thick myofilament may indicate a sliding filament mechanism of contraction. She (1965) also compared the "dense bodies," which interconnect fine myofilaments in a broad spectrum of invertebrate and vertebrate smooth muscles, with "fragmented" Z-discs in the correlation of myofilament movement in vertebrate skeletal muscles (Franzini-Armstrong and Porter, 1964).

The report of peripheral sarcotubular reticula in myofibers of cercariae of some Digenea by Kruidenier and Vatter (1958) was amplified by Lumsden and Foor (1968) and extended to cestodes (Lumsden and Byram, 1967). Specialization of cisternal membranes (thickenings) adjacent to sarcolemmae and of the interposed sarcoplasm (increased electron opacity) was reported by MacRae (1963, 1965) in two species of turbellaria. In *G. eucaliae*, still further specialization has occurred; the development of bridges between portions of sarcoreticular cisternae and approximating sarcolemmae would appear to stabilize the relationships of these membranes through contraction of the myofiber. Also, they could aid coordinated contraction by providing definite pathways for stimuli from (or to) sarcolemmae into (or from) sarcoplasm and myofilaments, in effect substituting for the involuted sarcolemma of the "T-tube system" in striated muscles. More numerous sarcotubules along borders of neighboring myofibers may indicate such function. The bridges might also more efficiently transmit the changes in the polarity of the sarcolemma to influence the calcium ion concentrations in cisternae which are important during contraction (Costantin et al., 1965). In *G. eucaliae*, this specialization may be correlated with the scarcity of intramyofiber dense bodies and possible differences in activity such as the contraction speed of its muscles.

In contrast to the relatively few internal "dense bodies" linking successive groups of thin filaments in body muscles of *G. eucaliae*, sarcodesmosomes are numerous and present an almost classical picture of the half-desmosome. Through their internal attachment to thin filaments and external insertion to the basal laminae and intercellular matrices, they apparently stabilize the internal and external relationships of the myofibers, connecting the contractile elements to nontensible body matrices. Also, their dispersal along the myofibers would certainly place limits on its contraction while providing the necessary footing for body movement.

The function given the sarcodesmosome supports the concept of Threadgold and Gallagher (1966) that the intracellular matrices comprise a skeletal framework in trematode bodies. These authors related the fibrils in the matrix to elastin fibers on the basis of gross physical characteristics. Pedersen (1968) suggested a collagenlike composition for comparable fibrils in nemertines based on their comparative histochemistry. In any case the fibrils would add tensile strength and recoverability to these matrices.

Acknowledgments

The authors wish to acknowledge field assistance from Dr. R. P. Hathaway and the fa-

cilities extended by the Central Electron Microscope Laboratory of the University of Illinois. This research was supported in part by a grant from the NIH (E-1319).

Literature Cited

Costantin, L. L., C. Franzini-Armstrong, and R. J. Podolsky. 1965. Localization of calcium-accumulating structures in striated muscle fibers. Science 147: 158–159.

Franzini-Armstrong, C., and K. Porter. 1964. The Z-disc of skeletal muscle fibrils. Z. Zellforsch. 61: 661–672.

Hockley, D. J. 1972. *Schistosoma mansoni*: The development of the cercarial tegument. Parasitol. 64: 245–252.

Katheriner, L. 1904. Ueber die Entwicklung von *Gyrodactylus elegans* V. Nordm. Zool. Jahrb., Suppl. 7, Festschr. 70 Geburtst. A. Weismann, p. 519–551.

Kruidenier, F., and A. Vatter. 1958. Microstructure of muscles in cercariae of the digenetic trematodes *Schistosoma mansoni* and *Tetrapapillatrema concavocorpa*. Proc. 4th Int. Conf. Electron Microscopy 2: 232–235.

Lumsden, R. D., and J. Byram III. 1967. The ultrastructure of cestode muscle. J. Parasit. 53: 326–342.

———, **and E. W. Foor.** 1968. Electron microscopy of schistosome cercarial muscle. J. Parasit. 54: 780–794.

Lyons, K. M. 1970a. The fine structure and function of the adult epidermis of two skin parasitic monogeneans, *Entobdella soleae* and *Acanthocotyle elegans*. Parasitol. 60: 39–52.

———. 1970b. Fine structure of the outer epidermis of the viviparous monogenean *Gyrodactylus* sp. from the skin of *Gasterosteus aculeatus*. J. Parasit. 56: 1110–1117.

———. 1971. Comparative electron microscope studies on the epidermis of the blood living juvenile and gill living adult stages of *Amphibdella flavolineata* (Monogenea) from the electric ray *Torpedo nobiliana*. Parasitol. 63: 181–190.

———. 1972. Ultrastructural observations on the epidermis of the polyopisthocotylinean monogeneans *Rajonchocotyle emarginata* and *Plectanocotyle gurnardi*. Z. Parasitenk. 40: 87–100.

———. 1973. Epidermal fine structure and development in the onchomiracidium larva of *Entobdella soleae* (Monogenea). Parasitol. 66: 321–333.

MacRae, E. K. 1963. Observations on the fine structure of pharyngeal muscle in the planarian *Dugesia tigrina*. J. Cell. Biol. 18: 651–662.

———. 1965. The fine structure of muscle in a marine turbellarian. Z. Zellforsch. 68: 348–362.

Mizelle, J. D., and D. C. Kritsky. 1967. Studies on monogenetic trematodes. XXX. Five new species of *Gyrodactylus* from the Pacific tomcod, *Microgadus proximus* (Girard). J. Parasit. 53: 263–269.

Morris, G. P., and D. W. Halton. 1971. Electron microscope studies of *Diclidophora merlangi* (Monogenea: Polyopisthocotylea). II. Ultrastructure of the tegument. J. Parasit. 57: 59–61.

Pedersen, K. J. 1968. Some morphological and histochemical aspects of nemertean connective tissue. Z. Zellforsch. 90: 570–595.

Threadgold, L. T., and S. S. E. Gallagher. 1966. Electron microscope studies of *Fasciola hepatica*. Parasitol. 56: 299–304.

Young, R. T. 1935. Some unsolved problems of cestode structure and development. Trans. Am. Microsc. Soc. 54: 229–237.

Redescription of a Nematode, *Seuratum cancellatum* Chitwood, 1938, from Bats in Texas

ROBERT D. SPECIAN[1] AND JOHN E. UBELAKER

Department of Biology, Southern Methodist University, Dallas, Texas 75275

ABSTRACT: *Seuratum cancellatum* Chitwood, 1938, is redescribed from male and female specimens recovered from the small intestine of *Anthrozous pallidus* as well as from the body cavity of *Eptesicus fuscus, Eumops perotis, Myotis californicus, M. yumanensis, Pipistrellus hesperus, Plecotus townsendii,* and *Tadarida brasiliensis* collected in western Texas. Scanning electron microscopy is used to elucidate the cephalic morphology and external cuticular modifications. This species can be separated from the other members of this genus by its lack of a vestibule and denticles, as well as caudal alae, and by having fewer rows of body spines.

Chitwood (1938) described a nematode, *Seuratum cancellatum*, based on a single male specimen encysted in the lung of *Natalus mexicanus* collected in Yucatan, Mexico. The female remained unknown until this report. Although the genus has a worldwide distribution in insectivores, rodents, and bats, *S. cancellatum* is the only representative from the Western Hemisphere. The paucity of information concerning this species, and a fortuitous collection of numerous adult specimens from bats in western Texas, prompted the present redescription.

Materials and Methods

Specimens were fixed in AFA or 70% ethanol and prepared for light microscopy by standard glycerin dehydration techniques. Specimens for scanning electron microscopy were prepared by the glycerin–KCl technique (Allison et al., 1972), and mounted on metal stubs and rotary-coated with gold palladium (20 nm or less). Nematodes were observed on an AMR-1000 scanning electron microscope.

The following redescription is based on measurements taken from 10 males and 25 females from *Anthrozous pallidus*. All measurements are in micrometers unless otherwise stated with the range followed by the mean in parentheses.

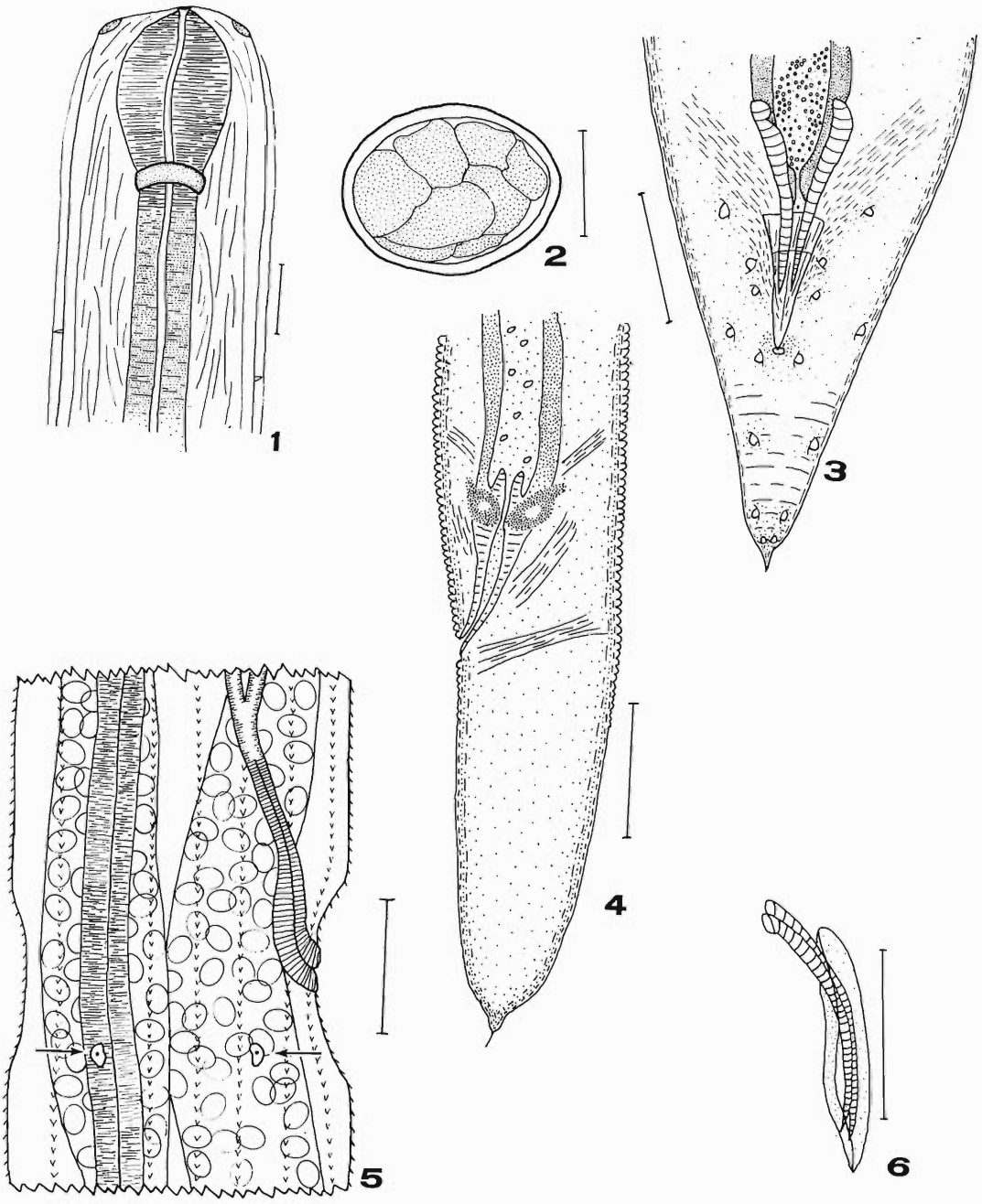
[1] Present address: Department of Biology, Tulane University, New Orleans, La. 70018.

Seuratum cancellatum Chitwood, 1938 (Figs. 1–13)

Description

The triangular oral opening is surrounded by an internal circle of six small, single papillae (Fig. 7). Each of the two lips bears two double papillae and an amphid (Figs. 7, 9). A single gravid female possessed a small protuberance located midway between an amphid and the oral opening (Fig. 7). Although perhaps an artifact, this protuberance (Fig. 8) appears to project above the surface and possesses a recessed center. A vestibule is absent and no denticles are found in the mouth region. The muscular, clavate esophagus, which is rounded and swollen anteriorly, lacks a glandular region.

The cuticle is thick and possesses conspicuous transverse striation. Sexual dimorphism in the arrangement of spines on the surface is observed in the genus for the first time. The female possesses small posteriorly directed spines which do not overlap (Figs. 10, 11). The spines on the male overlap, giving the appearance of their forming a cuticular ridge (Fig. 12). At higher magnification (Fig. 13), however, the spines are obviously separated at their tips. The spines in both sexes form continuous ridges that are equal in number, extending from slightly posterior to the nerve ring throughout the midregion of the body and disappearing anterior to the anal opening. Males: 1.64 to 2.90 mm (2.54 mm) long, 117 to 204 (153) wide. Cuticle bearing 20 longi-



Figures 1–6. ***Seuratum cancellatum*** **Chitwood, 1938 (line = 0.05 mm unless otherwise noted). 1. Anterior region of female, ventral view. 2. Ova (line = 0.015 mm). 3. Posterior region of male, ventral view. 4. Posterior region of female, lateral view (line = 0.10 mm). 5. Midbody vulvular region of female, showing two papillae (→), lateral view. 6. Gubernaculum and spicules, lateral view.**

Table 1. Comparison of life cycle and morphological data of the known species of the genus *Seuratum*.

Species	Vestibule	Denticles	Caudal alae	Caudal papillae	Rows of spines	Intermediate host	Definitive host	Authority
Seuratum mucronatum	Present	Absent	Absent	10 pairs sessile	16 male 28 female	Unknown	Bats	Biocca and Chabaud, 1951
Seuratum tacapense	Present	Absent	Present	8 pairs sessile, 2 pairs pedunculate	64 male 64 female	Unknown	Rodents	Seurat, 1915
Seuratum cancellatum	Absent	Absent	Absent	8 pairs sessile	20 male 20 female	Unknown	Bats	Chitwood, 1938; present study
Seuratum congolense	Present	Absent	Present	8–9 pairs sessile	16–20 male	Unknown	Bats	Sandground, 1937
Seuratum cadarachense	Present	Bicuspid or polycuspid	Present	8 pairs sessile, 2 pairs pedunculate	30–36 male 77–90 female	Locust (*Locusta migratoria*)	Rodents	Desportes, 1947 Quentin, 1970
Seuratum nguyenvanaii	Present	Polycuspid	Absent	10 pairs sessile	17 male 20 female	Cockroach (*Periplaneta americana*)	Insectivores	Le Van Hoa, 1964

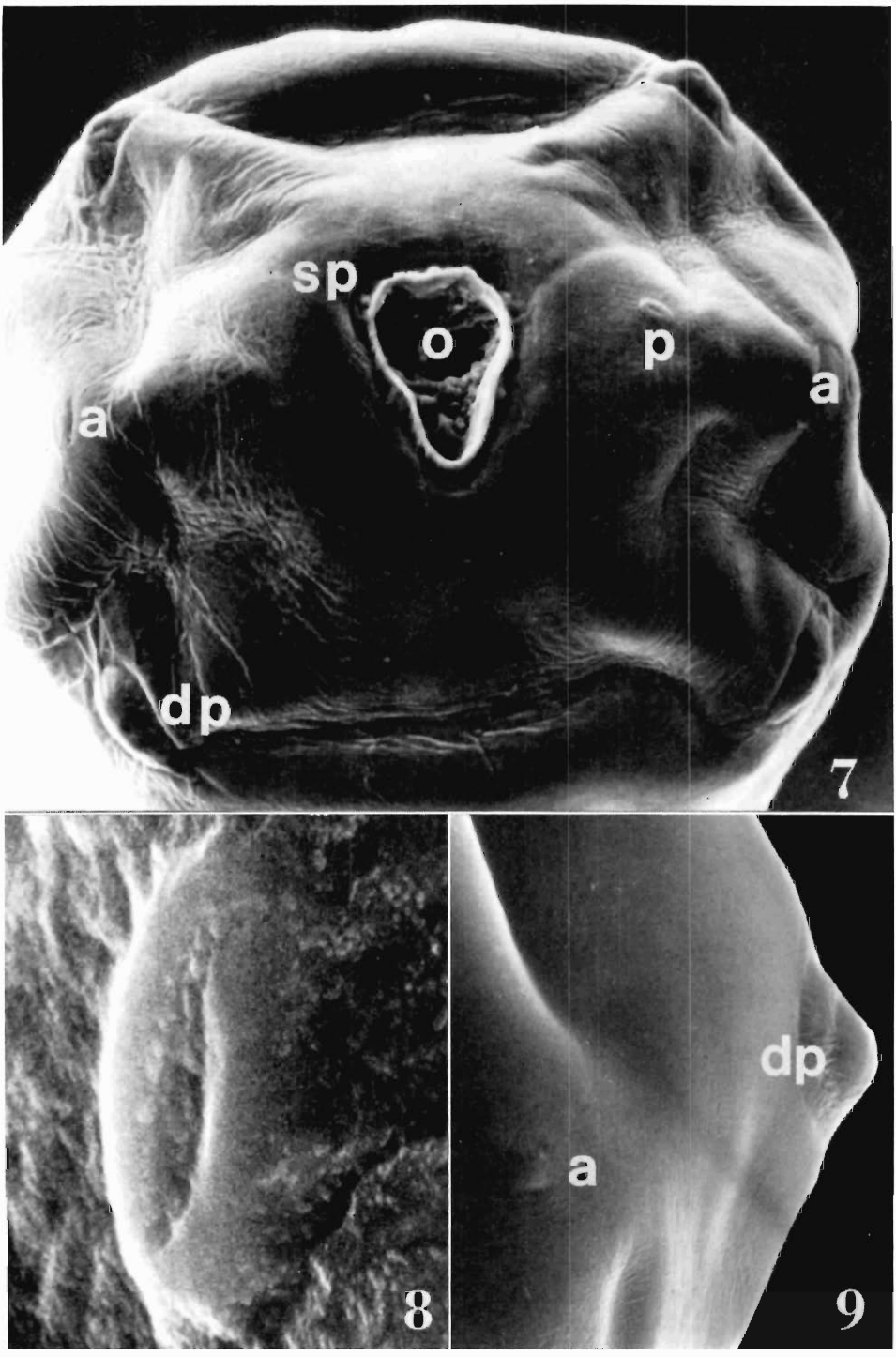
tudinal ridges 19 to 32 (24) apart, bearing posteriorly directed spines 4 to 6 (5) apart; ridges divided by transverse striae. Anus 74 to 101 (91) from posterior extremity, short terminal spike 9 to 11 (10) long. Eight pairs sessile caudal papillae; 3 pairs preanal, 5 pairs postanal. Caudal alae absent. Esophagus 314 to 438 (354) long, 146 to 219 (174) maximum width at anterior end. Excretory pore and nerve ring 116 to 155 (131) and 24 to 45 (35) from anterior end, respectively. Cervical papillae minute, 256 to 365 (310) from anterior end. Spicules equal 60 to 84 (75) long, lying within ventrally grooved gubernaculum 53 to 72 (65) long (Figs. 3, 6).

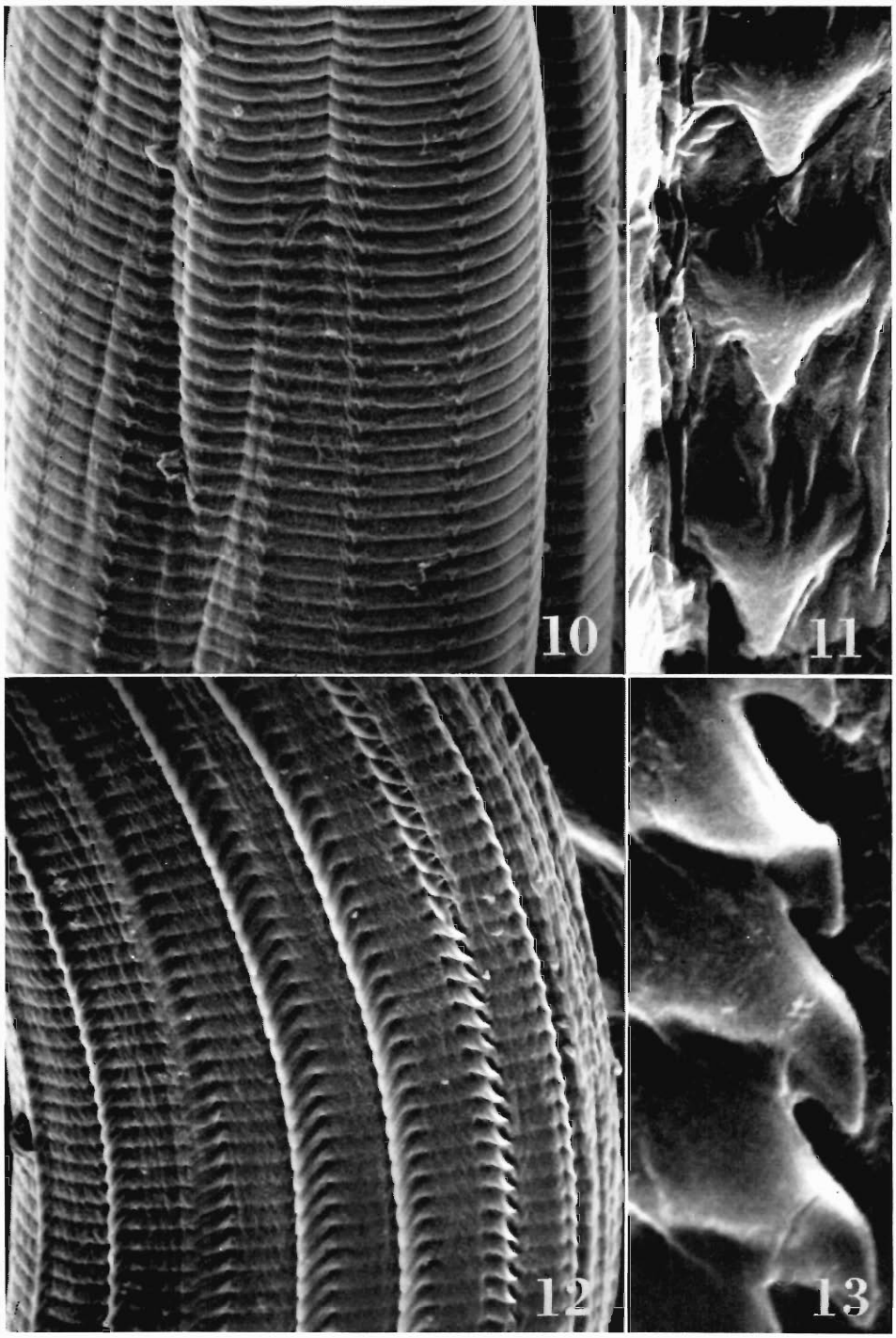
Females: 19.53 to 33.83 mm (25.56 mm) long, 380 to 591 (467) wide. Cuticle bearing 20 longitudinal ridges 47 to 54 (50) apart, bearing posteriorly directed spines 7 to 11 (10) apart; ridges divided by transverse striae. Anus 329 to 686 (594) from posterior extremity, short terminal spike 29 to 39 (34) long (Fig. 4). Esophagus 1,029 to 1,722 (1,348) long, 117 to 190 (139) maximum width at anterior end (Fig. 1). Nerve ring and cervical papillae 83 to 141 (118) and 230 to 277 (254) from anterior end, respectively. Vulva 8.09 to 12.50 mm (10.17 mm), from anterior end, marked by conspicuous annular constriction and two pairs of sessile papillae located laterodorsally and lateroventrally (Fig. 5). Uterus amphidelphic, thick-walled vagina

→

Figure 7. Scanning electron micrograph of *en face* view of *Seuratum cancellatum* female showing the inner circle of six single papillae (SP) surrounding the oral cavity (O). Also visible is the outer circle of four double papillae (DP), the two amphids (A), and an unpaired protuberance (P) of unknown function. × 655. Figure 8. A higher magnification of the unpaired protuberance reveals that it is slightly raised above the surface and has a depressed center. × 8,200. Figure 9. A lateral view of an amphid (A) and teatlike double papillae (DP). × 1,640.

Figure 10. Scanning electron micrograph of the body cuticle of a female specimen of *Seuratum cancellatum* showing the cuticular striations and numerous posteriorly directed spines. × 330. Figure 11. The spines at higher magnification appear short, pointed, and lie quite flat against the body. There is no overlap between spines. × 2,720. Figure 12. A scanning electron micrograph of the body cuticle of a male specimen of *Seuratum cancellatum* showing the cuticular striations and numerous posteriorly directed spines. × 3,280. Figure 13. The cuticle at higher magnification reveals the spines originating within one cuticular striation and extending over the origin of the next spine on the following cuticular striation. × 5,300.





48 to 84 (64) long, directed anteriorly. Eggs 29 to 33 (30) long, 17 to 29 (25) wide, embryonated when deposited (Fig. 2).

PRIMARY HOST: *Anthrozous pallidus* (Le Conte).

SITE: Small intestine.

OTHER HOSTS: *Eptesicus fuscus* (Beauvois), *Eumops perotis* (Schinz), *Myotis californicus* (Audubon and Bachman), *M. yumanesis* (Allen), *Pipistrellus hesperus* (Allen), *Plecotus townsendii* (Cooper), *Tadarida brasiliensis* (St.-Hilaire).

SITE: Body cavity.

LOCALITY: Black Gap Wildlife Management Area, Brewster County, Texas.

SPECIMENS: Hypotypes deposited, USNM Helm. Coll. No. 72947.

Discussion

The genus *Seuratum* is composed of six species: *S. cancellatum*, *S. mucronatum* (Rudolphi, 1809) and *S. congolense* Sandground, 1937, from bats; *S. tacapense* (Seurat, 1915) and *S. cadarachense* Desportes, 1947, from rodents; and *S. nguyenvanaii* Le Van Hoa, 1964, from a shrew. The comparison of those characters considered to be of specific value by previous authors is presented in Table 1.

As can be observed, *S. cancellatum* appears to be a specialized member of this genus with many characters reduced or absent. The evolution of species in this genus is quite difficult to discern; however, the species occurring in bats lack denticles and pedunculate papillae as well as having a smaller number of rows of spines on the cuticle.

The internal circle of six cephalic papillae has been reported from only three species in this genus. This discrepancy is probably due to oversight, and should not constitute a specific character. Papillae in the vulvular region of the female were not reported from *S. tacapense* and *S. congolense*; however, these may also have been overlooked.

Comparison of our specimens with the holotype of *S. cancellatum* showed them to be conspecific. Indeed, Chitwood's (1938) measurements fall within the range indicated in the present study, except in the case of specimen width and esophagus length; in both instances Chitwood's specimen was smaller. This could possibly be attributed to the fact that the single male specimen was found in the lung as opposed to the intestine, the latter location being regarded as normal because the intestine is the site of infection for the remaining five species in the genus. Our present description is based entirely on specimens recovered from *Anthrozous pallidus* where the site of infection was the small intestine. Nematodes recovered from the other seven species of bats were found in the body cavity. While these specimens are conspecific and gravid females were present, slight differences in some measurements were noted.

Acknowledgments

We wish to extend our gratitude to the Director, Hal P. Kirby, and to the staff of the Dallas Museum of Natural History for making possible the collection of specimens and aiding in the identification of bats. The Dallas Natural Science Foundation is also gratefully acknowledged for its support.

We also wish to thank Dr. J. Ralph Lichtenfels for the loan of the holotype of *S. cancellatum* from the USNM collection and Dr. David W. Fredericksen for his helpful comments on the manuscript.

Literature Cited

Allison, V. F., J. E. Ubelaker, R. W. Webster, Jr., and J. M. Riddle. 1972. Preparation of helminths for scanning electron microscopy. J. Parasit. 58: 414–416.

Biocca, E., and A. G. Chabaud. 1951. Redescription de *Seuratum mucronatum* (Rud. 1809) (Nematoda—Cucullanidae). Ann. Parasit. Hum. Comp. 26: 85–92.

Chitwood, B. G. 1938. Some nematodes from the caves of Yucatan. Carnegie Instit. Washington Publ. 491: 51–66.

Desportes, C. 1947. Sur les caracteres specifiques d'une nouvelle espece de Cucullanidae, *Seuratum cadarachense* n. sp., de l'intestin du lerot (*Eliomys quercinus* L.). Ann. Parasit. Hum. Comp. 22: 45–52.

Le Van Hoa. 1964. Etude d'une nouvelle espece de Seuratidae, *Seuratum nguyenvanaii* n. sp. dans l'intestin de la Musaraigne (*Suncus murinus*) au Sud Viet-Nam. Bulletin Soc. Path. Exot. 57: 138–150.

Quentin, J. C. 1970. Sur le cycle evolutif de

Seuratum cadarachense Desportes, 1947 et ses affinites avec ceux des Nematodes Subulures (Ascarida) et Rictulaires (Spirurida). Ann. Parasit. Hum. Comp. 45: 605–628.

Sandground, J. H. 1937. Three new parasitic nematodes from the Belgian Congo. Rev. Zool. Bot. Africaines 29: 230–236.

Seurat, L. G. 1915. Sur un nouvel *Ophiostomum* parasite du gundi. Comp. Rend. Sean. Soc. Biol. 78: 20–22.

Some Digenetic Trematodes of Birds from Taiwan[1]

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

ABSTRACT: Thirty-three species of digenetic trematodes of birds are reported from Taiwan. One new genus and eight new species are described: Eucotylidae, *Tanaisia* (*Paratanaisia*) *ectorchis* sp. n.; Brachylaimidae, *Glaphyrostomum taiwanense* sp. n.; Echinostomatidae, *Echinoparyphium anatis* sp. n., *E. taipeiense* sp. n., *Euparyphium hirundonis* sp. n., *E. taiwanense* sp. n., *Uroproctepisthmium taiwanense* gen. n., sp. n.; Dicrocoeliidae, *Platynotrema lophurae* sp. n. Previously described species reported are: Notocotylidae, *Notocotylus attenuatus*; Cyclocoelidae, *Cyclocoelum kossacki* (described), *C. obscurum*; Echinostomatidae, *Echinostoma chloropodis*, *E. revolutum*, *Hypoderaeum charadrii*, *H. conoideum*, *Nephrostomum bicolanum*, *Paryphostomum radiatum*, *Petasiger exaeretus*, *Acanthoparyphium spinulosum*, *Pegosomum egretti*; Dicrocoeliidae, *Brachylecithum capilliforme*, *B. mosquense*, *B. praetenue*; Lecithodendriidae, *Phaneropsolus borneoensis*; Microphallidae, *Maritrema gratiosum*; Clinostomidae, *Clinostomum complanatum*; Diplostomatidae, *Neodiplostomum* (*Neodiplostomum*) *toruligenitale*; Strigeidae, *Strigea elongata*, *Apharyngostrigea ramai*, *A. serpentia* (described), *Ophiosoma patagiatum*, *Parastrigea flexilis*, *Apatemon minor*. *Acanthoparyphium cambellense* Soota, Srivastava, and Ghosh, 1969, is declared a synonym of *A. spinulosum* Johnston, 1917.

The trematodes of this report were part of a collection made by one of us (REK) while a member of the United States Naval Medical Research Unit No. 2, Taipei, Taiwan. Worms were washed in saline, killed in hot water, and placed at once into FAA fixative; after 4–8 hr they were stored in 70% alcohol plus 2% glycerin; staining was with carmine or hematoxylin. Host names recorded are those listed by Kuntz and Dien (1970). An asterisk (*) preceding a host name denotes a new host record. Specimens of each trematode species have been deposited in the United States National Museum Helminthological Collection as noted. All measurements are in microns.

Tanaisia (*Paratanaisia*) *ectorchis* sp. n. (Figs. 1, 2)

HOSTS: Galliformes: Phasianidae. Type, *Bambusicola thoracica sonorivox* Gould, Formosan bamboo partridge; *Lophura swinhoii* (Gould), Swinhoe's blue pheasant.

HABITATS: Ureter, kidney.

LOCALITIES: Pu-li and Wu-sheh, Nan-tou Prefecture.

DATES: 14, 16 January, 7 February, 21 April 1959.

SPECIMENS DEPOSITED: No. 73342 (holotype, *B. thoracica*); No. 73343 (paratypes, *B. thoracica*); Nos. 73344, 73345 (paratypes, *L. swinhoii*).

Description

Eucotylidae. Body elongate, sides nearly parallel, extremities rounded, usually widest at testicular level, 2,745–4,230 long by 505–765 wide. Scales covering body, variable in size at all levels, lying slightly oblique to longitudinal body axis, wider than long, 3–10 by 8–24, base thicker than blade, with dark spots at base and subdivisions of blade in some, prongs absent. Oral sucker ventroterminal, transversely elongate, truncated posteriorly, 195–275 by 220–325. Acetabulum and prepharynx

[1] Contribution from the Department of Biological Sciences, State University of New York at Binghamton, Binghamton, New York 13901 (J. H. Fischthal).

[2] Address of R. E. Kuntz: Department of Parasitology, Southwest Foundation for Research and Education, P.O. Box 28147, San Antonio, Texas 78284.

absent. Pharynx overlapping oral sucker dorsally, transversely elongate, 73–121 by 102–131; esophagus 65–180 long; gland cells surrounding esophagus–pharynx junction; ceca narrow, bowed medianly at testicular level, united posteriorly; postcecal space 280–505 long.

Testes two, symmetrical to subsymmetrical, irregular in outline, entirely or mostly extracecal, longitudinally elongate, right testis 220–405 by 170–335, left testis 230–470 by 170–280. Cirrus sac thick-walled, muscular, anteroventral to ovary, median to submedian. Seminal vesicle saccular, 58–126 by 47–97. Genital pore median, at level of anteriormost part of ovary or more anteriorly. Ovary multilobed, sinistromedian, overlapping cecum, 188–260 by 143–335, lying 73–205 pretesticular and 750–1,075 from anterior extremity. Seminal receptacle postovarian, sinistral, large, 110–218 by 105–235. Mehlis' gland posteromedian to ovary. Vitelline follicles in narrow lateral fields, anteriormost extent varying from pharyngeal to just postbifurcal level, may be equal anteriorly or start at different levels (e.g., right field at midesophagus, left bifurcal), usually subequal posteriorly; postvitelline space 760–1,705 long. Transverse vitelline ducts postovarian; vitelline reservoir apparent in some worms. Uterus filling body posttesticularly, extending extracecally between ovary and cecal bifurcation, passing between testes, few coils occasionally extending prebifurcal. Eggs numerous, brown, with opercular collar, usually with anopercular thickening, knob, or short process, oval to one side slightly less rounded causing operculum and anopercular process to be shifted submedianly toward flatter side; 30 eggs measuring 30–40 (36.7) by 14–18 (16.8).

Discussion

Our collection contains nine and 11 adult worms from two *B. thoracica* (five measured), and 21 and 22 from two *L. swinhoii* (five measured). Our new species differs from all others in the subgenus *Paratanaisia* in having the testes extracecal. Our species is closest to *T.* (*P.*) *bragai* Santos, 1934, from a variety of birds from South America, Puerto Rico, United States, Philippines, and North Vietnam, and to *T.* (*P.*) *robusta* Freitas, 1951, from a tinamid bird from Brazil. Both differ further from ours in having differently shaped scales which frequently have distinct prongs (Stunkard, 1945; Freitas, 1951).

Glaphyrostomum taiwanense sp. n. (Figs. 3, 4)

HOSTS: Type, *Garrulax canorus taewanus* Swinhoe, Formosan laughing thrush (Passeriformes: Timaliidae); *Cissa caerula* (Gould), blue magpie (Passeriformes: Corvidae).

HABITAT: Small intestine.

LOCALITIES: Chang-hua, Chang-hua Prefecture; Wu-lai, Taipei Prefecture; I-lan, I-lan Prefecture.

DATES: 12, 13 February 1959; 1 February 1961.

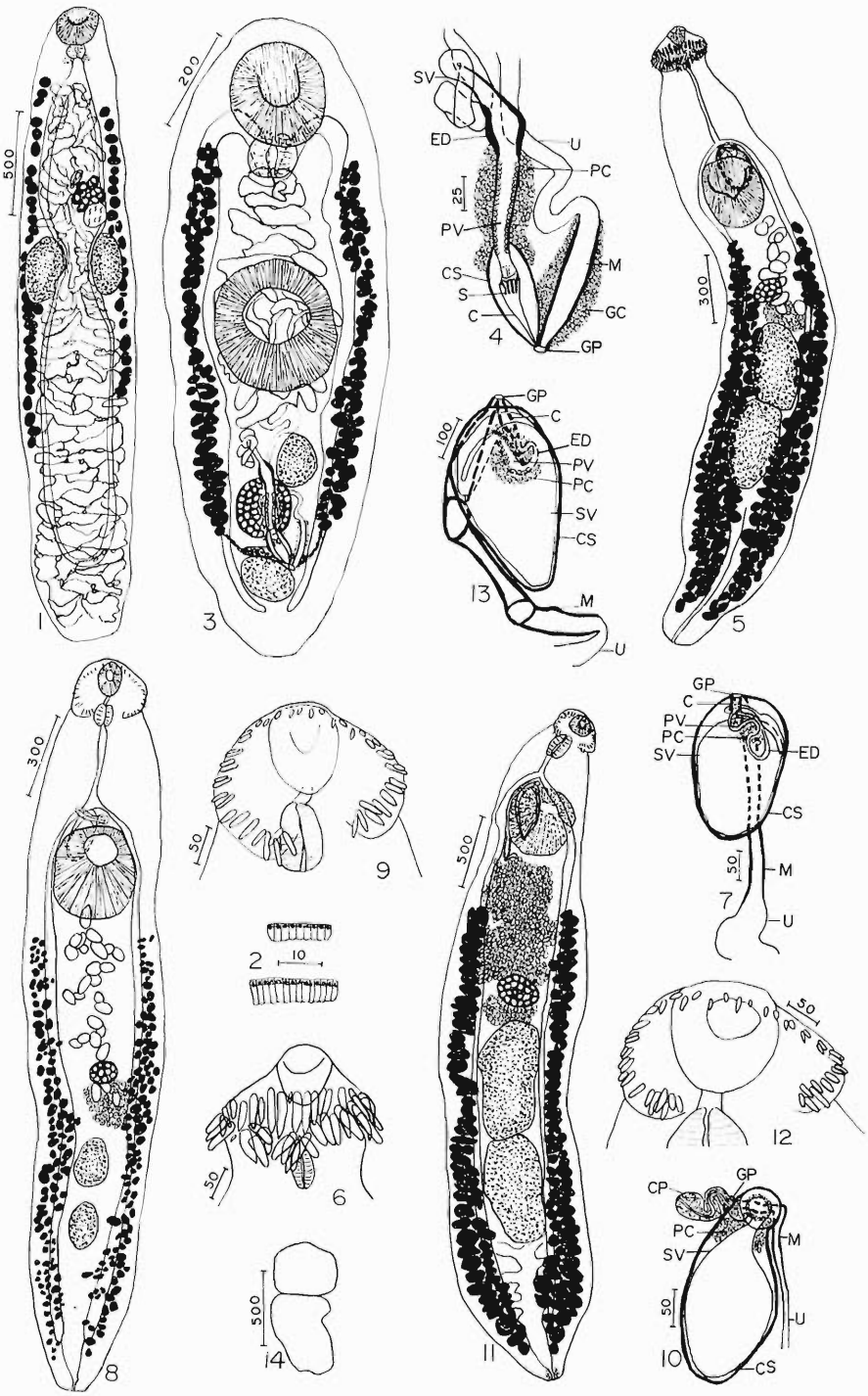
SPECIMENS DEPOSITED: No. 73346 (holotype and paratypes, *G. canorus*); No. 73347 (paratypes, *G. canorus*); No. 73348 (paratypes, *C. caerula*).

Description

Brachylaimidae. Body elongate, narrowing posteriorly, extremities rounded, entirely spined ventrally and laterally, anterodorsally spined over oral sucker and sometimes more pos-

→

Figures 1–14. ***Tanaisia* (*Paratanaisia*) *ectorchis*** **sp. n. 1. Adult, holotype, ventral view. 2. Body scales.** ***Glaphyrostomum taiwanense*** **sp. n. 3. Adult, holotype, ventral view. 4. Terminal genitalia, holotype.** ***Echinoparyphium anatis*** **sp. n. 5. Adult, holotype, ventral view. 6. Head collar and spines, holotype. 7. Terminal genitalia, holotype.** ***Echinoparyphium taipeiense*** **sp. n. 8. Adult, holotype, ventral view. 9. Head collar and spines, holotype. 10. Terminal genitalia, holotype.** ***Euparyphium hirundonis*** **sp. n. 11. Adult, holotype, dorsal view. 12. Head collar and spines, holotype. 13. Terminal genitalia, holotype. 14. Testes, paratype, dorsal view. C, cirrus; CP, protruded cirrus; CS, cirrus sac; ED, ejaculatory duct; GC, gland cells; GP, genital pore; M, metraterm; PC, prostate cells; PV, prostatic vesicle; S, spines; SV, seminal vesicle; U, uterus.**



teriorly to pharyngeal level or nearly to acetabulum, posterodorsally spined only at body tip, 1,197–2,560 long by 405–660 wide. Forebody 455–1,110 long; hindbody 385–1,165 long; forebody–hindbody length ratio 1 : 0.75–1.16. Oral sucker ventral, longitudinally oval, with narrow compact muscle layer within margins, 210–350 by 194–295; preoral space 5–52 long. Acetabulum longitudinally to transversely elongate, 240–330 by 215–330. Sucker length ratio 1 : 0.93–1.19, width ratio 1 : 1.10–1.27. Prepharynx short, usually not apparent; pharynx longitudinally to transversely elongate, 80–133 by 92–140; esophagus short, usually obscured by eggs; ceca narrow, ascending to oral sucker before looping posteriorly, terminating near posterior extremity. Excretory vesicle tubular, bifurcating posttesticular; pore dorsal, varying in position from near posterior tip of body to just posterior to level of cecal ends.

Testes two, diagonal, smooth, separated by ovary, intercecal; anterior testis sinistral, usually longitudinally elongate, 85–189 by 80–185, lying 46–450 postacetabular; posterior testis median, more or less embraced by cecal ends, 90–177 by 80–167; posttesticular space 32–165 long. Vas efferens emerging from anterior margin of posterior testis and posterior margin of anterior testis. External seminal vesicle tubular, coiled, dextral to anterodextral to anterior testis, usually much obscured by eggs. Ejaculatory duct muscular, straight to slightly winding, tubular for short distance, then expanding to form vesicle with walls 5–10 thick. Prostatic duct 50–114 by 20–39, straight, thick-walled, conspicuously cell-lined, surrounded by prostate cells, entering cirrus sac for short distance. Cirrus sac thick-walled, muscular, 50–92 by 30–56, commencing at ovarian level, usually terminating at posterior testis level but occasionally between ovary and latter. Cirrus thick-walled, muscular, straight proximally, distal part inverted within cirrus sac, chamberlike, circlet of usually eight spines at bottom of chamber (at anterior end of cirrus when everted). Cirrus spines usually curved, tapering toward free end, anchorlike at base, 16 spines measuring 10–20 (14.4) by 3–6 (4.1) at base. Genital atrium shallow. Genital pore usually at posterior testis level (anterior half), occasionally at anterior margin of latter, median to sinistromedian, on papillalike elevation of ventral body wall (most apparent in lateral view). Ovary usually longitudinally elongate, 100–175 by 80–148, smooth, dextral, intercecal, more dorsal than testes, contiguous with both testes or only posterior testis or separated from both, same size to smaller or larger than testes. Oviduct emerging from posteromedian side of ovary. Mehlis' gland posteromedian to ovary. Laurer's canal extending toward but not reaching dorsal surface at ovarian level. Vitelline follicles extending from level of oral sucker, pharynx, or rarely just postpharyngeal only on one side, to ovarian or anterior part of posterior testis level, lying ventral, lateral, and dorsal to ceca, occasionally few follicles slightly invading intercecal space. Vitelline ducts uniting anterosinistral to posterior testis forming reservoir. Uterine coils mostly preovarian, filling intercecal space to pharyngeal level or just posterior to latter, in worms over 2,000 long one or two uterine coils extending to posterior testis level or near to posterior extremity, occasionally few coils extending laterally to overlap ceca but rarely extracecally, not extending anterior to cecal loops lying lateral to pharynx. Metraterm sinistral to cirrus sac, about same length to slightly longer than latter, surrounded by dense mass of gland cells. Eggs numerous, yellow-brown, operculate, oval, occasionally one side somewhat flattened, 30 measuring 22–32 (27.1) by 13–19 (16.2).

Discussion

Our collection contains 49 adult worms (four measured) from one thrush and 38 and 145, respectively, from two magpies (three from each measured). Our new species differs from all known species in the genus in having a spined cirrus and a longitudinally oval oral sucker. It is closest to *G. adhaerens* Braun, 1901, from gruiform (Rallidae) and passeriform (Pteroptochidae) birds from Brazil, and to *G. pintoi* (Travassos and Kohn, 1964) Yamaguti, 1971, from a tinamiform (Tinamidae) bird from Brazil. The latter species differs further from ours in having a much wider and unspined body; a larger sucker ratio, pharynx, and testes; the ceca terminating at the posterior testis level; the cirrus sac containing only the cirrus; and the uterus extending anterior to the cecal loops lying lateral to

the pharynx. *G. adhaerens* differs further from ours in having spines only on the anterior end of the body, a larger sucker ratio (1 : 1.28–1.49), and smaller eggs (20 by 9–10).

Echinoparyphium anatis sp. n. (Figs. 5–7)

HOST: Domestic duck (Anseriformes: Anatidae).

HABITAT: Small intestine.

LOCALITY: Hua-lien, Hua-lien Prefecture.

DATE: 19 September 1958.

SPECIMENS DEPOSITED: No. 73349 (holotype); No. 73350 (paratype).

Description

Echinostomatidae. Body elongate, extremities rounded, 2,935–3,505 long by 455–555 wide; body spines lost. Forebody 630–915 long; hindbody 1,990–2,220 long; forebody–hindbody length ratio 1 : 2.4–3.2. Head collar 190 by 230 (holotype), with 41–42 spines; four corner spines (73–85 by 20–25) on each side, remainder in two alternating, uninterrupted rows; lateral oral spines 51–73 by 15–22, aboral 50–78 by 14–17; dorsal oral spines 42–74 by 13–16, aboral 53–77 by 12–22. Oral sucker ventroterminal, 97–126 long by 97 wide by 100 deep. Acetabulum 315–370 by 280–305, aperture tilted anteroventrally. Sucker length ratio 1 : 2.94, width ratio 1 : 2.89 (holotype). Prepharynx 58 long (holotype); pharynx 80–85 by 46 by 74; esophagus 332 long (holotype); cecal bifurcation close to acetabulum; ceca narrow, extending to near posterior extremity. Excretory vesicle with lateral branches, commencing just posttesticular; arms extending to acetabular level; pore terminal.

Testes two, tandem, contiguous, intercecal, smooth; anterior testis 330–365 by 230–245, posterior testis 400–445 by 190–220; posttesticular space 715–895 long. Cirrus sac thick-walled, muscular, widest anteriorly, 255–325 by 148–170, commencing 172–190 posterior to anterior margin of acetabulum (just posterior to midlength of latter), extending to cecal bifurcation. Seminal vesicle nearly filling cirrus sac, with tubular posterior loop anteriorly, 222–325 (longitudinal extent) by 136–160. Prostatic vesicle 85 by 46 (holotype), surrounded by prostate cells. Cirrus muscular, straight, protruded in paratype. Genital pore submedian, near beginning of left cecum. Ovary smooth, median to dextral, 115–158 by 124–130, lying 225–270 postacetabular and 70–155 anterior to anterior testis. Mehlis' gland large, between ovary and anterior testis, overlapping both. Vitellaria in lateral fields, extending from posteriormost part of acetabulum or just postacetabular to near posterior extremity, overlapping ceca, some follicles invading intercecal space especially posttesticular, fields not confluent but nearly so in paratype. Uterus short, with few loops between anterior testis and acetabulum, sperm in proximal coils. Metraterm thick-walled, muscular, commencing near posterior margin of acetabulum, sinistrodorsal to cirrus sac. Eggs numbering 14 and 18, yellow-brown, thin-shelled, operculate, four measuring 92–102 by 63–66.

Discussion

Our collection contains two adult worms. Three of the 42 collar spines apparently were lost in the holotype, one lateral oral immediately next to each group of corner spines and one dorsal oral; all three have been partly regenerated but are much smaller than the other spines. The grouping of collar spines follows the method given by Lie and Umathevy (1965) for their new species *Echinoparyphium dunni*. There are three species in the genus within a range of 41–43 collar spines that have four corner spines on each side: *E. oxyurum* Johnston, 1917 (42); *E. streptopeliae* Oshmarin, 1970 (43); *E. westsibericum* Isaichikov, 1924 (41). *E. oxyurum* differs from our new species in being larger, and in having the posterior extremity sharp-pointed, all but the corner spines arranged in a single row, a 1 : 4 sucker ratio, and a very long posttesticular space. *E. streptopeliae* differs from ours in having smaller corner spines (50 by 15), smaller dorsal collar spines (oral 35 by 10, aboral 50 by 12), four collar spines arranged in a single row next to the corner spines, a sucker ratio of about 1 : 4, and smaller eggs (85 by 55). *E. westsibericum* is closest to ours but differs in having narrower corner spines (13–15), narrower alternating oral collar spines (5–11), the cecal bifurcation considerably preacetabular, and a longer cirrus sac (360–380) which barely overlaps the acetabulum.

Echinoparyphium taipeiense sp. n. (Figs. 8–10)

HOST: Domestic chicken (Galliformes: Phasianidae).

HABITAT: Small intestine.

LOCALITY: Taipei, Taipei Prefecture.

DATE: 18 October 1957.

SPECIMEN DEPOSITED: No. 73351 (holotype).

Description

Echinostomatidae. Body elongate, extremities rounded, 2,750 long by 495 wide; body spines scalelike, extending ventrally to ovarian level but sparse posteriorly, absent dorsally and dorsolaterally from anterior tip of body to posteriormost part of oral sucker but present thereafter to near cecal bifurcation medianly and acetabular level dorsolaterally. Forebody 590 long; hindbody 1,840 long; forebody–hindbody length ratio 1:3.1. Head collar 215 by 280, with 42 spines; four corner spines on each side, two lateral ones on each side arranged in single row (44–52 by 10), remainder in two alternating, uninterrupted rows of 15 each; median oral corner spines 40–47 by 10, aboral 40–50 by 10; lateral oral corner spines 34–41 by 8, aboral 41–45 by 9; five spines in lateral alternating oral row 43–46 by 7–9, four in aboral row 34–42 by 8–9; dorsal and dorsolateral spines not measurable as not lying in flat plane. Oral sucker ventroterminal, 133 by 105. Acetabulum 320 by 290, aperture tilted anteroventrally. Sucker length ratio 1:2.41, width ratio 1:2.76. Prepharynx 55 long; pharynx 100 by 76; esophagus 270 long; cecal bifurcation close to acetabulum; ceca narrow, extending to near posterior extremity. Excretory vesicle with lateral branches, commencing just posttesticular; arms extending to acetabular level, filling intercecal space; pore terminal.

Testes two, tandem, intercecal, smooth, 35 apart; anterior testis 186 by 118, posterior testis 186 by 115; posttesticular space 435 long. Cirrus sac thick-walled, muscular, 235 by 140, dorsal to dextromedian part of acetabulum, commencing 145 posterior to anterior margin of acetabulum, extending nearly to cecal bifurcation. Seminal vesicle saccular, 180 by 120, nearly filling cirrus sac possibly because cirrus is protruded through genital pore. Latter sinistromedian, next to cecum. Prostatic vesicle not observed but anterior part of seminal vesicle and posterior part of cirrus surrounded by prostate cells. Ovary smooth, 98 by 100, lying 485 postacetabular and 375 pretesticular. Mehlis' gland large, postovarian. Vitellaria in lateral fields, extending from short distance postacetabular to posterior extremity, overlapping ceca, few follicles invading intercecal space, not confluent posteriorly. Uterus with few loops between Mehlis' gland and acetabulum, intercecal. Metraterm thick-walled, muscular, shorter than and sinistral to cirrus sac. Eggs numbering 29, seven measuring 75–85 (80.6) by 51–56 (54.3).

Discussion

Our collection contains only the holotype worm. There are four species in the genus within a range of 41–43 collar spines that have four corner spines, namely, the three species listed under *E. anatis* sp. n. and the latter. *E. anatis* differs from *E. taipeiense* sp. n. in lacking lateral spines in a single row next to the corner spines, and in having larger collar spines, a much longer metraterm which is longer than the cirrus sac, and larger eggs. *E. oxyurum* differs in being twice as long, and in having the posterior extremity sharp-pointed, all but the corner collar spines arranged in a single row, much longer collar spines (to 91), a 1:4 sucker ratio, a very long posttesticular space, and larger eggs (96–107 by 58–80). *E. streptopeliae* differs in having wider corner spines (15), four collar spines arranged in a single row next to the corner spines, a sucker length ratio of about 1:4 and width ratio of 1:3.4, and relatively larger testes (350–380 by 200). *E. westsibericum* differs in having larger corner spines (67–74 by 13–15) and aboral spines (58–67 by 13–14), the cecal bifurcation considerably preacetabular, relatively larger testes (260–480 by 180–220) and ovary (150–180 by 130–180), the cirrus sac only slightly overlapping the acetabulum, and larger eggs (90–108 by 63–72).

Euparyphium hirundonis sp. n. (Figs. 11–14)

HOST: *Hirundo daurica formosae* Mayr, Formosan striated swallow (Passeriformes: Hirundinidae).

HABITAT: Small intestine.
LOCALITY: Mei-nung, Kao-hsiung Prefecture.
DATE: 15 July 1961.
SPECIMENS DEPOSITED: No. 73352 (holotype and paratype).

Description

Echinostomatidae. Body elongate, anterior extremity rounded, posterior extremity bluntly pointed, 3,675–4,535 long by 910–965 wide; body spines scalelike, hardly projecting beyond tegument, extending to acetabulum ventromedianly and to posterior testis level ventrolaterally and laterally, sparse posteriorly, absent dorsally and dorsolaterally from anterior tip of body to posteriormost part of oral sucker but present thereafter to cecal bifurcation medianly and acetabular level dorsolaterally. Forebody 435–605 long; hindbody 2,780–3,460 long; forebody–hindbody length ratio 1:5.7–6.4. Head collar 218 by 350 (holotype), with 44 pointed spines; five corner spines on each side (three oral, two aboral), two lateral ones on each side arranged in single row (32–41 by 10–13), remainder in two alternating, uninterrupted rows of 15 each; oral corner spines 27–49 by 8–15, aboral 32–49 by 8–16; lateral oral spines 34–44 by 8–10, aboral 34–45 by 8–11; dorsal oral spines 22–34 by 8–12, aboral 25–35 by 8–12. Oral sucker ventroterminal, 160–172 long by 165 wide by 135 deep. Acetabulum 460–470 by 430 by 495, aperture tilted anteroventrally. Sucker length ratio 1:2.67–2.94, width ratio 1:2.61, depth ratio 1:3.67. Prepharynx 53 long (holotype); pharynx 153–177 by 129 by 138; esophagus 170 long (holotype); cecal bifurcation close to acetabulum; ceca narrow, extending to near posterior extremity. Excretory vesicle with lateral branches, commencing just posttesticular; arms extending to sides of acetabulum; pore terminal.

Testes two, tandem, contiguous, intercecal, slightly lobed; anterior testis 450–795 by 420–435, posterior testis 530–725 by 385–405; posttesticular space 785–925 long. Cirrus sac teardrop-shaped, thick-walled, muscular, 445–455 by 255 by 165, commencing 375–390 posterior to anterior margin of acetabulum (distances 80–85% of latter's length), extending anteriorly to cecal bifurcation. Seminal vesicle saccular posteriorly, with tubular posterior loop anteriorly, 345–400 (longitudinal extent) by 205 by 240. Prostatic vesicle 97 by 47 (holotype), surrounded by prostate cells. Cirrus muscular, straight. Genital pore postbifurcal, near beginning of left cecum. Ovary transversely elongate, 190–240 by 235–280, lying 705–730 postacetabular and 65–115 pretesticular. Seminal receptacle absent; sperm in proximal part of uterus. Mehlis' gland large, between ovary and anterior testis, overlapping both. Vitellaria in lateral fields, commencing 125–250 postacetabular, extending to near posterior extremity, not confluent posttesticular, some follicles overlapping ceca, some invading intercecal space. Uterus intercecal between anterior testis and acetabulum. Metraterm convoluted, thick-walled, muscular, commencing just postacetabular, sinistrodorsal to latter, ventral to anterior part of cirrus sac. Eggs moderately numerous, yellow-brown, thin-shelled, operculate, 10 measuring 83–94 (87.8) by 54–63 (55.7).

Discussion

Our collection contains two adult worms from one host. Our species appears closest to *E. paramurinum* Velasquez, 1964 (Philippines) obtained from experimentally infected guinea pigs; we have examined the holotype specimen (USNM Helm. Coll. No. 60247). The latter species differs from ours in having a sucker length ratio of about 1:4 as its oral sucker is significantly shorter (69–92 long), a much smaller pharynx (81–120 by 46–81), an ovate cirrus sac which lies mostly anterior to the acetabulum and seldom reaches its equator, a shorter uterus with considerably fewer eggs, and longer eggs (97–115 long).

Euparyphium taiwanense sp. n. (Figs. 15–17)

HOST: Domestic chicken (Galliformes: Phasianidae).
HABITAT: Small intestine.
LOCALITY: Taipei, Taipei Prefecture.
DATE: 17 June 1957.
SPECIMENS DEPOSITED: No. 73353 (holotype); No. 73354 (paratypes).

Description

Echinostomatidae. Body elongate, narrow, spined, posterior extremity bluntly pointed,

2,390–3,550 long by 345–540 wide. Forebody 435–620 long; hindbody 1,535–2,630 long; forebody–hindbody length ratio 1:3.1–4.8. Head collar 190–260 wide, with about 41 spines (holotype); four corner spines on each side, 14 measuring 32–56 (39.4) by 15–22 (17.2); all lateral and dorsal spines in two alternating, uninterrupted rows, nine lateral spines measuring 21–35 (28) by 10–16 (12.3) and nine dorsal 20–37 (25) by 10–15 (12.3). Oral sucker ventroterminal, 78–104 by 75–87. Acetabulum longitudinally elongate, aperture tilted anteroventrally, 320–390 by 245–270. Sucker length ratio 1:3.08–5.0, width ratio 1:3.10–3.27. Prepharynx short, 45 long in holotype; pharynx 85–107 by 62–90; esophagus 335–340 long (in two worms); cecal bifurcation close to acetabulum; ceca narrow, extending to near posterior extremity. Excretory vescile difficult to ascertain anteriorly; stem receiving lateral branches, mostly thin-walled except for thick-walled, muscular part surrounded by gland cells before terminal to dorsoterminal pore.

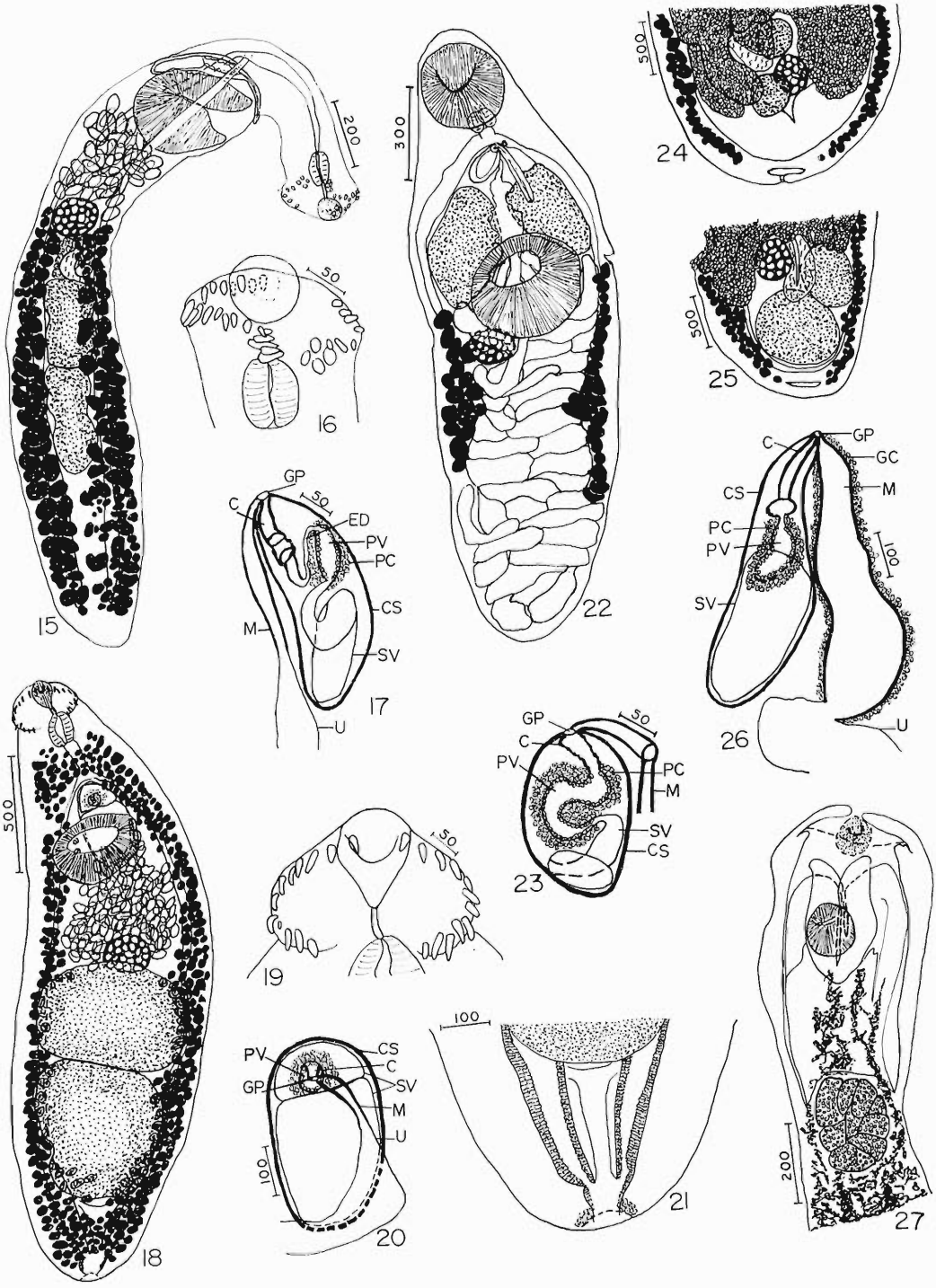
Testes two, tandem, with few indentations to being smooth, contiguous or nearly so, filling intercecal space at their levels to overlapping ceca, longitudinally elongate; anterior testis 250–435 by 175–245, posterior testis 310–465 by 160–230; posttesticular space 325–550 long. Cirrus sac thick-walled, muscular, 250–330 by 102–160, commencing dorsodextral to posterior half of acetabulum. Seminal vesicle thick-walled, muscular, saccular posteriorly, with tubular posterior loop anteriorly, 120–247 (longitudinal extent) by 68–102. Prostatic vesicle (in three worms) 58–65 by 36–42, surrounded by prostate cells. Cirrus elongate, convoluted. Genital pore submedian, dextral, bifurcal to postbifurcal, just preacetabular. Ovary smooth, intercecal, longitudinally elongate, 121–210 long by 133–160 wide by 136 deep, lying 208–820 postacetabular and 85–165 pretesticular. Seminal receptacle absent; sperm in proximal part of uterus. Mehlis' gland large, between ovary and anterior testis, overlapping both. Vitelline fields usually subequal anteriorly, commencing at level of posterior margin of acetabulum or up to 245 postacetabular, in separate fields through hindbody length, with narrow gap posttesticularly to being confluent, invading intercecal space at all levels, usually overlapping testes and ceca. Uterus relatively short, coiled between ovary and acetabulum, overlapping ceca and vitellaria; one worm with single loop extending short distance posterior to posterior testis. Metraterm thick-walled, muscular, shorter than cirrus sac. Eggs relatively few, brownish, thin-shelled, operculate, 15 measuring 77–92 (84.1) by 48–65 (56.1).

Discussion

Our collection contains eight somewhat macerated adult worms from one chicken; five were measured. Body spines are missing in all worms except for a patch on the forebody of one. Collar spines are entirely missing in some worms and many are gone in others. In the holotype the collar sinistral to the midline shows 18 spines plus scars left by two missing spines; only a few spines are present on the dextral half of the collar. A paratype shows that a spine is present on the midline dorsally and this is indicated in the holotype. Since the spine pattern on both halves of the collar in echinostomes usually is similar, we are able to estimate the total number in our holotype

→

Figures 15–27. ***Euparyphium taiwanense*** **sp. n. 15. Adult, holotype, anterior part of forebody and most of hindbody in dorsal view, acetabular region in dextrolateral view. 16. Head collar and spines, holotype. 17. Terminal genitalia, paratype, dorsal view.** ***Uroproctepisthmium taiwanense*** **gen. n., sp. n. 18. Adult, holotype, ventral view. 19. Head collar and spines, paratype, ventral view. 20. Terminal genitalia, holotype. 21. Posterior end of body showing uroproct, holotype.** ***Platynotrema lophurae*** **sp. n. 22. Adult, holotype, ventral view. 23. Terminal genitalia, paratype, ventral view.** ***Cyclocoelum kossacki*** **(Witenberg, 1923) Joyeux and Baer, 1927. 24. Posterior end of body of one worm showing relationship of gonads to one another, ventral view. 25. Posterior end of body of another worm showing relationship of gonads to one another, ventral view. 26. Terminal genitalia, ventral view.** ***Apharyngostrigea serpentia*** **Ukoli, 1967. 27. Anterior segment of body, dorsal view.**



specimen as 41. Our new species is closest to *E. murinum* Tubangui, 1931, from *Rattus norvegicus* Berkenhout (Rodentia: Muridae) from the Philippines. The latter species differs from ours in having 45–46 collar spines which are narrower (7.9–9.2), five corner spines on each side, the dorsal and lateral ones longer (range for all 35.3–45.7), 2–3 lateral spines on each side next to the corner ones arranged in a single row, and a considerably shorter esophagus (70–140 long).

Uroproctepisthmium gen. n.

DIAGNOSIS: Echinostomatidae, Echinochasminae. Body elongate, spinose. Head collar reniform, with dorsally interrupted row of spines. Prepharynx and esophagus present. Ceca opening into excretory vesicle to form uroproct. Acetabulum in anterior half of body. Testes large relative to body, tandem, at or near middle of hindbody. Cirrus sac anterodorsal to acetabulum. Seminal vesicle bipartite. Genital pore preacetabular. Ovary pretesticular. Vitellaria extending from pharynx to posterior extremity, confluent anterior to genital pore and posttesticular. Uterus short. Excretory vesicle Y-shaped, bifurcating posttesticular, serving as uroproct posteriorly. Parasitic in intestine of birds.

TYPE SPECIES: *Uroproctepisthmium taiwanense* sp. n.

Uroproctepisthmium taiwanense sp. n. (Figs. 18–21)

HOST: *Bubulcus ibis coromandus* (Boddaert), Indian cattle egret (Ciconiiformes: Ardeidae).

HABITAT: Small intestine.

LOCALITY: Nan-tou Prefecture.

DATE: 28 April 1959.

SPECIMENS DEPOSITED: No. 73355 (holotype); No. 73356 (paratype).

Description

Body elongate, 2,605–2,900 long by 720–810 wide; body spines on all but head collar, pointed, sparse but usually longer posteriorly. Forebody 615–680 long; hindbody 1,680–1,840 long; forebody–hindbody length ratio 1:2.7. Head collar reniform, 222–240 by 305–320, with 24–25 dorsally interrupted collar spines; four corner spines on each side in one worm, four on one side and five on other in second worm, median one more aboral, lateralmost one more oral, other two (three, on side with five) at level between them, 32–50 by 10–15; eight spines on each side of dorsal interruption (gap 38–57 wide) in single row, lateral ones 42–52 by 13–16, dorsal ones 34–42 by 13–15. Oral sucker ventroterminal, funnel-shaped, 148–155 by 105–124. Acetabulum transversely oval, 310–380 by 375–420. Sucker length ratio 1:2.0–2.58, width ratio 1:3.39–3.57. Prepharynx 53–60 long; pharynx 146–153 by 126–134; esophagus wide, 195–205 long; cecal bifurcation short distance preacetabular; ceca narrow, extending to near posterior extremity where they open into sides of excretory stem to form uroproct. Excretory vesicle Y-shaped, stem bifurcating just posttesticular. Uroproct pore dorsoterminal.

Testes two, tandem, contiguous, intercecal to slightly overlapping ceca, at or near middle of hindbody, large; anterior testis smooth, 470–500 by 535–640; posterior testis with few indentations, 610–670 by 465–565; posttesticular space 330–400 long. Cirrus sac thick-walled, muscular, large, 385–415 by 215–310, commencing 265–310 posterior to anterior margin of acetabulum (posterior fifth), extending to cecal bifurcation. Seminal vesicle bipartite; posterior chamber 278–350 by 205–255, anterior chamber 97–116 by 165–180. Prostatic vesicle ventral to anterior chamber of seminal vesicle, 54–68 by 61–65, surrounded by prostate cells. Cirrus short. Genital pore median, between acetabulum and cecal bifurcation. Ovary median to submedian, smooth, 180–208 by 205–230, lying 145–230 postacetabular, overlapping level of anterior testis 25–30. Mehlis' gland ventromedian to ovary. Vitellaria extensive, extending from pharynx to posterior extremity, in lateral fields from level of cecal bifurcation to posterior part of posterior testis, follicles invading intercecal space, confluent dorsally anterior to genital pore and ventrally posttesticular. Uterus short, coiled between anterior testis and acetabulum, proximal part containing sperm. Metraterm muscular, ventral to cirrus sac. Eggs few to moderate in number, thin-shelled, yellow-brown, operculate, 10 measuring 73–86 (80.2) by 44–49 (46.5).

Discussion

Uroproctepisthmium gen. n. is closest to *Episthmium* Lühe, 1909, differing from the latter in possessing a uroproct. Our collection contains two adult worms from one host. They readily fit the description of *Episthmium chauhani* Rai, 1963, from *Bubulcus ibis* (L.) from India, except for the uroproct. Since Rai's observations are based on 132 worms, we must assume the ceca end blindly near the posterior extremity as stated. Should a restudy of his specimens show a uroproct present, then Rai's species would become *Uroproctepisthmium chauhani* (Rai, 1963) comb. n. and our species would be a synonym of it. Rai's measurements for the collar spines are apparently erroneously recorded as his Fig. 2 indicates they are considerably smaller.

Platynotrema lophurae sp. n. (Figs. 22, 23)

HOST: *Lophura swinhoii* (Gould), Swinhoe's blue pheasant (Galliformes: Phasianidae).

HABITAT: Liver.

LOCALITY: I-lan, I-lan Prefecture.

DATE: 6 November 1959.

SPECIMENS DEPOSITED: No. 73357 (holotype and paratypes); No. 73358 (paratypes).

Description

Dicrocoeliidae. Body fusiform, extremities rounded, 1,848–2,435 long by 550–1,015 wide at acetabular level. Forebody 358–750 long; hindbody 965–1,310 long; forebody–hindbody length ratio 1:1.4–3.1. Oral sucker ventral, usually longitudinally elongate, 242–385 by 265–310; preoral space 16–41 long. Acetabulum usually transversely elongate, 310–385 by 355–400. Sucker length ratio 1:0.99–1.59, width ratio 1:1.16–1.48. Prepharynx absent; pharynx round or nearly so, overlapping oral sucker dorsally, 78–90 by 78–94; esophagus short; cecal bifurcation much closer to oral sucker than acetabulum; ceca narrow, extending to near posterior extremity. Excretory pore terminal; vesicle obscured by eggs.

Testes two, symmetrical, anterolateral to acetabulum, usually smooth, separated by ascending uterus, size varying considerably; right testis 110–385 by 105–260, left testis 130–350 by 97–215. Cirrus sac thick-walled, muscular, longitudinally oval in relaxed worms, transversely oval in those with forebody contracted, 107–215 by 115–170, proximal part overlapping acetabulum in worms with forebody contracted to commencing up to 172 preacetabular in relaxed ones. Seminal vesicle tubular, winding. Prostatic vesicle tubular, curved, surrounded by prostate cells. Cirrus protrusible, finely spined. Genital pore median to slightly submedian, just postbifurcal. Ovary smooth, posterodextral to acetabulum in nine worms, posterosinistral in 15, longitudinally to transversely elongate, 155–215 by 100–220. Seminal receptacle present. Vitelline follicles large, in lateral fields, commencing at level of posterior part of acetabulum, one field always longer than other, right field 440–740 long, left field 390–750 long; postvitelline space 450–725 long, distances 46.6–64.2% of hindbody length. Uterus filling most of hindbody, coils dorsal and anterior to acetabulum. Metraterm thick-walled, muscular, shorter than cirrus sac. Eggs numerous, yellow-brown, operculate, 20 measuring 40–47 (43.2) by 24–28 (26.3).

Discussion

Our collection contains 62 adult worms; seven were measured. Our new species is closest to *P. jecoris* Nicoll, 1914, from a gruiform (Burhinidae) bird from Queensland, Australia. The latter differs from ours in having a large gland cell mass around the genital pore which extends from the pharynx to the seminal vesicle level, a more extensive vitellaria, a much shorter postvitelline space, and smaller eggs (27–30 by 18–20).

Previously Described Species

1. *Notocotylus attenuatus* (Rudolphi, 1809) Kossack, 1911 (Notocotylidae) from the small intestine of *Anas platyrhynchos* L. (Anseriformes: Anatidae) and domestic chickens collected at Pu-yen, Chang-hua Prefecture, and Taipei, Taipei Prefecture, on 17 June 1957 and 16, 17, 20 June 1959. Specimens deposited: No. 73359 (*A. platyrhynchos*); No. 73354 (chicken).

2. *Cyclocoelum kossacki* (Witenberg, 1923) Joyeux and Baer, 1927 (Cyclocoelidae) (Figs. 24–26): two adult worms from the air sacs of the dunlin, **Calidris alpina sakhalina* (Vieillot)

(Charadriiformes: Scolopacidae) collected at Lo-tung, I-lan Prefecture, on 5 December 1959. Specimens deposited: No. 73360. Body 7,315–7,525 long by 1,820–2,360 wide; pharynx 190–215 by 190–230; prepharyngeal space 205–250 long; esophagus 305–315 long; testes contiguous, anterior testis 410–590 by 380–480, posterior testis 430–700 by 410–835; posttesticular space 275–640 long; cirrus sac thick-walled, muscular, club-shaped, 565–650 by 175–180, commencing at cecal bifurcation level; seminal vesicle saccular, straight to slightly winding, 335–365 by 130–175; prostatic vesicle 125–140 by 60–75, overlapping seminal vesicle; genital pore median, at midlength of pharynx; ovary 350–380 by 315–360, anterodextral to anterior testis in one worm but opposite latter in other one; vitellaria extending from esophageal level to posterior extremity, not confluent posteriorly; some uterine coils extending lateral to ceca to and into vitelline fields but not beyond, posteriormost coils surrounding gonads on both sides of body in one worm but only on one side in other; eggs oval, yellow- brown, operculate, 20 measuring 111–123 (117) by 61–70 (66.1), containing miracidium with eyespots in distal uterine coils; some miracidia free in uterus in one worm.

3. *Cyclocoelum obscurum* (Leidy, 1887) Harrah, 1922, from the air sacs of the sanderling, **Crocethia alba* (Pallas) (Charadriiformes: Scolopacidae) collected at Ali-lao, Taipei Prefecture, on 31 December 1960. Specimens deposited: No. 73361.

4. *Echinostoma chloropodis* (Zeder, 1800) Dietz, 1909 (Echinostomatidae) from the small intestine of the watercock, **Gallicrex cinerea cinerea* (Gmelin) (Gruiformes: Rallidae) collected at Ping-tung, Ping-tung Prefecture, on 11 July 1959. Specimen deposited: No. 73362.

5. *Echinostoma revolutum* (Froelich, 1802) Looss, 1899, from the small intestine of the teal, *Anas crecca crecca* L.; domestic duck; domestic chicken; domestic pigeon; Formosan turtle dove, **Streptopelia orientalis orii* Yamashina (Columbiformes: Columbidae); and **Hirundo daurica formosae* collected from Taipei, Hua-lien, Ping-tung, Tai-chung, I-lan, and Kao-hsiung Prefectures from 1957–61. Specimens deposited: Nos. 73363, 73351 (chicken); Nos. 73364, 73369 (duck); No. 73365 (*A. crecca*); No. 73366 (*S. orientalis*); No. 73367 (pigeon); No. 73352 (*H. daurica*).

6. *Hypoderaeum charadrii* (Tubangui and Masiluñgan, 1935) Yamaguti, 1971 (Echinostomatidae) from the small intestine of the eastern Kentish plover, **Charadrius alexandrinus nihonensis* Deignan (Charadriiformes: Charadriidae) collected at Ma-kung, Peng-hu Prefecture (Pescadores Islands) on 17 April 1961. Specimens deposited: No. 73368.

7. *Hypoderaeum conoideum* (Bloch, 1782) Dietz, 1908, from the small intestine of the domestic duck collected at Hua-lien, Hua-lien Prefecture, on 19 September 1958. Specimens deposited: No. 73369.

8. *Nephrostomum bicolanum* Tubangui, 1933 (Echinostomatidae) from the small and large intestine of *Bubulcus ibis coromandus* collected at Lin-tou, Peng-hu Prefecture (Pescadores Islands), Shin-she and Hsin-sheh, Tai-chung Prefecture, and Chi-hu, Chang-hua Prefecture, on 15 June, 19 August 1960 and 22 April, 6 May 1961. Specimens deposited: No. 73370.

9. *Paryphostomum radiatum* (Dujardin, 1845) Dietz, 1909 (Echinostomatidae) from the small intestine of the great or Chinese cormorant, *Phalacrocorax carbo sinensis* (Shaw) (Pelecaniformes: Phalacrocoracidae) collected at Sun Moon Lake, Nan-tou Prefecture on 22 January 1958. Specimens deposited: No. 73371.

10. *Petasiger exaeretus* Dietz, 1909 (Echinostomatidae) from the small intestine of *Phalacrocorax carbo sinensis* collected from Sun Moon Lake on 22 January 1958. Specimens deposited: No. 73372.

11. *Acanthoparyphium spinulosum* Johnston, 1917 (Echinostomatidae) from the small intestine of the eastern golden plover, *Charadrius dominicus fulvus* Gmelin (Charadriiformes: Charadriidae) collected at Chi-pei, Peng-hu Prefecture (Pescadores Islands) on 11 October 1961. Specimens deposited: No. 73373. From Great Nicobar Island in the Bay of Bengal, Soota, et al. (1970) described their new species *Acanthoparyphium cambellense* Soota, Srivastava and Ghosh, 1969, from the same host species as reported by Johnston (1917) for his new species *A. spinulosum* from Australia and by us herein from Taiwan. Soota et al. noted that their species is closest to *A. spinulosum*,

"but differs from it in the body shape, position of the testes, each lying on either side of the equatorial line, in position of the acetabulum and the ratio of the two suckers." Skrjabin and Bashkirova (1956) considered *A. spinulosum suzugama* Yamaguti, 1939, and *A. longivitellatum* Oshmarin, 1956, as synonyms of *A. spinulosum* Johnston; Soota et al. accepted this synonymy, adding *A. charadrii* Yamaguti, 1939. It seems apparent that Soota et al. depended on the accounts and illustrations of *A. spinulosum* given by Skrjabin and Bashkirova (1956), who did not reproduce Johnston's illustration. The latter figure and that given by Martin and Adams (1961) show a body shape similar to *A. cambellense*. Johnston notes that the testes lie in the middle of the body; their position in his illustration is exactly as in *A. cambellense*. Johnston's illustration shows the position of the acetabulum to be exactly as in *A. cambellense*. Johnston gives the sucker ratio as 1:3.5, and it is about the same for the worms of Martin and Adams; Bearup (1960) indicates a ratio of 1:2.6–3.4 in eight preserved worms and 1:3.8 in a living one; Yamaguti (1939) notes a ratio of 1:2.8 for *A. spinulosum suzugama*. Soota et al. record the sucker ratio as 1:2.79 for *A. cambellense*. We declare *Acanthoparyphium cambellense* Soota, Srivastava and Ghosh, 1969, a synonym of *A. spinulosum* Johnston, 1917, as we can find no difference between them. In our collection the 21 worms from one host have 23 collar spines 24–57 long by 10–20 wide, the sucker length ratio in six worms is 1:2.4–2.9, and eight eggs measure 85–100 (94.8) by 66–82 (71).

12. *Pegosomum egretti* O. N. Srivastava, 1957 (Echinostomatidae) from the liver of *Bubulcus ibis coromandus* from Nan-tou Prefecture taken on 28 April 1959. Specimens deposited: No. 73374.

13. *Brachylecithum capilliforme* Oshmarin in Skrjabin and Evranova, 1952 (Dicrocoeliidae) from the liver of a ground thrush, *Zoothera dauma varia* (Pallas) (Passeriformes: Musicapidae: Turdinae) collected at Hua-lien, Hualien Prefecture, on 2 April 1960. Specimens deposited: No. 73375.

14. *Brachylecithum mosquense* (Skrjabin and Isaichikov) Shtrom, 1940, from the liver of the white-eared sibia, **Heterophasia auricularis* (Swinhoe) (Passeriformes: Timaliidae) collected at Sun Moon Lake, Nan-tou Prefecture, on 22 January 1958. Specimens deposited: No. 73376.

15. *Brachylecithum praetenue* Oshmarin in Skrjabin and Evranova, 1952, from the bile duct of **Hirundo daurica formosae* collected at Kwo-shing hsiang, Nan-tou Prefecture, on 15 April 1959. Specimens deposited: No. 73377.

16. *Phaneropsolus borneoensis* Fischthal and Kuntz, 1973 (Lecithodendriidae) from the small intestine of the Formosan brown-eared bulbul, **Hypsipetes amaurotis nagamichii* Deignan (Passeriformes: Pycnonotidae) collected at Hung T'ou Ts'un, Lan Yü or Orchid Island, on 11, 17 March 1959. Specimens deposited: No. 73378.

17. *Maritrema gratiosum* Nicoll, 1907 (Microphallidae) from the small intestine of the ruddy turnstone, *Arenaria interpres interpres* (L.) (Charadriiformes: Scolopacidae) collected at Sha-kang, Peng-hu Prefecture (Pescadores Islands) on 16 October 1961. Specimen deposited: No. 73379.

18. *Clinostomum complanatum* (Rudolphi, 1814) Braun, 1899 (Clinostomidae) from the mouth of the Malay bittern, **Gorsakius melanolophus melanolophus* (Raffles) (Ciconiiformes: Ardeidae) collected at Peitou Mt., Taipei Prefecture, on 20 May 1958. Specimens deposited: No. 73380.

19. *Neodiplostomum (Neodiplostomum) toruligenitale* Dubois, 1964 (Diplostomatidae) from the small intestine of the Formosan black-eared kite, **Milvus lineatus lineatus* (Gray), and the crested goshawk, **Accipiter trivirgatus formosae* (Mayr) (both hosts Falconiformes: Accipitridae) collected at Ali-lao and Wu-lai, Taipei Prefecture on 25 February 1959 and 6 December 1960. Specimens deposited: No. 73381 (*M. lineatus*); No. 73382, 73388 (*A. trivirgatus*). Dubois (1964) described this species from the eastern marsh harrier, *Circus aeruginosus spilonotus* Kaup (Accipitridae) from Lo-tung, I-lan Prefecture, Taiwan. We have examined the holotype and a paratype (USNM Helm. Coll. No. 60030) and find our worms basically similar to them. Dubois recorded the egg size as 104–110 long by 63 wide. Fifteen eggs in our worms from *M. lineatus* measure 77–90 (84.9) by 52–61

(58.3). In 20 of the 80 worms in our collection selected at random three had no eggs, four with one egg, four with two, two with four, and one each with three, six, nine, 10, 22, 25, and 28. The two worms from *A. trivirgatus* had no eggs.

20. *Strigea elongata* Yamaguti, 1935 (Strigeidae) from the small intestine of the eastern buzzard hawk, **Butaster indicus* (Gmelin) (Falconiformes: Accipitridae), and the Japanese brown thrush, **Turdus chrysolaus chrysolaus* Temminck (Passeriformes: Musicapidae: Turdinae) collected at Lin-tou, Peng-hu Prefecture (Pescadores Islands) on 19 April 1961. Specimens deposited: No. 73383 (*B. indicus*); No. 73384 (*T. chrysolaus*).

21. *Apharyngostrigea ramai* (Verma, 1936) Vidyarthi, 1937 (Strigeidae) from the small intestine of *Bubulcus ibis coromandus* collected at Ma-kung, Peng-hu Prefecture (Pescadores Islands) on 15 April 1961. Specimen deposited: No. 73385.

22. *Apharyngostrigea serpentia* Ukoli, 1967 (Fig. 27) from the mouth and esophagus of the little egret, *Egretta garzetta garzetta* (L.) (Ciconiiformes: Ardeidae) collected at Tao Yuan, Tao Yuan Prefecture, on 9 December 1957. Specimens deposited: No. 73386. Body 3,870–5,530 long; anterior segment 995–1,445 long, maximum width (430–665) at or near oral sucker level, narrowest (260–395) at proteolytic gland level; posterior segument not constricted from anterior, 2,715–4,085 long, maximum width (380–615) at testicular level, narrowest (260–365) in attenuated preovarian region; length ratio of anterior to posterior segment 1:2.4–3.4; oral sucker 95–126 by 100–133; acetabulum 135–182 by 133–208; distance between suckers 105–232; sucker length ratio 1:1.14–1.63, width ratio 1:1.29–1.70; proteolytic gland 230–385 by 155–223; length ratio of anterior segment to proteolytic gland 1:0.16–0.33; posterior lobe of latter largest, most lobes anterior to it tending to be more chromophilic; tribocytic organ basically similar to that of *A. ramai*, consisting of long, wide ventral lobe with shallow anteromedian notch or longer, very narrow slit which may extend posteriorly to acetabular level, dorsal lobe dividing just postacetabular into two short to long (depending on state of contraction), narrow, roundish lips; testes filling body width at their levels, anterior testis 355–525 by 300–560, posterior testis 400–630 by 335–590; posttesticular space 235–495 long, distances 8.7–14.9% of posterior segment length; copulatory bursa 220–400 wide, not constricted from remainder of body; genital cone 145–360 by 133–310, finely spined; ovary 175–295 by 140–365, lying 15–61 pretesticular and 1,270–2,360 posterior to anterior–posterior segment junction, latter distances 46.8–57.8% of posterior segment length; vitellaria in anterior and posterior segments, entering ventral lobe of tribocytic organ, usually extending anteriorly to just postacetabular, occasionally few follicles at acetabular level or just preacetabular, rarely interrupted on both sides, occasionaly on one side, of proteolytic gland, at testicular level follicles only on left side of body but rarely with few scattered follicles on right side, filling posttesticular space; uterus ascending to near anterior part of posterior segment; proximal part filled with sperm; seminal receptacle absent; eggs relatively numerous in many worms, thin-shelled, operculate, 30 measuring 85–110 (99.3) by 56–71 (64.5).

Discussion

Our restudy of this species is based on 78 adult and four immature worms from one host; 10 in dorsal or ventral view were measured. The description of this species by Ukoli (1967), based on two worms from the same host subspecies from Ghana, is incomplete. Ukoli's illustration indicates a seminal receptacle present but this is in error as the sperm are contained in the proximal part of the uterus. Also, Ukoli gives the sucker length ratio as 1:2.4 which is greater than any noted by us. It is possible that Ukoli's measurements of the oral sucker were taken at the body surface where its dimensions are smaller rather than the embedded part where its dimensions are larger. This could readily account for the difference in length ratio of the suckers.

23. *Ophiosoma patagiatum* (Creplin, 1846) Dubois, 1937 (Strigeidae) from the large intestine of **Egretta garzetta garzetta* collected at I-lan, I-lan Prefecture, on 3 December 1959. Specimen deposited: No. 73387.

24. *Parastrigea flexilis* (Dubois, 1934) Dubois, 1955 (Strigeidae) from the small in-

testine of **Accipiter trivirgatus formosae* and **A. virgatus affinis* Hodgson (large Besra sparrow hawk) collected at Lin-tou, Peng-hu Prefecture (Pescadores Islands), and Wu-lai, Taipei Prefecture, on 25 February 1959 and 25 April 1961. Specimens deposited: No. 73388, 73382 (*A. trivirgatus*); No. 73389 (*A. virgatus*).

25. *Apatemon minor* Yamaguti, 1933 (Strigeidae) from the small intestine of the domestic duck collected at Hua-lien, Hua-lien Prefecture, on 19 September 1958. Specimens deposited: No. 73390.

Acknowledgments

Appreciation is due Mr. Dien Zuh Ming, Taiwan Museum, Taipei, and Mr. H. G. Deignan (deceased), Associate Curator, and Mr. George E. Watson, Curator, Division of Birds, U.S. National Museum, Washington, D.C., for host identifications.

Initial work for this study was supported by funding under Public Law 480, Section 104(c), by funds provided by the U.S. Bureau of Medicine and Surgery, Navy Department Work Unit MR005.20-0098, and by contract NR103-690/N0014-66-C0094 between the U.S. Office of Naval Research, Department of the Navy, and Southwest Foundation for Research and Education.

Additional support was by a Faculty Research Fellowship (No. 0001-01-040-73) awarded to the senior author by The Research Foundation of State University of New York.

Literature Cited

Bearup, A. J. 1960. Life history of *Acanthoparyphium spinulosum* Johnston, 1917 (Trematoda: Echinostomatidae). Austral. J. Zool. 8: 217–225.

Dubois, G. 1964. Un Néodiplostome nouveau de l'île de Formose et redécouverte du Pharyngostome (Trematoda: Strigeata). Rev. Suisse Zool. 71: 679–685.

Freitas, J. F. T. de. 1951. Revisão da familia Eucotylidae Skrjabin, 1924 (Trematoda). Mem. Inst. Osw. Cruz 49: 33–271.

Johnston, S. J. 1917. On the trematodes of Australian birds. J. and Proc. Roy. Soc. New S. Wales 50: 187–261.

Kuntz, R. E., and Z. M. Dien. 1970. Vertebrates of Taiwan taken for parasitological and biomedical studies by U.S. Naval Medical Research Unit No. 2, Taipei, Taiwan, Republic of China. Quart. J. Taiwan Mus. 23: 1–37.

Lie, K. J., and T. Umathevy. 1965. Studies on Echinostomatidae (Trematoda) in Malaya. X. The life history of *Echinoparyphium dunni* sp. n. J. Parasit. 51: 793–799.

Martin, W. E., and J. E. Adams. 1961. Life cycle of *Acanthoparyphium spinulosum* Johnston, 1917 (Echinostomatidae: Trematoda). J. Parasit. 47: 777–782.

Rai, S. L. 1963. On a trematode, *Episthmium chauhani* sp. nov. of the genus *Episthmium* Lühe, 1909 (Trematoda: Echinostomatidae). Indian J. Helm. 15: 20–25.

Skrjabin, K. I., and E. I. Bashkirova. 1956. [Family Echinostomatidae Dietz, 1909.] *In* K. I. Skrjabin (ed.), [Trematodes of animals and man.] Akad. Nauk SSSR, Moskva 12: 51–930. (Russian text.)

Soota, T. D., C. B. Srivastava, and R. K. Ghosh. 1970. Studies on the helminth fauna of the Great Nicobar Island. Part I. Trematoda. Proc. Indian Acad. Sci., B 72: 241–250.

Stunkard, H. W. 1945. The morphology of *Tamerlania bragai* dos Santos, 1934. J. Parasit. 31: 301–305.

Ukoli, F. M. A. 1967. On *Apharyngostrigea* (*Apharyngostrigea*) *simplex* (Johnston, 1904) new comb. and *A.* (*Apharyngostrigea*) *serpentia* n. sp. (Strigeidae: Trematoda) with an evaluation of the taxonomy of the genus *Apharyngostrigea* Ciurea, 1927 by the method of numerical taxonomy. J. Helm. 41: 235–256.

Yamaguti, S. 1939. Studies on the helminth fauna of Japan. Part 25. Trematodes of birds, IV. Jap. J. Zool. 8: 129–210.

ADDENDUM: Since this is our last paper on digenetic trematodes from Taiwan, we wish to report two additional species not recorded heretofore from this locality: 1. *Phyllodistomum macrobranchicola* Yamaguti, 1934 (Gorgoderidae), metacercaria, from the body cavity of a crayfish, *Macrobranchium* sp., collected at Ali-lao, Taipei Prefecture, on 27 January 1961; specimen deposited: No. 73939. 2. *Hydrophitrema gigantica* Sandars, 1960 (Hemiuridae) from the lungs of a sea snake, **Hydrophis spiralis* (Shaw) (Serpentes: Hydridae), collected at Ma-kung, Peng-hu Prefecture (Pescadores Islands) on 15 May 1961; specimens deposited: No. 73940.

Research Note

Prevalence of *Dirofilaria immitis* in Northern Virginia

During the winter of 1973–74, blood samples were drawn from 213 dogs found at the Fairfax County, Virginia, animal shelter and examined for microfilariae. The modified Knott's technique revealed that 39 (18%) were infected with *Dirofilaria immitis*. Eleven of these were missed by direct smear. *Dipetalonema reconditum* was not found in any dogs with either technique.

The data suggested that hair length may act as a deterrent to infection as only 14% of long-haired dogs had microfilariae as compared with 25% of short-haired dogs (Table 1). However, a Chi-square analysis yielded a *P* value of 0.07, which indicates no more than a possible borderline significance. Although all dogs examined are presumed to have had the same probability of exposures, the numbers involved are too few to warrant any finite interpretation. The prevalence in males and females was 19 and 17%, respectively. The ages at which infection was encountered most frequently appeared to be 1–3 years, although it was found in dogs of most any age. My observations also indicated that severe signs of infection occurred more often in older dogs than younger ones. However, over one-half of the dogs did not show any visible signs of the infection. Three long-haired German shepherds with very large numbers of blood microfilariae were sacrificed. On necropsy 37, 41, and 47 adult worms were found, only in the venae cavae and pulmonary artery.

A significant aspect of this study is that there is now evidence that contraction of *D. immitis* is occurring within northern Virginia; of the 39 dogs having *D. immitis*, previous owners of seven were contacted and responded that their animals had never been outside the region. Also, a survey of 25 northern veterinarians reporting on 3,285 dogs indicated that 15% of their cases of *D. immitis* apparently had become infected within the region. This is in accord with evidence presented by Mallack et al. (1971, J. Am. Vet. Med. As. 159: 177–179) of local transmission with a 44% infection rate in nearby Upper Marlborough, Maryland. It is in contrast to the previous finding of only 6% in Hyattsville, Maryland, more than a decade earlier (Wallenstein and Tibola, 1960, J. Am. Vet. Med. As. 137: 712–716).

Table 1. Rate of infection of *D. immitis* in dogs with short or long hair.

Number dogs examined	Short hair	Long hair (>2")	Positive *D. immitis*	% Positive *D. immitis*
213			39	18
	84		21	25
		129	18	14

I wish to thank Drs. Carl H. Ernst and Norman R. Sinclair, Department of Biology, George Mason University; Drs. William Swartz and Gordon Davis, Old Dominion Animal Hospital, McLean, Virginia; and Dr. Gilbert Otto, Department of Zoology, University of Maryland, for their assistance. The study was funded by Drs. Swartz and Davis and the Northern Virginia Veterinary Association.

JOHN W. KIMBELL
2161 Evans Court
Falls Church, Virginia 22043

Research Note

Evaluation of a Trichina-cyst Antigen for the Intradermal Diagnosis of Trichiniasis in Live Hogs

Beginning with Schwartz, McIntosh, and Mitchell, 1930 (J. Parasit. 17: 114) and extending to the present time (Bessonov, 1967, Veterinariya 2: 62–65; Bessonov, 1971, Sborn. Rabolt Gel'mint. 90 Pozhden. Akad. K. I. Skryabin, Moscow, p. 29–38), numerous workers have reported that skin reactions elicited by antigens made solely from decapsulated *Trichinella spiralis* larvae were in many instances nonspecific and could not be relied upon for the diagnosis of trichiniasis in swine by the intradermal test. In an attempt to find a more suitable antigen, one of us (CHH) conceived the idea of including the cyst and its contents in an antigen to be used for the diagnosis of trichiniasis in swine by this method.

Thirty-seven barn-raised, worm-free Hampshire pigs, farrowed by specific-pathogen-free sows, were used in this work. They were 4 to 15 months old and weighed 25.86 to 117.93 kg at the beginning of the experiments. All pigs were fed adequate quantities of a balanced ration composed of mixed ground feeds and minerals before and during the entire period of the experiments. Fresh water was available at all times.

Each of 22 pigs was experimentally infected *per os* with a single dose of *T. spiralis* larvae, ranging from 500 to 130,000 larvae per pig (Table 1). These doses were equal to 22.0 to 1,102.3 trichinae per kg of live weight. Fifteen comparable pigs served as uninfected controls.

Cysts containing viable trichinae and visibly free from pork tissue were obtained from fresh or refrigerated trichinous pork from recently killed infected pigs. The meat was ground in a meat grinder and 25 g was mixed with 75 ml tap water and macerated in a Virtis Homogenizer[1] for 2 min at speed 15. The cysts were then manually separated from the muscle tissue, washed 2 or 3 times with PBS, homogenized in a Virtis Homogenizer, and packed by centrifugation at 500 *g* for 10 min.

Three similar antigens were prepared by suspending 4, 4.75, and 7 ml of packed, homogenized trichina cysts in 10 ml of PBS, and stored at 4 or –20 C. All procedures were carried out at room temperature. One-tenth ml of each of these antigens and of PBS were separately injected intracutaneously into the infected and control pigs. The injections were spaced about 25 mm apart in a single or double row running longitudinally on the ventral aspect of the pig just anterior to the xiphoid process.

Four series of inoculations were administered, each consisting of injections of two or three of the antigens and PBS which were given at the same time (Table 1). All 37 pigs received the initial series which was administered 7 to 55 days postinfection (PI) (Table 2). Nineteen pigs received the second series, 6 pigs the third, and 6 pigs the fourth. These injections were administered 7 to 103 days after the initial inoculation or injection as shown in Table 2. A total of 161 injections of antigenic material and 68 injections of PBS were given.

A reaction was considered "positive" on the development of a reddish-purple, often hemorrhagic area, 10 to 15 mm in diameter, surrounding the injection site. The reactions were monitored at 15 min, 30 min, and 5 hr postinjection (pi) (Table 3).

The pigs were necropsied from 33 to 154 days PI, the pillars of the diaphram were examined for *T. spiralis* larvae by the digestion method, and the number of larvae per gram of muscle tissue was estimated and recorded (Table 1). Although the pigs had been raised under conditions that would preclude infection with other helminths, three were examined for

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

Table 1. Summary of data obtained from trichinous and nontrichinous pigs skin-tested with trichinacyst antigen.

Trichinous pigs										*Nontrichinous pigs*						
Pig No.	Experiment No.	Trichinae administered Total	Trichinae administered No./kg	Trichinae/g diaphragm muscle	Reactions/Injections Injection Series* I	II	III	IV	Totals R/I†	Pig No.	Trichinae/g diaphragm muscle	Reactions/Injections Injection Series* I	II	III	IV	Totals R/I†
1221	2	130,000	1,102	615	2/2				2/2	1301	0	0/2	0/2			0/4
1223	2	115,000	1,102	1,218	0/2				0/2	1303	0	0/2				0/2
1323	2	102,000	1,102	1,900	0/2				0/2	1321	0	1/2				1/2
1224	2	90,000	1,102	160	0/2				0/2	1312	0	0/2				0/2
1274	1	89,000	1,102	120	2/3	3/3			5/6	1271	0	0/3	0/2			0/5
1291	2	82,500	1,102	805	0/2				0/2	1313	0	0/2				0/2
1172	1	78,500	1,102	200	1/3	0/3			1/6	1163	0	0/3	0/3			0/6
1251	1	66,500	1,102	900	0/3	3/3			3/6	1252	0	1/3	0/3			1/6
1275	1	64,500	1,102	1,300	3/3	3/3			6/6	1272	0	1/3	0/2			1/5
1243	1	60,000	1,102	1,200	3/3	2/2			5/5	1202	0	0/3	0/3			0/6
1273	1	57,000	1,102	860	0/3	2/2			2/5	1254	0	0/3	0/3			0/6
1443	4	40,500	1,102	500	1/2				1/2	1445	0	0/2				0/2
1453	4	37,500	1,102	400	2/2				2/2	1455	0	0/2				0/2
1441	4	35,500	1,102	214	0/2				0/2	—						
1265‡	3	1,000	165	40	2/2	2/2	2/2	3/3	9/9	—						
1261	3	1,000	117	6	0/2	2/2	3/2	3/3	9/9	—						
1264	3	1,000	112	50	2/2	2/2	2/2	0/3	6/9	1242	0	0/2	2/2	0/2	2/3	4/9
1262	3	500	57	15	1/2	2/2	2/2	2/3	7/9	1263	0	0/2	0/2	0/2	0/2	0/8
1454	4	2,040	44	88	2/2				2/2	—						
1444	4	1,620	44	22	0/2				0/2	—						
1452	4	1,140	22	40	0/2				0/2	—						
1442	4	930	22	60	2/2				2/2	—						
Total recctions/total injections					23/50	21/24	8/8	8/12	60/94	Total reactions/ total injections		3/36	2/22	0/4	2/5	7/67
Per cent (R/I)					46.0	87.5	100	66.7	63.8	Per cent (R/I)		8.3	9.1	0	40.0	10.4

* PBS inoculations and reactions thereto, which were negative except in one pig, were not included so as to reduce the size of the table.
† R/I = No. reactions over No. injections.
‡ This pig reacted to the fourth PBS inoculation.

Table 2. Effect of postinfection and postinjection intervals on number of skin reactions to trichinacyst antigens in trichinous and nontrichinous pigs.

Postinfection and postinjection Intervals (Days)	Series I				Series II				Series III				Series IV			
	Trichinous pigs		Nontrichinous pigs		Trichinous pigs		Nontrichinous pigs		Trichinous pigs		Nontrichinous pigs		Trichinous pigs		Nontrichinous pigs	
	R/I*	%	R/I	%	R/I	%	R/I	%	R/I	%	R/I	%	R/I	%	R/I	%
0	–	–	3/36	8.3	–	–	–	–	–	–	–	–	–	–	–	–
7	5/8	62.5			3/3	100	0/3	0								
8	4/5	80.0			–	–	–	–								
11	–	–			3/3	100	0/3	0								
14	1/3	33.3			8/8	100	†2/4	50								
17	0/3	0			–	–	–	–								
21	3/5	60.0			3/3	100	0/3	0								
26	–	–			0/3	0	0/3	0	8/8	100	0/4	0				
29	7/14	50.0			–	–	–	–								
30	3/3	100.0			–	–	0/2	0								
34	–	–			–	–	–	–								
35	0/2	0			–	–	–	–								
39	–	–			–	–	0/2	0								
42	0/3	0														
44	0/2	0														
55	0/2	0														
62	–	–			–	–	–	–	–	–	–	–	8/12	66.7†	2/5	40.0
92	–	–			2/2	100										
103	–	–			2/2	100	0/2	0	–	–						

* Reactions/injections.
† These reactions occurred in the same pig.

Table 3. Postinoculation intervals required for maximum development of skin reactions in trichinous and nontrichinous pigs following single and multiple trichina-cyst antigen injections.

	Postinoculation intervals											
	15 min				30 min				5 hr			
	Trichinous pigs		Nontrichinous pigs		Trichinous pigs		Nontrichinous pigs		Trichinous pigs		Nontrichinous pigs	
Series No.	R/I*	%	R/I	%	R/I	%	R/I	%	R/I	%	R/I	%
I	16/23	69.56	1/36	2.78	6/23	26.09	0/36	0	1/23	4.35	2/36	5.56
II	9/21	42.86	2/22	9.09	12/21	57.14	0/22	0	0/21	0	0/22	0
III	1/8	12.50	0/4	0	5/8	62.50	0/4	0	2/8	25.00	0/4	0
IV	4/8	50.00	2/5	40.00	3/8	37.50	0/5	0	1/8	12.50	0/5	0
Total (II, III, IV)	14/37		4/31		20/37		0/31		3/37		0/31	
Average per cent R/I		37.83		7.75		54.24		0		8.1		0

* R/I Reactions/Injections.

other helminth species as a further check on possible extraneous parasitic infections.

Of the 50 inoculations of antigen administered to the 22 trichinous pigs given one set of injections, only 23 (46%) elicited significant reactions; 27 (54%) were considered to be false negative. Twelve (52.2%) of the 22 trichinous pigs were correctly diagnosed as harboring trichinae on the basis of these reactions. Of the 44 additional inoculations administered to the trichinous pigs, 37 (84%) elicited tissue reactions and seven (16%) were classified as false negative. These additional inoculations resulted in the positive diagnosis of three more trichinous pigs, two of which had received more than 50,000 larvae; the third, 1,000 larvae. This finding brings the efficacy of this intradermal test to 68.2%.

The reactions of the trichinous and nontrichinous pigs to single and multiple injections of trichina-cyst antigen are recorded in Table 3. These data show that more reactions occurred in the trichinous pigs 30 min and 5 hr after the additional injections than occurred in them following the initial injection. Since this phenomenon occurred rarely in the nontrichinous pigs, which for the most part did not react to the antigen, this finding may indicate that a component supplied by the parasite may bring about the increased sensitivity. The occurrence of four reactions in one of the nontrichinous pigs to the additional injections of antigen (Table 2) and the reaction of one trichinous pig to the fourth injection of PBS (Table 1) indicate the presence of a substance in the inoculated material that may or may not have been related to *T. spiralis*, but to which these pigs became sensitized.

The number of trichinae per gram of diaphram muscle in the trichinous pigs at necropsy ranged from six to 1,900 (Table 1). Although there was a positive correlation of 0.65 ($P <$ 1%) between the number of larvae in the muscle and the number of larvae administered to the pigs, it was not close enough to enable one to predict how many larvae would actually become established on the basis of the size of the larval dose. There was also a slight positive correlation among the results of the intradermal tests, the dosage of larvae received by the pigs, and the number of larvae that became established in the infected pigs. Nine (60%) of the 15 positive diagnoses made among the trichina-infected pigs occured in the 14 pigs that were given 35,500 or more larvae and harbored more than 100 larvae per gram of diaphragm, whereas, the other six diagnoses (40%) were made in eight pigs that received 2,040 or fewer larvae and harbored 88 or fewer larvae per gram of diaphram.

Trichinae were not found in the muscles of any of the uninfected control pigs, nor were extraneous infections with other species of helminths found in the three pigs examined for them at necropsy.

These observations have demonstrated that,

at least in trichinous pigs, tissue reactions are intensified by repeated injections of antigen. This is similar to the reaction in guinea pigs reported by Bachman (1928, J. Prev. Med. II: 513–523). They also indicate that the trichina-cyst antigen, as formulated and used in these experiments, cannot be relied upon to detect trichiniasis in swine.

JOHN S. ANDREWS,[1] CHARLES H. HILL,[2] AND LAWRENCE A. HENSON
United States Department of Agriculture
Animal Parasitology Institute
Agricultural Research Service
Beltsville, Maryland 20705

[1] Retired 31 July 1975.
[2] Retired 12 May 1973.

Research Note

New Host Records for *Anonchohaptor muelleri* (Trematoda: Monogenea) from Catostomid Fishes of the Kentucky River

This report is part of a continuous parasitological survey of Kentucky River fishes in order to expand the paucity of information concerning helminths of Kentucky freshwater fishes. Investigations on the monogenetic trematodes infesting Catostomidae in Kentucky are nonexistent.

One hundred and eight Catostomidae were collected from the Kentucky River from August 1973 through April 1974. All fish were autopsied and parasites stained by routine methods.

From 46 *Minytrema melanops* (Rafinesque), spotted sucker, 56 *Anonchohaptor muelleri* Kritsky, Leiby, and Shelton, 1972, were recovered with an infestation rate of 27%. The mean intensity of infestation was 5. From 62 *Moxostoma erythrurum* (Rafinesque), golden redhorse, five *A. muelleri* were recovered with an infestation rate of 6%. The mean intensity of infestation was 1. All flukes were recovered from the gills and mouth cavity.

Presently, there are two known species of the genus *Anochohaptor*: *A. anomalum* Mueller, 1938, and *A. muelleri*. Rogers (pers. comm.) confirmed that the species recovered in this study was not *A. anomalum* but could not identify it as *A. muelleri*. Recently, the species has been confirmed as *muelleri* as all anatomical features and measurements conform to the description of Kritsky et al. (1972, J. Parasit. 58: 723–731).

A. muelleri has been reported from river carpsucker, *Carpiodes carpio*, in North Dakota and quillback, *Carpiodes cyprinus*, in Illinois by Kritsky's group. Thus, the present report constitutes two new host records (*M. melanops* and *M. erythrurum*) and a range extension record to Kentucky for *A. muelleri*.

The authors would like to acknowledge the National Marine Fisheries Service for partial funding and equipment used under research grant No. 2-186-R; and Wilmer A. Rogers, Auburn University, Auburn, Alabama.

D. L. COMBS
N. E. Region Research Station
4101 Boston Ave., Muskogee, Oklahoma
J. C. WILLIAMS AND J. P. HARLEY
Department of Biological Sciences
Eastern Kentucky University
Richmond, Kentucky 40475

Research Note

New Host and Distribution Records of Helminth Parasites of the Mexican Free-tail Bat, *Tadarida brasiliensis*, from Texas and Louisiana

During 1969 Mexican free-tail bats (Molossidae, Chiroptera) were collected monthly from Bracken Cave near San Antonio, Texas, and a warehouse in New Orleans, Louisiana. Specimens were transported to the laboratory in an ice chest, killed with sodium pentobarbitol injections, and dissected. The digestive tract was removed and separated into the gallbladder, liver, stomach, and intestine, placed into normal saline, and examined for helminths. Selected trematodes and cestodes were flattened and fixed in AFA (alcohol–formalin–acetic acid), stained with Van Cleaves' hematoxylin (Van Cleave, 1953, Acanthocephala of North American Mammals, Univ. Ill. Press), and mounted in Permount. Other trematodes and cestodes were relaxed in distilled water, fixed with AFA, and transferred to 70% ethanol. Nematodes were fixed with glacial acetic acid, transferred to 5% glycerin and 70% ethanol solution until the alcohol evaporated and then into 100% glycerin for storage and examination.

Twelve species of helminths were found in *Tadarida brasiliensis mexicana* (Saussure, 1860) from Bracken Cave and nine species from *T. b. cynocephala* (LeConte, 1831) from New Orleans, Louisiana (Table 1). Eight of these were common to both colonies. Six new distribution records and three new host records are now established (Table 1). Large numbers of *Acanthatrium eptesci* were reported in *Tadarida brasiliensis* of Oklahoma [Rogers, 1965, Studies on the incidence of gastric and intestinal helminths of *Tadarida brasiliensis mexicana* (Saussure). M.S. thesis, Okla. State Univ., 53 p.]. In contrast only one of 297 bats from San Antonio, Texas, were found infected with *Acanthatrium* in 1969. My specimens differ from *A. eptesci* in having very small atrial spines. They correspond closely with the original description of *A. nycteridis* Faust, 1919, except for the atrial spines which were not scattered in my specimens (Dubois, 1961, Rev. Suisse Zool. 68: 273–302). Allowing for the possible differences due to preparation at the time of fixation or to normal variation, I prefer to consider my specimens as *A. nycteridis* until a larger series can be examined. This is a new host record.

Allassogonoporus marginalis Olivier, 1938, was originally described from the muskrat, *Ondatra zibethica* (Linnaeus, 1766) Link, 1795, and subsequently reported from the bats *Myotis californicus* (Audubon and Bachman, 1842) Miller, 1897, *M. lucifugus* (LeConte, 1831) Miller, 1897, *M. velifer* (Allen, 1890) Miller, 1897, *M. sodalis* Miller and Allen, 1928, *M. griscescens* Howell, 1909, and *Eptesicus fuscus* (Palisot de Beauvois, 1796) Mehely, 1900. This is the first report of this species from *Tadarida brasiliensis*. It has been reported from Oregon, Michigan, and, with this paper, New Orleans, Louisiana.

Ochoterenatrema labda was the predominant helminth species in New Orleans. It had the highest intensities of infection of any of the helminths in this study. *Ochoterenatrema labda* was described by Caballero (1943, Ann. Inst. Biol. 14: 173–193). The genus was synonymized with *Prosthodendrium* by Yamaguti [1958, Systema Helminthum, 1(1 and 2): 1575 p.] and was reestablished and emended by Cain (1966, J. Parasit. 52: 351–357) based upon the presence of the pseudogonotyl located next to the acetabulum. *O. caballeroi* Texeira de Freitas, 1957, was synonymized by Cain with *O. diminutum* (Chandler, 1938) Dubois, 1960. The only differences recognized between *O. labda* and *O. diminutum* was sucker ratio. Cain found that his specimens provided a continuous series in body size with dimensions overlapping between the two species. He found sucker ratio to be the one characteristic that did not overlap. Though uncertain about the validity of the two species he chose to con-

Table 1. Occurrence of helminth parasites of *Tadarida brasiliensis* from Texas and Louisiana. (+)—present, (–)—absent.

Parasite	Texas	Louisiana
Trematoda		
Acanthatrium nycteridis	+	–
Allassogonoporus marginalis	–	+
Limatulum oklahomense	+	–
Ochoterenatrema labda	+	+
Urotrema scabridum	+	+
Plagiorchis vespertilionis	+	+
Dicrocoelium rileyi	+	+
Conspicuum icteridorum	+	+
Cestoda		
Hymenolepis gertschi	+	+
Nematoda		
Molinostrongylus delicatus	+	+
Tricholeiperia sp.	+	–
Physaloptera sp. (immature)	+	+
Rictularia sp.	+	–

sider them separate. Until larger series can be examined I will consider the two species distinct. In my collection difficulty in identifying the genus arises in ovigerous worms where the large number of eggs tends to obscure the area of the pseudogonotyl. In the past this has resulted in some worms being identified as *Prosthodendrium*. Until more is known about the growth and development of the pseudogonotyl I prefer to recognize the two genera as distinct. *O. labda* has been reported from *Cynomops planirostris* (Peters, 1865) Thomas, 1920, *Natalus mexicanus*, and *Tadarida brasiliensis* from New Mexico, Mexico, Brazil, and for the first time in this paper in Texas and Louisiana.

This is the first record of the dicrocoeliid *Conspicuum* in a bat. Previous records were from birds. The occurrence of this parasite may be related more to flight of both hosts involved and daytime activity of the infected intermediate than to the phylogeny of the final hosts. Crepuscular activity observed in bats may allow for occasional exposure to infected arthropod hosts and account for low incidence in bats. My specimens agree with the description for *Conspicuum icteridorum* described by Denton and Byrd (1951, Proc. U. S. Nat. Mus. 101: 157–202) in the gall-bladder of grackles.

Cestodes from both sites were identified as *Hymenolepis gertschi* (Macy, 1947, Am. Midl. Nat. 37: 375–378). The holotype was collected from *Myotis californicus* in Oregon and also was reported in *Tadarida brasiliensis* in New Mexico. This is the first report of *H. gertschi* from Texas or Louisiana.

Three specimens of *Conspicuum icteridorum* have been deposited in the United States National Museum Helminthological Collection (Nos. 71528, 71591).

Supported in part by Grant-in-Aid of Research from The Society of Sigma Xi and a research grant (GB 7938) from the National Science Foundation.

D. R. MARTIN
Department of Biology
Tulane University
New Orleans, Louisiana 70118

(Present address:
Department of Zoology
The Ohio State University
Lima, Ohio 45804)

Research Note

Some Parasites of *Fundulus diaphanus* and *Pungitius pungitius* from Insular Newfoundland

During a study of the parasites of the mummichog, *Fundulus heteroclitus* (L.) (Dickinson and Threlfall, 1975. Proc. Helm. Soc. Wash. 42: 111–116), we encountered additional metazoan parasites in the banded killifish, *F. diaphanus* (Lesueur), and the nine-spine stickleback, *Pungitius pungitius* (L.), from insular Newfoundland, Canada. Dillon (1966, Va. J. Sci. 17: 21–31) and Hoffman (1967, Univ. of California Press, Berkeley and Los Angeles,

Table 1. Metazoan parasites recovered from the banded killifish (*F. diaphanus*) and the ninespine stickleback (*P. pungitius*) in insular Newfoundland.

Parasite	Host	Site of infection	Prevalence [No. infected (%)]	Mean No./ infected fish	Range Nos.
Gyrodactylus stephanus Mueller, 1937	*P. pungitius* †	Gills	8 (12)	3	1–6
Urocleidus angularis Mueller, 1934	*F. diaphanus**	Gills	16 (57)	3	1–25
Brachyphallus crenatus Rudolphi, 1802	*P. pungitius*	Intestine	3 (5)	3	1–5
Proteocephalus sp.	*P. pungitius*	Intestine	1 (2)	2	–
Neoechinorhynchus rutili (Mueller, 1780)	*P. pungitius*	Intestine	29 (45)	5	1–15
Thersitina gasterostei (Pagenstecher, 1861)	*P. pungitius*	Gills	20 (31)	4	1–18

† New host record.
* New Canadian host record.

486 p.) have listed parasites reported from the killifish, while the latter author (Hoffman, op. cit.) and Hanek and Threlfall (1970, Can. J. Zool. 48: 600–602) listed those from the stickleback. Others are reported herein.

Collections during the summer months of 1973 provided 28 killifish from Seal Cove Brook (47°48′ N 58°28′ W) and 64 sticklebacks from Clark's Brook (49°46′ N 58°08′ W). Hosts and parasites were examined using the techniques outlined in Fernando, Furtado, Gussev, Hanek, and Kakonge (1972, Univ. of Waterloo Biology Series No. 12, p. 1–76).

Metazoan parasites recovered from the two host species are listed in Table 1. *Urocleidus angularis* was originally described from *F. diaphanus* by Mueller (1934, Roosevelt Wild Life Annals 3: 335–373) and was the only parasite found on this host during the present study. Due to the description being incomplete by today's standards, supplemental data are presented. Measurements (microns) of *U. angularis* obtained during the present study were as follows [mean (range)]: body length 387 (286–442); body width 70 (52–88); pharynx (max diam) 26 (20–30); haptor length 44 (37–50); haptor width 72 (62–93); peduncle 52 (46–62); length of anchors 22 (22); length of basal part 12 (10–13); length of point 8 (5–10); length of inner root 6 (5–10); length of connecting bar 3 (3–5); width of connecting bar 22 (20–27); length of marginal hooks and shaft 15 (15); length of marginal hooks 3 (3).

The only other monogenean recovered from this host in Canadian waters is *Gyrodactylus prolongis* Hargis, 1955, which was taken from *F. diaphanus* in Ontario (Hanek and Fernando, 1971, Can. J. Zool. 49: 1331–1341). *G. prolongis* was not found on *F. diaphanus* in this survey, although it was found on *F. heteroclitus* from the same sample area (Dickinson and Threlfall, op. cit.).

The present recovery of *G. stephanus* from *P. pungitius* represents a new host record. Hanek and Threlfall (1970, Can. J. Zool. 48: 600–602) noted the presence of *G. avalonia* Hanek and Threlfall, 1969, and *G. canadensis* Hanek and Threlfall, 1969, on this host during their study.

We wish to thank the National Research Council of Canada and Environment Canada for the grants, to William Threlfall, that funded the study.

Anthony B. Dickinson and
William Threlfall

Department of Biology
Memorial University of Newfoundland
St. John's, Newfoundland, Canada
A1C 5S7

Research Note

Histochemical Observations on the Body Surface of *Leucochloridiomorpha constantiae* (Trematoda) Cultivated in Vitro

Fried and Contos (1973, J. Parasit. 59: 936–937) cultivated *Leucochloridiomorpha constantiae* (Mueller, 1935) metacercariae to ovigerous adults in defined medium NCTC 135 supplemented with fresh hens' egg yolk in a ratio of 4 : 1. The developmental criterion in that study consisted solely of maturation of sexual organs based on whole worm examination and the methods used precluded observations on the body surface. Harris and Cheng (1973, J. Parasit. 59: 749–751) reported histochemical and morphological changes in the body surface of *L. constantiae* associated with postmetacercarial development in the domestic chick. Harris, Cheng, and Cali (1973, Parasitology 68: 57–67) examined ultrastructural changes in the tegument associated with postmetacercarial development of *L. constantiae* in the domestic chick. In addition, they reported that maintenance of metacercariae in nonnutrient Locke's solution at 22–25 C for about 3 days was not sufficient stimulus to permit the tegumentary transformation observed during postmetacercarial development in the chick. The purpose of the present study was to determine histochemically whether changes occur in the body surface of *L. constantiae* metacercariae cultivated in NCTC 135 medium with hens' egg yolk supplemented at 37.5 and 41 C in a manner comparable to that reported for worms grown in the chick.

Metacercariae were cultivated as described previously (Fried and Contos, 1973, loc. cit.) and worms were removed from culture at 6 and 12 hr and then daily from days 1 to 7. For comparative purposes, 5- and 7-day-old adults were grown in domestic chicks (Fried and Harris, 1971, J. Parasit. 57: 866–868). Metacercariae removed directly from *Campeloma decisum* (Say) snails, and worms grown in vitro and in chicks were fixed in neutral buffered formalin and embedded in paraffin or frozen for cryostat sections. Paraffin sections were predigested with 0.5% malt diastase followed by treatment with periodic acid-Schiff (PAS) for mucopolysaccharides (Mowry, 1963, Ann. N. Y. Acad. Sci. 106: 402–423), or stained with alcian blue pH 2.5 for acid mucopolysaccharides (Mowry, 1963, loc. cit.) or mercuric bromphenol blue for protein (Mazia, Brewer, and Max, 1953, Biol. Bull. 104: 57–67). Frozen sections were stained with Oil Red O for neutral fat (Lillie, 1944, Stain Technol. 19: 55–58).

There appeared to be no appreciable staining differences in the body surface of worms cultivated at 37.5 and 41 C. The body surface of all worms stained weakly with mercuric bromphenol blue. The body surface of metacercariae and 6 hr in vitro worms stained intensely with PAS following diastase digestion suggesting the presence of large amounts of mucopolysaccharides in the tegument. The intensity of the staining diminished gradually during worm maturation resulting in a weak PAS reaction in the body surface of 4- to 7-day-old in vitro worms that was comparable to that observed in worms grown in chicks. Metacercarial body surfaces stained intensely with alcian blue confirming the presence of acid mucopolysaccharides as described by Harris and Cheng (1973, loc. cit.). After 6 hr in vitro only the outermost portion of the body surface (approximately 1 μm in thickness) stained intensely. Staining intensity diminished progressively during cultivation, and from days 5 to 7 the alcian blue reaction was comparable to that of worms grown in chicks. The body surface of metacercariae and worms grown in vivo was Oil Red O negative, whereas in vitro worms revealed small ORO positive droplets in the tegument suggesting the presence of neutral fat.

After 6 hr in vitro the thick ridges characteristic of the metacercarial body surface disappeared giving the tegument a smoother appearance as noted and figured by Harris and Cheng (1973, loc. cit.) for worms grown in the chick for 8 hr. By 1 day the body surface of in vitro worms was smooth and considerably reduced in thickness from that of the metacercaria. After 4 days in vitro the body surface was comparable in thickness and smoothness to that of worms grown in chicks.

The thick, ridged body surface of *L. constantiae* metacercariae appears to contain large amounts of mucopolysaccharides as indicated by intense PAS and alcian blue staining. During maturation in the chick, the reduction in thickness of the body surface is accompanied by a progressive decrease in mucopolysaccharide concentration as evidenced by decreased staining intensity (Harris and Cheng, 1973, loc. cit.). The results of our study suggest that a culture medium of NCTC 135 with yolk supplement at 37.5 and 41 C permits tegumentary transformation during maturation of *L. constantiae* in vitro approximating that observed in worms grown in the chick by Harris and Cheng (1973, loc. cit.).

NICHOLAS CONTOS[1] AND BERNARD FRIED
Department of Veterinary Science
University Park, Pennsylvania 16802
and
Department of Biology
Lafayette College
Easton, Pennsylvania 18042

[1] Present address: Department of Biological Science, Florida State University, Tallahassee, Florida 32306.

Research Note

Effect of Haloxon and Thiabendazole on the Free-living Stages of *Haemonchus contortus*

Control of parasitic nematodes usually is attempted through oral drenching of infected animals with various broad-spectrum anthelmintics such as haloxon and thiabendazole. Haloxon (O,O di-(2-chloroethyl)O-(3-chloro-4-methylcoumarin-7-yl)phosphate), an anthelmintic manufactured by Cooper, USA, Inc., Research Triangle Park, N. C., is effective against the more common adult nematode parasites and some of their immature forms (Brown et al., 1962, Nature 149: 379). Thiabendazole (2-4′-thiazolyl)-benzimidazole), produced by Merck and Co., Inc., Rahway, N. J., is known to remove adult and immature worms and inhibit egg production and larval development (Brown et al., 1961, J. Amer. Chem. Soc. 83: 1784–1765). The ovicidal and larvicidal activity of thiabendazole on various species of helminths has been reviewed by Egerton (1969, Texas Rep. Biol. Me. 27: 561–580). He reported also that the unembryonated egg and first-stage larvae of *Haemonchus contortus* were adversely affected but did not isolate those free-living stages prior to exposure to the drug. The objective of this project was to determine the effect of the two anthelmintics mentioned above on the isolated free-living stages of *H. contortus*.

The unembryonated ova, embryonated ova, first-, second-, third-, and exsheathed third-stage larvae of *H. contortus* were isolated as thoroughly as possible from extraneous organic material, and exposed to haloxon and thiabendazole at suspensions of 5.0 1.0, 0.5, 0.25, 0.12, and 0.05%, for exposure times of 0.25, 0.5, 1, 2, 4, 5, and 16 hr. In addition, the above stages were also exposed to a saturated solution of each drug for the same time periods. Haloxon has a low solubility in water of about 2 ppm (Murch, 1972, Veterinary Director, Cooper, USA, Inc., pers. comm.). Thiabendazole is 3.84% soluble in water at pH 2.2 and

decreases in solubility above and below this point (Seneca, 1971, Biological Basis of Chemotherapy of Infections and Infestations, F. A. Davis Co., Philadelphia). All experiments were conducted at pH 7.0 and at 25 C, except those on exsheathed third-stage larvae which were done at 37 C. All samples were agitated at 120 rpm during exposure. Survival of each stage was assessed by observing any subsequent development for the egg stages or motility for larval stages.

Haloxon was ineffective against all free-living stages and the exsheathed third-stage larvae. This was probably due to either the inability of the drug to penetrate the ova or larval cuticle or else to the fact that it did not interfere with existing metabolic pathways. Thiabendazole had a noticeable effect only upon the unembryonated egg. This stage was inhibited in its development by suspensions of 0.05% within 15 min exposure. At that time, the range of survival percentages for samples exposed to suspensions between 0.05 and 5.0% varied between 10 and 18% (average, 14.0%) as compared to 100% survival in untreated controls. The percentage survival of unembryonated eggs exposed to a saturated solution of thiabendazole at pH 7.0 ranged from 24 to 32% for up to 4 hr. The survival percentages noted did not decrease with increasing concentrations of the drug levels tested. After 4 hr, survival percentages of the treated samples still ranged between 10 and 24 (average, 15.8%). After 8 hr, however, all unembryonated eggs, in all concentrations tested, were dead.

Egerton (1969, loc. cit.) reported larvicidal activity of thiabendazole against the first-stage larvae of *H. contortus* when previous development occurred in the presence of the drug. The fact that first-stage larvae which were hatched prior to exposure to the drug were not affected by thiabendazole in this study suggests that the parasite must be exposed prior to embryonation in order for the anthelmintic to be effective.

GARY L. MCCALLISTER,
Biology Department, Mesa College,
Grand Junction, Colorado 81501

Research Note

Macrovalvitrematoides micropogoni (Pearse, 1949) (Monogenea: Diclidophoroidea) on the Atlantic Croaker, *Micropogon undulatus* (Linnaeus) from Texas

Sixteen collections of *Micropogon undulatus* were made from 10 September 1970 through 4 August 1971. When two collections were obtained during the same month the data were grouped. All fish were captured in the morning by trawl from Clear Lake or the channel connecting the lake with Galveston Bay, Texas. Immediately after capture, fish were placed on ice in insulated cooler chests, and transported to the laboratory at College Station. Each specimen was assigned a number and measured for standard length. Gills were then removed, placed in separate approximately numbered plastic bags along with a small amount

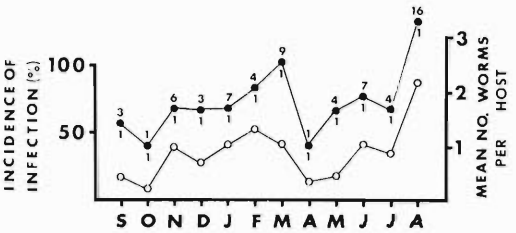


Figure 1. Incidence (open circles) and mean number (closed circles) of *Macrovalvitrematoides micropogoni* on *Micropogon undulatus* by month. Numbers below and above closed circles represent the range of worms recovered from individual hosts.

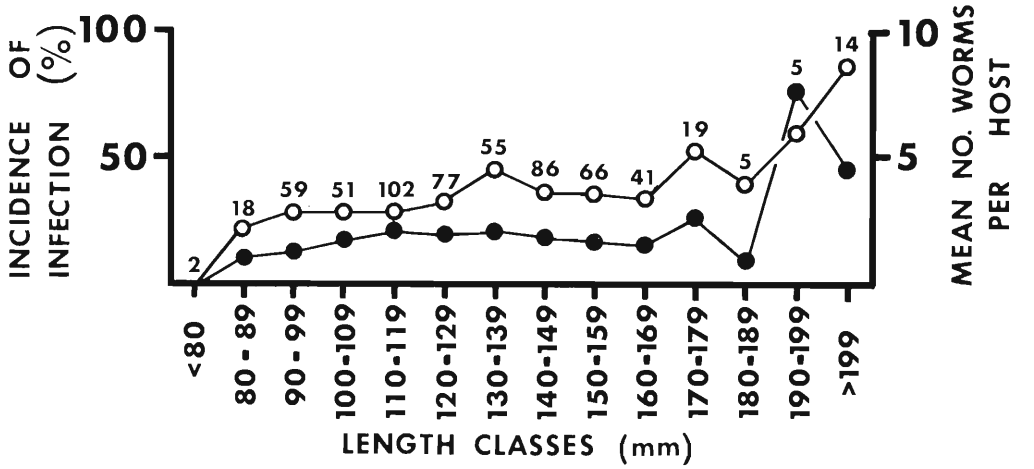


Figure 2. Incidence (open circles) and mean number (closed circles of *Macrovalvitrematoides micropogoni* on *Micropogon undulatus* by fish length class. Numbers above open circles represent the number of fish in that length class.

of water, and frozen. Examination of all gill samples for trematodes was done within a 10-day period following the method of Mizelle (1936, Am. Midl. Nat. 17: 785–806). Freezing for this length of time was in no way detrimental to the parasites. Mizelle proposed a maximum freezing time of 24 hr for freshwater species. All *M. micropogoni* specimens recovered were fixed and stored in 10% formalin.

Macrovalvitrematoides micropogoni was found on the gills of 213 (35.5%) of the 600 croaker examined. The mean infection rate during a 12-month period was 2.1 individuals per host. Thus, while a significant percentage of the croaker population was infected, there were relatively few *M. micropogoni* per host. Even though the number of parasites per host for any given month was linked with the percentage of croaker infected, no strict seasonal variations were evident (Fig. 1).

To determine the relationship of fish length to incidence and intensity of infection, the total catch of 600 croaker was grouped into 14 length classes. With the exception of the two largest length classes there was but a slight variation in incidence and virtually no change in the mean number of *M. micropogoni* per host as fish length increased (Fig. 2).

Macrovalvitrematoides micropogoni has been previously reported on the croaker from Beaufort, N. C. (Pearse, 1949, Proc. U. S. Natl. Mus. 100: 25–38); Alligator Harbor, Fla. (Hargis, 1956, Proc. Helm. Soc. Wash. 23: 5–13); York River, Va. (Kingston et al., 1969, J. Parasit. 55: 544–558); Clear Lake, Tex. (Joy, 1972, Tex. J. Sci. 23: note sect.); and Mississippi (Overstreet, pers. comm.).

This research was supported, in part, by institutional grant GH-101 made to Texas A&M University, by the National Oceanic and Atmospheric Agency's Office of Sea Grants, Department of Commerce.

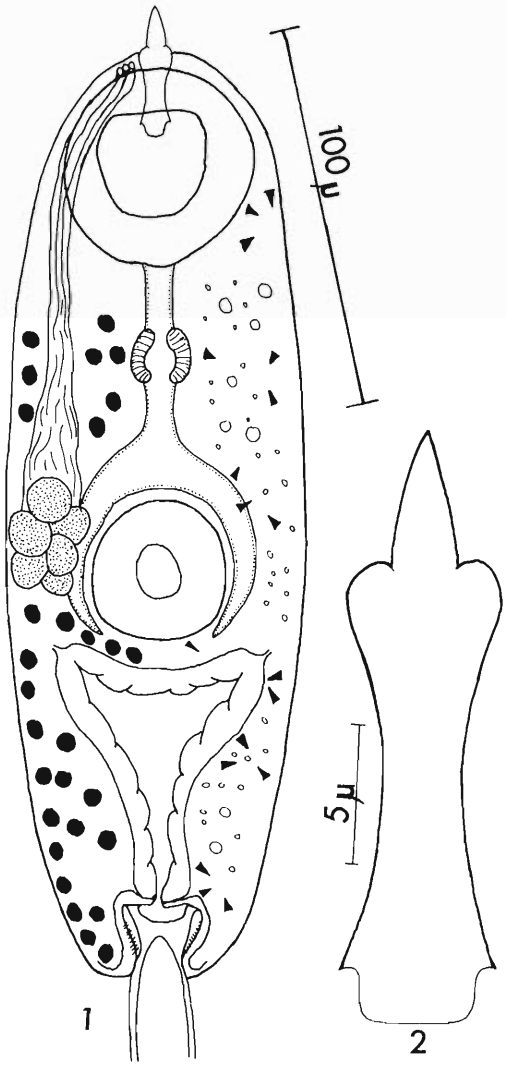
JAMES E. JOY
Department of Biological Sciences
Marshall University
Huntington, W. Va. 25701
AND
W. WAYNE PRICE
Department of Biology
Texas A&M University
College Station, Texas 77843

Research Note

Parasites of Amphibians of the Great Plains. I. The Cercaria of *Cephalogonimus brevicirrus* Ingles, 1932 (Trematoda: Cephalogonimidae)

From March 1973 until October 1974 50 specimens of a species of *Cephalogonimus* Poirier, 1886 (Digenea: Cephalogonimidae) were collected from two species of leopard frogs, *Rana pipiens* Schreber and *R. blairi* Mecham et al., in Nebraska. After comparison with specimens of *C. americanus* Stafford, 1902, *C. amphiumae* Chandler, 1923, *C. retusus* (Dujardin, 1845) Odhner, 1910, *C. vesicaudus* Nickerson, 1912, *C. salamandrus* Dronen and Lang, 1974, and published data on all species of *Cephalogonimus*, our specimens were provisionally identified as *C. brevicirrus* Ingles, 1932. It has been shown (Dronen and Lang, 1974, J. Parasit. 60: 75–79) that cercarial morphology may provide characters indicative of differences among species of *Cephalogonimus*, whose adult morphology is very similar. Accordingly, cercariae-producing infections were established in the laboratory. *Helisoma trivolvis* Say, the same experimental host used by Lang (1968, J. Parasit. 49: 84) and Dronen and Lang (1974, loc. cit.), was chosen to minimize the effect of host-induced variation.

Most adult worms were removed from the host small intestine, flattened with slight coverslip pressure, fixed with AFA, stored in 70% ethanol, then stained with Mayer's hematoxylin and mounted in Canada balsam for study as whole mounts. The morphology of the adults collected in Nebraska is included in a report in press (Brooks, Bull. Univ. Neb. State Mus.). Representative specimens have been deposited in the Harold W. Manter Laboratory, Division of Parasitology, University of Nebraska State Museum. Five specimens taken from the small intestine of a specimen of *Rana pipiens* collected 1.5 miles north of Hooper, Nebraska, were teased apart with insect pins to obtain eggs. Ten specimens of *Helisoma trivolvis* were exposed to infection following the procedure outlined by Lang



Figures 1, 2. Cercaria of *Cephalogonimus brevicirrus*. 1. Ventral view of cercaria. 2. Enlargement of stylet.

(1968, loc. cit.) and Dronen and Lang (1974, loc. cit.). Branching sporocysts developed in the hepatopancreas of two of the *H. trivolvis*, and cercariae were first shed 45 days after exposure to eggs. The snails were then crushed to observe the sporocysts, and mature cercariae were collected. Cercariae were stained with Neutral Red and studied live. Measurements are in microns. Figures were drawn with the aid of a camera lucida.

Cephalogonimus brevicirrus Ingles, 1932 (Figs. 1, 2)

DESCRIPTION OF CERCARIA (measurements based on 50 specimens; mean in parentheses): Body 210 to 252 (230) long by 55 to 66 (60) wide. Oral sucker 42 to 47 (45) in diameter; prepharynx 20 to 25 (21) long; pharynx 20 to 23 (22) long by 18 to 21 (20) wide; esophagus 20 to 25 (21) long; acetabulum 31 in diameter; tail straight, 107 to 115 (110) long by 18 to 21 (20) wide. Stylet: length 19 to 23 (22); width at wing 4.9 to 5.7 (5.3); width at base 4.9 to 5.7 (5.3); width of bulb 3.3; width at narrowest point of shaft 3.3. Refractile globules 70 to 100 per side. Cystogenous glands extending to level of pharynx, confined to lateral areas and acetabular zone, 30 to 40 per side. Six pairs of penetration glands in acetabular zone, with ducts emptying through six terminal pores. Excretory bladder Y-shaped; arms of bladder may extend to posterior margin of acetabulum; primary collecting tubules entering posterior to tips of arms; flame cell pattern 2 [(3 + 3 + 3) + (3 + 3 + 3)] = 36. Tail attachment pocket with caudal pockets containing spines. Excretory pore at anterior margin of attachment pocket.

Life cycle data is known for three other species of *Cephalogonimus*: *C. americanus* (by Lang, 1968), *C. salamandrus* Dronen and Lang, 1974 (by Dronen and Lang, 1974), and *C. europaeus* Blaizot, 1910 (by Combes, C., and Coll, A-M, 1974, Bull. Soc. Neuchat. Sci. Nat. 97: 203–214). The cercariae of all four species develop in branching sporocysts in the hepatopancreas of the molluscan host, and are xiphidiocercariae with identical flame cell patterns. The cercaria of *C. brevicirrus* is unique in possessing a prepharynx which is as long as the esophagus. It resembles the cercaria of *C. europaeus* in the size and morphology of the stylet, but is only one-third as large; in size of the body, tail, suckers, and pharynx the cercaria of *C. brevicirrus* is intermediate between *C. americanus* and *C. salamandrus*. *Helisoma trivolvis* serves as the experimental molluscan host for the North American species, while *Lymnaea limnosa* L. serves as the host for *C. europaeus*.

Cephalogonimus brevicirrus has previously been reported only from California (Ingles, 1932, Univ. Cal. Publ. Zool. 37: 203–210; Ingles, 1936, Tr. Am. Micr. Soc. 55: 73–92). Nebraska constitutes a new distribution record; *Rana pipiens* and *R. blairi* are new hosts; and *Helisoma trivolvis* is reported as an experimental molluscan host for *C. brevicirrus*.

The authors express appreciation to Dr. Bruce Z. Lang, Eastern Washington State College, for the loan of specimens of *C. americanus*, *C. salamandrus*, and *C. vesicaudus*; and to Mrs. Mary H. Pritchard, under whose direction this study was undertaken.

DANIEL R. BROOKS[1] AND
NANCY J. WELCH

School of Life Sciences
University of Nebraska–Lincoln and
Harold W. Manter Laboratory,
Division of Parasitology
University of Nebraska State Museum
Lincoln, Nebraska 68508

[1] Present address: Gulf Coast Research Laboratory, P.O. Box A. G., Ocean Springs, Mississippi 39564.

Book Review

Pictorial Key to Genera of Plant-Parasitic Nematodes. Fourth edition, Revised, 1975. W. F. Mai with H. H. Lyon, Photographer. 219 p.

This fourth edition of the Pictorial Key, first published in 1960, is presented for the first time in regular book format (paperback) with sewn binding, high quality paper, and with convenient page size of 18 by 25.5 cm. The printing, though rather small, is clear and attractive. Reproduction of illustrations is good, and the arrangement of contents further contributes to easy use of the book.

Following the Preface, outlines of two classification systems of the Order Tylenchida are given, the first being by A. M. Golden in 1971 and the second by M. W. Allen and S. A. Sher in 1967. Though differing in many important respects, these systems will orient the serious users of the book to the overall classification of the majority of plant nematodes. A brief classification outline of the plant-parasitic forms in the Order Dorylaimida is also included. A concise key to 66 genera of plant-parasitic nematodes, without pictures or illustrations, is given. This is followed by the same key with drawings (from original authors) or excellent photomicrographs of the type or representative species of the genus, generally presented on the page facing the one on which the genus is keyed out. In the key each genus carries a plate number referring to the illustration for that particular genus, a helpful inclusion. For each genus the technical description is given, the type species (with author and date) is listed, and one or more paragraphs on the general characteristics of the genus are included. The keys are intended to quickly lead the user through the higher taxa down to generic level, and the first five plates of illustrations assist in this by showing several different kinds of nematodes and their gross morphology.

Literature references are extensive. The section on Selected References contains 1,440 citations, and a list of pertinent taxonomic references is given under each of the 66 genera. This approach expedites retrieval of literature on a particular nematode. A General Reference section has 21 additional literature citations, mainly on books and other major publications on nematodes. A Glossary of Nematological Terms contains 84 definitions which will be helpful to many users, especially students, though a few of the definitions are somewhat lacking in accuracy and clarity. The book ends with an Index to Genera that locates the generic description, illustration plates, and selected references for each genus.

This book will be of particular value to students in nematology, and at the same time it should be very useful to most of the current workers in the field engaged in other than taxonomic research. The book is reasonably priced at $9.75 (U. S.) and can be obtained from Cornell University Press, 124 Roberts Place, Ithaca, New York 14850, USA, or Cornell University Press Ltd., 2–4 Brook Street, London, WIY IAA.

A. Morgan Golden
Nematology Laboratory
Bldg. 011A, BARC-West, USDA
Beltsville, Maryland 20705

PRESENTATION

1974 Anniversary Award of the Helminthological Society of Washington

492nd Meeting, 10 May 1975

Dr. E. J. Lawson Soulsby

According to the Constitution of this Society, the Anniversary Award is to be given annually or less frequently to a past or present member of the Society who has made outstanding contributions to science and this Society through his research and other activities which bring honor and credit to this Society.

The list of past recipients of this award is indeed a distinguished one, and your awards committee considers that it has added another illustrious name to that list in selecting Dr. Ernest Jackson Lawson Soulsby as the recipient of the 1974 Anniversary Award.

Dr. Soulsby was born in Haltwistle, England, in 1926. The institutions at which he received his professional training included the Royal (Dick) School of Veterinary Studies, University of Edinburgh, where in 1948 he became a Member R.C.V.S. and received his D.V.S.M. in 1949. In 1952, he received his Ph.D. from the Faculty of Medicine, University of Edinburgh; in 1954, the M.A., University of Cambridge; and in 1972, the A.M. (h.c.), University of Pennsylvania.

His career included general veterinary practice in Penrith; Veterinary Officer, Edinburgh; Lecturer in Clinical Parasitology, University of Bristol; and University Lecturer in Animal Parasitology, University of Cambridge. In 1964 he was appointed Professor of Parasitology, School of Veterinary Medicine, and Professor of Parasitology, Graduate School of Arts and Sciences, University of Pennsylvania; and in 1965, Chairman, Department of Pathobiology, School of Veterinary Medicine, University of Pennsylvania.

Of the many special appointments he has had, I have selected only a few to illustrate his involvement in global parasitology. These are as follows: Ian McMaster Fellow, McMaster Animal Health Laboratory, Sydney, Australia; Senior Fellow, Organization for European Economic Cooperation, Poland; World Health Organization Visiting Research Worker, USSR; Ford Foundation Visiting Professor, University of Ibadan, Nigeria; Visiting Professor, University of Guadalajara, Mexico; he has been a member of several World Health Organization Scientific Groups and Expert Committees, as well as Vice-President and President, World Association for the Advancement of Veterinary Parasitology; and President, 5th International Conference of the World Association for the Advancement of Veterinary Parasitology.

He is a member of some two dozen scientific societies. Among the offices he has held were those of Vice-President, British Society for Parasitology; and Recording Secretary, Vice-President, and President of the Helminthological Society of Washington.

He has served on the Editorial Boards of the British Veterinary Journal, Experimental Parasitology, Advances in Pathobiology, Proceedings of the Pennsylvania Academy of Science, and the Pahlavi Medical Journal.

Dr. Soulsby has trained a number of graduate students, and as one examines the titles of their Ph.D. dissertations, one can observe an underlying theme of immunity to parasitic infections. This also is evident in the more than 80 scientific research papers that he has written up to the present time.

He is the author of *Textbook of Veterinary Clinical Parasitology*, Blackwell Scientific Publications, Oxford; and *Helminths, Arthropods and Protozoa of Domesticated Animals*, 6th Edition of Mönnigs *Veterinary Helminthology and Entomology*, Balliere, Tindall and Cassell, London. He also is the editor of several other books on veterinary parasitology, including *Immunity to Animal Parasites*, Academic Press, New York; and he has written or revised 14 chapters on parasitology in 10 other books.

The Anniversary Award is presented to Dr. E. J. L. Soulsby by Dr. A. O. Foster.

In recognition of his many contributions to parasitology as an administrator, advisor, teacher, and investigator, the Committee is proud to present the Anniversary Award of the Helminthological Society of Washington to Dr. Lawson Soulsby.

(Committee: Lloyd E. Rozeboom, Chairman; John M. Vetterling, George W. Luttermoser)

Announcement

INTERNATIONAL REGISTER OF COMPUTER PROJECTS IN SYSTEMATICS

Sponsored By

The International Association For Plant Taxonomy, and
The Society of Systematic Zoology

CALL FOR INFORMATION ON PROJECTS, PROGRAMS AND DATA FILES

The above two international associations are the prime sponsors of an International Register of Computer Projects In Systematics. For the purpose of the Register, systematics includes taxonomy, biosystematics, evolution, and biogeography of all biological taxa. The Register also welcomes information about nonbiological data files of use to systematics (e.g., the long range weather data tapes of the U.S. Weather Bureau). For the present, our project is a Register, which hopefully can direct people to the source of information desired. Depending on demand, it could be extended into a repository *and* clearing house for computerized files of systematic value.

As in the first such Register (see Taxon 19:63–76 [1970]) we welcome systematic information on computerized data files about living organisms, preserved organisms, experimental data, literature files, etc. We also welcome information on well-written and documented computer program packages (other than basic statistics) that are of value for systematic research and/or teaching.

If you or a colleague use computers in systematics (or definitely plan to), please *write* to the Chairman of the Register, and *request* as many copies of the Register Questionnaire as you have separate projects or program packages. You will be helping systematics in general by avoiding duplication of effort and by contributing to our attempts to minimize the incompatibility of computerized systematic data, or programs generated on different projects. You will be helping yourself because not only might you discover that someone else has already written the program, or computerized the data that you want, but also the data and programs you have created may be useful to others, thus enhancing their value.

The Register will be computerized and available for customized search requests by September 1976. As demand warrants it, published summaries will also appear. This Register will be compatible with a similar Register for all of biology that Crovello is organizing for the American Institute of Biological Sciences.

Please address all suggestions, requests for information, and for Register Questionnaires, to:

Theodore J. Crovello, Chairman
International Register
Department of Biology
University of Notre Dame
Notre Dame, Indiana 46556 U.S.A.

In Memoriam

JEAN GEORGES BAER
February 21, 1975
Member since June 3, 1950

EDUARDO CABALLERO Y CABALLERO
October 26, 1904–December 30, 1974
Member since October 17, 1945

Errata

Andrews, S. E., and W. Threlfall. 1975. Parasites of the Common Crow (*Corvus brachyrhynchos* Brehm, 1822) in Insular Newfoundland. Proc. Helm. Soc. Wash. 42 (1): 24–28.

Anderson (1959) under heading Nematoda should read Anderson and Freeman (1969). In the Literature Cited the reference Anderson, R. C. 1959. is incorrect and should be as follows:

Anderson, R. C. and R. S. Freeman. 1969. *Cardiofilaria inornata* (Anderson, 1956) from Woodcock with a review of *Cardiofilaria* and related genera (Nematoda: Filarioidea). Trans. Amer. Microsc. Soc. 88(1): 68–79.

MEMBERS OF THE HELMINTHOLOGICAL SOCIETY OF WASHINGTON

(Alabama through Mississippi; remainder of list will appear in July issue)

Alabama
Bailey, W. S.
Cairns, E. J.
Duncan, B. L.
Ernst, John V.
Ford, B. R.
Keppner, Edwin J.
Porter, Dale A.
Rogers, W. A.

Alaska
Shults, L. M.
Williamson, F. S. L.

Arizona
Anderson, G. A.
Crook, James R.
Minckley, Saundra K.
Wilkes, S. N.

Arkansas
Hoffman, G. L.

California
Ash, L. R.
Baker, N. F.
*Chitwood, May B.
Cross, John H.
Dailey, M. D.
Glaudel, R. J.
Graham, G. L.
Hart, W. H.
Hass, D. K.
Heyneman, D.
Holdeman, Q. L.
Krassner, S. M.
Lear, B.
Lie, Kian-Joe
Maggenti, A. R.
Mankau, R.
Martin, W. E.
Nahhas, F. M.
Noel, G. R.
Noffsinger, Ella Mae
Olson, A. C., Jr.
Paxman, G. A.
Poinar, G. O., Jr.
Raski, D. J.
Rothman, A. H.
Sen, A. K.
Sher, S. A.
Siddiqui, I. A.
Steele, A. E.
Van Gundy, S. D.
Voge, Marietta
Wagner, E. D.
Walker, K. A.
Weinmann, C. J.
Viglierchio, D. R.

Colorado
Hathaway, Ronald P.
Olsen, O. W.
Schmidt, G. D.
Stabler, R. M.

Connecticut
Huffman, Jane E.
James, Hugo A.
Penner, L. R.
Pohley, W. J.
Pondick, Jeffrey

District of Columbia
Buchheit, R. J.
*Buhrer, Edna M.
Dooley, J. R.
Duxbury, R. E.
Erickson, D. G.
Gore, R. W.
Hope, W. D.
Jackson, G. J.
Kinnamon, K. E.
Lee, Clarence M.
Perry, Ray A.
Redington, Bryce C.
Reid, W. A., Jr.
Rothstein, N.
Wolfe, M. S.

Florida
Ager, A. LeRoy, Jr.
Bergner, J. F., Jr.
Dunn, R. A.
Esser, R. P.
Forrester, D. J.
Grieve, R. B.
Hannon, C. I.
Leigh, W. Henry
O'Bannon, J. H.
Overman, Amegda J.
Perry, V. G.
Short, R. B.
Smart, G. C., Jr.
*Taylor, A. L.

Georgia
Chang, J.
Ciordia, H.
Davidson, W. R.
Denton, J. F.
Fincher, G. T.
Goodchild, C. G.
Heard, R. W., Jr.
Husain, Ansar
Kagan, I. G.
Krissinger, W. A.
LeFlore, W. B.
Minton, N. A.
Powders, V. N.
Purseglove, Samuel R., Jr
Rana, S. S.
Rawson, Mac V., Jr.
Ruehle, J. L.
Stewart, T. B.
Wehunt, E. J.

Hawaii
Apt, W. J.
Schroeder, Paul

Idaho
Kritsky, Delane C.
Leiby, P. D.
Schell, S. C.

Illinois
Ahern, W. B.
Cordell, R. L.
Dunagan, T. T.
Dyer, W. G.
Edwards, D. I.
Ehrenford, F. A.
Garoian, G.
Huizinga, H. W.
Kruidenier, F. J.
Levine, N. D.
Malek, R. B.
Ridgeway, B. T.
Seed, T. M.
Singer, Ira
Todd, K. S., Jr.

Indiana
Boisvenue, R. J.
Cable, R. M.
Ferris, Virginia R.
Kazacos, K. R.
Thorson, R. E.
Weinstein, P. P.

Iowa
Goss, R. C.
Greve, J. H.
Hendrickson, G. L.
Oaks, J. A.
Ulmer, M. J.
Wacha, R. S.
Wittrock, D. D.
Zimmermann, W. J.

Kansas
Coil, W. H.
Dickerson, O. J.
Hansen, M. F.
Miller, T. A.

Kentucky
Chapman, R. A.
Drudge, J. H.
Eversmeyer, H. E.
Harley, J. P.
Lyons, E. T.
Whittaker, F. H.

Louisiana
Beaver, P. C.
Besch, E. D.
Birchfield, W.
Christian, F. A.
Corkum, K. C.
Eberhard, M. L.
Esslinger, J. H.
Greer, G. J.
Hollis, J. P., Jr.
Klei, T. R.
Little, M. D.
Lumsden, R. D.
Martin, W. J.
Murad, J. L.
Specian, R. D.
Turner, H. M.
Warren, L. G.

Maine
Meyer, M. C.
Samuel, G.

Maryland
Anderson, William R.
Andrews, J. S.
Bang, F. B.
Bawden, M. P.
Beacham, Bruce E.
Beaudoin, R. L.
Billeter, P. A.
*von Brand, T.
Burke, J. C.
Carney, W. P.
Chute, A. M.
†Chute, M. Barry
Colglazier, M. L.
Diamond, L. S.
Doran, D. J.
Douvres, F. W.
Edwards, Shirley J.
Endo, B. Y.
Enzie, F. D.
Farr, Marion M.
Fayer, R.
Feldmesser, J.
Ferguson, M. S.
*Foster, A. O.
Friedman, H. C. Hechler
Friedman, W.
Gasbarre, L. C.
Goldberg, A.
Golden, A. M.
Gwadz, R. W.
Haley, A. J.
Herlich, H.
Hood, Martha Walker
Isenstein, R. S.
Jachowski, L. A., Jr.
Jacobs, L.
Jones, A. W.
Kates, K. C.
Knight, R. A.
Krusberg, L. R.
Leek, R. G.
Lichtenfels, J. R.
Lincicome, D. R.
Lund, E. E.
Lunde, M. N.
Luttermoser, G. W.
Malakatis, G. M.
McCullough, C.
*McIntosh, A.
McLoughlin, D. K.
Morris, J. A.
Munson, D. A.
Nickle, W. R.
Olsen, J. L.
*Otto, G. F.
Palmer, T. T.
Phillips, B. P.
Pilitt, Patricia A.
Poiley, Judith A.
Poole, J. B.
Powers, K. G.
Price, D. L.
Rebois, R. V.
Richards, C. S.
Roby, T. O.
Romanowski, R. D.
Rosenfield, A.
*Rozeboom, L. E.
Sawyer, T. K.
Sayre, R. M.
Schiller, E. L.
Schinski, V. D.
Scott, J. A.
Shaw, Judith H.
Sheffield, H. G.
Shiroishi, Tsugiye
Simpson, T. W.
Sprague, V.
Steck, E. A.
Stirewalt, Margaret A.
Stringfellow, F.
Traub, R.
Tromba, F. G.
Turner, J. H.
Underwood, P. C.
Vegors, H. H.
Vetterling, John M.
Wehr, E. E.
Wergin, W. P.
Wiseman, H. G.

Massachusetts
Boyd, Elizabeth M.
Bruce, John I., Jr.
Byram, J. E., III
Campbell, R. A.
Hurley, F. J.
Riser, N. W.

Michigan
Bird, G. W.
Blankespoor, H. D.
Clarke, M. D.
DeGiusti, D.
*Dikmans, G.
Greene, L. K.
Peters, L. E.

Minnesota
Ballard, N. B.
Vande Vusse, F. J.

Mississippi
Brooks, D. R.
Cake, E. W., Jr.
Minchew, C. D.
Overstreet, R. M.
Wellborn, T. L., Jr.

* Life Member
** Honorary Member
† Spouse Member

ALLEN PRESS, INC. PRINTED IN U.S.A. LAWRENCE, KANSAS

VOLUME 43 JANUARY 1976 NUMBER 1

CONTENTS

(*Continued from Front Cover*)

Date of publication, 25 February 1976

* * *

ALLEN PRESS, INC. PRINTED IN U.S.A. LAWRENCE, KANSAS