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Binder 206, Life histories A-B [Trematoda Taxon Notebooks]

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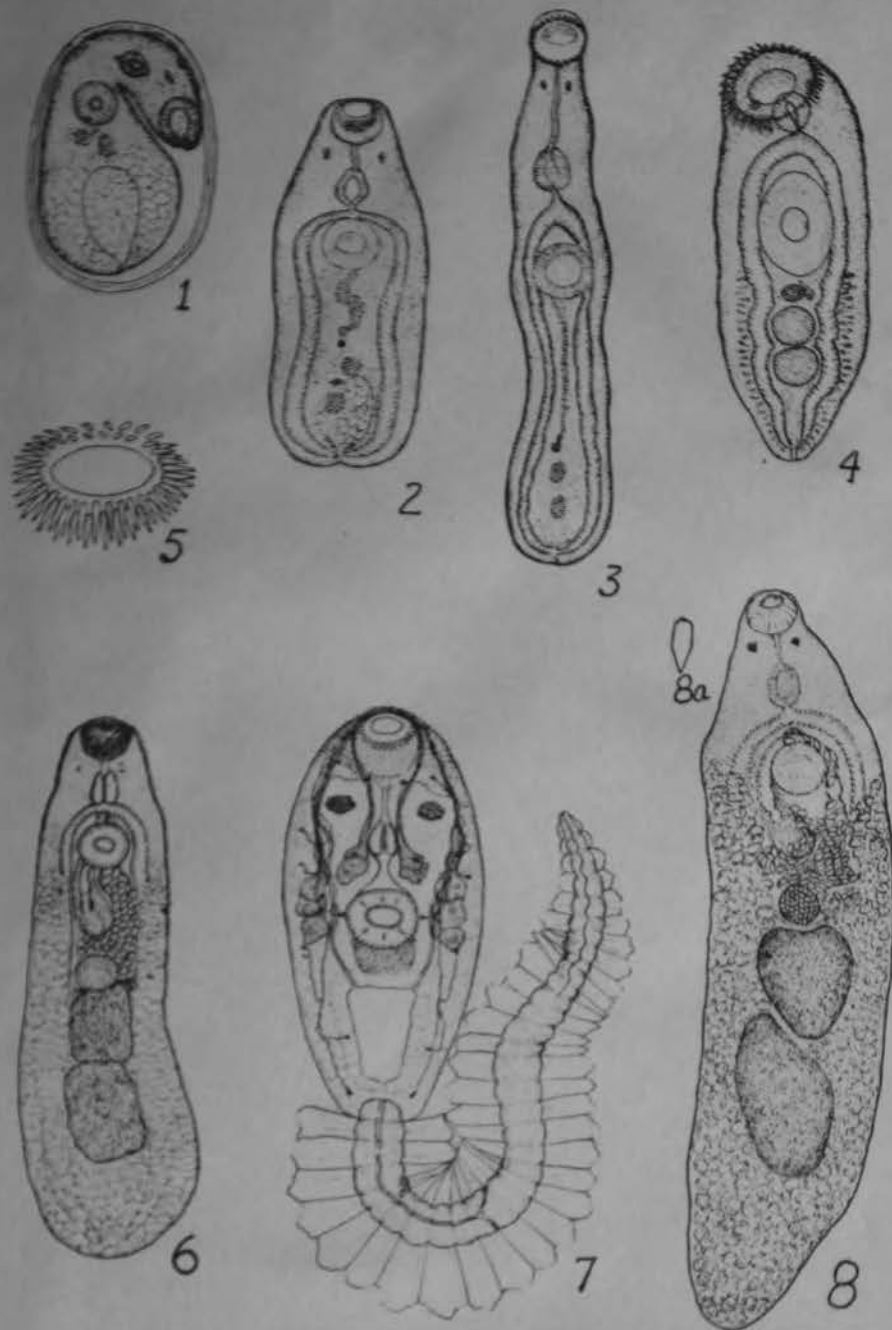
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Cort (1941), A Symposium of Hydrobiology, p.116, states that the life cycles of more than 200 digenetic trematodes belonging to more than 30 families are known.



FIGURES 1-8a.

Cercaria dipteroerca Miller and Northup, 1926 and Stephanostomum dentatum (Linton, 1900) Manter, 1931.

- 1-2 Metacercaria from Menidia menidia exposed to C. dipteroerca.
 3 Metacercaria from Fundulus heteroclitus, Woods Hole, Mass.
 4-6 Stephanostomum dentatum from Paralichthys dentatus
 7 Cercaria dipteroerca from Nassa obsoleta
 8 Stephanostomum dentatum from P. dentatus.

DISCUSSION

The tendency for members of *Stephanostomum* to lose cuticular spines has led to confusion and taxonomic difficulties as noted by Pratt (1916), Manter (1934) and other authors. Attempts to correlate particular larval and adult stages have not been fruitful, although the taxonomic problems, identity and number of valid species, and systematic position of the genus will not be finally resolved until life-cycle data are available.

Differences in the accounts of Martin (1939) and Wolfgang (1954, 1955a) on the life-histories of *S. tenue* and of *S. baccatum*, respectively, are perplexing. According to Martin, the cercaria of *S. tenue* has a simple tail with a sticky tip, a stenostomate excretory pattern and a flame-cell formula of 2 (3 + 3 + 3 + 3 + 3 + 3 + 3). According to Wolfgang, the cercaria of *S. baccatum* lacks a stylet and peristomial spines, has a simple tail with a sticky tip, a mesostomate excretory pattern with the pore at the tip of the tail, but the flame-cell pattern was not worked out. Wolfgang noted that the cercaria of *S. baccatum* is distinctly different from that of *S. tenue*. But his observation that the excretory vesicle discharges through a duct which traverses the tail and opens at the tip is so unusual that it can be accepted only after confirmation. Moreover, his description of a mesostomate excretory pattern in the cercaria and a stenostomate arrangement in the metacercaria would necessitate a major alteration in the collecting tubules and suggests that the cercaria and metacercaria belong to different species.

Cercaria dipteroerca differs from the cercaria described by Martin as the larva of *S. tenue* in several important features. It lacks a stylet, has lateral and dorsoventral cuticular fins on the tail, and the flame-cell formula is simpler, 2 (3 + 3 + 3). These differences are far greater than ordinarily encountered between cercariae of species in a single genus and present as yet unresolved problems.

The genus *Stephanostomum* has been assigned to the family Acanthocolpidae but the relationships of that family are uncertain. Most authors have included the Acanthocolpidae in the Allocreadioidea. La Rue (1957) presented a classification of the digenetic trematodes based on life-history data and designed to show genetic relationships. The system was founded primarily on the formation of the excretory bladder, supplemented by other morphological and bionomic data. The Digenea were divided into the Anepitheliocystidia and the Epitheliocystidia. The first group comprised three orders; Strigeatoidea, Echinostomida, and Rencolidia, in which the excretory vesicle is thin, membranous, not epithelial at any stage, and in which the cercariae have forked or single tails and the excretory ducts extend into the tails of developing cercariae. In the second group, the excretory vesicle has a primary membranous wall which is replaced by an epithelium derived from a mesodermal cell-mass. It comprises two orders: the Plagiorchiida and

the Opisthorchiida. These groups were distinguished by the location of the primary excretory pores, which in the Plagiorchiida are at the furrow between body and tail and in the Opisthorchiida on the lateral margins of the tail, near its base. The order Plagiorchiida contains two superfamilies: the Plagiorchioidea Dollfus, 1930 and the Allocreadioidea Nicoll, 1934. As noted, *Stephanostomum* has been accepted as a member of the Acanthocolpidae in the Allocreadioidea. But in *Stephanostomum* the excretory ducts extend into the tail of the cercaria, which would exclude the genus from the Allocreadioidea and require its transfer to the Opisthorchioidea. Such a disposition would require that the genus be removed from the Acanthocolpidae or the transfer of the entire family. Indeed, such an allocation has been suggested; at the annual Midwest Conference of Parasitologists, Peters reported on the development of the excretory system in an acanthocolpid cercaria and in the mimeographed abstract of the paper stated, "Thus, the Acanthocolpidae must be excluded from the Allocreadioidea and may be closer to the Echinostomatidae, or possibly to the Opisthorchioidea." At the same meeting, Cable, Peters and Berger discussed the affinities of the Acanthocolpidae and noting substantial agreement with members of the family Campulidae, suggested possible genetic and taxonomic relationship, even inclusion in the same family. Pande (1960) erected a new genus *Brijicola* to contain a new species, *B. caballeroi*, with morphological similarities to a number of genera at present assigned to such different families as Acanthocolpidae Lühe, 1909; Acanthostomatidae Poche, 1926 emend. Nicoll, 1935; Echinostomatidae Looss, 1902 emend. Poche, 1926; Maseniidae Yamaguti, 1953; Heterophyidae Odhner, 1914; and Plagiorchiidae Lühe, 1901 emend. Ward, 1917. The genus was assigned to the Acanthocolpidae with the comment that the present concept of the family remains greatly confused and unsatisfactory.

FROM
STUNKARD,

SUMMARY

The morphology, composition and distribution of the genus *Stephanostomum* are considered. Taxonomic uncertainties and difficulties are discussed. It is postulated that the difficulties can be resolved only with knowledge of life-cycles, larval forms, and developmental stages. Previous accounts of life-histories in the genus are reviewed. The cercariae described by Miller and Northup (1926) from *Nassa obsoleta* at Woods Hole are listed and their life-cycles are traced. *Cercaria dipteroerca* Miller and Northup, 1926 penetrated and encysted in laboratory-reared specimens of *Menidia menidia*. They continued their development and the mature metacercariae manifest such precise agreement in number and shape of peristomial spines and in general morphology with juvenile and mature specimens of *Stephanostomum dentatum* (Linton, 1900) Manter, 1931, that *C. dipteroerca* may be the larval stage of *S. dentatum*. *Cercaria dipteroerca* is very different, however, from the cercariae described by Martin (1939) and Wolfgang (1954, 1955a) as the larvae of *Stephanostomum tenue* and *Stephanostomum baccatum*, respectively. The larvae described by Martin and Wolfgang differ markedly from one another. These differences are far greater than ordinarily encountered between species of a single genus and present as yet unresolved problems. The systematic position of *Stephanostomum* and the family to which it belongs are equivocal. If the genus is a member of the Acanthocolpidae, and if La Rue's system is valid, the family must be transferred from the Allocreadiidae to the Opisthorchioidea.

FROM
STUNKARD,

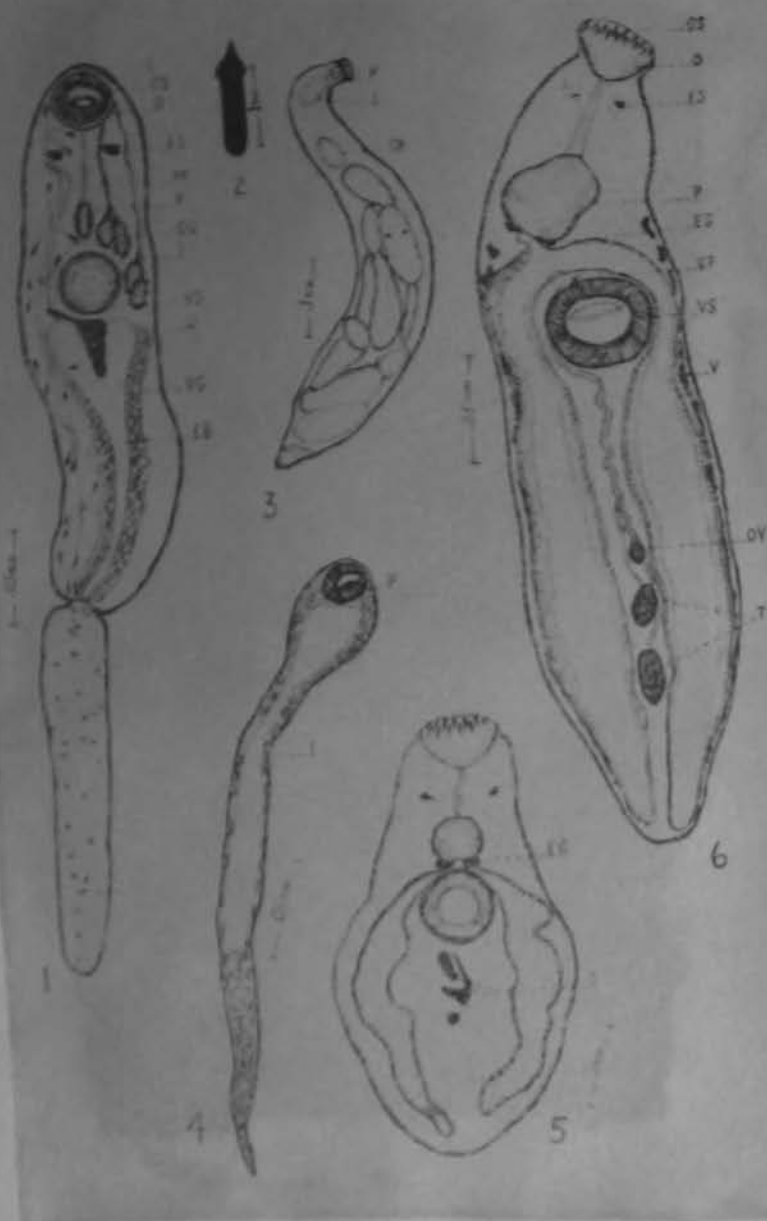


FIG. 1. CERCARIA, VENTRAL VIEW

FIG. 2. STYLET OF CERCARIA

FIG. 3. REDIA WITH GERM BALLS AND CERCARIA

FIG. 4. YOUNG REDIA SHOWING ELONGATE INTESTINE

FIG. 5. METACERCARIA

FIG. 6. ADULT

SUMMARY

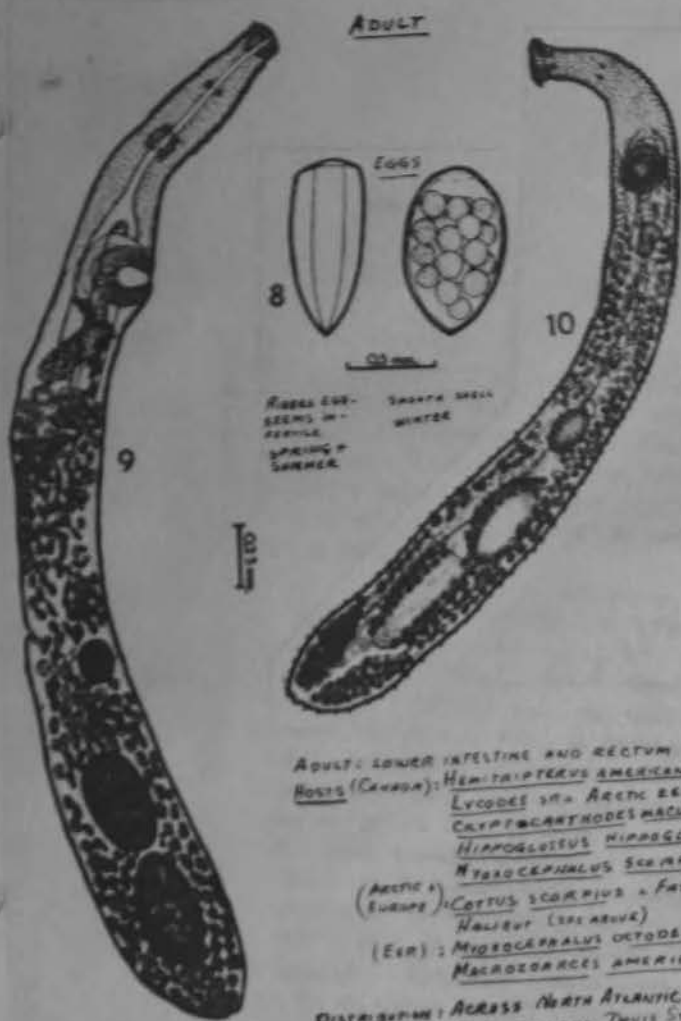
It was found that the life cycle of *Stephanostomum tenue* involves the development of rediae and cercariae in the marine snail, *Nassa obsoleta*, the utilization of the small fish, *Menidia menidia notata*, as the second intermediate host, and the development of the adult worm in the intestine of the puffer, *Spheroides maculatus*. Although the puffer may serve as the experimental definitive host, the striped bass, *Roccus lineatus*, is probably a natural one.

About 4 per cent of the *Nassa obsoleta* observed were infected with this parasite.

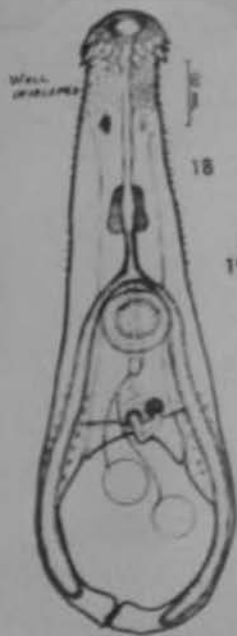
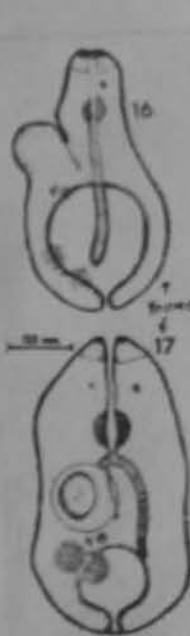
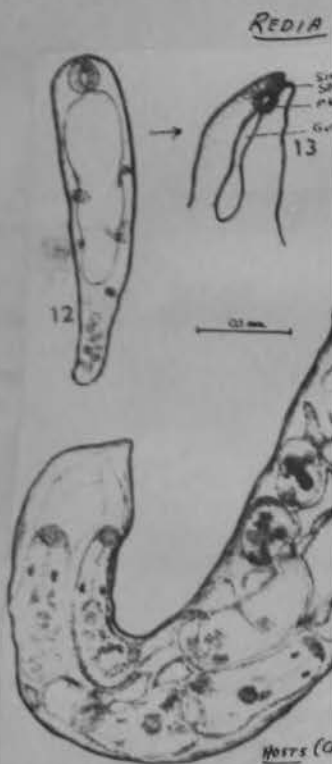
The excretory system of the cercaria is represented by the formula $2[3+3+3+3+3+3+3]$.

The arrangement of the reproductive organs, some similarity in the excretory systems, and the fact that fishes serve as hosts to the adult worms suggest an affinity of the Acanthocolpidae to the family Allocreadiidae.

FROM: MARTIN, 1939
Biol. Bull.



ADULT: LOWER INTESTINE AND RECTUM
 HOSTS (CANADA): HEMIRHAMPHUS AMERICANUS = SEA RAVEN
LYCODES sp. = ARCTIC BEL POUT
CRYPTOCARINUS MACULATUS = WHYMOUTH
HIPPOGLOSSUS HIPPOGLOSSUS = HALIBUT
MYDIOCEPHALUS SCORPIUS = SHORT-HORNED SCULPIN
 (ARCTIC EUROPE): COTTUS SCORPIUS = FATHER LATHER
HALIBUT (SEA RAVEN)
 (EUR): MYDIOCEPHALUS OCTODECIMPINOSUS = LONG-HORNED SCULPIN
MACRODARCES AMERICANUS = OCEAN POUT
 DISTRIBUTION: ACROSS NORTH ATLANTIC COAST, BAY OF FUNDY, NOVA SCOTIA,
 NEWFOUNDLAND, DAVIS STRAIT IN GREENLAND, NORTH SEA



CERCARIA

SETTLE TO BOTTOM
 CRAWL OR QUIET
 SPERMALMS
 SPERMALMS
 SPERMALMS
 SECONDARY
 LOSS OF
 TAIL
 PEEKY
 UPON
 CONTACT
 WITH
 FLOUNDER

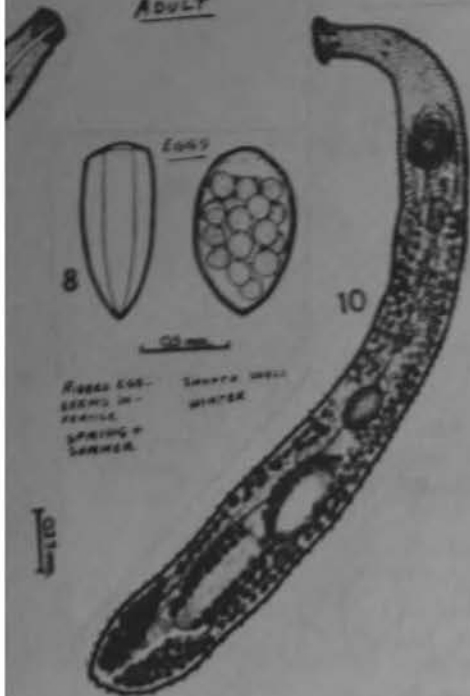
HOSTS (EUROPE): WITCH, LONG
 ROUGH DAB (= AM. PERCIS),
 DAB (= LIMANDA LIMANDA (L.)),
 LEMON SOLE (= SPICASTOMA KITI
 (WALBAUM)),
 PLICULE (= PLEURANECTES
 MURINA (L.))
 DIST: AS ADULT

METACERCARIA

LOCATION: GILLS, DERMAL PICTURE, SOMATIC MUSCLE
 HOSTS (NO. AM.): PLEURANECTES AMERICANUS (WALBAUM) = WINTER FLOUNDER
LIMANDA FOSTRANUS (GÜL) = SMOOTH ALBUCLER
LEMONSOLETTA HADDO (MITCHELL) = BRILL
LIMANDA CHARADRIUS (SPOHR) = YELLOW TAIL
GYMNOCEPHALUS CYTHAROTUS (L.) = WITCH
HIPPOGLOSSUS PLATESSIDUS (WARR)
 = AMERICAN PLICE
 FROM WOLFGANG

Stomum baccatum (Nicoll, 1907) Manter, 1934

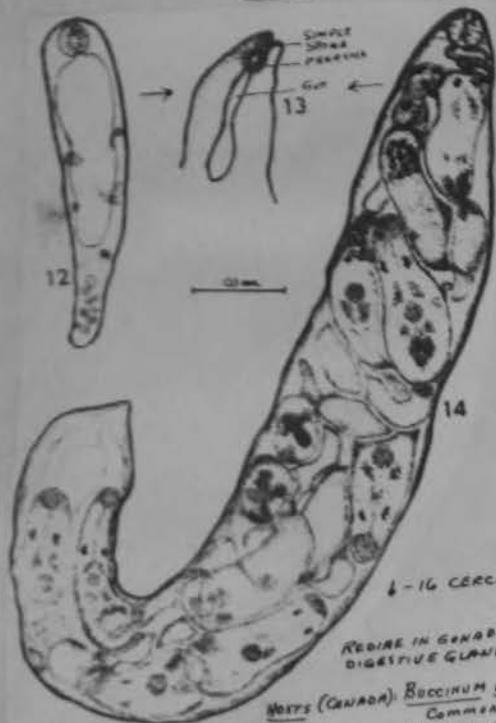
ADULT



8 EGG
9 EGGS
10 ADULT

ADULT EGGS - SEEDS IN - FERTILE, SPRING - SUMMER
SEEDS IN WINTER

REDIA



12
13
14
4-16 CERCAIRAE
REDIAE IN GONADS AND DIGESTIVE GLAND

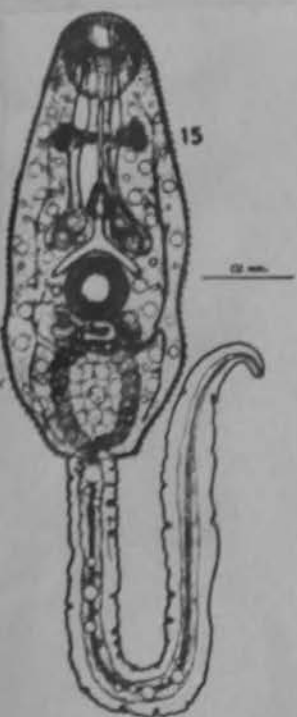
HOSTS (CANADA): *BUCCINUM UNSATUM* COMMON WHELL
NERITUNA DECEMLI-FRATUM 10-BANDED WHELL

NO BIRTH PORE; CERCAIRAE LIBERATED BY RUPTURE

ADULT: LOWER INTESTINE AND RECTUM
HOSTS (CANADA): *HEMIRHAMPHUS AMERICANUS* - SEA RAVEN
LYCODES sp. - ARCTIC EELPOUT
CLYPTACANTHODES MACULATUS - WATNOTH
HIPOPLEGIUS HIPPOGLOSUS - HALIBUT
MYXOCERPHALUS SCORPIUS - SMOOTH-NOSED SCULPIN
(ARCTIC): *COTTUS SCORPIUS* - FATHER LASKER
(EUROPE): *HALIET* (SEA HAKE)
(EAS): *MYXOCERPHALUS UNTODECIMSPINOSUS* - LONG-HORNED SCULPIN
MALLODERRIS AMERICANUS - OCEAN POUT
DISTRIBUTION: ACROSS NORTH ATLANTIC OCEAN, BAY OF FUNDY, NOVA SCOTIA, NENHUNGUNDANG, DWIT STRAIGHT IN GREENLAND, NORTH SEA

CERCARIA

SETTLE TO BOTTOM
CRAWL OR BURROW
EPITHELIAL STIPPLED-CELLS
SECONDARY LOSS OF STYLET
PERITONIA UPON CONTACT WITH SLOWLY



HOSTS (EUROPE): WITCH, LONG ROUGH DAB (= AM. PLICE)
DAB - *LIMANDA LIMANDA* (L.)
LEMAN SOLE *SMILASTOMA KITT* (MULLER)
PLATYCOLEPIS PLATYCOLEPIS (L.)
DIST: AS ADULT

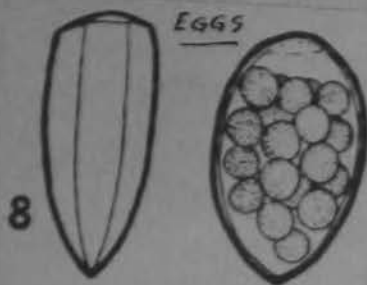
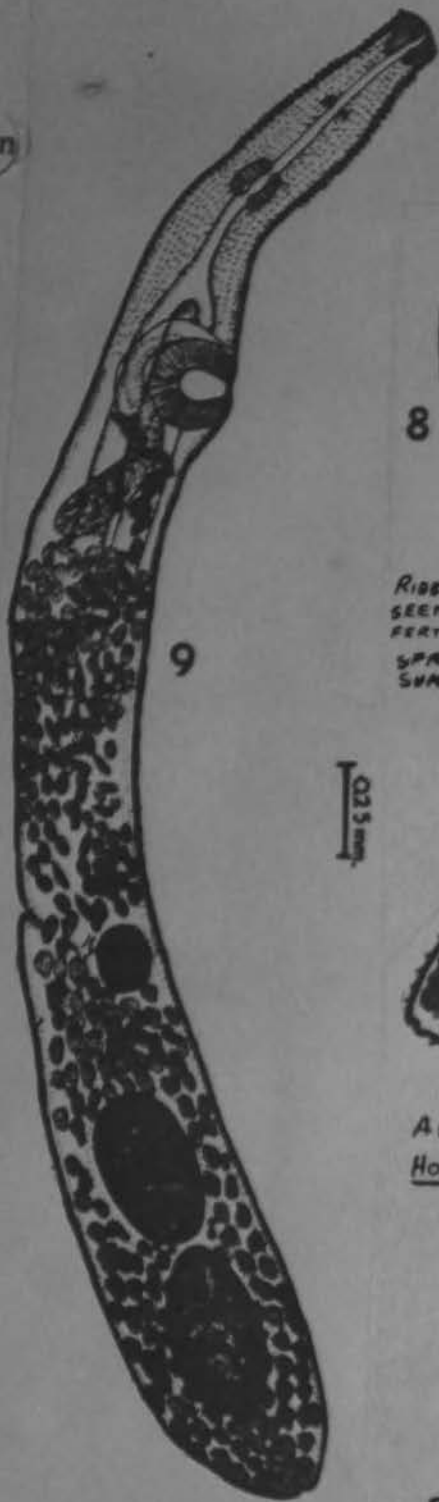
METACERCARIA

ALL DERMAL TISSUE, SOMATIC MUSCLES
HEMIRHAMPHUS AMERICANUS (WILKINSON) - WINTER FLOUNDER
LEHMANIA PATRACHI (KUMI) - SMOOTH HOLLOWER
LEHMANIA ARBOREA (MITCHELL) - BRILL
LEHMANIA CERISENA (SPENCER) - YELLOW TAIL
GETTNERIA LUTULOSA (L.) - WITCH
HIPOPLEGIUS PLATELLOIDES (RANKIN) - AMERICAN PLICE

FROM WOLFGANG (1955)

ADULT

En



RIBBED EGG - SEEMS INFERTILE. SPRING + SUMMER
SMOOTH SHELL WINTER

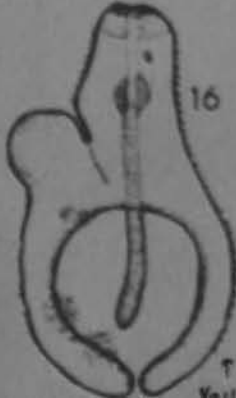
0.5 mm

ADULT: LOWER INTESTINE AND RECTUM

- HOSTS (CANADA): HEMITRIPTERUS AMERICANUS = SEA RAVEN
LYCODES sp. = ARCTIC BELPOUT
CRYPTOCANTHODES MACULATUS = WYMOUTH
HIPPOGLOSSUS HIPPOGLOSSUS = HALIBUT
MYOXOCEPHALUS SCORPIUS = SHORT-HORNED SCULPIN
- (ARCTIC + EUROPE): COTTUS SCORPIUS = FATHER LASSER
 HALIBUT (SEE ABOVE)
- (EXR): MYOXOCEPHALUS OCTODECIMSPINDSUS = LONG-HORNED SCULPIN
MACROZARCES AMERICANUS = OCEAN POUT

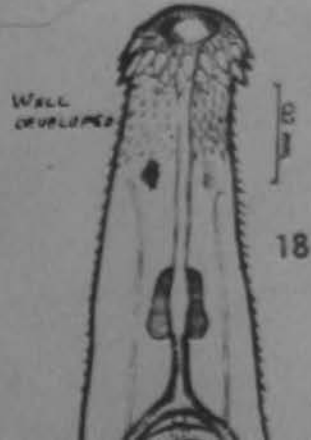
DISTRIBUTION: ACROSS NORTH ATLANTIC MAINE, BAY OF FUNDY, NEWFOUNDLAND, DAVIS STRAIGHT IN GREENLAND, NO

Fr



16

↑ YOUNG



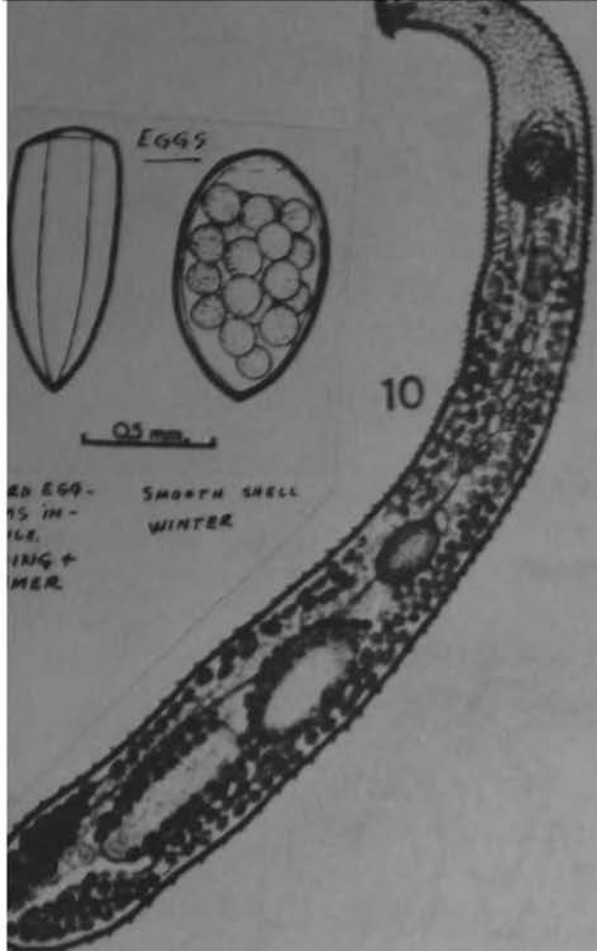
WALL WRINKLED

18



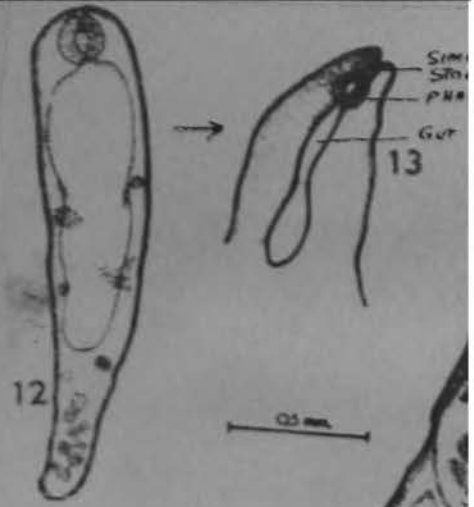
TYPICAL ORAL SPINES

19



RED EGG-
S IN-
ICE,
ING +
MER.

SMOOTH SHELL
WINTER



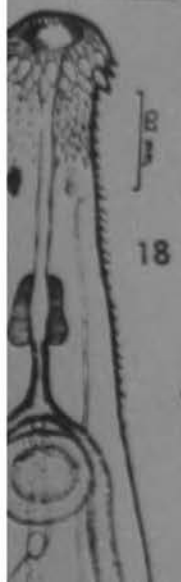
- MULT: LOWER INTESTINE AND RECTUM
- HOSTS (CANADA): HEMITRIPTERUS AMERICANUS = SEA RAVEN
LYCODES sp. = ARCTIC BELLOUT
CRYPTOCANTHODES MACULATUS = WRYMOUTH
HIPPOGLOSSUS HIPPOGLOSSUS = HALIBUT
MYOXOCEPHALUS SCORPIUS = SHORT-HORNED SCULPIN
- (ARCTIC & EUROPE): COTTUS SCORPIUS = FATHER LASHER
 HALIBUT (SEE ABOVE)
- (EKR): MYOXOCEPHALUS OCTODECIMPINOSUS = LONG-HORNED SCULPIN
MACROGEARCES AMERICANUS = OCEAN POUT

REDI
DIGE

HOSTS (CANADA)

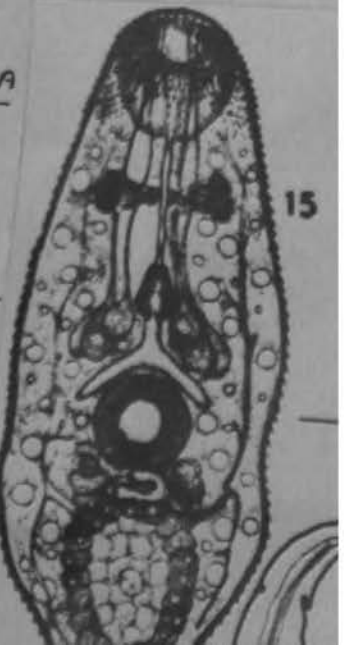
NO BIRTH PO
LIBERATE

DISTRIBUTION: ACROSS NORTH ATLANTIC, MAINE, BAY OF FUNDY, NOVA SCOTIA,
 NEWFOUNDLAND, DAVIS STRAIGHT IN GREENLAND, NORTH SEA



CERCARIA

- BETTER TO BOTTOM
- CRAWL OR QUIESCENT
- OPHTHALMO-TIRIBIO-CERCOS
- SECONDARY LOSS OF STYLET
- PENETRATE UPON CONTACT WITH FLOUNDER



REDIA



6-16 CERCAIRAE

REDIAE IN GONADS AND DIGESTIVE GLAND

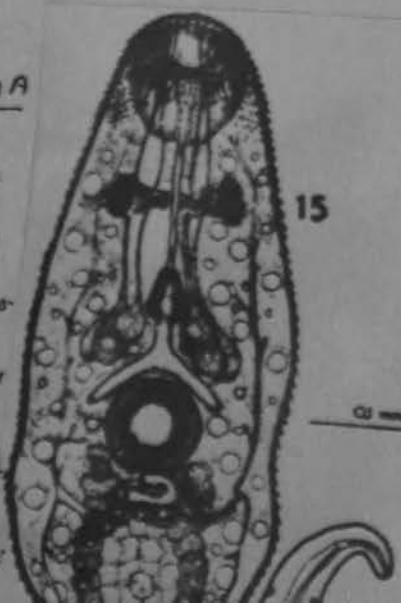
HOSTS (CANADA): BUCCINUM UNDATUM
COMMON WHELK
NEPTUNEA DECEMCOSTRATUM
10-BANDED WHELK

NO BIRTH PORE; CERCAIRAE LIBERATED BY RUPTURE

- TUM
- RICANUS = SEA RAVEN
- ERLPOUT
- MACULATUS = WYMOUTH
- OGLOSSUS = HALIBUT
- OPRIUS = SHORT-HORNED SCULPIN
- FATHER LASHER
- ODECIMSPINDOSUS = LONG-HORNED SCULPIN
- RICANUS = OCEAN POUT
- ATIC MAINE, BAY OF FUNDY, NOVA SCOTIA,
- S STRAIGHT IN GREENLAND, NORTH SEA

CERCARIA

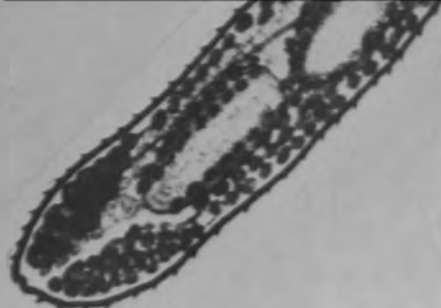
- SETTLE TO BOTTOM
- CRAWL OR QUIESCENT
- OPHTHALMOXIPHRIDIO-CERCOSUS
- SECONDARY LOST OF STYLET
- PEREYRATED UPON CONTACT WITH FLOUNDER



0.5 mm



0.25 mm



(tan)

ADULT: LOWER INTESTINE AND RECTUM

HOSTS (CANADA): HEMITRIPTERUS AMERICANUS = SEA RAVEN

LYCODES sp. = ARCTIC BELLOUT

CRYPTOCANTHODES MACULATUS = WRYMOUTH

HIPPOGLOSSUS HIPPOGLOSSUS = HALIBUT

MYOXOCEPHALUS SCORPIUS = SHORT-HORNED

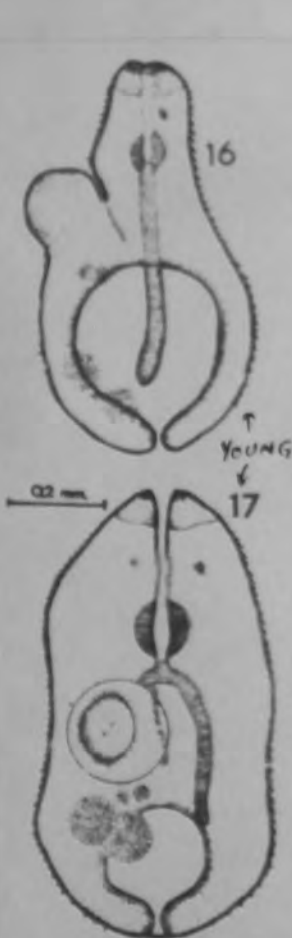
(ARCTIC + EUROPE): COTTUS SCORPIUS = FATHER LASHER

HALIBUT (SEE ABOVE)

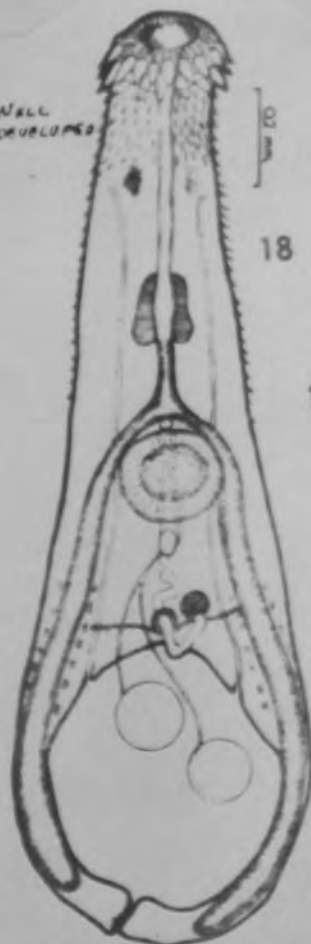
(EXP.): MYOXOCEPHALUS OCTODECIMSPINOSUS = LONG

MACROZARCES AMERICANUS = OCEAN POU

DISTRIBUTION: ACROSS NORTH ATLANTIC (MAINE, BAY OF NEWFOUNDLAND, DAVIS STRAIGHT IN GREENLAND)



WALL DOUBLED



TYPICAL ORAL SPINES



IRREGULAR AND PUBESCENT ORAL SPINES



HOSTS (EUROPE): WITCH,

ROUGH DAB (= AM. P.)

DAB (= LIMANDA LIMANDA)

LEMON SOLE (MICROGASTER (WALBAUM))

PLAICE (= PLEURONECTES)

PLATESSA (= PLATESSA)

DIST: AS ADULT

METACERCARIA

LOCATION: GILLS, DERMAL TISSUE, SOMATIC MUSCLES

HOSTS (No. Am.): PSEUDOPLEURONACTES AMERICANUS (WALBAUM) = WINTER FLOUNDER

LIPSETTA PUTNAMI (GILL) = SMOOTH FLOUNDER

LOPHOSETTA AQUOSA (MITCHILL) = BRILL

LIMANDA ERRUGINEA (STORER) = YELLOW TAIL

GLYPTOCEPHALUS CYNOGLOSSUS (L.) = WITCH

HIPPOGLOSSOIDES PLATES

= AMERICAN PLAICE

INTESTINE AND RECTUM

HEMITRIPTERUS AMERICANUS = SEA RAVEN

LYCODES sp = ARCTIC BELPOUT

CRYPTOCANTHODES MACULATUS = WRYMOUTH

HIPOGLOSSUS HIPOGLOSSUS = HALIBUT

MYOXOCEPHALUS SCORPIUS = SHORT-HORNED SCULPIN

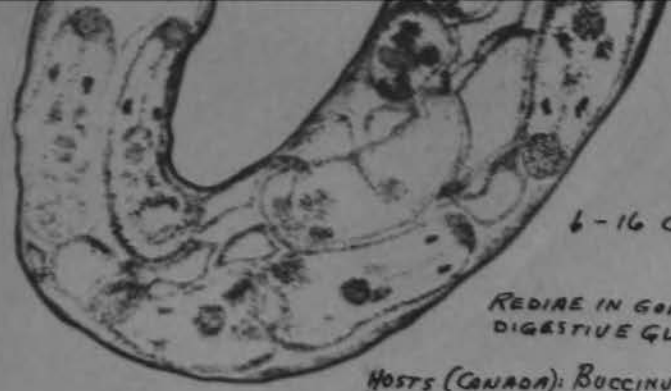
COTTUS SCORPIUS = FATHER LASHER

HALIBUT (SEE ABOVE)

MYOXOCEPHALUS OCTODECIMSPIROSUS = LONG-HORNED SCULPIN

MACROZARCES AMERICANUS = OCEAN POUT

ACROSS NORTH ATLANTIC CANADA, BAY OF FUNDY, NOVA SCOTIA,
NEWFOUNDLAND, DAVIS STRAIGHT IN GREENLAND, NORTH SEA



6-16 CER

REDIAE IN GONAD
DIGESTIVE GLAND

HOSTS (CANADA): BUCCINUM

COMMON

NEPTUNEA

TATUM 10
WHELK

NO BIRTH PORE; CERCARIA
LIBERATED BY RUPT

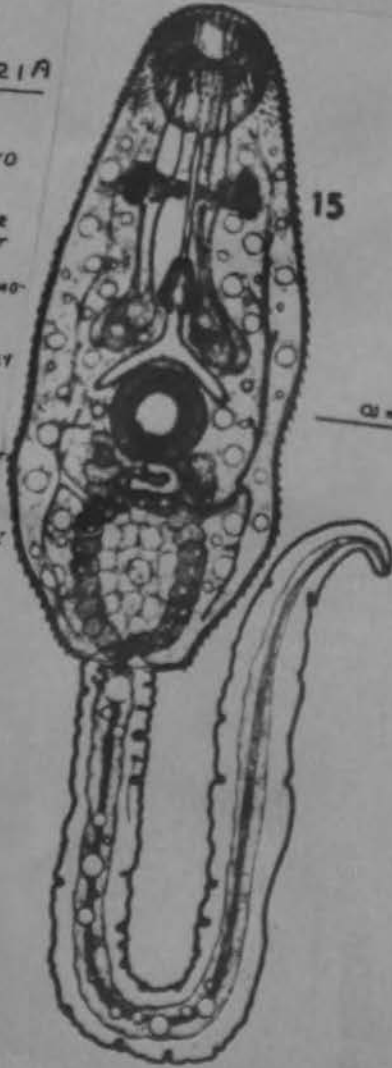
CERCARIA

SETTLE TO BOTTOM
CRAWL OR QUIESCENT

OPHTHALMO-
TYPHLO-
CERCOSIS

SECONDARY
LOSS OF
STYLET

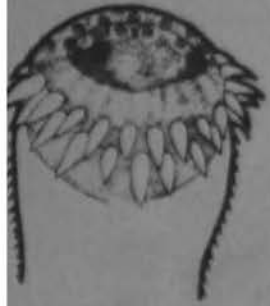
PERETRATION
UPON
CONTACT
WITH
FLOUNDER



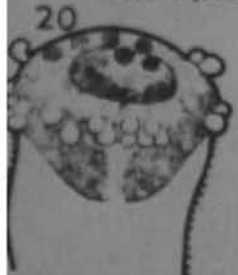
15

0.1 mm

TYPICAL ORAL
SPINES



IRREGULAR
AND PUBESCENT
ORAL SPINES



0.1 mm

20

HOSTS (EUROPE): WITCH, LONG
ROUGH DAB (= AM. PLAICE),
DAB (= LIMANDA LIMANDA (L.))
LEMON SOLE (MICROSTOMA KITTE
(WALBAUM))
PLAICE (= PLEURONECTES
PLATESSA (L.))

DIST: AS ADULT

MUSCLES

WINTER FLOUNDER

FLUNDER

W TAIL

WITCH

HIPOGLOSSOIDES PLATESSOIDES (FABRIC.)
= AMERICAN PLAICE

FROM WOLFGANG (1955)

11. *Stephanochasmus* larva with 36 circumoral spines

Pl. VI, fig. 19.

Encysted in wall of gill chamber of *Hippocampus coronatus* Temm. et Schleg. from Ise Bay. Cyst round, 0.25–0.3 mm in diameter, with very thin, membranous wall, enclosed in lamellar connective tissue capsule of host origin 0.6–0.65 mm in diameter. Between this capsule and the cyst proper is abundant, greyish white, granular detritus. Metacercaria floating in cyst proper, approximately lageniform, 0.56–0.7 mm long by 0.15–0.25 mm broad at middle of hinbody, beset with minute spines except at posterior extremity and immediately behind oral sucker. Oral sucker terminal, 70–85 × 80–105 μ ; circumoral spines 36 in number, arranged in two alternating rows, measuring in life as follows:

Ventral oral spines	21–27 × 4–6 μ
Ventral aboral spines	15–20 × 3–3.5 μ
Dorsal oral spines	20–24 × 4–6 μ
Dorsal aboral spines	18–24 × 3.5–5 μ

Prepharynx 0.13–0.22 mm long, with a large eye-spot on each side. Pharynx pyriform, 40–72 × 35–40 μ , at anterior half of middle third of body. Ceca slender, terminating at posterior extremity, one on each side of posterior end of excretory vesicle and not opening into the latter. Acetabulum 68–96 μ in diameter, at 4th sixth of body or at its junction with 5th sixth. Anlagen of testes small, rounded, one behind the other ventral to excretory vesicle. Anlage of cirrus pouch extending from a point about 30 μ back of acetabulum to its anterior end. Ovarian anlage not well defined, immediately in front of excretory vesicle a little to right of median line. Vitellarian anlagen not distinctly recognizable. Excretory vesicle occupying posterior half or more of hinbody, with its maximum breadth coinciding with that of body, abruptly narrowed posteriorly and opening at slightly notched posterior extremity.

From the number and arrangement of the circumoral spines it seems very probable that this larva develops into *Stephanochasmus cestricillus* (Molin, 1858) Looss, 1901, parasitic in *Lophius piscatorius*.

From Yamaguti, 1942

ACANTHOCOLPIDAE

Cercaria floridensis McCoy, 1928

Two New Marine Trematode Life Histories. O. R. McCoy, Johns Hopkins University.

Cercaria floridensis n. sp. from the marine snail *Cerithium litteratum* at Tortugas, Florida, has been identified as the larva of a member of the genus *Acanthochasmus* Looss. This larva is a lophocercous "monostome" cercaria characterized by the presence of eye spots, seven pairs of penetration glands and a dorso-ventral fin-fold on the tail. The cercariae were found experimentally to encyst in the fins and underneath the scales of small fish. Most of the adult characters then develop in the metacercaria; a ventral sucker is formed, the digestive tract develops and most striking a single row of 27 large spines appears in a complete circle around the mouth. Although the adult has not yet been determined, the cercaria can almost certainly be assigned to the genus *Acanthochasmus*. This observation throws light upon the type of life history to be expected of several described species of cercariae very similar to *C. floridensis* which heretofore have been grouped under the monostomes.

OBSERVATIONS ON THE LIFE HISTORY OF A MARINE LOPHOCERCOUS CERCARIA *

OLIVER R. MCCOY

In the course of a study of marine trematode life histories at Tortugas, Florida, a binoculate lophocercous "monostome" cercaria commonly occurring in *Cerithium litteratum* Born, was found experimentally to continue its life cycle by encysting in the fins and underneath the scales of small fish. After encystment a number of the adult structures, which were not present in the cercaria, developed in the metacercaria. Most notable of these was a single row of 27 spines which appeared in a complete circle around the mouth. Although the adult has not yet been determined, on the basis of the structure of the metacercaria the cercaria probably is the larva of a member of the genus *Acanthochasmus* Looss. A preliminary report of the observations in this paper has already been published (McCoy, 1928).

The cercaria used in these life history experiments was first found at Tortugas by Miller (1926) and was described by him as *Cercaria P* in his preliminary report on the behavior of Tortugas cercariae. This description, although brief, contains all the details essential to the identification of the species. In the present paper, however, the cercaria will be described more completely and given the name *Cercaria floridensis* sp. nov.

Cercaria floridensis (Fig. 1) is a lophocercous cercaria belonging to the Pleurolophocerca Group of Sewell (1922: 23). It shows all the distinguishing characteristics of the group, namely, an oral sucker modified into a protrusible organ for penetration, a pair of pigmented eye spots, conspicuous penetration glands, fin-folds on the tail, and the absence of a ventral sucker and digestive tract. The cercaria is an intermittent but very rapid swimmer and reacts to a number of light and mechanical stimuli. A detailed study of its behavior has been reported by Miller (1926; 1927).

The tail of *C. floridensis* is more than twice as long as the body and is provided with a well-developed dorso-ventral fin-fold which extends along the posterior three-fourths of the tail on the dorsal side, continuing around the tip and along the posterior third on the ventral side. At its widest point, the dorsal fin is about as broad as the tail, but



Fig. 1.—Lateral view of *Cercaria floridensis*.

ventrally it is only about half that wide. There is also a pair of inconspicuous lateral fin-folds on the anterior third of the tail. The oral sucker, which occupies about the anterior fifth of the body, is actively protrusible and although definitely distinct from the rest of the body, does not have the typical appearance of a sucker. A small mouth is located at the anterior tip slightly on the ventral side. No pharynx or digestive tract was distinguished. A number of very small spines are present on the anterior tip of the body around the mouth, but the rest of the body and the tail are devoid of spines. Immediately posterior to the oral sucker is a pair of prominent, darkly-pigmented eye-spots. A small amount of pigment is scattered over the dorsal surface of the anterior third of the body but it is not conspicuous.

The central part of the body (Fig. 2) is occupied by a group of fourteen large, granular glands whose nuclei may be counted with difficulty under high magnification. Ducts from these glands pass anteriorly in four bundles and open on the dorsal lip of the mouth. The two median bundles, which are located dorsally, each contain four ducts, while the two lateral bundles are made up of three ducts each. Immediately posterior to the glands is a small round mass of cells which represents the rudiment of the ventral sucker. A large thick-walled excretory vesicle occupies the posterior part of the body. When expanded, it has a shortened Y-shape. The flame cell pattern was not determined. Along the sides of the body posterior to the eye spots are numerous small glandular cells probably cystogenous in character.

The cercariae develop in small, colorless, sac-like rediae ranging up to 0.9 mm. in length (Fig. 3). The rediae do not possess any collar or locomotor appendages, but a well-developed pharynx 30μ in diameter is present. The short, rhabdocoele gut, however, is degenerate and could only be distinguished in a few specimens. Miller reported the excretory system of the redia to be composed of four flame cells on each side, two emptying into an anterior and two into a posterior collecting tubule. As many as 15 cercariae were seen developing in a single redia but apparently they do not remain inside the redia to complete their development, for when the digestive gland of an infested snail was teased apart, immense numbers of cercariae, not all completely developed, were found free in the tissues.

The average measurements taken from ten cercariae killed by gentle heat were as follows: body, 192μ by 61μ ; tail, 434μ by 26μ ; and oral sucker, 40μ in diameter.

Specific diagnosis of *Cercaria floridensis*: binoculate lophocercous cercaria from *Cerithium litteratum*. Fin-fold along posterior three-fourths of tail dorsally and along posterior third ventrally; also narrow lateral fin-folds on anterior third of tail. Pigmented eye-spots present but no pharynx or digestive tract visible. Oral sucker in form of protrusible anterior organ; ventral sucker rudimentary. Small spines on anterior tip of body only. Fourteen large glands in center of body; ducts in four bundles emptying on dorsal lip of mouth. Large excretory vesicle in posterior part of body. Development in simple rediae without collar or locomotor appendages.

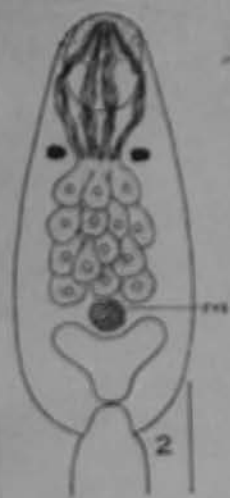


Fig. 2.—Dorsal view of the body of the



Fig. 3.—Redia.

Cercaria floridensis continues its life cycle by encysting in the fins and underneath the scales of small fish. Almost any species of fish may serve as the intermediate host, for experimentally the cercariae have been found to encyst in the following twelve species of fish representing the most common genera present on the reef where the infested snails were collected: *Eupomacentrus analis*, *Abudefduf saxatilis*, *Neomacris apodus*, *Neomacris synagris*, *Haemulon sciurus*, *Iridia bivittatus*, *Blenius cristatus*, *Malacotenus moorei*, *Scarus croicensis*, *Lagodon rhomboides*, *Sparisoma flavescens*, and *Ocyurus chrysurus*. No other species of fish were exposed. Heavy infestations of the fish with the cysts were obtained by exposing them for one-half hour to a large number of the cercariae in about 100 cc. of water. When such a small amount of water was used, it was necessary to bubble oxygen through it in order to keep the fish alive. After exposure the fish were transferred to an aquarium, and the development of the metacercaria was studied over a period of 38 days.

In the experimentally infested fish, encystment took place within 12 hours after the penetration of the fish by the cercaria. The cyst was thin-walled and transparent, and was considerably larger than the contained metacercaria (Fig. 4). The cyst did not grow appreciably after it was formed; cysts 40 hours old averaged 156μ by 128μ in size, while cysts which had been in the fish for 22 days measured 166μ by 133μ . The cysts were found almost exclusively in the fin rays and underneath the scales of the fish, but occasionally cysts occurred in other parts of the body—in the muscles and around the gills. The cysts which occurred underneath the scales were more nearly spherical than those in the fins, the average measurement for four specimens 9 days old being 157μ by 150μ . The cyst wall became thicker after the cyst had been in the fish for some time, but it always remained transparent and never became pigmented.

The development of the metacercaria was not very rapid. The only changes from the cercaria to be noted in the metacercaria five days after encystment were the appearance of a pharynx at the level of the eye spots and the disintegration of the 14 large glands located in the central part of the body. The small mass of cells in the posterior third of the body appeared more prominently and could be recognized as the rudiment of the ventral sucker. The whole body had an opaque appearance and was only sluggishly motile inside the cyst.

After nine days, the body of the metacercaria had become slightly lengthened (Fig. 5). A digestive tract had appeared, with the esophagus forking near the middle of the body and the ceca extending to the posterior end. The ceca contained large refractive bodies cuboidal in shape. The eye spots had begun to disintegrate but masses of the pigment were still plainly visible. At this stage the ventral sucker definitely had the typical appearance of a sucker, but it was very small, measuring only 27μ in diameter. The oral sucker was much larger, 45μ by 50μ . The shape of the excretory vesicle was strikingly different from the form present in the cercaria; the stem was long and thick-walled and there were lateral arms which extended anterior to the ventral sucker. There was no notable accumulation of concretions in the excretory vesicle.



Fig. 4.—Cyst 12 hours after the penetration of the fish by the cercaria.



Fig. 5.—Metacercaria 9 days after penetration.

In a metacercaria dissected from the cyst 12 days after the penetration of the cercaria, a single row of spines was noticed developing in a circle around the mouth. The spines were considerably larger in a metacercaria 15 days old and measured about 8μ in length. At this stage the eye spots had completely disappeared but there were no other important changes in structure. By the end of 22 days, the oral spines were 15μ by 3μ in size and were more prominent. They were 27 in number and were arranged in a single uninterrupted circle around the mouth. When seen in lateral view, the spines were somewhat curved and appeared much broader at the base (Fig. 6). A few rows of small spines were present in between and posterior to the larger spines. The rest of the body of the metacercaria, however, was devoid of spines.

Three weeks after the penetration of the fish, the metacercaria (Fig. 7) had apparently attained its complete development, for only a slight increase in size and no changes in structure were noted in specimens two weeks older. A dim mass of very small excretory concretions had accumulated in the excretory vesicle the lateral arms of which extended to the anterior edge of the pharynx. The pharynx, which was located at about the anterior third of the body, was nearly as large as the ventral sucker, which occupied a position in the middle of the body. The oral sucker was very large in proportion to the ventral sucker and was distinctly funnel-shaped, with the open end directed anteriorly and encircled by the single row of 27 large oral spines. The metacercaria had grown considerably in length and was usually doubled up inside the cyst. The worms were quite active and frequently changed position. The average measurements from six specimens 22 days after the penetration of the fish were: body, 324μ by 74μ ; oral sucker, 65μ in diameter; ventral sucker, 34μ in diameter; and pharynx, 36μ by 20μ .

One natural occurrence of a cyst identical in appearance with the cysts in experimentally infested fish was found in the caudal fin of a

small snapper, *Neomaenis synagris*, caught on the reef where *Cercaria floridensis* occurred in the snails. The structures of the metacercaria in this cyst agreed in every respect with the mature metacercariae experimentally developed from *C. floridensis*. Attempts were made to procure the adult of *C. floridensis* by feeding fish heavily infested with the cysts to several larger fish, the gray snapper, *Neomaenis griseus*, common grunt, *Haemulon plumieri*, and black grouper, *Mycteroperca bonaci*, but no adult worms were recovered.

Although the adult has not yet been determined, on the basis of the structure exhibited by the metacercaria *C. floridensis* apparently belongs in the genus *Acanthochasmus* as defined by Looss (1901). The characters on which this identification is based are principally the large, funnel-shaped oral sucker with the opening surrounded by a single, uninterrupted circle of spines, and the "Y"-shaped excretory vesicle with the lateral arms extending anteriorly to the region of the pharynx. The small size of the ventral sucker in proportion to that of the oral sucker and the long prepharynx and the large pharynx with the digestive ceca extending to the posterior end of the body are also characteristic of the genus *Acanthochasmus*. The metacercaria of *C. floridensis* also, in certain respects, resembles the genus *Asocotyle* of the family Heterophyidae, but the absence of the oral cecum found in *Asocotyle* and the presence of the long lateral arms of the excretory vesicle characteristic of *Acanthochasmus* make it much more probable that *C. floridensis* belongs to this latter genus rather than to the genus *Asocotyle*. Since the structure of the reproductive system could not be determined in the metacercaria, the identification cannot be made with absolute certainty. It is worthy of note that *Cercaria floridensis* does not show any characters which might indicate its systematic position. All of the distinguishing structures, oral spines, ventral sucker, digestive tract, and even the distinctive "Y"-shape of the excretory vesicle first appear in the metacercaria.

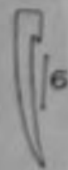


Fig. 6.—Oral spine in lateral view.



Fig. 7.—Mature metacercaria 22 days after penetration of fish.

C. floridensis in general structure resembles a number of previously described cercariae but it probably is most closely related to *C. quadriptygia* described by Sinitsin (1911) from the Black Sea. According to the classification of Sewell (1922), both of these forms belong in the Pleurolophocerca Group of lophocercous "monostome" cercariae. There are about 12 species of cercariae which should fall into this group on the basis of the group characters defined by Sewell, but since the classification is probably an unnatural one, these forms may not necessarily be closely related. In fact, some of these cercariae apparently form a graded series with distome cercariae of the Parapleurolophocerca Group, certain of which are known to be larvae of members of the genus *Monorchotrema*, family Heterophyidae (Faust and Nishigori, 1926).

This study of the development of the metacercaria of *C. floridensis* throws light upon the type of life history to be expected for other similar cercaria of the Pleurolophocerca Group. A general similarity in the structure and life cycle of *C. floridensis*, the cercaria of *Clonorchis sinensis*, and cercariae of *Monorchotrema* may be pointed out. All show a general resemblance in bodily structure, possess eye spots and fin-folds on the tail, and continue their life cycle by encysting in the fins and underneath the scales of small fish as second intermediate hosts. A more complete knowledge of life histories will probably make possible the formation of larger natural groups among families of trematodes which at present are not known to be related.

ACANTHOS TOMI DAE

Cercaria owreae (Hutton, 1954) Dawes, 1959

Fig. 1.—*Cercaria owreae*. A, B, C, D, and E representing specimens 4, 7, 8, 13 and 12 respectively. A—D from *Sagitta Asaphes* collected 250 miles N.N.W. of Colon. E, specimen kept *in situ* in the same host collected off W. end of Roatan Island.

SYSTEMATIC POSITION

It is unusual to attempt to refer a cercaria to its systematic position but in this instance two important characters enable us to make the attempt. The extension of the caeca into the appendages is taken by the writer as an indication that the corresponding adult will prove to be a trematode with anal openings situated in the wall of the excretory vesicle. This character occurs in members of various families but it seems to be a character of the seven genera of the Accacoeliidae. In one genus of this family each of the anterior extensions of the caeca has six diverticuli, an unusual character which may be significant in the present instance. Judging by the occurrence of two unusual characters together it seems possible that *Cercaria owreae* is the larva of a species of *Accacodocoelium* Odhner, 1928. To which of four species it belongs cannot be decided, but the grotesquely pedunculate ventral sucker would seem to rule out *A. paucisporum* Odhner, 1928. The remaining three species are *A. nigroflavum* (Rudolph, 1819), *A. macrocoyle* (Diesing, 1858) sensu Monticelli, 1893, and *A. alveolatum* Robinson, 1934. Dallfus (1935) separated the three species according to differences in the vitellaria, which are not developed as such in the writer's specimens. He also figured *A. nigroflavum* (Fig. 5-6) as a form with a finely furrowed cuticle and suckers situated rather near together. The same is true however of *A. alveolatum*, in which the cuticle around the excretory pore is modified to form anastomosing vertical ridges—a sort of "honeycomb" from which the trematode gets its specific

JACCACOEILLIDAE

LIFE HISTORIES OF ALLOCREADIIDAE

Hopkins (1934) points out that at least three types of life histories are known (1) *Allocreadium*, *Crepidostomum*, *Megalogonia* and possibly *Bunodera* have an ophthalmocephalid cercaria developing in rediae in Sphaeriidae and encysting in various vertebrates.

(2) *Hamacreadium*, *Helicometrina*, *Plagioporus*, and *Podocotyle* *Sphaerostoma* use snails as molluscan hosts, cercariae are *Opeoeloides* *Cotocacium* cotylocercous with stylet but without eyes and develop in sporocysts; the metacercaria encysts in different intermediate hosts.

(3) *Lepocreadium* and *Pharyngora*. The cercaria is trichocercous and develops in rediae in snails. The metacercaria may live in a variety of intermediate hosts but does not encyst.

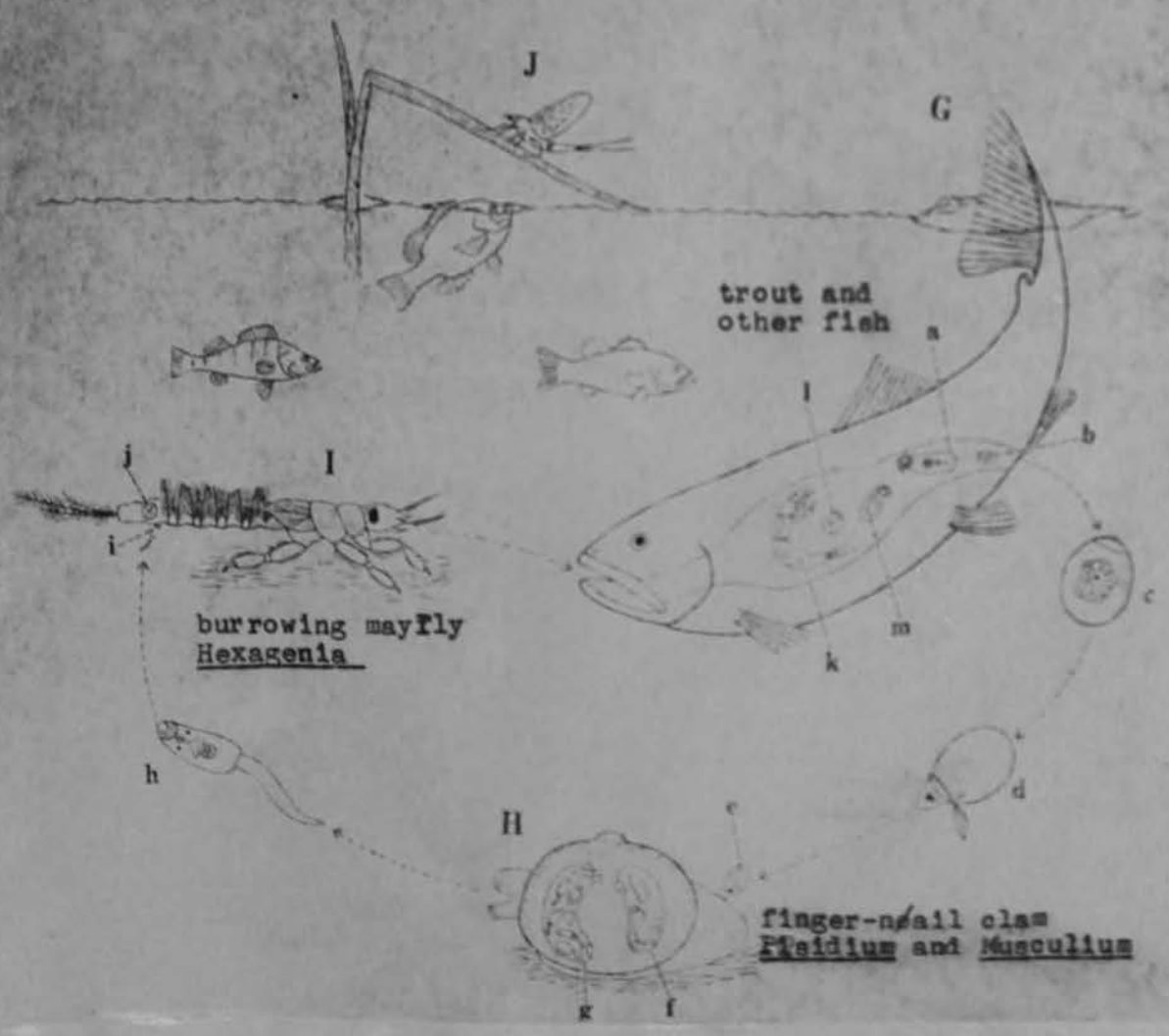
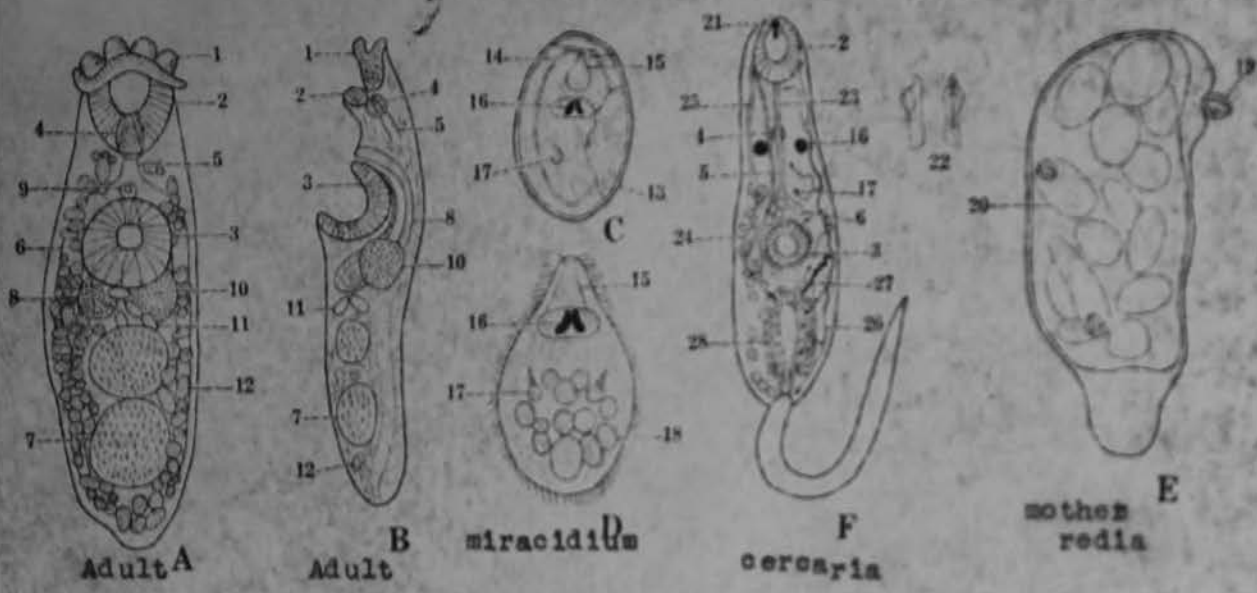
(4) Hopkins (1934) (*Jour. Parasit.*, 23:94-97) described cercariae of *Analocreadium armatum* and *Microcreadium parvum*. Metacercariae encysted in *Musculium ferrissi* (a mollusc). *Analocreadine* type cercaria: distome cercaria with straight slender tail, undivided sac-like excretory bladder, pigmented eyespots, cuticular spines, no stylet, numerous setae on sides of body, and three pairs on tail. Developing in rediae in freshwater snails.

Similar cercaria for ~~*Podocotyle*~~ *Peropristia*

SUMMARY

Embryology of the excretory system was studied in four types of cercariae included in the allocreadiid complex of digenetic trematodes. A conflict regarding that process in allocreadiid larvae (ophthalmoxiphidiocercariae developing in sphaeriid bivalves) is resolved by location of the primary pores in the body-tail furrow; at no stage of development does the excretory system enter the tail proper. A leprocreadiid (marine trichoaceros) larva has primary excretory pores in the body-tail furrow and otherwise agrees with the Allocreadiidae. The marine ophthalmoxiphidiocercaria of the Acanthocolpidae has primary pores on the sides of the tail well posterior to its junction with the body. For that reason, the Acanthocolpidae is excluded from the Allocreadiidae, being perhaps closer to the Echinostomatoidea. *Cercaria pomatiopsalis*, an ophthalmoxiphidiocercaria developing in a freshwater gastropod, has primary excretory pores in the body-tail furrow and a vertically set stylet as in the Allocreadiidae.

From PETERS (1961, *Proc. Helminthol. Soc. Wash.* 28:
102-108)





genetic metacercaria of *Crepidostomum cornutum*, showing over 20 eggs within the uterus.

Crepidostomum Cornutum for Demonstrating Immature Fluke Stages

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te College
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ites, rather than preserved or
nes, certainly arouse and hold

a student's interest in a biology laboratory. And it requires little effort to obtain specimens and a minimum of space, materials, and equipment to maintain them. Practically every vertebrate has parasites, and so do invertebrates; the crayfish is a good example. In fact, several fluke genera, one *e.g.*, *Crepidostomum cornutum*, parasitize crayfishes (Stafford, 1931).

Crepidostomum cornutum is found from Canada to Texas and in a variety of hosts, from fishes to crayfishes (Hopkins, 1934). Such versatility points out its value as a laboratory animal to demonstrate several of the stages of a digenetic fluke life cycle. I became acquainted with the metacercariae of this fluke during a study of the crayfish, *Procambarus clarkii*, a common species in southeast Texas (supported by an American Philosophical Society Grant, No. G31, Johnson Fund, 1965). The metacercariae were encysted most often in the gonads.

The whitish cysts are ruptured easily, liberating the metacercariae, Fig. 1. They

eggs will contain miracidia, and rarely, an egg will hatch while under observation. Usually, though, they must be incubated for several weeks before they will hatch. If fingernail clams, *Sphaerium* spp., are available, they can be exposed to the hatching miracidia; later sporocysts, rediae, and cercariae may be obtained from the clams which are the first intermediate hosts for *C. cornutum*.

Thus, the crayfish, a common laboratory animal, and one of its parasites, *Crepidostomum cornutum*, can be utilized very effectively in a biology laboratory to demonstrate parasitism, as well as several stages of a digenetic fluke life cycle.



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Cornutum Immature eggs

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The whitish cysts are ruptured easily, liberating the metacercariae, Fig. 1. They are ideal for demonstrating several im- mature fluke stages, for studying morphol- ogy, behavior, and metabolic systems.

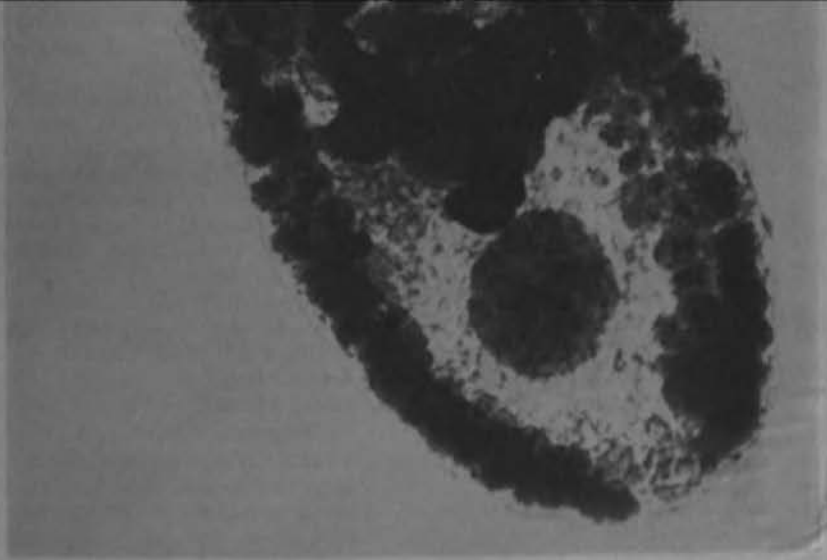
Often the metacercariae are sexually mature, i.e., progenetic, and contain viable eggs within the uterus. Occasionally, the

eggs will contain miracidia, and rarely, an egg will hatch while under observation. Usually, though, they must be incubated for several weeks before they will hatch. If fingernail clams, *Sphaerium* spp., are available, they can be exposed to the hatch- ing miracidia; later sporocysts, rediae, and cercariae may be obtained from the clams, which are the first intermediate hosts for *C. cornutum*.

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Stafford, E. W. 1931. Platyhelminia in aquatic in- sects and Crustacea. J. Parasit. 18:131.



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Fig. 1. Progenetic metacercaria of *Crepidostomum cornutum*, showing over 20 eggs within the uterus.

Crepidostomum Cornutum for Demonstrating Immature Fluke Stages

by ESTON O. MORRISON
Department of Biology
Tarleton State College
Stephenville, Texas 76401

Live parasites, rather than preserved or mounted ones, certainly arouse and hold

a student's interest in a biology laboratory. And it requires little effort to obtain specimens and a minimum of space, materials, and equipment to maintain them. Practically every vertebrate has parasites, and so do invertebrates; the crayfish is a good example. In fact, several fluke genera, one e.g., *Crepidostomum cornutum*, parasitize crayfishes (Stafford, 1931).

**COMPARATIVE MORPHOLOGY OF FOUR SPECIES OF ALLOCREADIID
MIRACIDIA (TREMATODA)***

Wesley E. Peters and Richard P. LaBonte
Northern Michigan University, Marquette

ABSTRACT: Miracidia of *Allocreadium lobatum* Wallin, 1909; *A. neotenicum* Peters, 1957; *Bunodera lappaseae* (O. F. Mueller, 1776); and *Bunoderina sacculata* (Van Cleave and Mueller, 1932) Yamada, 1953 have ciliated epidermal cells in four tiers (6, 6, 4, and 2 cells per tier in anterior to posterior sequence), with some variations in number per tier in the last two species. Differences among species include the number of apical gland openings and number and arrangement of cephalic gland pores. These four are compared with related species.

Allocreadium ictaluri Pearse, 1924

Syn. A. halli Mueller & VanCleave, 1932

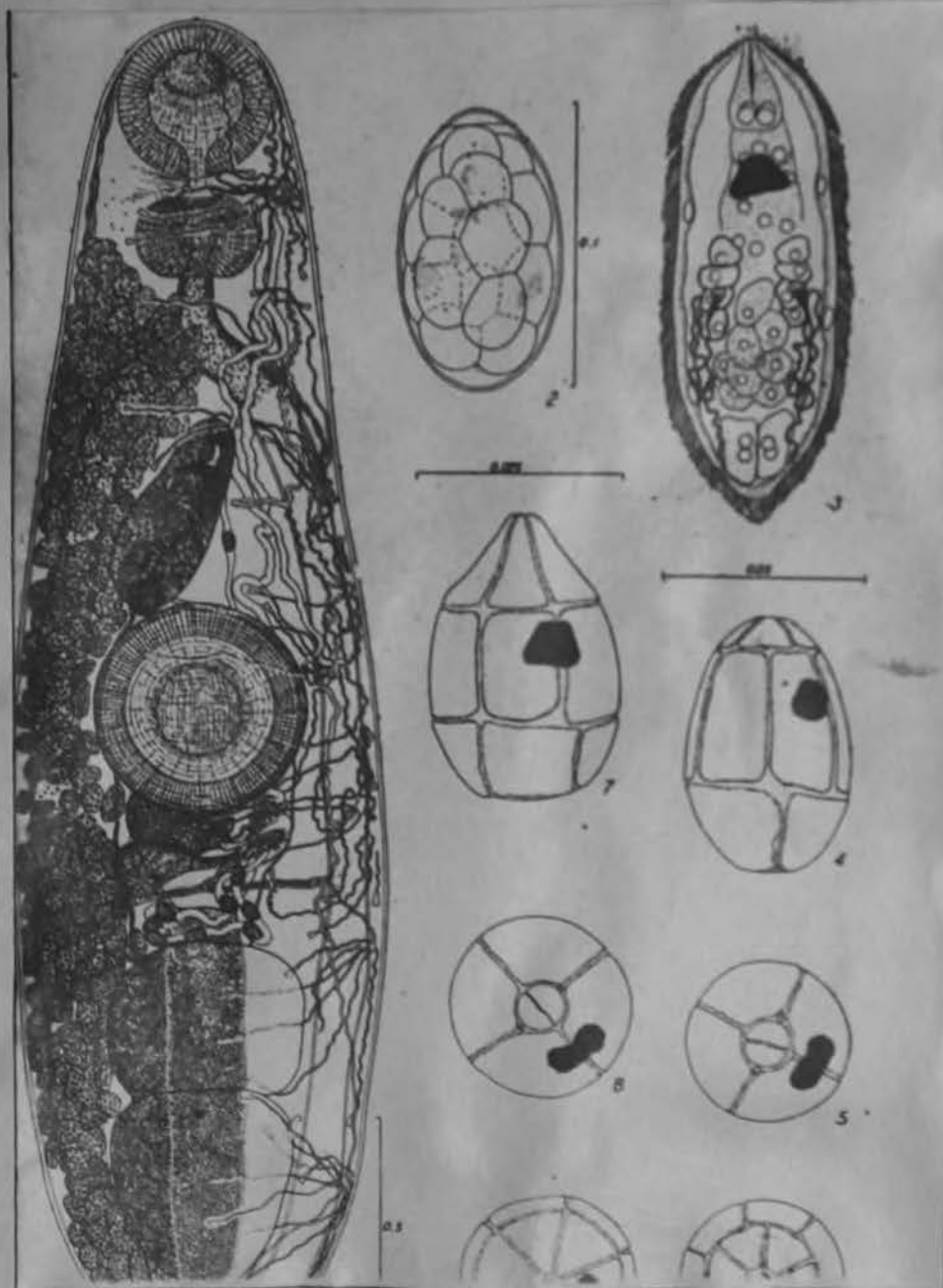
Final hosts: Ictalurus punctatus, catfish
I. furcatus
Ameiurus nebulosus

Eggs hatch after 10 days in water

Molluscan host: Pleurocera acuta, a tall pointed snail
Ophthalmocercariae develop in rediae

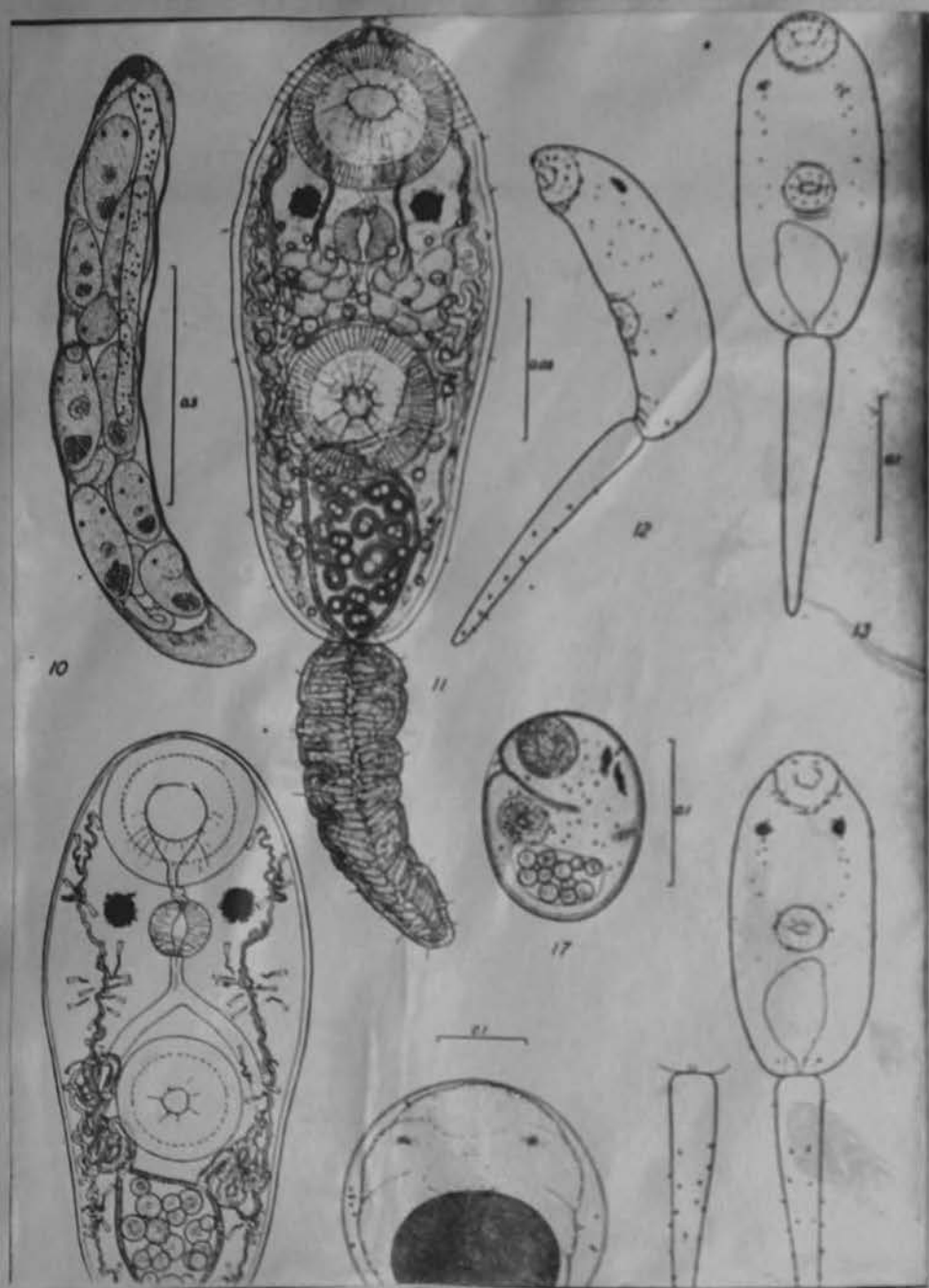
Second Intermediate host: various unionid bivalves

Reference: Seitner, 1951. Jour. Parasit., 37(3):223-244



(over)

Allocreadium ictaluri (continued)



THE LIFE CYCLE OF *BUNODERELLA METTERI* (ALLOCREADIIDAE: BUNODERINAE), A TREMATODE PARASITE OF *ASCAPHUS TRUEI*

John A. Anderson,* Stewart C. Schell,[†] and Ivan Pratt:

ABSTRACT: The life cycle of *Bunoderella metterii* Schell, 1964, an intestinal parasite of the tailed frog *Ascaphus truei* Stejneger in the Pacific Northwest, is described. Eggs are unembryonated when laid. Cercariae do not hatch in water. Ophthalmoxiphidocercariae develop in rediae in the fingernail clam *Pisidium idahoense* Roper. Larvae and pupae of the caddisfly, *Rhyacophila grandis* Banks, and dipteran larvae of the family Chironomidae serve as hosts for the encysted metacercariae. Immature specimens of *B. metterii* were recovered from the intestine of experimentally infected, laboratory-treated *Rana aurora* Girard and *Ascaphus truei*.

1965
J.P. 51: 579-582



FIG. 1



FIG. 2



FIG. 3



FIG. 4



FIG. 5

FIGURES 1-5. *Bunoderella metterii*. 1. Egg with developing miracidium, 12 days. 2. Egg with miracidium, 37 days. 3. Redia and cercarial stages. 4. Cercaria. Flame cells indicated on left side of body; penetration glands indicated on right side only. 5. Metacercaria.

on moist filter paper at room temperature. Thirty-five to 37 days were required for development of the miracidium. The eggs of *B. metterii* are normally amber and contain opaque particles which are pushed to one side as the miracidia develop (Fig. 1). By the time a fully developed miracidium appears the shell is translucent, and the miracidium and opaque particles are easily observed. The miracidium (Fig. 2), 31 to 32 long by 20 to 21 wide, contains one pair of flame cells, a sac-like g

and four or five faintly visible germ cells; cilia cover the body. Embryonated eggs did not hatch in water. Unsuccessful attempts were made to infect young specimens of *Pisidium idahoense* by allowing them to ingest embryonated eggs.

Redia (Fig. 3)

The redial stage was observed only in naturally infected clams. Of 198 clams examined

The only known bunoderid life cycle is that of *Bunodera luciopercae* (Müller, 1776) Lühe, 1909, an intestinal parasite of freshwater fishes, reported by Wisniewski (1958). In Europe, cercariae develop in rediae in the freshwater clams *Sphaerium cornutum* Linn. and *S. nicola* Lamarck, and encyst in several species of Cladocera and Copepoda. Fishes become infected by ingesting the infected crustaceans. This paper presents the life cycle of an additional species.

Bunoderella metterii Schell, 1964, is an intestinal parasite of the tailed frog, *Ascaphus truei* Stejneger, in the Pacific Northwest. Studies of its life cycle were undertaken concurrently in Idaho and Oregon.

MATERIALS AND METHODS

Adults of *Ascaphus truei* were collected at night in cold mountain streams in northern Idaho, western Oregon, and eastern Washington. The eggs remained alive many weeks when kept in water at 40 to 50 F. The water was changed every 10 days and saved as a source of parasite eggs that had passed in the feces of the host. Eggs isolated by the sedimentation technique were placed in petri dishes on moist filter paper. Asexual stages of the parasite were studied alive. Vital dyes (azocine red and Nile blue sulphate) were used to observe gland and flame cells of the cercariae. Naturally infected first intermediate hosts, *Pisidium idahoense* Roper, were collected from the same localities. The clams were kept alive for many weeks in dishes containing cold stream water and about 0.5 inch decaying vegetation. Measurements are in microns unless otherwise indicated.

Miracidium (Figs. 1, 2)

The eggs of *Bunoderella metterii*, 45 to 50 long by 30 to 37 wide, are unembryonated when passed in the feces of the definitive host (Schell, 1964). In the laboratory miracidia developed only in those eggs that were kept

in Oregon, rediae were found in 21 or 10.7%. The percentage of clams infected in Idaho and Washington areas was less than 1%. The greatest number of rediae found in any one clam was 18. Younger rediae, in which cercarial embryos are forming, contain a weakly developed pharynx but no gut. In mature rediae, the esophagus each about twice the length of the pharynx. Bifurcation of the gut occurs midway between the pharynx and the acetabulum; the ceca, about three times the length of the pharynx, terminating at the level of the acetabular cavity.

Four pairs of penetration glands are present; the anterior pair draining through separate ducts passing median to other gland ducts. Separate cystogenous glands were not observed. The stylet, 17 long, has well-developed shoulders at the base of a dorsally curving blade. Pigmented eyespots are 6 to 8 in diameter. Genital anlagen are dorsal to the ventral sucker. The excretory system consists of an elongate excretory vesicle with thick, cellular walls, a pair of main collecting ducts joining at the anterior end of the vesicle, anterior and posterior collecting tubules, and 28 pairs of flame cells; flame cells are lacking in the tail. In the laboratory cercariae emerge from clams mainly about midday, and tend to attach by the ventral sucker to any solid surface.

Metacercaria

(Fig. 5)

The cercariae penetrate and encyst in the mucocoel of several kinds of aquatic insects. Natural infections were found in 80% of the larvae and pupae of the caddisfly, *Rhyacophila grandis* Banks, collected at the site of the frog and clam colonies in Oregon. The greatest number of cysts found was 35, the average number 9.3. In Idaho and Washington, dipterous larvae of the family Chironomidae were also found infected with metacercariae. Mayfly nymphs (*Heptagenia* spp.) and the chironomid larvae were infected experimentally in the laboratory. In the mayfly nymphs the metacercariae failed to undergo subsequent development.

Fifteen metacercarial cysts removed from naturally infected *Rhyacophila grandis* averaged 518 (253 to 738) in diameter. The cyst membrane is thin and clear. Ten excysted metacercariae (Fig. 5) measured 1.270 mm (0.707 to 2.216 mm) long by 0.287 mm (0.239 to 0.490 mm) wide, and the diameter of the oral sucker was 134 (93 to 191). Two short oral papillae project laterally from the oral sucker. The prepharynx is short, and the nearly spherical pharynx is located at the posterior margin of the oral sucker. The esophagus

extends to a point midway between the oral sucker and the acetabulum, and the ceca extend from this point to the posterior end of the body. An elongate excretory vesicle, extending to the mid-body region, is filled with refractile granules. Gonadal anlagen are evident in mature metacercariae.

Fourteen metacercariae were fed to young laboratory-reared *Bombus terrestris* Beul and *Cirsium*

and six young flukes were recovered from the small intestine after 3 days. Metacercariae were also fed to adult *Ascaphus truei* that had been unfed and kept in a cold room for 2 months. When examined at the end of 13 days, young flukes, lacking eggs, were recovered.

Of 160 adult *Ascaphus* examined in Oregon, 66.9% were infected with *B. metterii*, 1 to 23 trematodes being found per frog. The infections ranged from 50.0% (22 frogs examined) in June to 84.3% (32 frogs examined) in August. In specimens of *Ascaphus* collected in Idaho and Washington, the infections varied from 20 to 35% in different collections.

DISCUSSION

The life cycles of *Bunoderella metterii* and *Bunoderella luciopercae* are similar in that sphaeriid clams serve as the first intermediate host. Although the cercariae of both species are ophthalmoxiphidial there is a marked difference in the number of flame cells. Wisniewski (1958) illustrates a cercaria of *Bunoderella luciopercae* with 36 flame cells arranged according to a formula of $2(3+3+3) + (3+3+3)$. The cercaria of *Bunoderella metterii* contains 56 flame cells. This is believed to be the full number, but the flame cell formula could not be determined because collecting tubules were not observed. The cercaria of *Bunoderella metterii* contains one more pair of smaller penetration glands than *Bunoderella luciopercae*, which drain through separate ducts. Wisniewski did not mention or illustrate the miracidium of *Bunoderella luciopercae*. In both species the metacercariae, and in some cases the very young specimens in the definitive host, retain at least a remnant of the pigmented eyespots.



the pharynx is completely degenerated. Such rediae are colorless, transparent, thin-walled sacs, containing up to 38 well-formed cercariae plus some cercarial embryos and germinal cells. Cercariae escape through an opening in one end of the redia (Fig. 3). The largest rediae attain a length of over 2 mm.

Cercaria

(Fig. 4)

The cercaria is ophthalmoxiphidial (Fig. 4). The nonspinous body is 340 to 440 long by 120 to 170 wide at the level of the ventral sucker. The contractile tail, usually drawn against the ventral body wall, is nearly equal to the body length when extended. Oral and ventral suckers are round, of equal size, from 52 to 56 in diameter. Prominent adhesive papillae are attached to the margin of the acetabulum and are drawn in and out of the acetabular cavity with the movements of the margin; papillae are lacking on the oral sucker. The pharynx is 21 long by 20 wide, prepharynx

Grepidostomum cornutum (Osborn, 1903)

Final hosts: Ambloplites rupsetris, Micropterus salmoides.

Molluscan host: a bivalve, Sphaerium striatinum
rediae on gills
daughter rediae in hepatopancreas

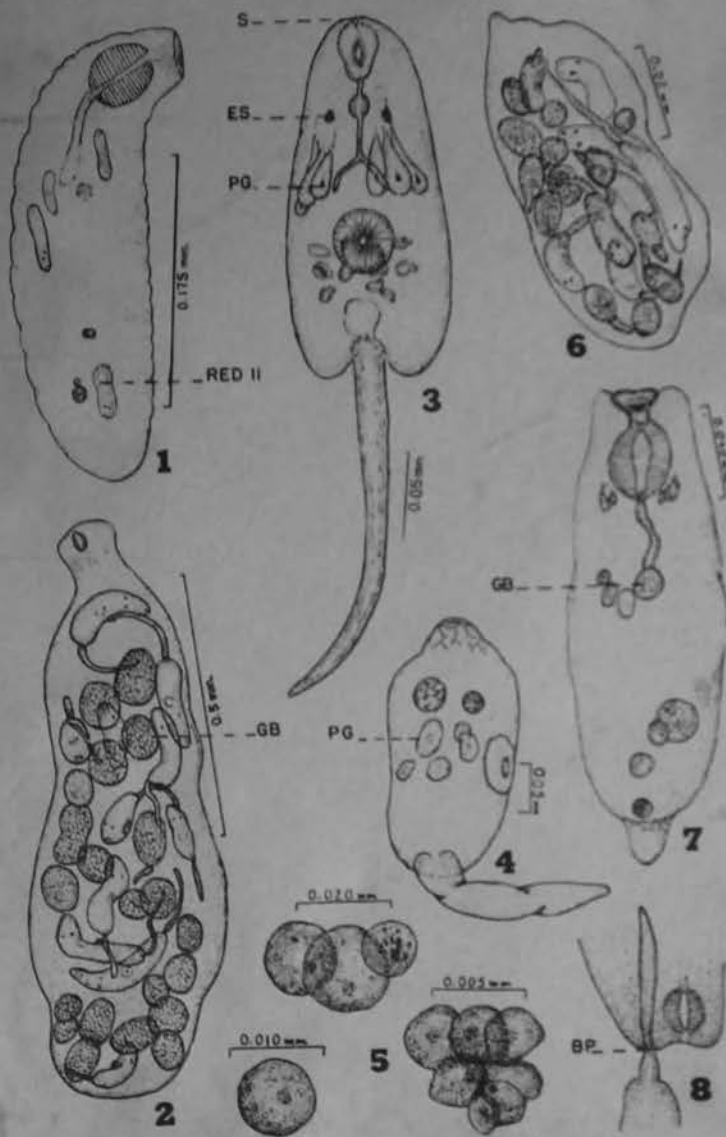
cercaria a simple-tailed xiphidiocercaria

Cheng & James (1960) noted the morphogenesis
of the tail was like that in Opisthorchioidea
and Heminroidea

Reference: ~~#####~~ Chaeng & James (1960) Trans. Amer. Micros. Soc.,
79(1):75-85.

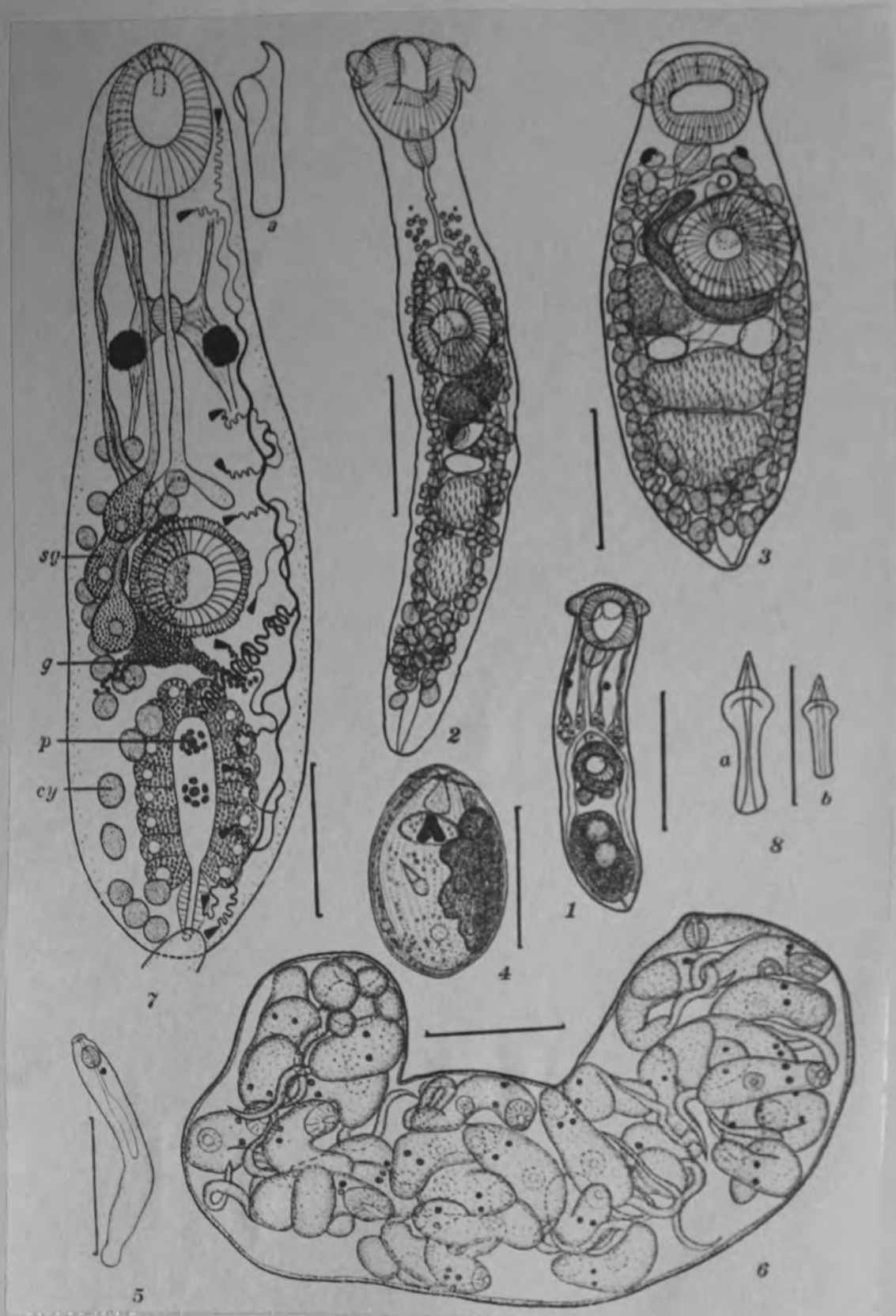
GERM CELL CYCLE OF *CREPIDOSTOMUM*
cornutum (Osborn, 1903)

This study is primarily concerned with the development of the cercariae. Although the genesis of the cercarial stage in the Digenea supposedly follows the pattern of miracidial differentiation (see Rees, 1940) and this has been adequately reviewed by Hyman (1941), the demonstration of the developmental stages, especially the morphogenetic stages, has been negligible in the literature.



From Cheng & James, PLATE I
 1960.

Trans. Amer. Micros. Soc. 79 (1)



Crepidostomum cooperi Hopkins, 1931 from Hopkins, 1934
 1. metacercaria. 2. adult, 3. adult contracted. 4. miracidium in egg. 5. young redia 6. mature redia with cercariae. 7. cercaria (a. stylet) 8. stylets of (a.) C. cooperi (b) Megalogonia ictaluri.

ALLOCKREAR DIOJEA

Aporocotyliidae of Fishes: Life Cycles

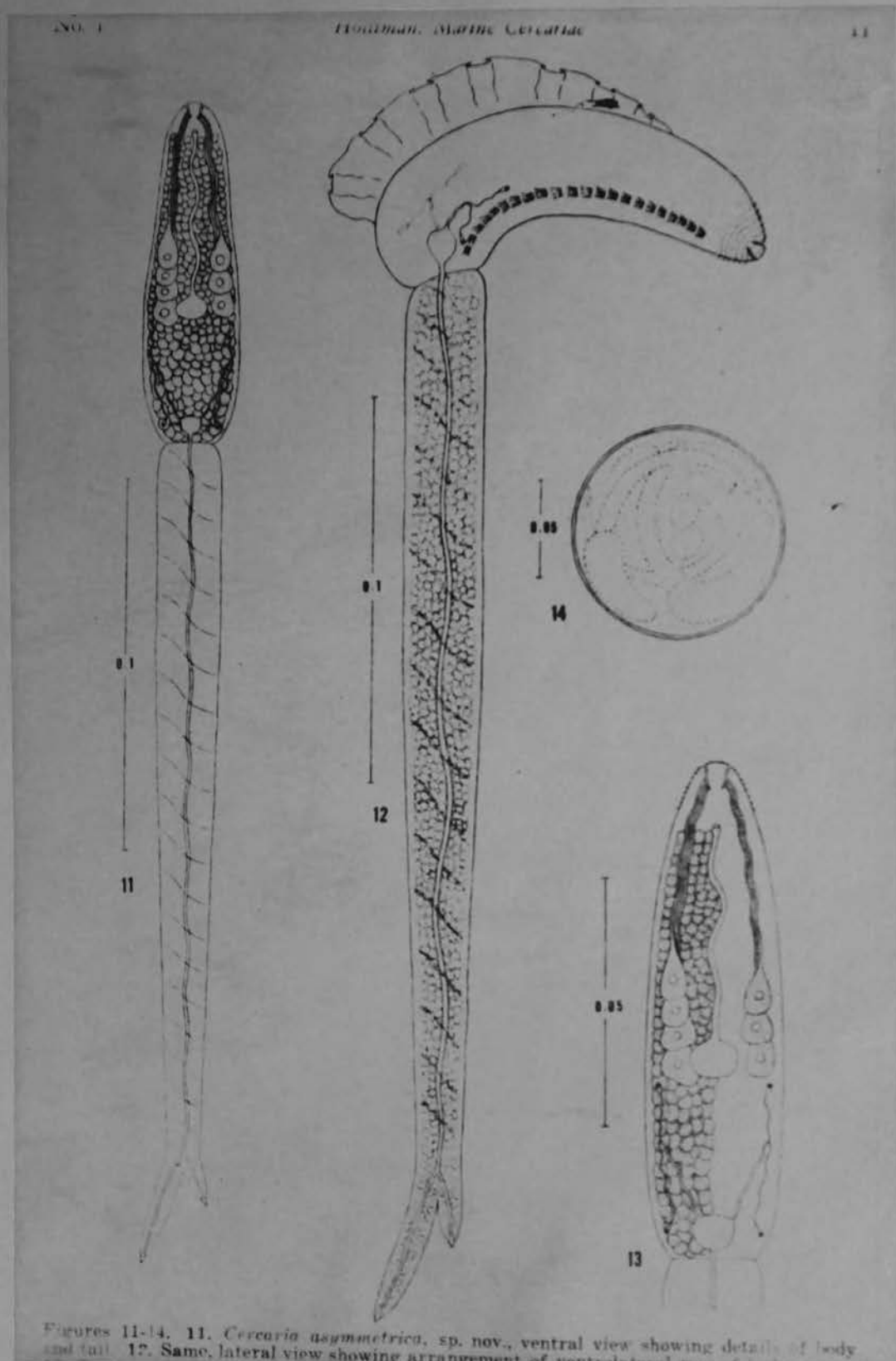
<u>Aporocotyloid cercaria</u>	<u>Host:</u>	<u>Locality</u>	<u>Authors</u>
<u>Cercaria loossi</u>	<u>Eupotamus dianthus</u> (an annelid)	WoodsHole	Linton, 1915 Martin, 1944, 1952
<u>C. hartmanae</u>	<u>Lanicides vayssierei</u> (an annelid)	Ross Island, Antarctica	Martin, 1952
<u>C. amphictus</u>	<u>Amphictus gunneri</u> (an annelid)	<u>floridus</u> Florida	Oglesby, 1961
<u>C. solemyae</u>	<u>Solemya velum</u> (a clam)	Woods Hole	Martin, 1944
unnamed	<u>Aequipecten irradians</u> (scallop)		Linton, 1915
<u>C. asymmetrica</u>	<u>Donax variabilis</u> (clam)	Florida	Holliman, 1961
██████████			
<u>C. cristulata</u>	<u>Chione cancellata</u> (clam)	Florida	Holliman, 1961

Eggs hatch in capillaries of gills in a blood fluke of trout (Wales, 1958)

From Holliman (1961:10)

The cercariae of the family Aporocotylidae have the following diagnosis:

Apharyngeate, non-ocellate, brevifurcate cercariae developing in marine lamellibranchs and annelids. The tail is variously modified with symmetrical or asymmetrical furcae, no furcae, or reduced to a small pointed structure. Finfold present or absent on the dorsal ~~##~~ body surface and on furcae. Cephalic organ reduced or lacking; penetration gland ducts discharge through pores on spinous anterior end of body. Acetabulum absent except in C.hartmanae Martin, 1952. Cercariae penetrate the definitive host and develop to adult worms in the blood vascular system or rarely in the coelom of fishes.



Figures 11-14. 11. *Cercaria asymmetrica*, sp. nov., ventral view showing details of body and tail. 12. Same, lateral view showing arrangement of ventrolateral zone of body. 13. Same, ventral view showing details of anterior portion of body. 14. Same, detail of ventrolateral zone of body.

APOROCOTYLIDAE

Life cycle of Cotylogaster occidentalis Nickerson, 1902.

1900

(Index-Catalogue)<sup>M. H. P.
10 Aug 73</sup>

Adult flukes, with viable eggs in the uterus, are recovered from Goniobasis snails. It is to be concluded that the snails are normal hosts; that the trematode is not dependent on a vertebrate host.

Fish, formerly reported as the final host, were found occasionally with the fluke, but in each case evidence was present that the fish had fed upon Goniobasis snails.

This supports the contention that Aspidogastrea is a valid subclass of Trematoda.

E. Eugene Dickerman, 1948. J. Parasit. 34(2):

Lophotaspis interiora

From Hendrix and Short, 1972

ABSTRACT: The sexually immature postlarva, or juvenile stage, of *Lophotaspis interiora* Ward and Hopkins, 1931, is described from the pericardial cavity and kidney of pelecypod mollusks in the family Unionidae, taken from Northwest Florida rivers. It is characterized by having 52 to 65 alveoli (mean of 58) in the ventral holdfast, 2 excretory bladders and pores in the smaller juveniles, and formed but nonfunctional reproductive systems. This is the second species reported in the genus with an immature stage in mollusks and adults in turtles.

Description of juvenile

(Figs. 1-4)

Body elongate, shaped like adult (Fig. 4), length 3.105 mm (2.092 to 4.081). Ventral holdfast large, elongate, length 2.494 mm (1.690 to 3.196), width 843 (695 to 958); divided into 4 rows of alveoli, 2 peripheral, 2 medial; number of peripheral alveoli 32 (29 to 35); number of medial alveoli 26 (23 to 30); total number of alveoli in 9 worms 58 (52 to 65). Marginal organs in peripheral rim between all but the 2 most posterior alveoli; extensible papillae (Fig. 1) present at the junction between each group of 3 alveoli, number of papillae 81 (72 to 93). Tegument spinous. Eyespots absent.

Mouth subterminal, opening through oral cone 272 (153 to 423) in diameter; prepharynx absent; pharynx ovoid, length 289 (234 to 345), width 264 (180 to 348); esophagus short, length 165 (120 to 246), width 141 (69 to 219); intestine simple, saccate, length 1.634 mm (0.960 to 2.031), width 285 (210 to 405).

Excretory pores double in smaller juveniles, median, posterodorsal with excretory bladders separate; bladders joined in larger juveniles and discharging through a single pore, bladder length

tory ducts uniting before discharging through a single genital pore which is midventral and anterior to pharynx.

Ovary more or less ovoid, elongate, and bent upon itself anteriorly, dextral, anterior to testis, length 99 (57 to 160), width 62 (42 to 90). Oviduct passing posteriorly from near anterior end of ovary, with internal ridges. Ootype and Mehlis' gland present but not well developed. Seminal receptacle absent. Laurer's canal present, extending from oviduct posterodorsally to open on left dorsolateral surface. Uterus proceeding transversely from ootype to near testis, then anteriorly to genital pore; metraterm absent. Eggs absent. Vitelline follicles poorly developed, in 2 lateral bands generally in middle third of body. Vitelline reservoir small, anteromedial to testis. Common vitelline duct entering oviduct just proximal to ootype.

Hosts (see also Table I): *Elliptio crassiden* (Lam.), *E. strigosus* (Lea), *Fusconia succinea* (Lea), *Lampsilis hydiana* (Lea), *Ligumia subangulata* (Lea), and *Pleurobema strodeanum* (B. H. Wright).

Location in host: Pericardial cavity and kidney.

Localities: Escambia River at Molok and State Highway 1, Escambia Co.; Chipola River at State Highway 20, Calhoun Co.; and at U. S. 90, Jackson Co., all in Florida.

Deposited specimens: USNM Helm. Coll. N 33086.

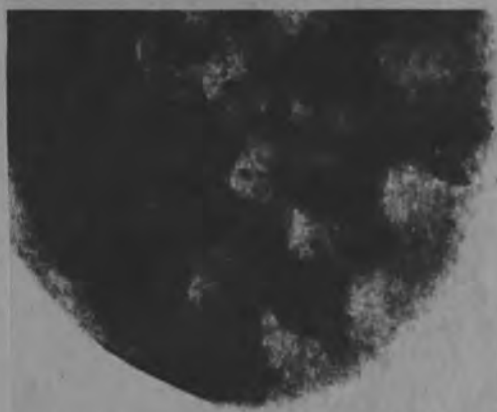
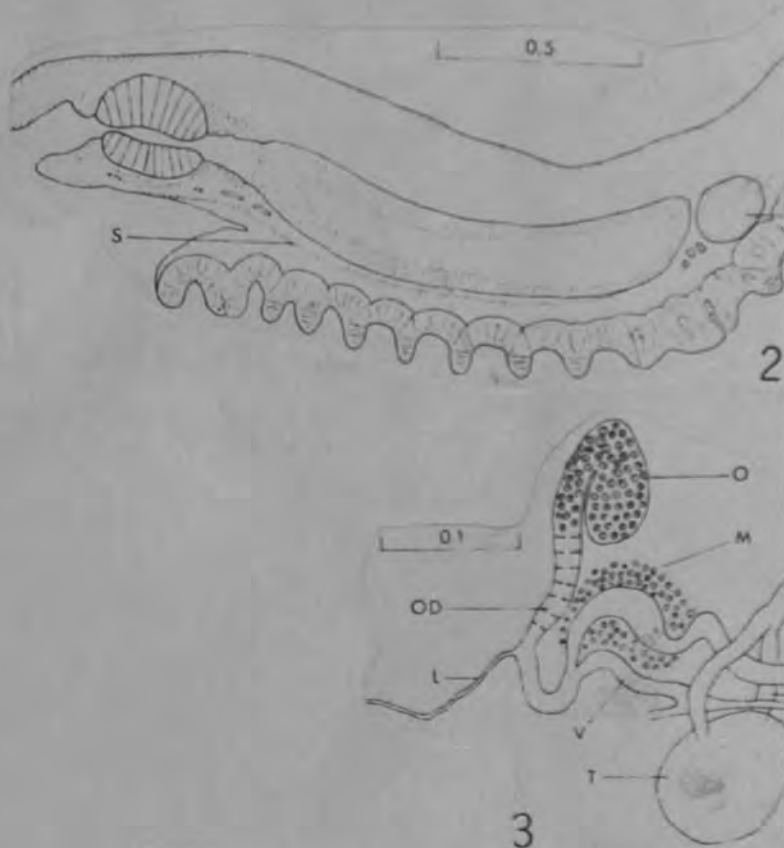


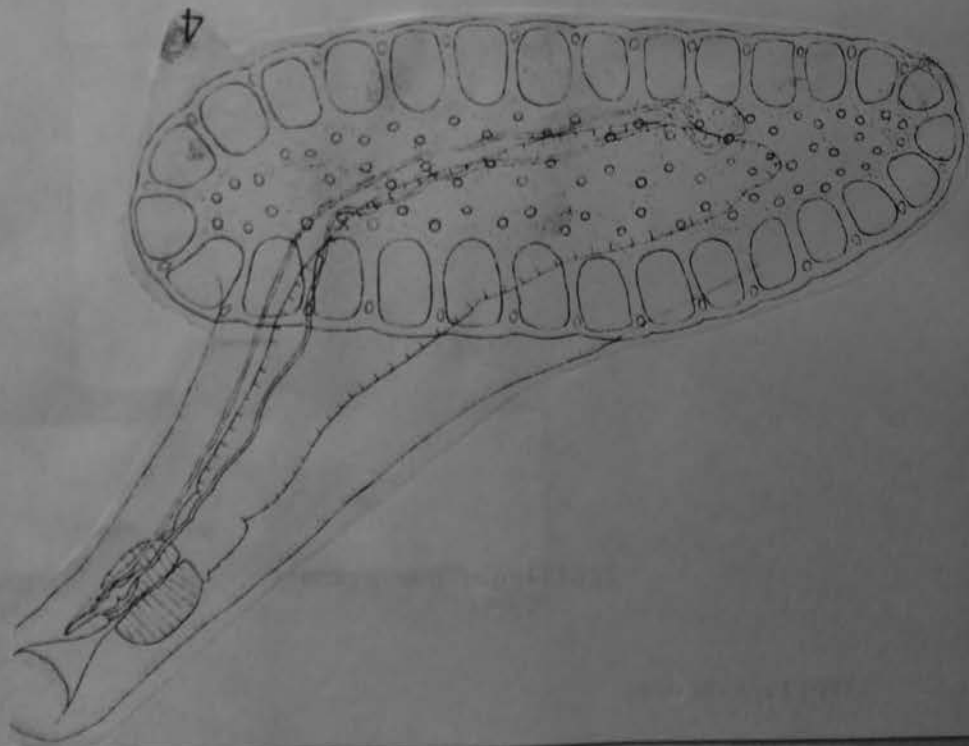
FIGURE 1. The juvenile of *Lophotaspis interiora*. Portion of ventral holdfast of an unstained whole mount with papillae extended.

87 (66 to 135), width 61 (39 to 129) (5 pairs of bladders measured); excretory system stenostomate, ciliation lacking in the main ascending ducts.

Horizontal septum (Fig. 2) present, beginning at level of pharynx and extending posteriorly, ventral to intestine, to anterior margin of ovary where it joins ventral wall of intestine. Testis, ovary, Mehlis' gland, and vitelline reservoir posterior and ventral to septum. Vas deferens and uterus mostly dorsal to it.

Testis single, ovoid, median to sinistral in posterior third of body, length 172 (105 to 275), width 154 (75 to 225). Two vasa efferentia extending anteriorly from testis, one dorsal, the other ventral to right vitelline duct and uterus, uniting at level of ootype. Vas deferens narrow, entering cirrus sac within which it enlarges to form an internal seminal vesicle. Cirrus sac at level of anterior half of pharynx, containing rudimentary prostate cells. Cirrus absent. Uterus and ejacula-





ASPIDOGASTRIDAE

CYSTOPHOROUS CERCARIAE

Willey (1930) says "characterised by possession of a vesicular tail with various appendages upon it."

Horsfall (1934) says the term "cystocercous" was first used to indicate cercariae in which the tail enveloped the young distome. It included three types of cercariae: "cystophorous", macrocercous, and "mirabilis" as each was named after the first species of its group to be correctly classified. Horsfall limited the term to the "mirabilis" group which evidently develop into adults of the family Azygiidae. She recognizes nine species as valid. Cercaria mirabilis Braun, 1891 is the larva of Azygia lucii Muller, (see Szidat, 1932) Cercaria macrostoma Faust, 1918 is the larva of Proterometra macrostoma (Faust, 1918) Horsfall, 1933 (see Horsfall, 1934).

Horsfall recognizes the following valid species of the mirabilis group:

1. C. macrostoma Faust, 1918
 synonyms: C. fusca Pratt, 1919
 Cercaria of Cahn, 1927
 Cercaria X of Dickerman, 1931
 C. melanophora Smith, 1932
2. C. hodgesiana Smith, 1932
3. C. stephanocauda Faust, 1921
4. C. wrightii Ward, 1916
5. C. mirabilis Braun, 1891
6. C. splendens Szidat, 1932
7. C. anchoroides Ward, 1916
8. C. brookoveri Faust, 1918
9. C. pekinensis Faust, 1921

These probably are all larvae of Azygiidae. Horsfall points out that C. stephanocauda suggest Leuceruthrus micropteri. She thinks, too that C. anchoroides and C. brookoveri are larvae of the genus Azygia.



Cystocercous cercariae of Lühe

The term cystocercous was used by Lühe to refer to any cercaria capable of drawing its body into the base of its very large tail. Cercaria macrocerca Filippi, 1854 was the first to be known. Such cercariae have always been termed macrocercous cercariae. It is now known that three types of trematodes are represented here. These have been termed:

- A. Cystophorous cercariae
- B. Cystocercous cercariae
- C. Gorgoderine cercariae

This grouping is accepted by Miller, 1936.

Cystophorous cercariae usually develop in rediae (exception: C. vaullegeardii); lack stylets, and cystogenous and cephalic glands. There is a central vesicle in the tail into which the body can be withdrawn. 15 species up to 1936, listed by Miller (1936). Hemiuridae

(over)

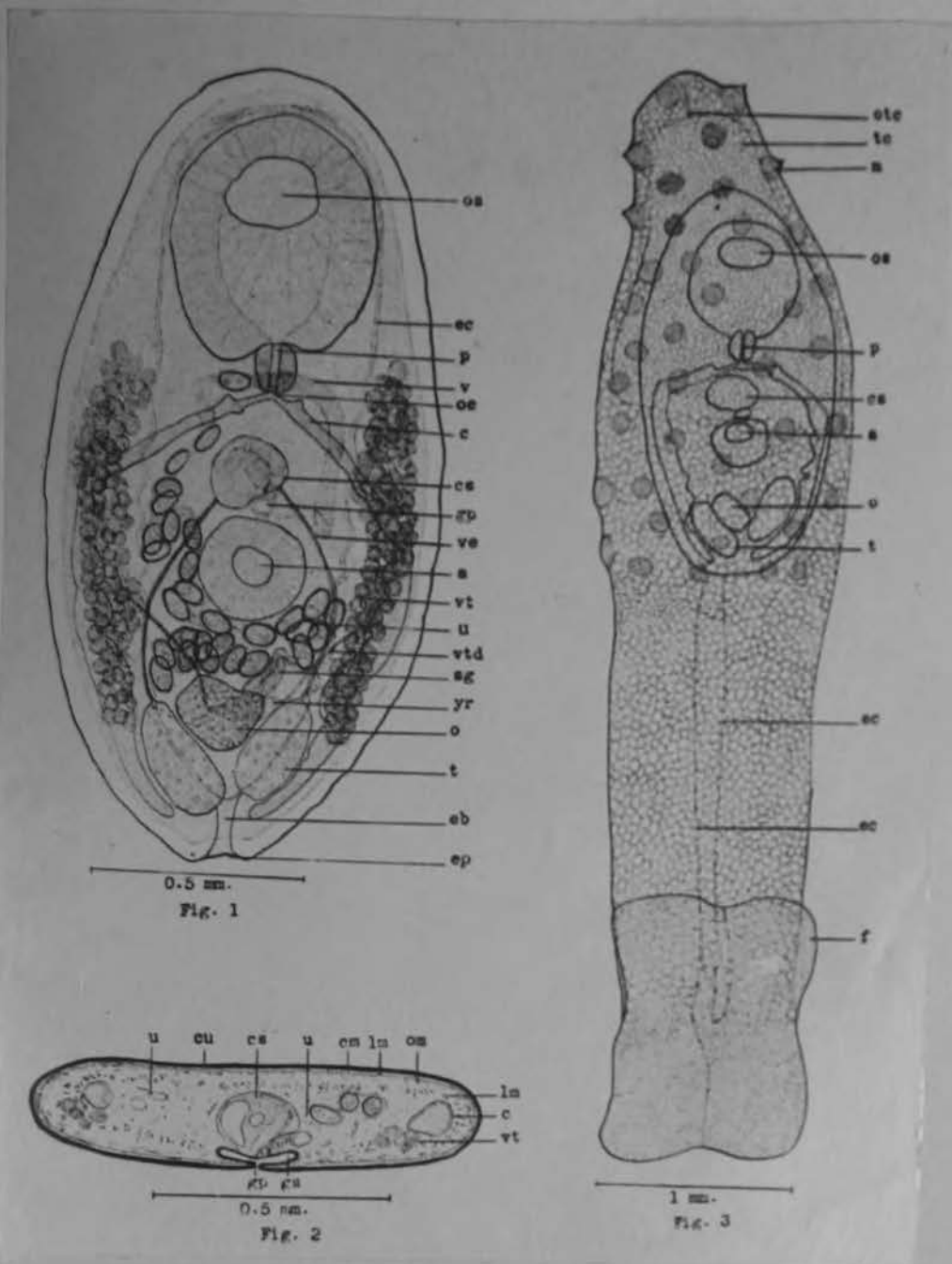
Tail with a pair of flat furcae.

Cystocercous cercariae : anchor-tailed cercariae, Y-shaped excretory vesicle, with large, wide tail into which the body may be partially or completely withdrawn, developing in sporocysts. The first was named C. mirabilis Faust Braun, 1891. Miller (1936) lists 11 species. Azygiidae

Gorgoderine cercariae: tail not forked; stylet ~~lacking~~; develop in sporocysts in bivalves. To 1936, 7 species. See Miller, 1936 Gorgoderidae

Azygiidae

Proterometra macrostoma Horsfall, 1933



Final hosts: Pomoxis sparoides, crappie; Helioperca incisor, blue gills; Eupomotis gibbosus, sunfish. In esophagus.
 Snail host: Goniobasis livescens correcta
 Cercariae cystocercous of the Mirabilis group.
 These large yellow cercariae are eaten by the fish.
 Reference: Dickerman, 1934. Trans. Amer. Micros. Soc., 53:8-21.

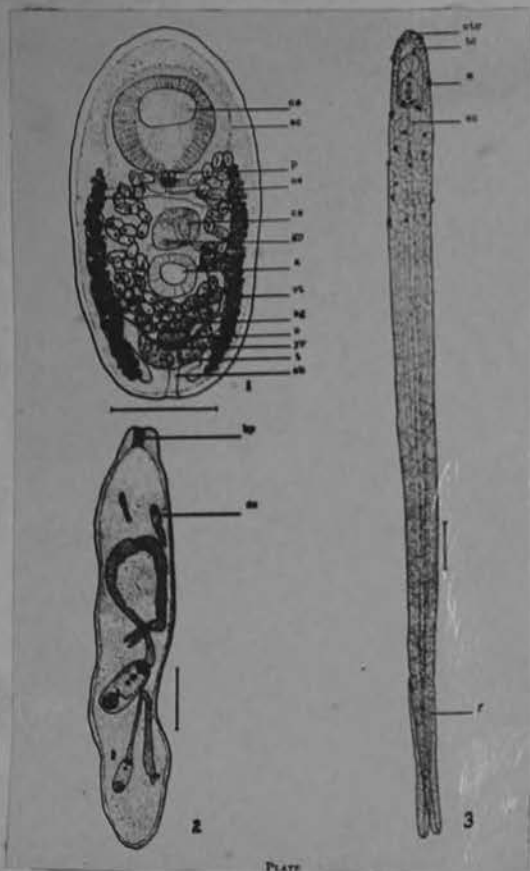
Azygiidae

Proterometra sagittaria Dickerman, 1946

Final hosts: freshwater fishes, family Centrachidae.
experimentally in Eupomotis gibbosus

Intermediate hosts: Goniobasis and Pleurocerca

Cystocercous cercariae, Cercaria sagittaria,
develop in rediae.



Reference: Dickerman 1946
Trans. Amer. Micros. Soc.,
65(1):37-44. (see reprint)

Ptychogonimus megastoma (Rud.)

Final hosts: many selachians

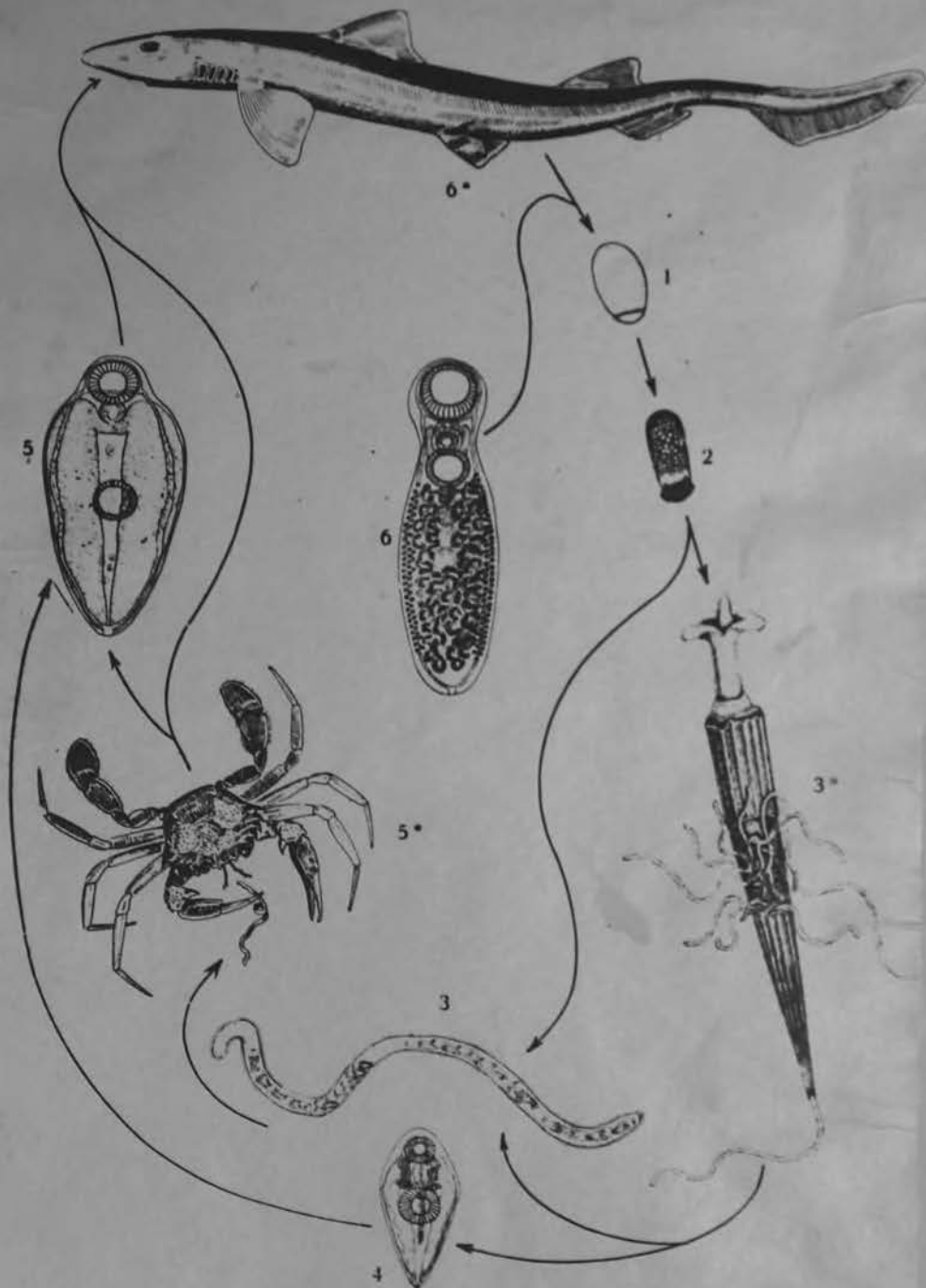
First intermediate host: Scaphopod molluscs, Dentalium vulgare,
D. alternans

Second intermediate host: marine crabs, 28 species.

Unusual features: sporocysts leave molluscs and are eaten by crabs. Metacercariae are not encysted.

RIVISTA DI PARASSITOLOGIA - VOL. VI.

TAV. I



Ref. Rivista di Parassitologia,
vol 6 (3): 117-172, 1 pl.

LOOSE LEAF ORGANIZER

AZYGILLDAE

SCHEDULE

TELEPHONE



BIVESICULA CARIBBENSIS SP. N. (TREMATODA: DIGENEA) AND ITS LIFE HISTORY*

R. M. CABLE AND F. M. NAHHAS

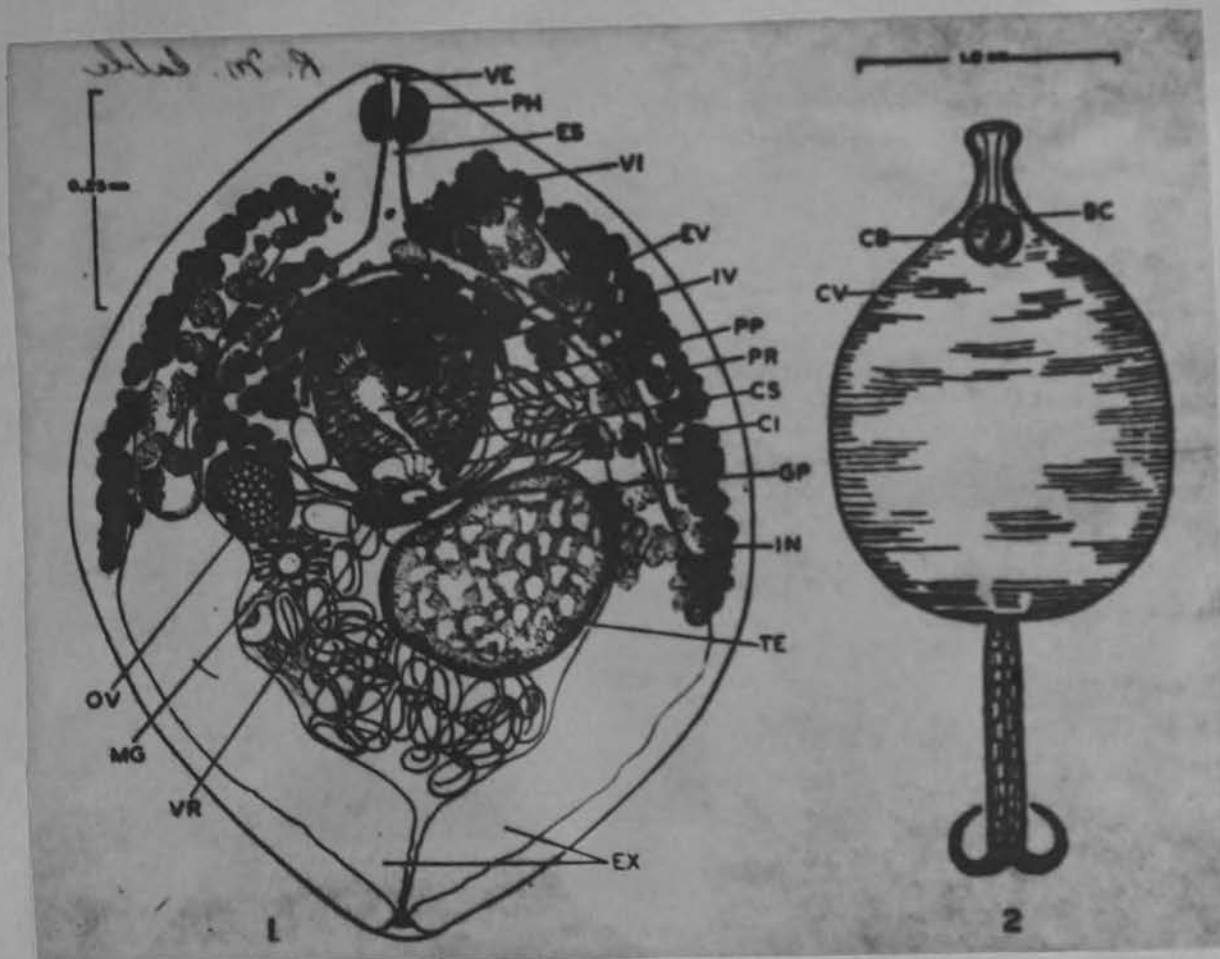
Department of Biological Sciences, Purdue University, Lafayette, Indiana,
and Caraibisch Marien-Biologisch Instituut, Curaçao, N. A.

ABSTRACT

Bivesicula caribbensis sp. n. occurs in the pyloric ceca of the squirrel-fish, *Myripristis jacobus*, in Curaçao and Jamaica. The adult is described and a key to the species of *Bivesicula* is given. Ecological data and limited experimental evidence indicate that the cercaria of *B. caribbensis* is a previously undescribed larva which develops in *Cerithium literatum* and matures directly when eaten by the definitive host.

1962

SEE DESCRIPTION OF SPECIES



A. W. Manter

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BIVESICULA CARIBBENSIS SP. N. (TREMATODA: DIGenea) AND ITS LIFE HISTORY*

R. M. CABLE AND F. M. NAHNAS

From Pearson (1968)

Fig. 8. Cercaria, before retraction of body into tail, dorsal view. (Figs. 8, 10 drawn to same scale).

Fig. 9. Cercaria, after retraction. Lateral view, showing muscular flaps of tail.

Fig. 10. Cercaria, after retraction. Ventral view, showing arrangement of pigment in

caudal chamber.

BIVESICULA CARIBBENSIS SP. N. (TREMATODA: DIGENEA) AND ITS LIFE HISTORY*

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In February, 1961, a new species of *Bivesicula* was found in the squirrel-fish, *Myripristis jacobus*, collected along the south coast of Curaçao. Although nearly all *M. jacobus* examined were infected, young specimens harbored more worms, including many immature ones of various sizes, than did large fish, which yielded mostly mature parasites. In June, the species was recovered also from two of three large *M. jacobus* collected in Jamaica. Siddiqui and Cable (1960) found no trematodes in one specimen of *M. jacobus* in Puerto Rico where, like Jamaica, that squirrel-fish is much less common than another species, *Holocentrus ascensionis*. The reverse was found in Curaçao where *M. jacobus* is the more abundant form.

EVIDENCE BEARING ON THE LIFE HISTORY

There is convincing evidence as to the identity of the cercaria, although well-controlled experimental demonstration of the life history was not feasible. On two occasions, the snail, *Cerithium literatum*, was found aggregating in large numbers on sandy bottom in water 2 to 3 meters deep at St. Michiel's Baai, Curaçao. Small *Myripristis jacobus* were abundant among nearby coral heads and vegetation. Both snails and fish were collected and found to harbor respectively a single species of bivesiculid cercaria and adult. Moreover, no other bivesiculid, larval or mature, was found in a large number and variety of other mollusks and fishes in Curaçao, including the abundant silverside, *Hepsetia stipes*, which harbors *Bivesicula hepsetiae* in Florida and Puerto Rico.

The cercarial type in the family Bivesiculidae

was first recognized by Le Zotte (1954) and, although he did not demonstrate the life cycle experimentally, he presented evidence that it is completed directly when the cercaria, often large and with conspicuous pigmentation and swimming movements, attracts the attention of a fish which ingests the larva. We obtained additional evidence in one feeding experiment, utilizing a school of small *Myripristis jacobus* of uniform size. The fish were held in a tank for 1 week. Then seven were placed in a closed aquarium with a filter and aerator and the remaining ones were left in the first tank as controls. The experimental fish quickly ate all of several hundred cercariae placed in their aquarium and thereafter were fed brine shrimp but began to die on the second day when unfavorable conditions developed in the aquarium. All contained many small immature worms of uniform size in addition to larger ones from previous natural infections whereas the control fish yielded only larger worms. These results and the ecological evidence given above indicate that the cercaria in question is the larva of the adult bivesiculid naturally infecting *M. jacobus*.

The adult and cercaria are described below. All measurements are in millimeters. Adults were measured as whole mounts of specimens killed under light cover glass pressure in corrosive sublimate-acetic acid and stained with Semichon's carmine. Measurements of cercariae are from larvae that emerged spontaneously and were killed in hot sea water either after the body retracted into the caudal vesicle and it became fully inflated, or before that occurred in order to measure the free cercarial body. Further studies have confirmed Le Zotte's (1954) observation that the structure usually described as the oral sucker in bivesiculids is actually a pharynx and that what has

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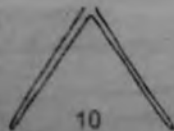


Fig. 10
Fig. 9

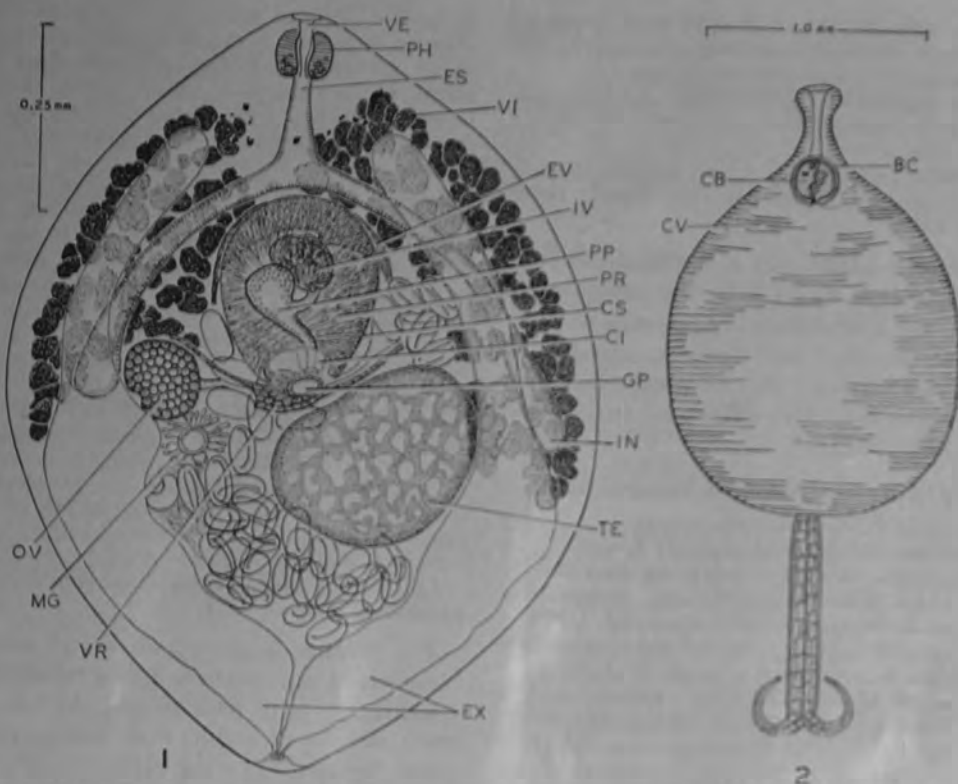


FIGURE 1. Adult *Bivesicula caribbensis* sp. n. Holotype, ventral view. CI, cirrus; CS, cirrus sac; ES, esophagus; EV, external seminal vesicle; EX, excretory vesicles; GP, genital pore; IN, intestinal caecum; IV, internal seminal vesicle; MG, Mehlis' gland; OV, ovary; PH, pharynx; PP, pars prostatica; PR, prostate cells; TE, testis; VE, vestibule; VI, vitellaria; VR, vitelline reservoir.

FIGURE 2. Cercaria, drawn from heat-killed specimen. BC, body capsule; CB, cercarial body; CV, caudal vesicle.

been described as a rudimentary pharynx is part of the muscular esophagus.

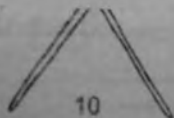
Bivesicula caribbensis sp. n.

ADULT

(Fig. 1)

Diagnosis: With characters of the genus *Bivesicula*. Body pyriform to oval with bluntly pointed ends. Entire cuticle with extremely fine spines in rows giving edge of body a faintly annulated appearance. Ovigerous specimens 0.654 to 1.020 long, 0.560 to 0.820 wide. Suckers absent, a short vestibule leading directly into pharynx 0.066 to 0.073 long, 0.067 to 0.080 wide. Esophagus 0.060 to 0.137 long, widening posteriorly, without obvious localized thickening of musculature; intestinal bifurcation immediately anterior to cirrus sac, ceca terminate near midlevel of body. Cirrus sac ovoid, 0.20 to 0.285 long, 0.140 to 0.227 wide, median, directed posteriorly toward median, subequatorial genital pore. Testis single, entire, ovoid to somewhat irregular, 0.20 to 0.30 long, 0.160 to 0.293 wide, on left at beginning of posterior half of

body or slightly anterior to that level; with two vasa efferentia which expand anteriorly, uniting to form crescentic external seminal vesicle dorsal to anterior part of cirrus sac. From external vesicle, a short duct enters cirrus sac to join internal seminal vesicle connecting with voluminous, pouched pars prostatica, followed by a short cirrus; remainder of cirrus sac filled with numerous prostate cells. Ovary on right, at about level of genital pore, 0.093 to 0.127 by 0.08 to 0.107, usually with one lateral indentation but occasionally with more. Vitelline follicles in lateral fields from esophageal level to or slightly beyond ends of ceca, extending into intercecal space and confluent dorsal to intestinal bifurcation and cirrus sac; vitelline receptacle immediately posterodorsal to cirrus sac. True seminal receptacle absent; sperms stored in beginning of uterus which extends posteriorly to right of testis, filling post-testicular space between excretory vesicles, then anteriorly to median side of ovary, crosses to left and turns anterior to testis to join genital atrium. Large specimens contain up to 50 eggs measuring 0.067 to 0.075 by 0.040 to 0.046 when not collapsed. Excretory vesicles 2,



10



9



8

Fig. 6. Cercaria, after retraction. Ventral view, showing attachment of caudal chamber.

Fig. 7.

Fig. 8. C

some sea

Fig. 9. C

Fig. 10.

Cercaria, after retraction. Ventral view, showing attachment of caudal chamber.

(b) *Egg and miracidium*

One of the most striking features of this species is the presence in the uterus, particularly the distal half, of large eggs containing fully developed miracidia, the large eyespots of which are a conspicuous feature of the living worm.

Eggs laid by adult worms in sea water hatch within a few minutes, and the miracidia which emerge swim about actively for some hours.

The examination of a small number of living miracidia revealed the following features. The clavate body is covered, except at the anterior end, by uniformly ciliated epidermal plates in four tiers. The apical gland extends from the anterior end (apical papilla) to the brain, and contains four nuclei posteriorly. There is a pair of conspicuous lateral papillae between the plates of the first and second tiers, and two pairs of papillae, one dorsal and one ventral, anteriorly between the plates of the first tier. There is a single pair of flame-cells. The two large eyespots are fused.

These sketchy observations supplement those of Le Zotte (1954) on the miracidium of *Bivesicula hepsetiae*, the only other bivesiculid miracidium described, and support the view that the family Bivesiculidae belongs in the order Strigatoidea.

(c) *Redia*

The mother sporocyst was not observed, but as only advanced infections were found (by isolating snails for the emergence of cercariae), it may be that the mother sporocyst had disappeared earlier.

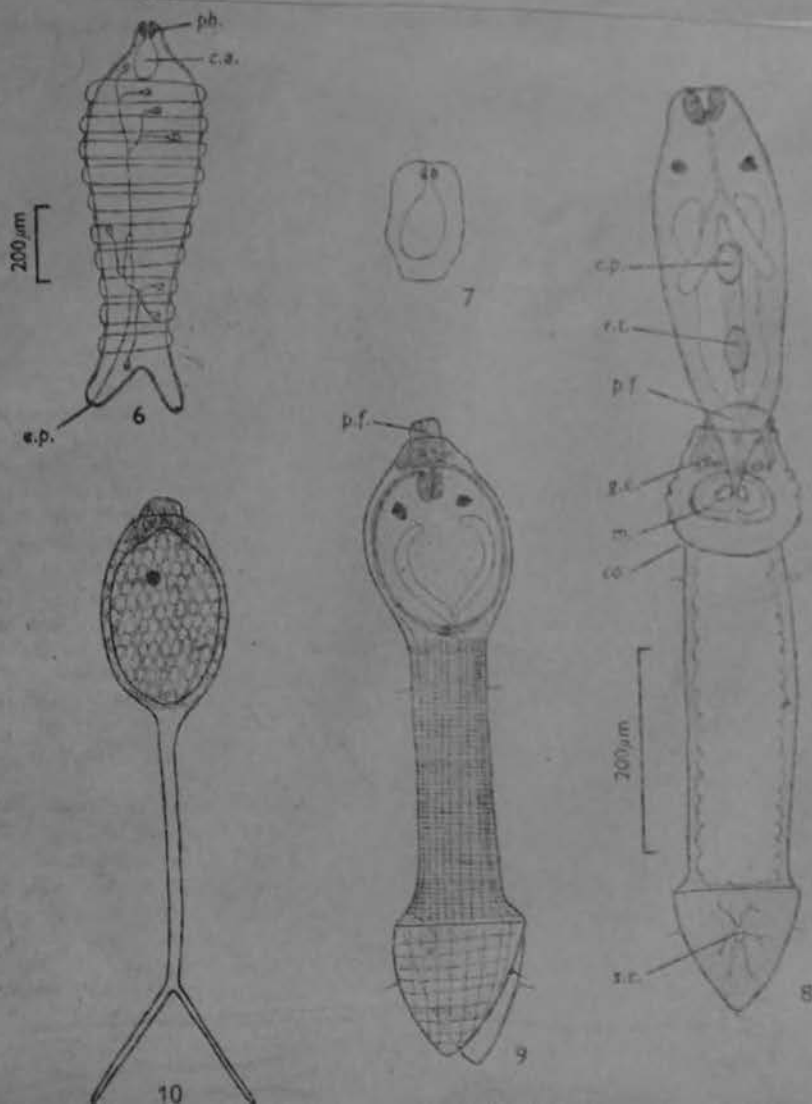


Fig. 6. Redia, showing external ridges and one half of excretory system (di-developing cercariae omitted).

Fig. 7. Young redia, from haemocoel of snail.

Fig. 8. Cercaria, before retraction of body into tail, dorsal view (Figs 8, 10 drawn to same scale).

Fig. 9. Cercaria, after retraction. Lateral view, showing muscle (Figs 9, 11).

Fig. 10. Cercaria, after retraction. Ventral view, showing arrangement of pigment in caudal chamber.

From Pearson (1968)

I would suggest that the absence of the metacercarial stage in the life-cycle of the above groups is primitive, as borne out by the advanced development of the reproductive system in the cercariae in *Transversotrema*, *Azygia*, *Proterometra* and *Paucivitellosus*, and that the life-cycle represents an earlier stage than is found in the typical (commoner) two-host life-cycle as seen in fasciolids and paramphistomes.

SUMMARY

Paucivitellosus fragilis is redescribed from the bleenny, *Salarias meleagris*, found on beach-rock intertidally at Heron Island, Great Barrier Reef. The adult was also found in the mullet, *Mugil cephalus* and *Crenimugil crenilabis* at Heron Island, and *Liza argentea* at Brisbane.

Paucivitellosus differs from *Bivasicula*, *Bivasiculoides* and *Treptodemus* in having: (i) the vitellaria reduced to a single follicle on each side, (ii) two primary loops in the uterus, (iii) fully embryonated eggs in the terminal coils of the uterus, and (iv) the cirrus pouch orientated dorso-ventrally. The diagnosis of the family Bivasiculidae is amended.

The molluscan host at Heron Island is *Cerithium penthausarum*, in which cercariae develop in 'fork-tailed' rediae.

The cercaria is furcocystocercous and differs from known bivasiculid cercariae in having a protrusible glandular fold, within the mouth of the invaginated caudal chamber, by which the cercaria attaches to objects.

Evidence is presented for the view that the life-cycle is a two-host one, that there is no metacercarial stage, and that the cercaria is ingested by browsing.

Egg and Miracidium (Fig. 25)

In *B. hepsetiae* the eggs are large (0.075–0.080 by 0.045–0.050 in living material), operculate, and few in number; the shell is smooth and thin. When eggs were teased from the worm and placed in standing sea water at room temperature, development occurred normally in some of them. The eyespot of the miracidium appeared on the 6th to 7th day as a pair of well-separated pigment cups which with further development moved together to form a united structure. About two weeks are required for the miracidium to become fully developed. The larva has distinct epidermal plates bearing long cilia and resembles the miracidia of *Clinostomum* and strigeoids more than those of azygiids. The structure of the miracidium indicates that it normally hatches and penetrates the molluscan host. However, all attempts to induce hatching were unsuccessful. After reaching full development and exhibiting much motility, the miracidia died and disintegrated. Thus what is known of miracidial structure was observed through the egg shell. No flame cells could be observed.

Le Zotte (1954)



25

Miracidium in egg:
2 wk development*The Redia* (Figs. 20, 21, 27, 29, 30)

All species of bivesiculid cercariae described below develop in rediae in the branchial region of the snail host. The redia has a cleft posterior extremity and transverse muscle bands which are prominent in the contracted state. Under the lower powers of a dissecting microscope, young redia (Fig. 20) are easily confused with cercarial embryos when the infected snail is cracked.

A golden-brown pigment is discernible throughout the entire body of the redia. The gut is usually filled with a darker brown pigment. The older redia of *Cercaria caribbea* XLV measures 0.441 to 0.688 in length and 0.125 to 0.213 in width. The pharynx is almost spherical, measuring 0.025 to 0.033 in diameter. The gut is short, 0.092 to 0.134 long. Longitudinal sections show what probably is a birth pore slightly posterior to the pharynx. A discrete mass of germinal cells is present; in all rediae observed it was attached to the median wall of one of the posterior lobes and close to their confluence so that the mass is to one side of the mid-line of the redia (Fig. 30).

The excretory pattern was determined for the redia of *Cercaria caribbea* XLV (Fig. 21). The pores are at the tips of the posterior lobes and from each pore an excretory canal extends anteriorly, receiving an anterior and a posterior collecting tubule. The anterior collecting tubule is joined by capillaries of two groups of flame cells of which four were observed in the anterior group and three in the second. The posterior collecting tubule receives capillaries from three groups of flame cells, the two more anterior of which also are in three's, while the posterior group contains four flame cells. In groups containing four flame cells, the common tubule divides and both of the resulting tubules divide again to form four capillaries. In groups containing three flame cells, the common tubule divides but only one of the resulting tubules divides again to form capillaries, the other serving a single flame cell. The excretory formula for this redia accordingly is $2[(4+3) + (3+3+4)] = 34$ flame cells, a pattern which is very similar to that of the cercaria, as described below.

Le Zotte (1954)

Redia. Excretory
system of oneYoung redia
showing cleft
posterior extremity
and resemblance to
cercarial embryo.

Cercariae

Bivesiculid cercariae evidently escape from the redia and complete their development in the tissues of the snail. All the six species here reported have many features in common. Thus, repetition may be avoided by first giving a:

General diagnosis: Furcocystocercous cercariae developing in rediae in the branchial region of marine prosobranch snails. Photopositive, swimming tail first and resting intermittently. Tail often characteristically pigmented, with vacuolated parenchyma, and divided into a vesicle into which the body is withdrawn, a stem sharply set off from the vesicle, and a pair of furcae; tail stem and furcae laterally compressed. The vesicle has powerful circular muscles and is concave posteriorly to receive the base of the tail stem. In fully developed cercariae, the body is enclosed in a spherical muscular capsule which has radial fibers and does not occupy all of the caudal vesicle. When containing the body, the capsule is distended and thin but is much smaller and thick-walled when empty (Figs. 3, 14). The body when free is rounded anteriorly and attenuated posteriorly. It is covered with minute spines and body pigment is limited to a pair of conspicuous eyespots. Oral and ventral suckers are lacking, there being a well-developed pharynx, heretofore interpreted as an oral sucker, and anterior to it a short but distinct vestibule. Esophagus muscular; intestine triclad with long ceca extending to near the posterior end of the body. Numerous cephalic glands are situated near the intestinal bifurcation and have ducts opening into the vestibule (Fig. 9). Cystogenous glands lacking.

The genital primordium is median, intercecal, in the posterior fourth of the body and sometimes shows indication of dissociation to form the gonads and their ducts.

The right and left halves of the excretory system remain separate throughout development. The pair of embryonic excretory tubules extend through the tail to diverge and open at the tips of the furcae. Consequently the body contains two separate thin-walled excretory vesicles each with its own sphincter (Figs. 8, 31). The excretory vesicles usually are filled with spherical concretions. From the anterior end of each vesicle, a ciliated recurrent tubule extends posteriorly, passing first medially and then dorsal to the vesicle to receive at about mid-body level an anterior and a posterior collecting tubule. The anterior tubule receives capillaries from two groups of flame cells while the posterior is joined by three flame cell groups, the last of which is in the tail. Each flame cell group has dichotomous branching of the capillaries so that the caudal vesicle receives one-half of the posterior-most flame cell group and the proximal region of the tail stem the other half. Empirically, the excretory formula is $2[(n+n) + (n+n+n)] = 10n$ flame cells.

The embryology of the excretory system (Figs. 15-19) was traced to the extent of observing the major changes during development. In the young embryo each primary tubule extends anteriorly and expands as a small ciliated chamber from which a tubule loops posteriorly and divides into capillaries with a pair of flame cells. Then as the embryo elongates the first suggestion of the anterior-posterior asymmetry of the system appears when a flame cell is added to the posterior tubule on each side. By the time primordia of the eyespots and the tail region of the embryo are evident, each of the ultimate five groups of flame cells is represented by a single flame cell and with further development these cells become paired so that there are 10 flame cells on each side, the posterior pair being in the developing tail. Finally, the number is doubled to give the complete pattern of the emerging cercaria.



- Cercarial body:
9. Showing vestibule, cephalic glands and d.
 8. Showing separate sphincters and pores of two excretory v.

Le Zoffe (1954)

Cercaria caribbea XLIII

(Fig. 1)

Specific diagnosis: Species of moderate size with the general characters of the group. Rests occasionally with the body downward and furcae spread. The anterior end of the caudal vesicle with a yellowish pigment which fades posteriorly. Just posterior to the body capsule there is an area which appears lighter, is devoid of pigment and may be a cavity. Tail stem and furcae without obvious pigment. Eyespots 0.010 long and 0.014 wide. Pharynx 0.028 long and 0.034 wide. Capsule with body in it 0.115 to 0.145 in diameter. Caudal vesicle 0.275 to 0.287 long and 0.281 to 0.308 wide; tail stem 0.411-0.425 long measured on lateral surface from the base of furcae to attachment to vesicle and 0.056 in maximum width. Furcae 0.165 long and 0.030 wide in lateral aspect. Excretory vesicle without refractile concretions.

Host: *Cerithium variabile*.

Localities: Mayagüez (Punta Arenas) and Lajas (Parguera), Puerto Rico.

"... believed --- larva of *Bivesicula hepsetiae*, but --- experimental proof is lacking"
Le Zotte (1954)

Le Zotte (1954)



Cercaria caribbea XLIV LE ZOTTE, 1954 (Fig. 9)

Description: with the characteristics of the bivesiculid group. Body within caudal capsule 0.113-0.116 long, 0.109-0.113 wide; not retract into tail, 0.258-0.265 long, 0.108 in maximum width. Caudal vesicle 0.221-0.242 (0.193-0.207) long, 0.166-0.200 (0.145-0.153) wide. Tail stem 0.450-0.462 (0.410-0.435) long from attachment at vesicle posterior notch between bases of furcae, about 0.10 in maximum height, 0.06 in maximum width. Furcae extend 0.197-0.214 (0.214-0.228) from their lateral confluence with tail stem, about 0.05 high, 0.020-0.022 (0.027-0.034) in maximum width.

Host and locality: *Cerithium variabile* C. B. ADAMS*; Lagoon, Port Royal, Jamaica.

Coble (1963)

Cercaria caribbea XLIV

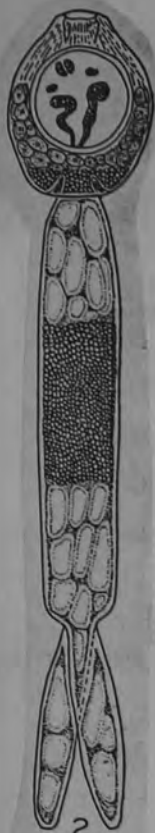
(Figs. 2, 3)

Specific diagnosis: Species of moderate size with the general characters of the group. Resting position with furcae spread. Caudal vesicle and tail stem with characteristic pigmentation; anterior portion of vesicle with dense longitudinal striae, probably muscles, followed by a region occupied by large cells with a pinkish-yellow to orange pigmentation. The posterior region of the caudal vesicle contains a reticulum of purplish-black pigment and approximately the middle third of the tail stem is characteristically marked by similar pigment. Eyespots 0.010 long and 0.014 wide; cuticula fairly thick. Oral vestibule 0.011 in depth; pharynx 0.022 to 0.025 long and 0.030 to 0.042 wide. Diameter of body retracted in caudal vesicle 0.110; detached body 0.275 long and 0.116 wide. Caudal vesicle 0.192 long and 0.144 wide; tail stem 0.48-0.49 from the attachment to vesicle to base of furcae, 0.080-0.085 in maximum width, and tapering toward each end. Furcae 0.192-0.233 long and 0.018 wide in dorsal aspect, 0.034-0.042 in lateral. Excretory vesicles filled with concretions of various sizes.

Host: *Cerithium algicola*.

Locality: Boquerón Bay, Puerto Rico.

Le Zotte (1954)



body not withdrawn into tail capsule.



Cercaria caribbea XLVI

(Figs. 4, 5)

Specific diagnosis: This is the largest species of the group. It rests with furcae extended (Fig. 5). The caudal vesicle except the anterior protuberance is evenly pigmented a dark red color which is almost black in reflected light. So dense is this pigmentation that it is difficult to see the body capsule. No pigment is discernible in the tail stem.

Tail vesicle 0.384 long and 0.322 wide; tail stem 0.603 to 0.650 in length and 0.130 in width. Furcae 0.377-0.410 long and 0.103 wide. Detached body 0.355 long and 0.144 in maximum width at a level one-third from the anterior end. Body retracted in caudal capsule 0.178 in diameter. Pharynx 0.032 long and 0.036 wide; eyespots 0.009-0.011 long and 0.014-0.015 wide. Excretory vesicles filled with small refractile concretions.

Host: *Cerithium algicola*.

Locality: Boquerón Bay, Puerto Rico.

Le Zotte (1954)

Cercaria caribbea XLVII

(Figs. 12, 13)

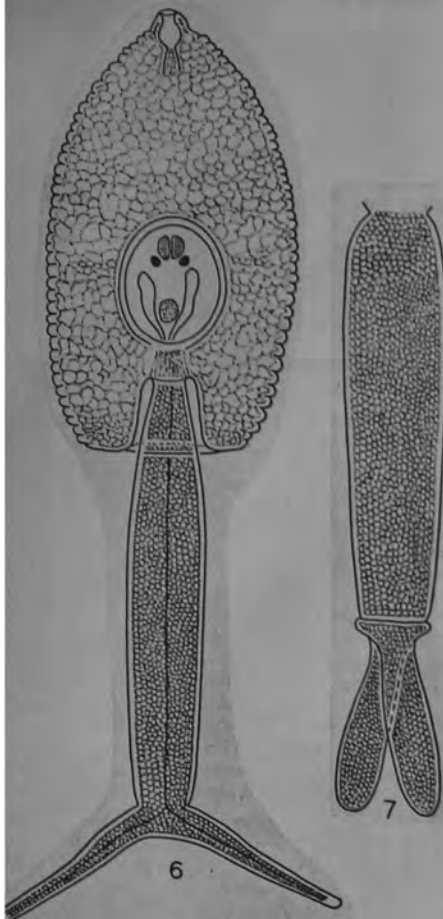
Specific diagnosis: This species is by far the smallest of the group. The caudal vesicle has a bright pink-red pigment and the tail stem a lighter pink coloration. The shape is considerably altered in the heat-killed specimens (cf. Figs. 12 and 13).

Diameter of the body capsule 0.071-0.072; caudal vesicle 0.178 long and 0.117 wide; length of tail stem 0.210, width in lateral aspect 0.062, and 0.041 to 0.047 in dorsal. Furcae 0.085-0.088 long, 0.028 wide in lateral aspect, and 0.020 in dorsal. Excretory vesicles filled with small refractile concretions.

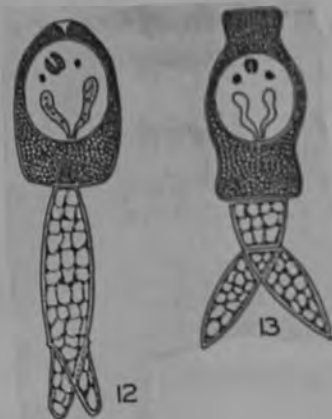
Host: *Cerithium floridanum*.

Locality: Cabo Rojo (Sucia Bay), Puerto Rico.

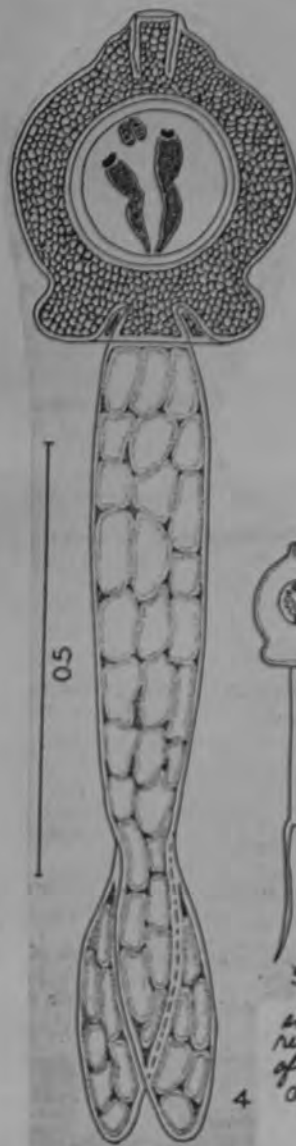
Le Zotte (1954)



dorsal/ventral view



lateral view of tail stem



lateral view



shape and resting position of living *Cercaria*

Cercaria caribbea XLVIII

(Figs. 6, 7)

Specific diagnosis: Species of moderate size, tending to congregate at the surface; without noticeable pigment. The shape is not altered appreciably by heat-killing. The caudal vesicle is greatly enlarged, measuring 0.514 in length and 0.288 in maximum width; body capsule slightly longer than wide, measuring 0.142 long and 0.118 wide. Tail stem 0.493 long, 0.118 wide in lateral, and 0.082 wide in dorsal aspect. Furcae 0.220 in length, 0.048 wide in lateral, and 0.023 in dorsal view.

Body attached to tail but not retracted measures 0.350 in length. Pharynx 0.025 long and 0.028 wide; eyespots cup-shaped with a maximum width of 0.010.

Host: *Cerithium algicola*.

Locality: Cabo Rojo (Salinas Bay), Puerto Rico.

Le Zotte (1954)

MATERIALS AND METHODS

The usual methods of studying cercariae were used. Care was necessary, however, that data of a descriptive nature be obtained from fully developed larvae because of a tendency to emerge before the body is retracted into the tail or even full size is attained. This was especially true after infected snails were kept in the laboratory for a period of time, because often redia as well as incompletely developed cercariae escaped from them. Prematurely emerging cercariae were weak and did not swim in the normal manner. These larvae may differ to such an extent from the fully developed ones as to make identification difficult. For these reasons freshly emerged, active larvae with bodies retracted into the tail were used for measurements after being killed in near-boiling sea water and transferred to a slide with an excess of water to avoid cover glass pressure. By this method specimens were remarkably uniform in size and sources of error were minimized.

Infected snails were cracked to obtain developmental stages. Both larvae and adults were fixed in corrosive sublimate-acetic acid and stained with either Harris' hematoxylin or Semichon's carmine.

Cercariae described in this paper are given the same designations under which they are to be included by Prof. R. M. Cable in a projected monograph of the marine larval trematodes of Puerto Rico.

LIFE CYCLE OF THE BIVESICULIDAE

The evidence at hand concerning the bivesiculid life cycle is not beyond question; technical difficulties prevented experimental studies of a conclusive nature. In the first place, species in this family are evidently highly specific in respect to their definitive hosts. Although hundreds of fishes representing dozens of species were examined and immature bivesiculids were found repeatedly, only *Bivesicula hepsetiae* was obtained sexually mature in natural infections. This species was found in the mature state only in *Atherinomorus stipes* (= *Hepsetia stipes*), the same host from which Manter (1947) reported *B. hepsetiae* at Tortugas, Florida.

Although several species of fish were exposed to cercariae, adult worms were not recovered from any of them. This was not surprising because the chances of finding a suitable definitive host by this method were remote indeed. Difficulty was experienced in obtaining *A. stipes* alive and maintaining it in the laboratory for experiments with the cercaria believed to be the larva of *Bivesicula hepsetiae*, which occurs naturally in that host.

There is good evidence that the life cycle in the BIVESICULIDAE, as in the AZYGIDAE, does not include a second intermediate host. Instead, it seems that the definitive host becomes infected by ingesting the cercaria. The larva is large and an active swimmer; because of these characteristics and its positive reaction to light, the cercaria would attract the attention of the small fishes which are predominantly hosts of the described species of the family. Although cephalic glands are present, there is no indication of cystogenous glands and their absence indicates the lack of an encysted metacercarial stage at least. Finally, the immature worms found repeatedly in the intestine of fishes, were no different in size and appearance from the cercarial body. These all are facts suggesting that the cercariae develop directly to maturity in the intestine of suitable fishes which ingest them.

On an ecological basis, it is believed that the species described below as *Cercaria caribbea* XLIII is the larva of *Bivesicula hepsetiae*, but this cercaria is not so designated because experimental proof is lacking.

Whether or not the life cycle in the BIVESICULIDAE requires a second intermediate host, there can be no question that the cercariae described below are the larvae of members of that family. The unique situation in respect to the digestive and excretory systems and complete agreement between the cercarial stage and the adult leave no room for doubt.

DISCUSSION

When La Rue (1926) proposed the order STRIGEATOIDEA, he included in it three major groups: the blood flukes, the strigeids, and the gasterostomes. At that time, fewer life histories were known than at the present and as additional ones were traced it became evident that still other groups belong in the STRIGEATOIDEA. Thus, have been added the CLINOSTOMATIDAE by Hunter and Hunter (1934), AZYGIIDAE by Szidat (1932), and BRACHYLAEMIDAE by Allison (1943). More recently, Cable (1953) assigned the FELLODISTOMATIDAE to the STRIGEATOIDEA. He traced the life history of a gymnophalline species and concluded that the GYMNOBALLINAE, instead of belonging to the HETEROPHYIDAE or MICROPHALLIDAE, should be placed in the FELLODISTOMATIDAE. His view is supported by observations on several larval fellodistomatids and particularly the life history of *Fello-distomum fellis* as reported by Chubrik (1952). Thus, as additional life histories have been determined, the scope of the order STRIGEATOIDEA has been enlarged far beyond that originally conceived by La Rue. The present study adds still two other groups to the order, namely, the BIVESICULIDAE and the TRANSVERSOTREMATIDAE fam. nov., which is characterized below.

Of particular interest to the present study is the family AZYGIIDAE because its larvae, like those of the BIVESICULIDAE, are cystocercous cercariae with a forked tail. It is suggested that the term furcocystocercous be used to distinguish such larvae from other cystocercous forms, such as the cercariae of the GORGODERIDAE.

In describing the life history of *Hysteromorpha triloba*, a strigeid, Lutz (1931) noted the similarity of the cercaria to *Cercaria mirabilis* Braun and *C. anchoroides* Ward, both of which are furcocystocercous forms. He, accordingly, postulated an affinity of such cercariae to the strigeids and thus anticipated Szidat's (1932) conclusion that the cystocercous larvae of the AZYGIIDAE are basically furcocercous. Wesenberg-Lund (1934), Dickerman (1934), and Hussey (1943) presented further evidence supporting Szidat's view.

In the embryology of the excretory system, bivesiculid cercariae have much in common with the larvae of the cyathocotylids on one hand and those of the azygiids, on the other. In complexity, bivesiculid cercariae are intermediate to the larvae of those well-known groups. While the furcae of the bivesiculid cercariae lack flame cells, the excretory system in the tail is much like that described by Hussey (1943) for the larva of *Proterometra macrostoma* and by Komiya (1941) for *Cercaria shanghaiensis*. The chief difference between these azygiid larvae and the cercariae of the BIVESICULIDAE concerns the excretory tubules in the tail; in the AZYGIIDAE, the tubules fuse in the tail stem, either along its entire extent or with places where the embryonic tubules remain apart and form loops whereas fusion occurs at no place in the tail stem or body of the BIVESICULIDAE. An interesting aspect of the excretory pattern in the BIVESICULIDAE is the antero-posterior asymmetry with one more group of flame cells on the posterior collecting tubule than on the anterior, as compared to the symmetrical arrangement observed in most of the strigeid and cyathocotylid larvae.

Although the adults of the BIVESICULIDAE are similar to the MONORCHIIDAE, a careful examination shows that such resemblances are secondary and that the adult bivesiculids as well as their larvae have more in common with the strigeatoids. In several strigeatoid families, the genital pore is at the posterior end of the body and the cirrus sac is inverted, that is, directed posteriorly, as in the BIVESICULIDAE. In that family, however, the absence of a ventral sucker gives no point of reference for the location of the genital pore, which can be described only as being on the ventral side of the body and posterior to the mid-level. The excretory system of both larval and adult bivesiculids is entirely compatible with features of that system in the STRIGEATOIDEA. Furthermore, the few large eggs in the BIVESICULIDAE are similar to those found in many strigeatoids, and the development of the miracidium, so far as was determined, corresponds to that of the strigeids and schistosomes. The bivesiculids are, however, different from other members of the order in a number of respects, including the presence of an external seminal vesicle, the complete separation of the right and left halves of the excretory system, and the presence of a single testis, which, however, has two vasa efferentia.

Le Zote (1954)

Bivesiculid cercariae

For a general diagnosis of the group see CABLE (1956). Previously overlooked in these larvae was the fact that in retracting into the caudal vesicle after emerging from the snail, the body turns so that it presents a lateral view when the tail is observed from its dorsal or ventral aspect.

One new bivesiculid cercaria found during this study has been described as the larva of *Bivesicula caribbensis* by CABLE and NAHHAS (1962). It was found only in Curaçao where the definitive host is much more common than in Jamaica and Puerto Rico but the adult was recovered from that host in Jamaica. No other bivesiculid larvae were found in Curaçao where the molluscan hosts, exclusively species of *Cerithium*, were abundant. Moreover, a large number of hard-head silver-sides (*Hepsetia stipes*) examined there contained no *Bivesicula hepsetiae*, a common parasite of that fish in Puerto Rico. The bivesiculids, then, strongly indicate the isolation of certain host populations in waters adjacent to islands of the Caribbean Sea.

In contrast to Curaçao, bivesiculid cercariae were abundant in Jamaica. However, their identity is uncertain because they resemble species reported from Puerto Rico and yet show differences and variations that are difficult to evaluate. That situation is well illustrated by the first species below; it is much like one in Puerto Rico and is tentatively so identified. It evidently has a pigmented and non-pigmented form but the snail sheds one or the other and not both as in the zygocercous species, *Cercaria clausii* which, however, is not a bivesiculid larva. The pigmented form is larger in some dimensions than the non-pigmented one, suggesting that the species may be shed as more completely developed larvae by one snail than by another; it is not unusual for immature cercariae and even rediae of the bivesiculids to escape from snails isolated for several days. However, when two infected ones were observed closely for two weeks, one shed large numbers of the non-pigmented form daily before 8:00 A.M. whereas the other snail shed many pigmented cercariae each day at almost exactly 11:00 A.M. Although the hosts received no food during that time, the larvae that escaped from each one were uniform in size, and no cercarial embryos or rediae were observed in the dishes.

In the following description, dimensions in parentheses are of non-pigmented larvae when different from the pigmented form which agrees very closely with the original description of the species, even though the host in Jamaica is a much smaller snail than the one in Puerto Rico. The non-pigmented form shows a colorless reticulum in the caudal vesicle and tail corresponding to pigmentation in the other form. In measurements of the tail stem and furcae, "width" and "height" are transverse dimensions from dorsal (or ventral) and lateral views, respectively.

Cable (1963)

BIVESICULID CERCARIAE

Since the family Bivesiculidae is represented by a single known adult species in the Gulf-Caribbean area, it was most unexpected to find 6 species of cercariae that could hardly be other than larvae of that group. It was equally surprising to find that the life history affords convincing evidence that the Bivesiculidae, hitherto believed related to the Monorchiidae, instead are to be included in the Strigeatoidea. The writer's student, L. A. Le Zotte, Jr., has made this group the subject of his doctoral thesis, and his observations have been published elsewhere (Le Zotte, 1952, 1954). For completeness, however, brief descriptions of the cercariae he reported are included here. Their common characteristics are given in the following general diagnosis:

Furcycystocercous, *i.e.*, with tail bifid distally and base enlarged to form a caudal vesicle into which the body typically is withdrawn in fully developed, spontaneously emerging larvae; caudal vesicle sharply set off from remainder of tail. Tail often strikingly pigmented, stem and furcae flattened laterally and efficient in swimming. Body small, spherical when in caudal vesicle, rather spindle-shaped with more rounded anterior end when free or outside vesicle but attached to it. Entire body spinose. Body pigment restricted to a pair of black eyespots. Mouth terminal, a short atrium leading into muscular bulb having more the appearance of a pharynx than an oral sucker, as it has been interpreted in adult bivesiculids. Esophagus rather long and muscular, joined by two narrow ceca that extend well toward posterior end of body. A number of cephalic glands near intestinal bifurcation with ducts opening into oral atrium. Primordia of reproductive system usually well developed. Most conspicuous feature of cercarial body is a pair of long tubular thin-walled excretory vesicles extending well anterior to mid-level, narrowing posteriorly, with separate sphincters, and usually filled with refractile concretions. Excretory vesicles continuous, with right and left caudal tubules that extend posteriorly without fusing and diverge to pass through furcae to pores at their tips. Caudal excretory tubules difficult to trace except in developmental stages, being obscured in emerging cercariae by the vacuolated parenchyma of tail. From anterior end of each excretory vesicle, a ciliated recurrent tubule extends posteriorly median to vesicle, crosses it at about mid-level, and receives an anterior and a posterior collecting tubule, both of which may be ciliated to the point that the first flame cell group is received. Anterior tubule with 2 groups of flame cells, posterior with 3, of which one is in the tail with half its flame cells in the vesicle and half in the proximal regions of the tail stem. Develop in rediae with a bifurcated posterior end; excretory pores of rediae at the tips of the blunt processes. Radial excretory pattern basically the same as in the cercaria. Hosts: marine prosobranch gastropods.

Cable (1956)

Cercaria caribbea XLV
(Figs. 10, 11)

Specific diagnosis: This is the second largest species of the group. It swims for short periods and rests on the bottom with the furcae extended (Fig. 11). Tail with distinctive pigmentation; the caudal vesicle has 2 pairs of prominent black pigment masses confluent posteriorly with similar pigment around the capsule itself. A dorsal and ventral mass form a pair which is somewhat anterior to the less conspicuous lateral masses. A more diffuse golden-brown pigment occurs around the passage through which the body is withdrawn into the caudal vesicle. Similar brownish pigment is distributed along the edges of the tail stem while the furcae have a marginal reticulum of purplish-black pigment. This black pigment persists after the specimens are heat-killed or even fixed and prepared as whole mounts. Such treatment, however, causes contraction of circular muscles so that the shape of the tail is considerably altered from the living specimens in which the vesicle is more bell-shaped.

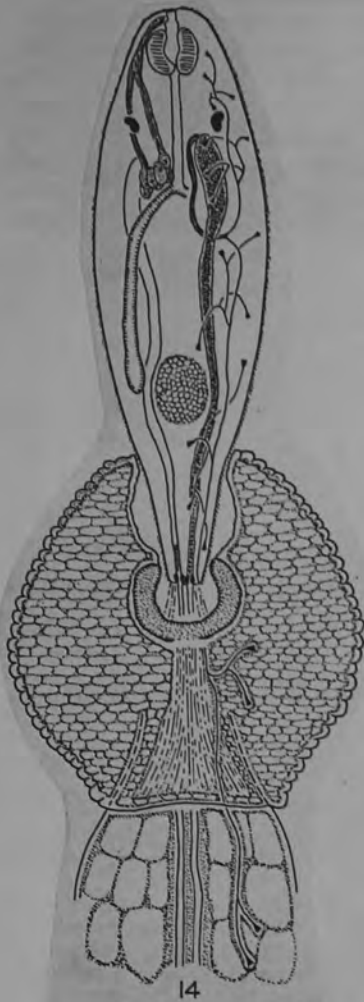
Caudal vesicle 0.308-0.320 long with a maximum width of 0.178; tail stem 0.575 long from attachment to base of furcae and 0.130 in maximum width at about middle. Furcae 0.384 long and 0.130 wide in lateral view. Retracted body 0.137-0.150 in diameter. Eyespots 0.011 long and 0.014 wide. Pharynx spherical, 0.031 in diameter.

Excretory vesicles filled with refractile spherical concretions of various sizes and opening into a slight depression at the posterior end of the detached body (Fig. 8). Flame cell formula of cercaria 2 [(4+4) + (4+4+4)] and of redia 2 [(4+3) + (3+3+4)].

Host: *Cerithium algicola*.

Locality: Boquerón Bay, Puerto Rico.

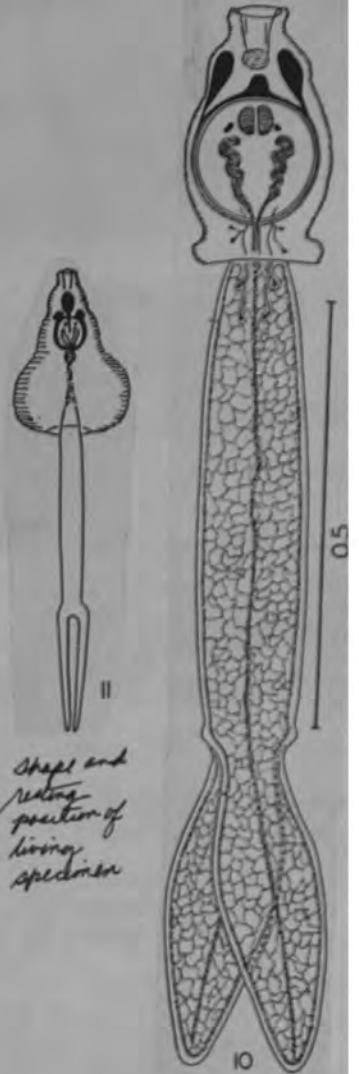
Le Zotte (1954)



body and proximal tail region enlarged to show details of excretory system.



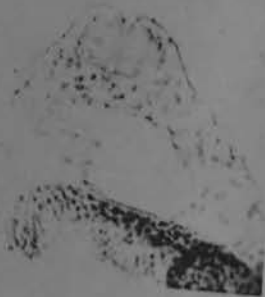
Developmental stages of excretory system.



shape and resting position of living specimen

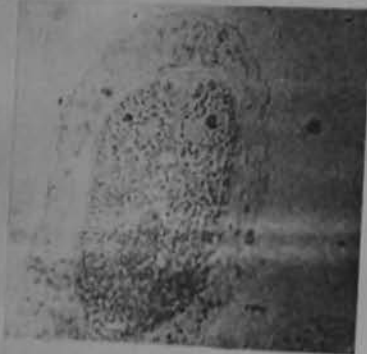
lateral view

Cercaria caribbea XLV



27

longitudinal section
through pharynx of
redia.



28

frontal section of advanced
conary.



29

whole mount of redia
photographed to show
cleft of posterior end.



30

lateral end of redia
showing location of
germinal mass (arrow).



31

frontal section of
cercarial body showing
genital primordia, uterine
vesicles and their
sphincters.

Cercaria caribbea LVI n. sp. (Figs. 10 and 11)

Description: small cercaria with characteristics of the bivesiculid group. Retracted body 0.094—0.125 long, 0.094—0.103 wide, with pharynx 0.021—0.025 long, 0.028—0.032 wide; body not retracted, 0.221—0.265 long, 0.084—0.097 in maximum width, with pharynx 0.025—0.030 in diameter. Cuticle finely spinose, eyespots 0.012—0.014 by 0.009—0.010. Excretory vesicles with relatively few scattered concretions. Entire tail pink in reflected, brownish-pink in transmitted light. Some specimens with purplish pink pigment in middle third of vesicle, others with pigment scattered through anterior third as well. Tail stem with anterior yellowish zone followed by gradually deepening pink coloration; furcae pinkish. Caudal vesicle 0.186—0.242 long, 0.169 to 0.210 wide; tail stem 0.275—0.310 long from attachment at vesicle to base of furcae, 0.083—0.095 high, 0.045—0.048 wide; furcae 0.090—0.105 long, 0.025—0.030 in maximum height, 0.016—0.021 in maximum width. Development in furcocercous rediae in branchial region of host; excretory pores at tips of furcae. Intestine of redia short, yellowish; body wall with annulated appearance when contracted, containing yellow to orange yellow pigment.

Host and locality: *Cerithium variable* C. B. ADAMS; Lagoon, Port Royal, Jamaica.

This species resembles most *Cercaria caribbea* XLVII but has a larger body and caudal vesicle and a longer tail stem. Like other bivesiculid cercariae, it is strongly photopositive. The larva rests infrequently and then but momentarily whereas other species may rest long enough or remain sufficiently quiet under light coverglass pressure to be measured and drawn as living specimens. For that reason, Fig. 11 was drawn from a specimen killed in cold corrosive sublimate-acetic acid in which the size and shape closely approximated those of the living cercaria. The above measurements, however, are from heat-killed specimens.

Cable (1963)



cold fixation and
approximating appearance
of living specimen

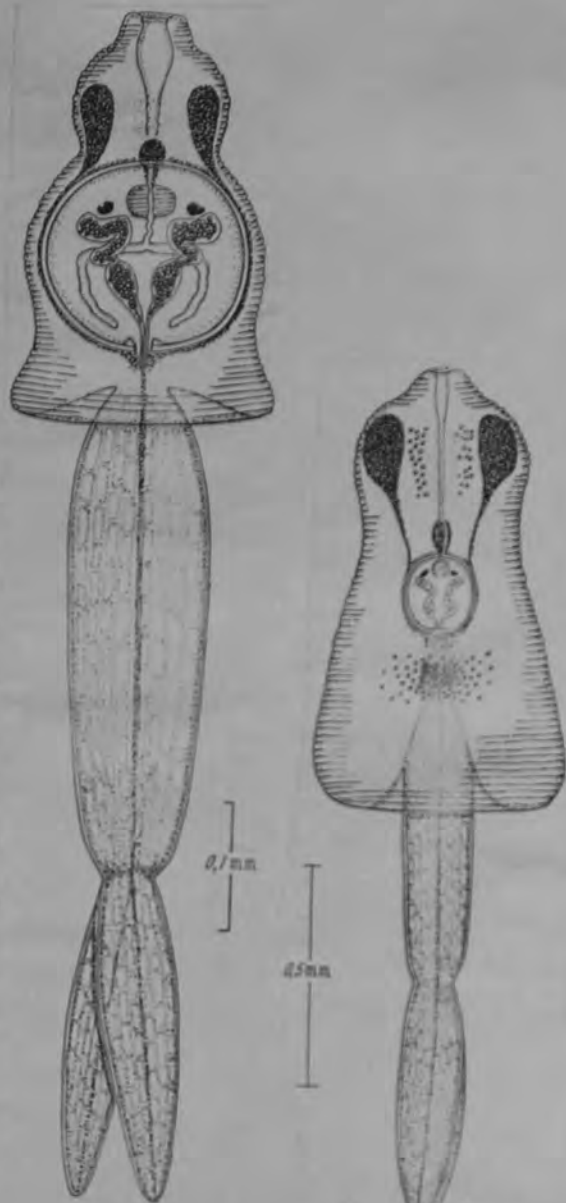
Cercaria caribbea LVII n. sp. (Figs. 12 and 13)

Description: with the characters of the bivesiculid group. Body within caudal capsule 0.133—0.135 long, 0.142—0.145 wide, difficult to see because of surrounding pigment; body not retracted, 0.290—0.331 long, 0.145 in maximum width, with pharynx 0.031—0.038 long, 0.036—0.039 wide. Eyespots 0.010 by 0.020. Excretory concretions numerous, very refractile. Caudal vesicle bell-shaped, somewhat variable in heat-killed specimens, 0.311—0.317 long; its maximum width 0.173 to 0.206, sometimes at posterior flange, sometimes at midlevel of body capsule. Vesicle with yellow pigment and colorless droplets around base of anterior funnel; a dorsal and a ventral mass of purplish-black pigment, narrowing posteriorly and blending into layer of similar pigment surrounding body capsule; a smaller and more posterior pair of lateral, smudge-like pigment masses close to surface of vesicle, independent of other pigment. Mid-region of vesicle posterior to body capsule with numerous droplets. Tail stem 0.380—0.393 long, 0.110—0.117 high, 0.062—0.070 in maximum width; dorsal and ventral edges of tail stem with brownish-orange pigment except near base. Furcae 0.235—0.270 long, 0.055—0.059 in maximum height, their greatest width 0.028—0.030; edges of furcae with reticulum of reddish-black pigment. Development in furcocercous rediae as in preceding species.

Host and localities: *Cerithium algicola* C. B. ADAMS; Kingston Harbor and Lagoon, Port Royal, Jamaica.

This cercaria may be a variant of *C. caribbea* XLV because their caudal pigmentation is so similar and distinctive. Also most of their measurements agree but the tail stem and furcae of the present form are much shorter than those of *C. caribbea* XLV with the stem being but little more than half as long as in that species.

In embryos of this cercaria, the conspicuous pigment masses of the caudal vesicle are yellow at first but change through orange, red and purple, which are soluble in hot sea water and histological reagents, to purplish black pigment which is not. This change and observations on the preceding species imply that caution must be exercised in using pigmentation to differentiate species of bivesiculid cercariae. This study brings to 9 the number of such larvae reported from the Caribbean region. Yet despite the examination of many fishes there, but 2 adult bivesiculid species have been recognized. Others probably will be found in small host species that have not yet been examined in sufficient numbers to disclose them. Immature bivesiculids were found in a variety of fishes but probably were the bodies of recently ingested cercariae and could not persist and become mature in those hosts. It thus seems that the bivesiculids are host specific to a high degree.



Cable (1963)

13
lateral view of
heat-killed specimen

12
lateral view of
living specimen

Cercaria caribbea XLIII (FIGURE 105)

Specific diagnosis: with the characters of the group. Body in caudal vesicle oval, 0.135 to 0.145 by 0.115; vesicle with narrow invaginated anterior protuberance and 0.278 to 0.287 in total length; increases to a maximum width of 0.281 to 0.308 posteriorly just before turning under to join tail stem, the attachment of which is hidden by posterior edge of vesicle. Yellowish pigment especially prominent near anterior end of vesicle, fading out posteriorly where there is a light area having the appearance of a cavity. Tail stem measured along lateral margin from attachment to base of furcae 0.410 to 0.425 in length; width from dorsal or ventral aspect 0.056 to 0.063. Furcae about 0.150 to 0.165 long and 0.030 to 0.040 wide. Tail stem and furcae without noticeable pigment. Pharynx 0.028 long and 0.034 wide when body is in caudal vesicle.

Host: *Cerithium variabile*.

Localities: Punta Arenas, Isla de Ratonas, and La Gata, off Parguera.

This species swims tail first by flexing the tail stem, resting occasionally body downward with furcae spread. It is strongly photopositive, and the larvae soon concentrate in the most strongly illuminated part of the dish.

Cercaria caribbea XLIV (FIGURES 106 to 107)

Specific diagnosis: with the characters of the group. Anterior part of caudal vesicle with dense longitudinal striae, probably muscles, followed by a pigmented zone shading from yellow to orange with a reticulum of purplish-black pigment conspicuous at posterior edge of vesicle. Tail stem with nonpigmented basal portion followed by a wide zone of purplish-black pigment. Caudal vesicle 0.192 long and 0.144 in maximum width at about middle. Body 0.110 in diameter when in caudal vesicle, 0.275 long and 0.116 in maximum width in heat-killed detached bodies. Tail stem 0.48 to 0.49 long and 0.080 to 0.085 in maximum width; furcae 0.192 to 0.233 long and 0.018 wide at base from dorsal aspect, 0.034 to 0.042 in lateral. Pharynx 0.022 to 0.025 long and 0.030 to 0.032 wide. Eyespots about 0.010 by 0.014.

Host: *Cerithium algicola*.

Locality: Boquerón Bay.

This species has essentially the same behavior as the preceding one. It is decidedly less common.

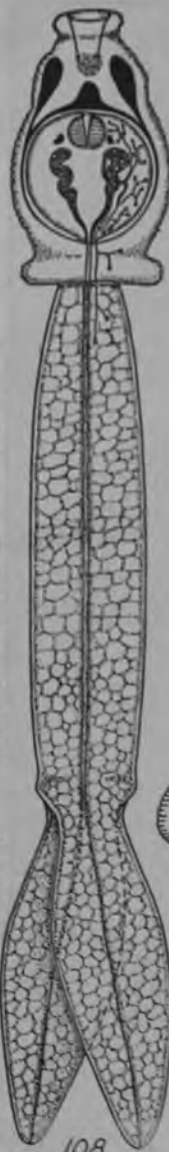
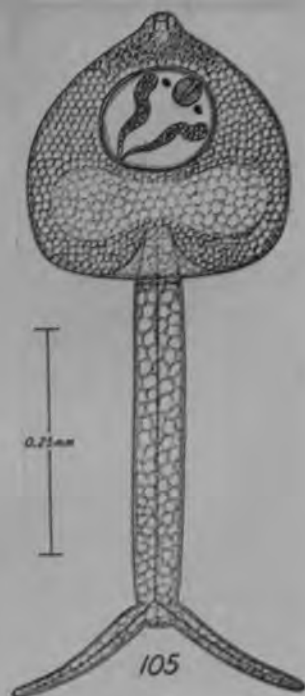
Cercaria caribbea XLV (FIGURES 108 and 109)

Specific diagnosis: with characters of the group. Distinctively pigmented: Caudal vesicle with golden-brown pigment near inner end of passage for body and with very conspicuous paired lateral and dorsoventral black pigment masses having the appearance of eyespots anterior to body capsule, with lines extending posteriorly from them and blending into a thin layer of black pigment enclosing the retracted body. Dorsal and ventral edges of tail stem with golden-brown pigment, furcae with a marginal reticulum of purplish-black pigment. Caudal vesicle bell-shaped and expanded posteriorly in living specimens, more contracted and with a distinct posterior flange in heat-killed ones. Vesicle 0.308 to 0.320 long and 0.178 in maximum width. Tail stem 0.575 long and about 0.130 in maximum width from lateral aspect, furcae 0.38 to 0.39 long and about 0.130 in maximum width from lateral aspect. Body within caudal vesicle 0.137 to 0.150 in diameter, pharynx 0.030 to 0.032 in diameter, eye spots about 0.011 to 0.014. Excretory formula $2[(4 + 4) + (4 + 4 + 4)]$ with the last group on each side in the tail, 2 flame cells in the vesicle, and 2 in the tail stem. Excretory formula of redia $2[(4 + 3) + (3 + 3 + 4)]$.

Host: *Cerithium algicola*.

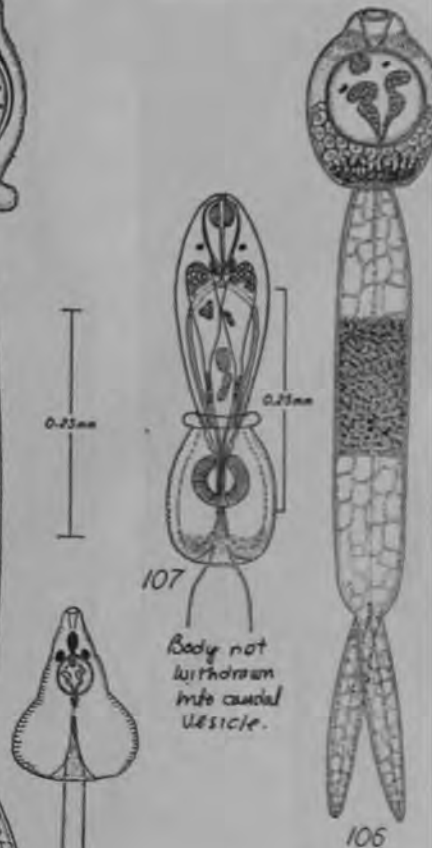
Locality: Boquerón Bay.

This species is large and immediately recognized by the black pigment masses in the caudal vesicle. It swims tail-first toward the light with furcae spread and tail stem vibrating. It rests on the bottom with the tail extended and furcae together (FIGURE 109). A number of cercariae resting in this manner, all parallel and with tails toward the light, is a striking sight.



Cable (1956)

Lateral view showing flattened tail stem and furcae.



Body not withdrawn into caudal vesicle.

Furcae in side view.



Shape of living specimen; tail stem and furcae in edge view.

Cercaria caribbea XLVI (FIGURE 110)

Specific diagnosis: the largest species of its type and with a deep red caudal vesicle almost black by reflected light. Tail stem and furcae usually colorless, but sometimes with very light pink pigmentation. Caudal vesicle 0.38 to 0.39 long and 0.322 in maximum width at about mid-level; posterior end with a prominent flange in both living and heat-killed specimens. Body retracted 0.178 in diameter; free, 0.355 long, and 0.144 in maximum width. Tail stem 0.60 to 0.65 long and 0.13 in maximum width from lateral aspect; furcae 0.377 to 0.410 long and 0.103 wide. Pharynx 0.032 long and 0.036 wide, eye spots 0.009 to 0.011 by 0.014 to 0.015. Flame-cell formula $2[(+ + 4) + (4 + 4 + 4)]$ with the last group on each side in the tail, 2 flame cells in the vesicle, and 2 in the tail stem.

Host: *Cerithium algicola*.

Locality: Boquerón Bay.

The large size and deep red pigmentation of the caudal vesicle distinguish this species from others of its type. In swimming activity and behavior, it is much like *Cercaria caribbea* XLV but swims rather more energetically. When killed in hot water, the shape and size of the caudal vesicle is much less altered than in that species, but the red color escapes into the water, whereas the black pigment of the preceding cercaria is unaffected and is distinct in specimens prepared as stained whole mounts.

Cercaria caribbea XLVII (FIGURES 111 and 112)

Specific diagnosis: the smallest species of its type. Caudal vesicle bright pink-red in color, tail stem with pigment less concentrated and light pink in appearance. Shape considerably altered when heat-killed. Body within caudal vesicle 0.071 to 0.073 in diameter. Caudal vesicle 0.17 to 0.18 long and 0.115 to 0.120 wide. Tail stem about 0.20 long and with a maximum width of 0.062 in lateral aspect, 0.041 to 0.047 in the horizontal plane. Furcae 0.085 to 0.088 long and 0.028 wide at base in vertical plane, 0.020 in horizontal.

Host: *Cerithium muscarum*. (corrected identification).

Locality: Sucia Bay near tip of Cabo Rojo.

Cercaria caribbea XLVIII (FIGURE 113)

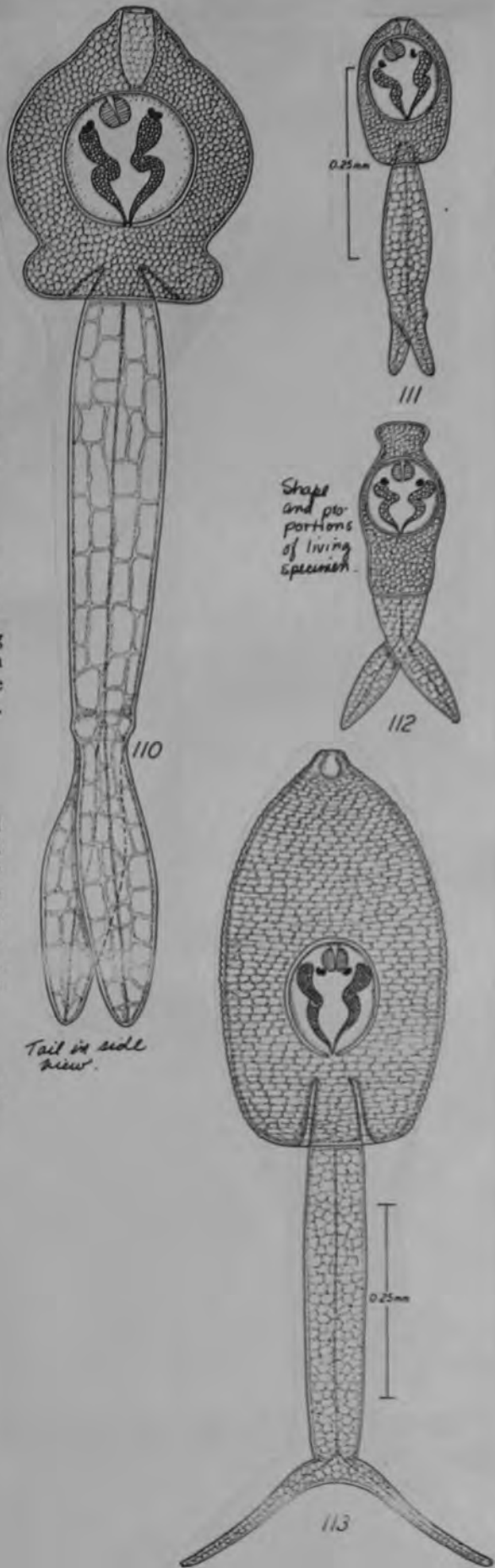
Specific diagnosis: species of moderate size and with greatly inflated caudal vesicle which may remain so when heat-killed. Length of body within caudal vesicle, 0.140 to 0.145; width 0.118 to 0.120; outside but attached to tail, body is about 0.350 long. Tail without noticeable pigmentation, vesicle 0.510 to 0.514 long and 0.286 to 0.290 in maximum width; stem 0.490 to 0.496 long and with a maximum width of 0.082 in horizontal plane, 0.118 from lateral aspect. Furcae about 0.22 long and with a maximum width of 0.023 in horizontal plane, 0.048 from lateral aspect. Pharynx 0.025 long and 0.028 wide. Eyespots with a maximum dimension of about 0.01.

Host: *Cerithium muscarum*. (corrected identification).

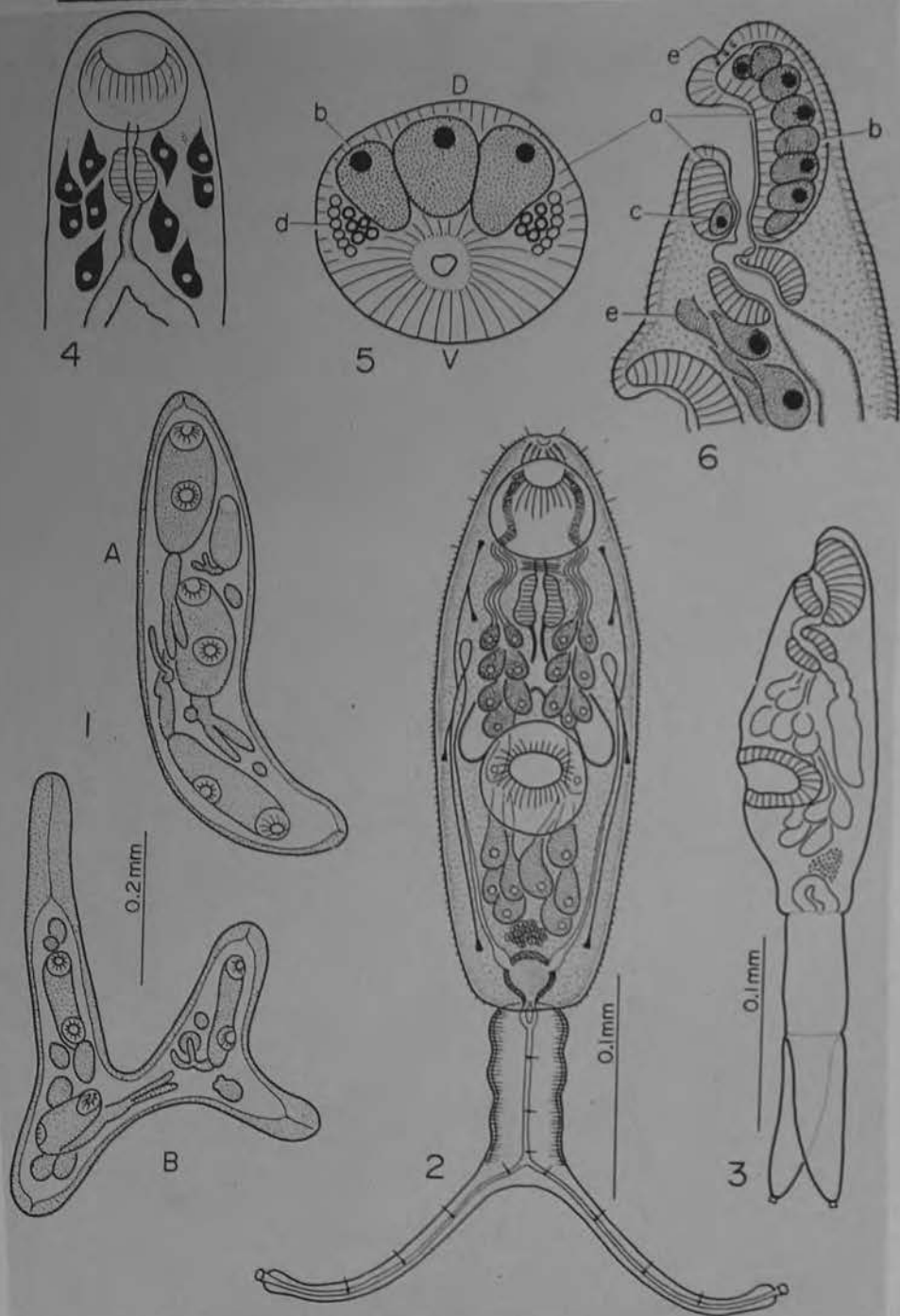
Locality: Salinas Bay near Punta Jagüey, Cabo Rojo.

This species is distinguished by the greatly inflated caudal vesicle and absence of pigment. The larvae swim tail first toward the light and congregate near the surface.

Cable (1956)



RIVESIBULIPAE

Amblosoma suwaense Shimazu, 1974

Explanation of Figures

- Figs. 1-6 The sporocyst and cercaria of *Amblosoma suwaense* Shimazu, 1974, found in *Simotata quadrata* (Benson).
- Fig. 1 An unbranched (A) and a branched (B) sporocyst.
- Fig. 2 A fully-formed cercaria, ventral view.
- Fig. 3 Another fully-formed cercaria, lateral view.
- Fig. 4 Mucoid glands in a mature cercaria in a sporocyst.
- Fig. 5 A transverse section of the oral sucker (a) of a mature cercaria, showing acidophilic, unicellular gland cells (b) located between the bundles of the penetration-gland ducts (d) in the dorsal wall. D: dorsal, V: ventral.
- Fig. 6 A sagittal section of a mature cercaria through the oral sucker (a), showing acidophilic, unicellular cells (b) packed densely in the dorsal wall of the oral sucker, a basophilic, unicellular gland cell (c) in the bottom of the ventral wall of the oral sucker, and the penetration glands and their ducts (e).

Sporocyst

Sporocysts were found in the interlobular connective tissue of the digestive gland of *S. quadrata*. They were white in colour, and unbranched or branched in shape. Unbranched ones were sausage-shaped (Fig. 1A). It was impossible to determine what extent the sporocysts had branched out to, because they were easily torn to pieces when dissected out. In branched ones taken out intact (Fig. 1B), some of the terminal tips of outgrowths appeared to open to serve as birth-pores. The sporocysts of both shapes contained only the cercarial generation at various stages of development from germ balls to fully-formed cercariae.

Cercaria

The morphology and measurements of mature cercariae were as follows (Figs. 1-6):

Body proper elongate-oval, slightly wider anteriorly than posteriorly, spinous, 0.203-0.257 mm long by 0.063-0.102 mm wide. Tail forked, well developed, functional, aspinose; stem 0.050-0.084 mm long by 0.021-0.027 mm wide; furcae laterally flattened, 0.063-0.143 mm long. Sensory hairs numbering at least 32, five pairs on lateral margins of anterior part of body, three pairs on ventral and dorsal mid-lines of tail stem, and four pairs on ventral and dorsal margins of each tail furca. Many minute papillae without sensory hairs scattered around ventral orifice of oral sucker. Eye-spots, stylet, and finfolds absent.

Oral sucker ellipsoidal, subterminal, 0.042-0.046 mm long by 0.038-0.049 mm wide. Ventral sucker rounded, slightly posterior to middle of body, 0.037-0.046 mm long by 0.034-0.044 mm wide. Prepharynx very short. Pharynx barrel-shaped, 0.020-0.027 mm long by 0.017-0.020 mm wide. Oesophagus short. Intestinal caeca short, extending only to mid-level of ventral sucker.

Penetration glands divided into two distinct groups; anterior one consisting of six or seven pairs of smaller gland cells, more finely granular, acidophilic, distributed between pharynx and ventral sucker; posterior one composed of about five pairs of larger cells, finely granular, basophilic, situated dorsal and posterior to ventral sucker. Fine ducts of penetration glands on each side of body running forward in a bundle, passing through oral sucker, in which the ducts of the anterior group and those of the posterior group lie in an outer or lateral and an inner layer of bundle respectively (Fig. 5, d), opening separately into a small pit on anterior end of body. Many unicellular glands (number unknown) packed densely between two bundles of penetration-gland ducts in dorsal wall of oral sucker, ovoid, large, with acidophilic cytoplasm (Figs. 5 and 6, b). One or more large unicellular glands with basophilic cytoplasm seen in

bottom of ventral wall of oral sucker (Fig. 6, c). Mucoid glands consisting of five pairs of cells, three in inner longitudinal rows and two in outer, located between oral sucker and intestinal bifurcation (Fig. 4).

Primordium of reproductive organs forming a mass of cells situated immediately anterior to excretory bladder. Excretory system stenostomate. Excretory bladder not epithelial, thick-walled, globular, small, in posteriormost part of body, with spined internal surface, discharging with a median caudal tube, which runs down through the tail stem, bifurcates at the furcae, and opens through a cup on each furcal tip. Lateral main collecting tube on each side of body reaching to oesophageal level, there turning backward to near ventral sucker; ascending limb short, bearing three cilia; descending limb non-ciliated, forming a small dilation just before entering bladder. Flame-cell formula $2[(1+1)+(1+1)]=8$; no flame-cells in tail. Cort's island present.

Results of experimental infection

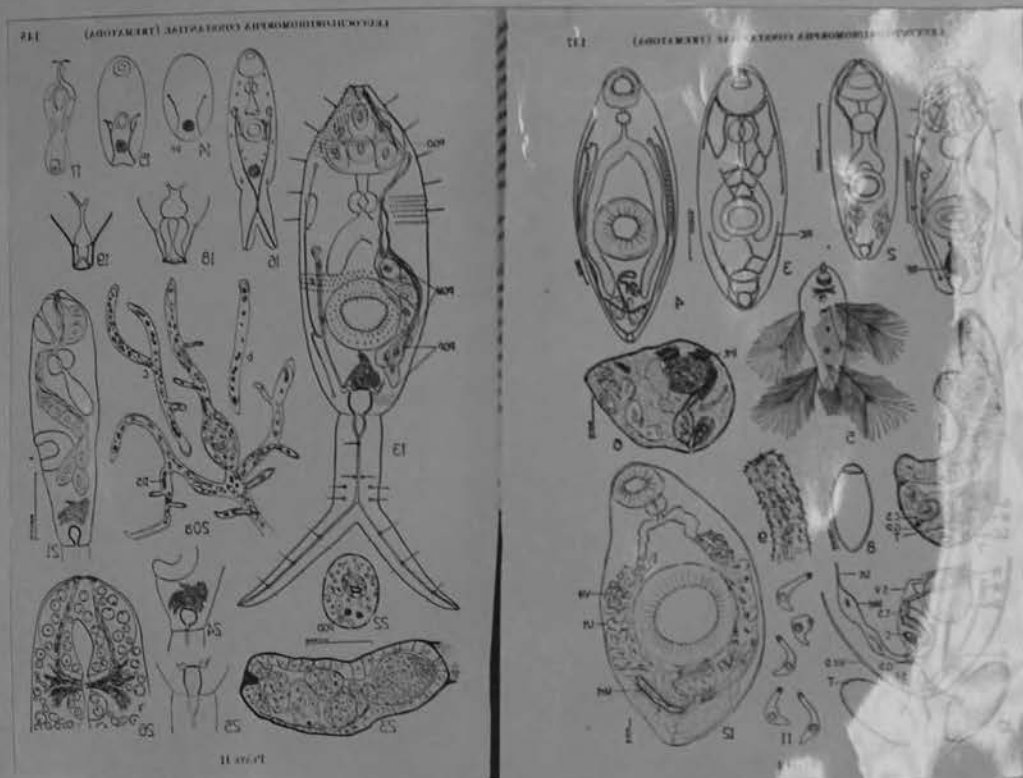
Of the 40 experimental snails used, 19 survived and were examined for metacercarial infections. Each of them harboured 3 to 24 (mean 12.6) unencysted metacercariae in the bottom of the space between the digestive gland and shell. All the metacercariae recovered were identified as *A. sawaense*.

One month after exposure 34 metacercariae were recovered. They were closely similar in morphology to the previously-described cercaria except for the following minor differences: The tailless body was slightly larger in size, measuring about 0.25 mm long by 0.13 mm wide; the intestinal caeca were a little longer and more largely distended; and the penetration glands had disappeared. The genital primordium still remained a cellular mass. The excretory system was the same as that of the cercarial body proper. Afterwards, the growth and development of the metacercariae were slowly progressive. Five months after exposure 45 worms were recovered. They were still immature, and fourteen of them were measured as follows: body 0.816-1.550 mm long by 0.265-0.448 mm wide; oral sucker 0.085-0.140 mm long by 0.097-0.157 mm wide; ventral sucker 0.097-0.170 mm long by 0.110-0.208 mm wide; and pharynx 0.055-0.085 mm long by 0.055-0.072 mm wide. The major genitalia had already been feebly differentiated except the vitelline glands which were not yet recognizable.

From SHIMAZU, 1978

Leuchloridiomorpha constantiae (Mueller, 1935) Allison, 1943

Reverse prints.
 From Allison, 1943 (see reprint)
 Trans. Am. Micr. Soc. 62: 127-168



Postharmostomum helcis (Leidy, 1847) Robinson, 1949

LIFE HISTORY OF POSTHAR MOSTOMUM HELCIS

325

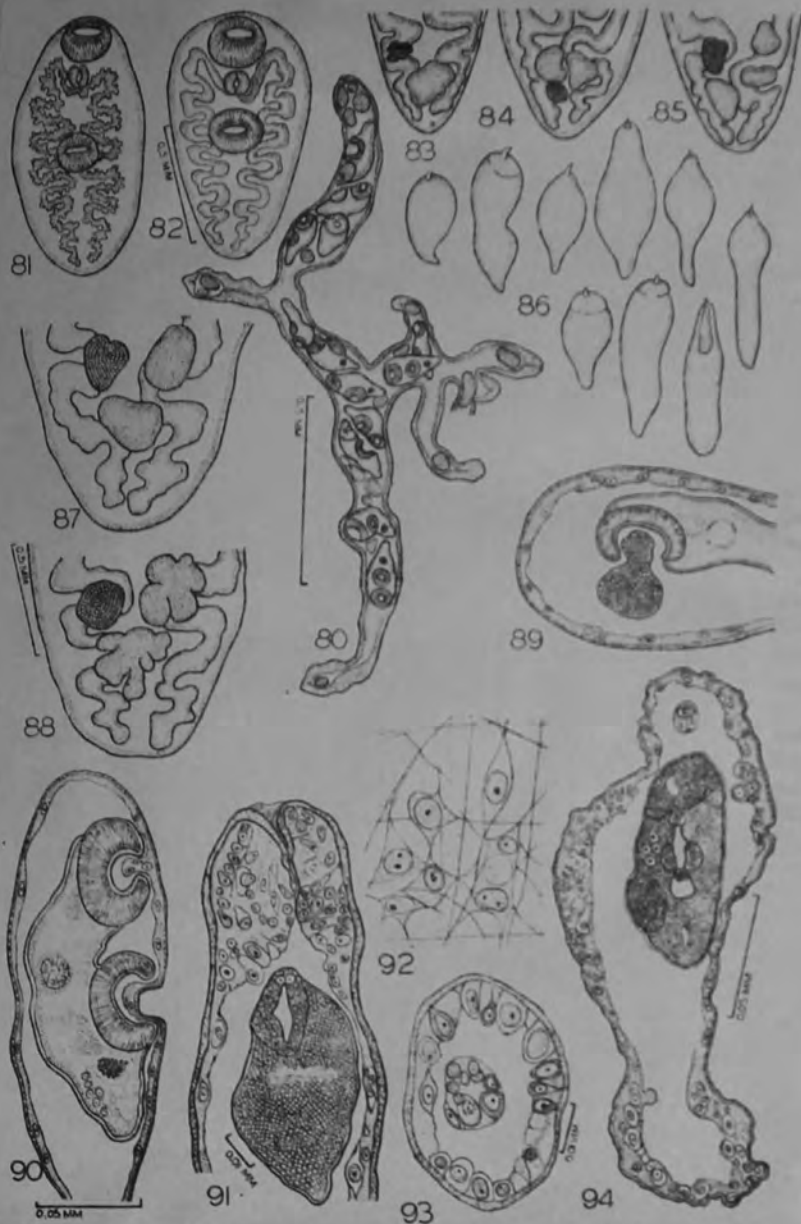


- FIGS. 45a, 46a, 47a, 48a and 49-52. Stages in the development of the excretory system of *Postharmostomum helcis* from the early embryo to the nearly mature cercaria, all in dorsal view except Figure 47a which is in lateral view. Vitelline membrane and nuclei shown only in Figure 47a. Penetration glands and ducts omitted.
- FIG. 53. Cross-section of cercaria of *P. helcis* within sporocyst, through region of pharynx, showing ducts of penetration glands.
- FIG. 53a. Mature emerged cercaria of *P. helcis*, dorsal view. Camera lucida outline of formalin-fixed specimen with details added from living specimens. Excretory system shown only on one side. Note presence of vitelline membrane, although nuclei of membrane are not visible.
- FIG. 53b. Variations in number and arrangement of pre-acetabular groups of flame cells in emerged cercaria. Free-hand drawings.
- FIG. 53c. Variations in arrangement of flame cells of post-acetabular groups in emerged cercaria. Free-hand drawings.
- FIG. 54. Mature emerged cercaria of *P. helcis*, lateral view, showing course of ducts of penetration glands.

All drawings were made with the aid of the camera lucida, unless otherwise specified.

From ULMER, 1951

-over-



- FIG. 80. Portion of 20-week (daughter) sporocyst of *Postharmostomum helicis* containing numerous cercariae and embryos.
- FIGS. 81, 82. Variations in appearance of intestinal crura in 4-day adults of *Postharmostomum helicis*. Unflattened stained specimens from the same mammalian host (*Peromyscus maniculatus*).
- FIGS. 83-85. Anomalies in genital glands of adult *P. helicis*.
- FIG. 86. Miracidia of *P. helicis*, various positions.
- FIGS. 87, 88. Variations in shape of testes of *P. helicis* adults. Both specimens from same feeding experiment, adults of similar age (80 days).
- FIG. 89. Cercaria of *P. helicis* within sporocyst, attached to cercarial embryo by means of oral sucker.
- FIG. 90. Cercaria of *P. helicis* within sporocyst showing attachment to sporocyst wall by means of oral sucker and acetabulum.
- FIG. 91. Birth pore of daughter sporocyst, 13-week infection.
- FIG. 92. Surface of daughter sporocyst, 13-week infection.
- FIG. 93. Cross-section of branch of daughter sporocyst, 13-week infection.
- FIG. 94. Longitudinal section through 13-week (daughter) sporocyst. Note well-developed cercaria within lumen.

FROM ULMER, 1951

Brachylaimus oesophagei Shaldybin, 1953

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Life History of *Brachylaimus oesophagei*

worms were obtained from cat, chicken, dog, opossum and rat. Krull (1935) also showed that two types of infected snails, *Polygyra thyroides* exist in the life history of *B. virginiana*, those snails with and those without sporocysts. Infected specimens of *P. thyroides*, harbouring sporocysts from which cercariae were emerging, could be detected by examining the surface of the body of *P. thyroides*, which are usually covered with active cercariae wandering in the slime produced by the snail. The cercariae may be transferred by contact from one snail to another, where they develop into metacercariae in the kidney. Alicata (1940) also established that cercariae of *Postharmostomum gallinum* (Witenberg, 1923) developed into metacercariae in terrestrial snails, other than those in which the cercariae were found. Sinitsin (1931) on the other hand suggested that cercariae of the Brachylaimidae emerge from the digestive gland of the snail and leave by the anus to re-enter the host through the adjacent kidney opening. He indicated that, since the cercariae of this family are of the microcercous type, the tails were not needed to transfer the cercariae from one snail to another.

A review of the above literature, therefore, indicated that a terrestrial gastropod, occurring in the vicinity of the burrows of *Sorex araneus*, was likely to act as the intermediate host of *B. oesophagei*. Lewis (1968b) showed that the kidney of the terrestrial snail *Z. excavatus* harboured cercariae and metacercariae of *B. oesophagei* and when the latter stages were experimentally fed to *Sorex araneus*, they mature in the oesophagus after about nine days. Presumably a similar pattern exists in nature when *S. araneus*, *S. minutus* and *Neomys fodiens*, during their foraging, feed upon infected snails. Eggs containing developing miracidia are released from adult worms of *B. oesophagei* and are passed out with the faeces of the shrew, and if the life history of *B. oesophagei* is assumed to be similar to that of known brachylaimid life histories, e.g. *B. virginiana*, the eggs are ingested by a suitable gastropod first intermediate host, hatching taking place in the intestine. The released miracidia, with the aid of stylets and penetration gland cells, penetrate the intestinal wall and migrate to the digestive gland of the gastropod, where the sporocyst generation develops. The sporocysts give rise directly to microcercous cercariae which eventually emerge from the digestive gland and migrate to the exterior. Successful cercariae may then enter the renal aperture of the second intermediate host, *Z. excavatus* and travel the length of the ureter to enter the kidney chamber. The cercariae having shed their small blunt tails, develop into metacercariae which attach themselves and begin to feed on the

SUMMARY

1. *Brachylaimus oesophagei* Shaldybin, 1953 from the common shrew, *Sorex araneus castaneus* Jenyns is described and compared with that of Shaldybin (1953) and a closely related species *B. fulvus* Dujardin, 1843.
2. Despite unsuccessful attempts in hatching the egg of *B. oesophagei*, some morphological features of the miracidium are described and compared with previous studies on brachylaimid miracidia. Neither flame cells nor epidermal plates have been observed in miracidia of this family and present observations confirm this.
3. A description is given of the cercaria and metacercaria of *B. oesophagei* from the kidney of the hollowed snail *Zonitoides excavatus* (Bean) at Aberystwyth, but no sporocysts or cercariae were found in the digestive gland.
4. Previous work on brachylaimid life histories is discussed, together with a resumé of the life history of *B. oesophagei*.

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J. W. LEWIS

renal tissue. The metacercariae continue to inhabit the kidney of *Z. excavatus*, until eaten by the shrew, where they develop into adult worms in the oesophagus. The sporocyst generation with cercariae was not found in any of *Z. excavatus* examined and it is suggested that another terrestrial mollusc living in close association with *Z. excavatus* acts as the first intermediate host. The statement by Sinitsin (1931) that cercariae, emerging from the digestive gland, can re-enter the same snail host through the kidney opening does not, therefore, seem to apply in the case of *B. oesophagei*. If, on the other hand, an examination of larger numbers of *Z. excavatus* in the future should reveal the sporocyst generation, the life history of *B. oesophagei* could closely resemble that of *B. virginiana* and *Postharmostomum gallinum* described by Krull (1935) and Alicata (1940) respectively, where the same species of snail acts as first and second intermediate host, with sporocysts and cercariae developing in the first and metacercariae in the second host.

BRACHYLAEMIDAE

level between the sucker and the intestine, and the third at the level of the intestine. Each tertiary branch has two flame cells with their respective capillaries. The posterior secondary excretory tube runs laterally downwards and gives off the fourth tertiary branch at a level of the upper testis, the fifth at a level of the lower testis and the sixth near the posterior end of the body. The fourth tertiary branch has constantly three flame cells with their respective capillaries, whereas the other five branches have two cells usually, but may eventually have three with their corresponding capillaries. Thus the flame cell pattern of this metacercaria is shown by the following formula: basic form, $2 \times [2+2+2] + (3+2+2)$, eventually $2 \times [(2+2+2) + (3+2+3)]$ or $2 \times [(2+2+2) + (3+3+2)]$. It is further to be noted that in one case the flame cell pattern of one side was $[(2+2+2) + (3+3+2)]$, while that of the other side was $[(2+2+2) + (3+2+3)]$.

Concerning the excretory system of Bucephalidae the report of Tennes (1906) on the cercaria of *Bucephalus (Bucephalopsis) haimeanus* (fig. 43) and that of Woodhead (1930) of the cercaria of *Bucephalus elegans* (fig. 44) are available. In these two species the arrangement of flame cells appears to be so irregular that it can hardly be expressed by a mathematical formula, while that of the metacercaria of *Prosoerhynchus echinatus* is definite and is given by $2 \times [(2+2) + (3+3+2)]$ and that of the metacercaria of *Rhytidocotyle linguialis* shows fundamentally a certain regularity: the flame cell pattern in the anterior secondary excretory tube remains always to be $(2+2+2)$, and that of the posterior one is represented in its basic form by $(3+2+2)$, though it eventually shows some fluctuations. It is to be noted that the pattern of both our metacercariae shows a remarkable similarity to each other and those of the above-cited two species of *Bucephalus* and *Bucephalopsis* also resemble each other very closely. However, these two groups of Bucephalidae, one comprising *Bucephalus* and *Bucephalopsis*, and the other, *Prosoerhynchus* and *Rhytidocotyle*, show a considerable difference in the fundamental plan of arrangement of their flame cells. We think that this comparison is safe although the above-stated flame cell pattern of the former group is for cercariae and that of the latter for metacercariae. Thus, if the mode of arrangement of flame cells has an important significance in a natural system of classification,

the body. The oval testes, having eventually a slight indentation on their lateral margins, are found under the ovarium one behind the other. The cirrus sac is club-shaped, measures about one third of the length of the body, and is found at its posterior end. Its opening is ventral and subterminal. The elongated oval ovarium is found near the left lower margin of the intestine and in contact with it. The vitelline glands are small masses, numbering about ten on each side, are placed slightly anterior to the uterus and laterally to the intestine. The excretory bladder is elongated and sac-formed; it occupies most of the body cavity and is situated obliquely from the lateral margin of the sucker to the posterior end of the body and opens at its posterior end. The basic flame cell pattern is $2 \times [(2+2+2) + (3+2+2)]$.

DISCUSSION

It is generally acknowledged that the flame cell pattern of the mature cercaria can always be shown by a definite mathematical formula and is always constant in one species. In the metacercaria, however, this pattern cannot always be expressed by a definite arithmetical formula. In some species it is constant and unchanged as compared with that in the cercaria stage, whereas in others this pattern undergoes remarkable changes and the number of the flame cells increases considerably as compared with the number found in cercaria. In the previous paper the senior author (1938) described examples of such cases, i. e. certain metacercariae of *Strigeata* and showed that in these the development of their excretory system was performed with a mathematical regularity. Here we notice another type of trematode excretory system in the metacercaria stage. In the metacercariae of *Metorchis orientalis*, *Metorchis taiwanensis* and *Metacercaria hasegawai* a only one to three flame cells are added to each flame cell group as they develop.

Thus, based on the excretory pattern, metacercariae can be divided into the following three different groups at least.

a) *First group.* metacercariae whose excretory pattern is the same as that of its cercaria and remains unchanged in the whole metacercaria stage.

The metacercariae of *Fasciola hepatica* (Kawana, 1939), *Echinochasmus japonicus*, *E. perfoliatus*, *Opisthioglyphe ranae* (Komiya,

1950), *Exorchis oviformis*, *Prosorhynchus echinatus*, *Prosorhynchus chasmoechinatus* belong to this group. The metacercaria of *Echinochasmus perfoliatus* and *Rhipidocotyle lingualis* should be added to this group though their excretory pattern shows at times a slight variation. Among these *Fasciola hepatica* needs no second intermediate host in the strict sense and its encystment occurs freely on the surface of water vegetation or other materials. Such metacercaria suffers relatively slight change, if any, in their developmental stages. Correspondingly their metabolic requirements are not so large, and the burden which its flame cells have to perform does not materially increase as compared with that in the cercaria stage. Therefore the number of flame cells need not increase and remains the same as in cercaria. In a similar metacercaria, e. g. that of *Fasciolopsis* or of *Diplodiscus* the number and arrangement of flame cells is supposed to remain the same as that of its cercaria stage. The metacercariae of *Echinochasmus perfoliatus* and *japonicus* encyst in gills of fishes. Their cysts are very small and vary very little in size. These facts indicate their metabolic requirements are not extensive. The metacercaria of *Opisthoglyphe ranae* encysts in snails, and shows also no marked development either in size or in form. The metacercaria of *Exorchis oviformis* is found encysted mainly in the muscles of fishes. This metacercaria develops apparently and grows about twice as large as its initial size during its whole stage. The number and arrangement of flame cells, however, remains just the same as that of its cercaria. This indicates that the growth of the worm in size is not always accompanied by an increase in the number of its flame cells⁵. The metacercariae of *Prosorhynchus* and *Rhipidocotyle lingualis* are found encysted in muscles of fishes and seem to grow to a certain amount. However, their flame cells appear to be able to meet the requirements of their increased metabolism. In the case of *Prosorhynchus echinatus* a progenesis is sometimes found. Even in such a case the excretory pattern remains unchanged, whereas its body structures are almost perfectly developed. Judging from this fact, the adult worm of *Prosorhynchus echinatus* is supposed to have the same excretory pattern as that of its metacercaria.

It is noticed that in such cases the flame cell increases usually in size to meet the requirement of increased metabolism.

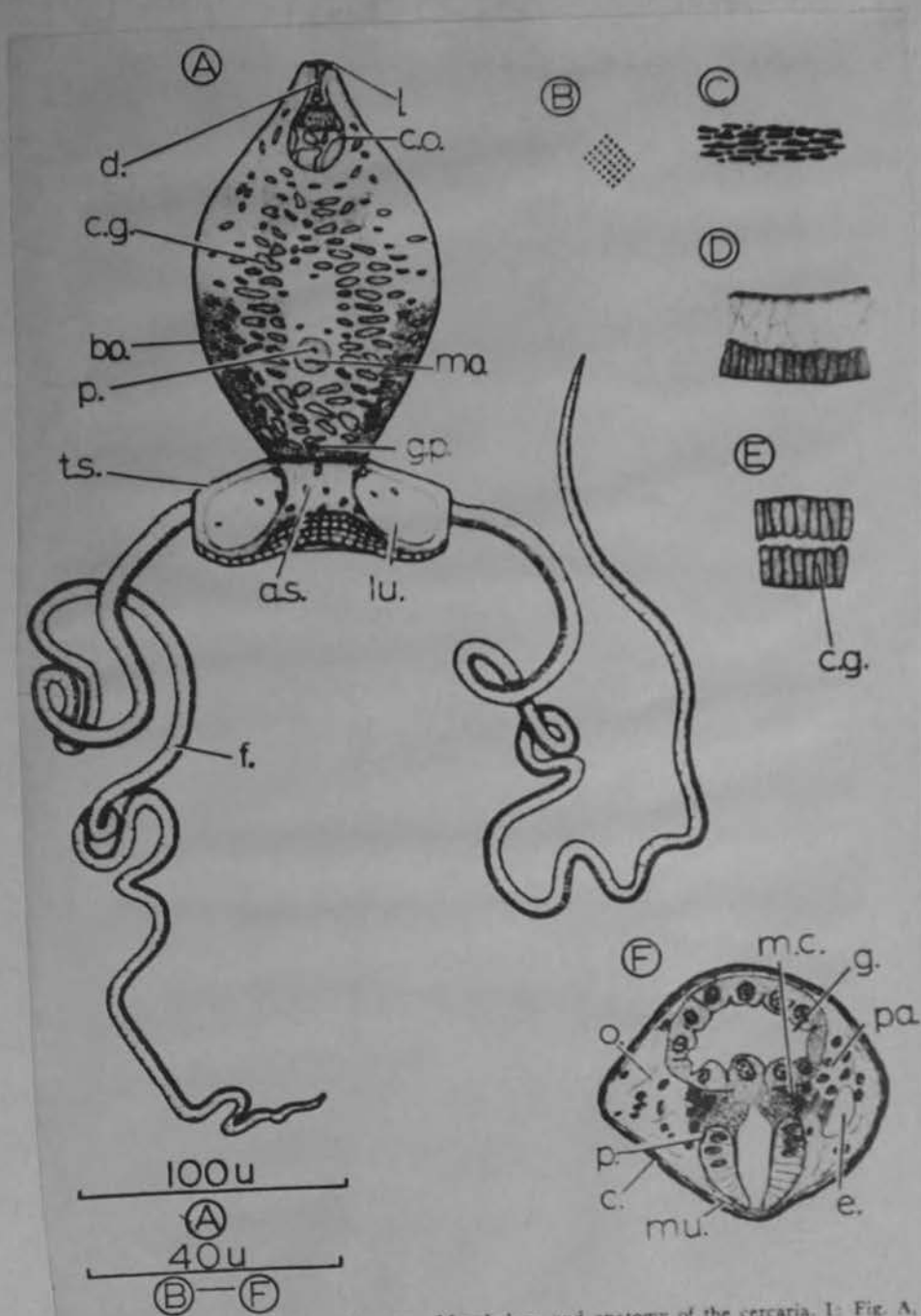
Generally speaking, the excretory pattern of those adult worms of small size whose metamorphose during the metacercaria stage is not so prominent, is supposed to remain the same as that of its cercaria or metacercaria. *Exorchis oviformis*, *Prosorhynchus chasmoechinatus* and *Rhipidocotyle lingualis* probably belong to this category.

The excretory pattern of *Clonorchis sinensis* remains the same throughout the whole stage of metacercaria as that of mature cercaria.

b) *Second Group*. Metacercariae whose excretory pattern changes only by the addition of a few flame cells to the primary flame cell groups of the young metacercaria or of its cercaria.

Metacercaria hasegawai a, the metacercariae of *Metorchis orientalis*, *M. taiwanensis*, and *Opisthorchis felineus* (Vogel, 1934) belong to this group. Among the trematodes belonging to this group *Opisthorchis felineus* is the only one in which the excretory pattern of the cercaria is known. There exist five groups of flame cells in it, each group having in turn five flame cells. In its metacercaria the number and arrangement of flame cells is only slightly different from that of the cercaria. "Wie bei dieser sind fünf Gruppen von Wimperzellen vorhanden. Die vom vorderen Aste entspringende Gruppe besteht wie bei der Cercarie gewöhnlich aus 5, seltener aus 6 Wimperzellen. Die übrigen 4 Gruppen des hinteren Astes setzen sich in der Regel aus je 6, hin und wieder auch nur aus 5 Einheiten zu." (Vogel, 1934, p. 58)⁶. The arrangement of flame cells is quite similar in *Metacercaria hasegawai a* and in the metacercariae of *Metorchis orientalis* and *M. taiwanensis*. The only difference is that in *Metorchis* one to three flame cells are added, in the course of development, to each flame cell group except the foremost one, instead of one or two. If it is acknowledged that closely related species have a similar mode of development of their excretory system, the excretory pattern of the cercaria of *Metacercaria hasegawai a* and the above-mentioned two *Metorchis* can easily be deduced from that of its metacercaria.

⁵ Vogel shows the excretory pattern of *Opisthorchis* cercaria and metacercaria as $2 \times [(5)+(5+5+5+5)]$ and $2 \times [(5)+(6+6+6+6)]$ respectively. But we think it is most probable that their excretory pattern is $2 \times [(5+5)+(5+5+5)]$ and $2 \times [(5+6)+(6+6+6)]$ respectively. In the closely related species, *Clonorchis sinensis*, *Metorchis orientalis* and *M. taiwanensis*, the pattern is generally expressed as $2 \times [(a+b)+(c+d+e)]$, where the contents of the first bracket indicate the flame cell groups of the anterior secondary tube, and those of the latter that of the posterior secondary tube. Further observation, it is hoped, will decide this problem.

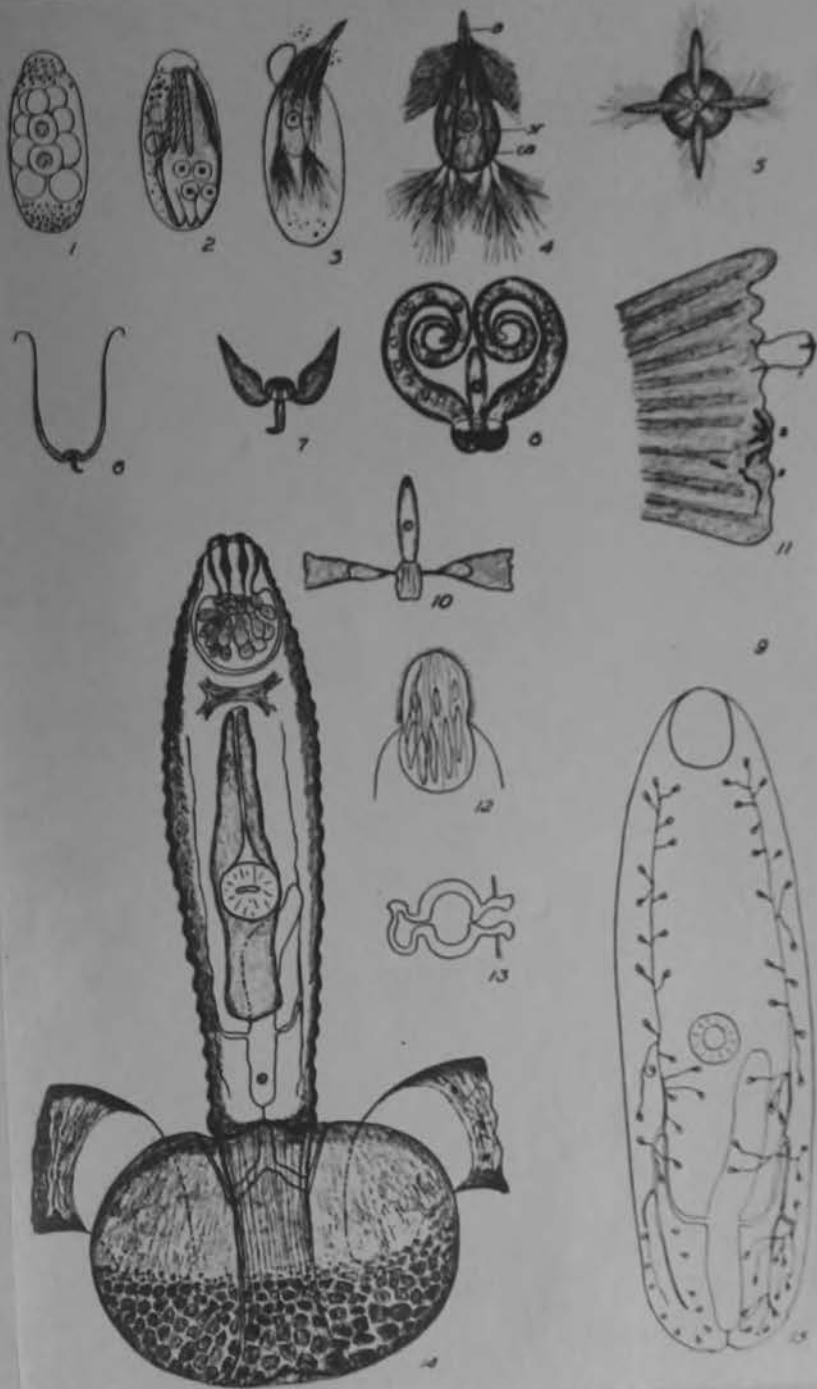
Bucephalus longicornutus (Manter, 1954) Howell, 1966

TEXT-FIG. 3—*Bucephalus longicornutus*. Morphology and anatomy of the cercaria. 1: Fig. A.

From HOWELL, 1966

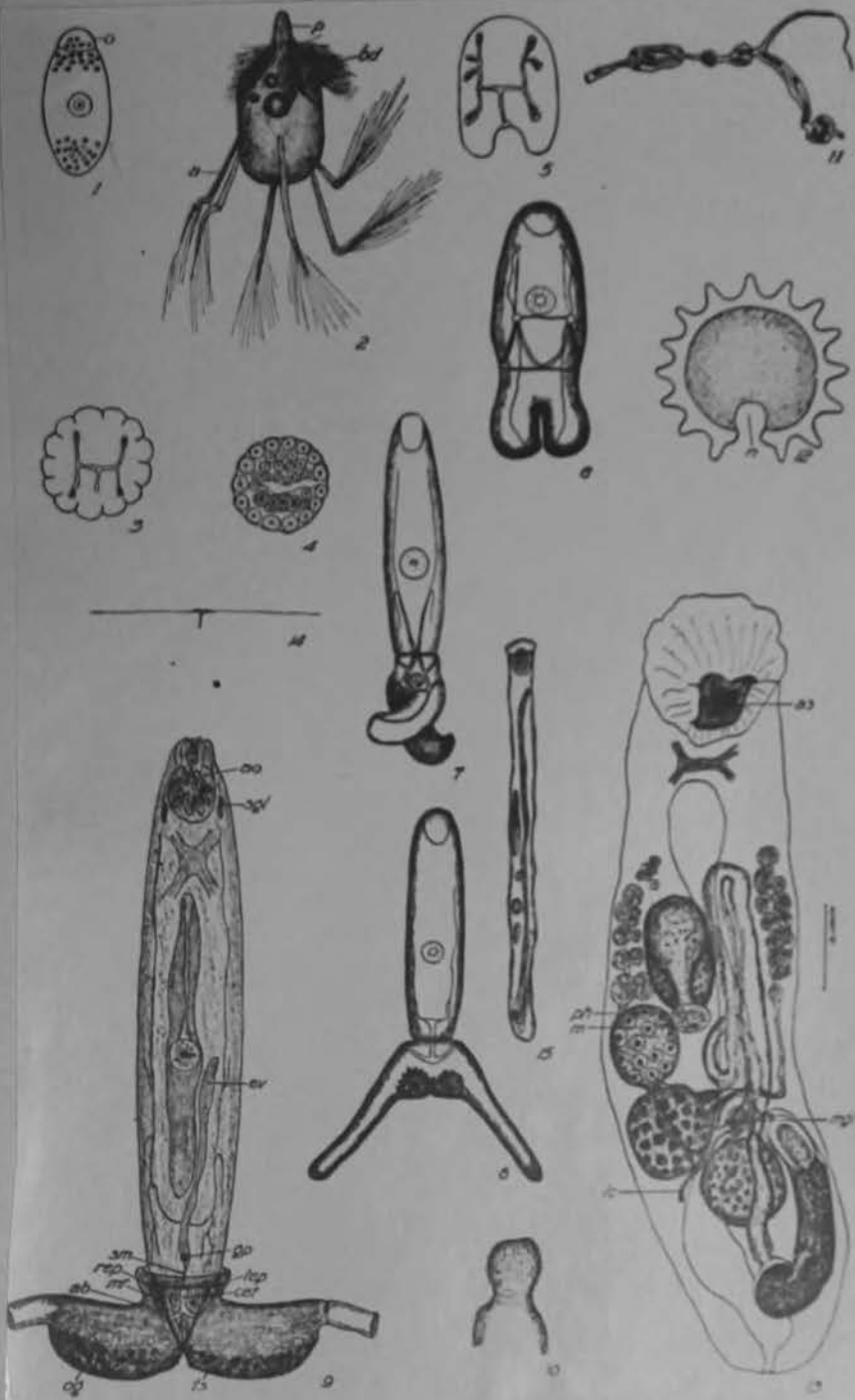
Bucephalidae

Bucephalus elegans Woodhead, 1930



Final host: Ambloplites rupestris, red-eye or rock-bass
 (experimentally in Lepomis pallidus)
 Miracidium with 4 cephalic plates; 1 pr. skeletal appenadges each
 with 2 side branches. Enters bivalve, Eurynia iris
 Cercariae encyst on small fishes.
 Reference: Woodhead, A.E. 1930. Trans. Am. Micros. Soc., 49:1-17

Bucephalus papillosum Woodhead, 1929
 Syn.: B. pusillus of Cooper, 1915



Adult: cecal pouches of Micropterus dolomieu; Aplites salmoides
 Miracidium penetrates Elliptio dilatatus ; cercariae develop in
 sporocysts; cercariae encyst at base of fin rays of Ambloplites
rupestris, rock bass
 Reference: Woodhead, Arthur E. 1929. Trans.Amer.Micros.Soc.,
 58:256-275.

Parmi les métacercaires qu'héberge *Atherina mochon* C. V., vivant dans les gîtes de la Camargue, nous en signalons deux qui correspondent à des Trématodes de poissons carnassiers.

La première appartient à la famille des Gastérostomidés. Le ver adulte, obtenu expérimentalement, a les caractères suivants : corps globuleux, ovoïde ou piriforme, mesurant 400μ à 780μ sur 320μ à 650μ ; épines de la cuticule bien développées, notamment dans la région antérieure, mais existant sur tout le corps; organe adhésif de 80μ à 155μ suivant son degré d'étalement, avec des mamelons non filiformes; pharynx latéral, arrondi de 60μ de diamètre; intestin sacciforme, remplissant la partie centrale et postérieure du corps; testicules symétriques, dans le tiers postérieur du corps, ayant 80μ à 150μ ; poche du cirre droite et allongée, d'avant en arrière, mesurant 110μ à 190μ sur 40μ à 60μ , s'ouvrant au pore génital subterminal, de 20μ de diamètre; ovaire de 50μ de diamètre environ, situé entre les testicules; vitellogènes latéraux; circonvolutions utérines dans la région postérieure, s'avancant jusqu'au milieu du corps et le dépassant légèrement; œufs : 25μ sur 16μ .

Ce Gastérostomidé rentre dans le genre *Dolichoenterum* Osaki, 1924. Il diffère de l'unique espèce décrite : *D. longissimum* Oz., 1924 (Japon), par son aspect globuleux, la position symétrique des testicules, la forme de l'intestin, moins allongé. Néanmoins, la situation de l'ovaire entre les testicules, l'aspect de l'organe adhésif, me permettent de le maintenir dans les *Dolichoenterum*, et d'éviter la création d'un nouveau genre. Manter (1934) a aussi récolté un *Dolichoenterum* immature, dont la diagnose spécifique n'a pu être établie : il diffère de notre espèce, notamment par la position des testicules, placés l'un derrière l'autre. Nous proposons le nom de *Dolichoenterum lamirandi* sp. nov.

La métacercaire est abondante dans le foie d'*Atherina mochon* C. V., de Camargue. L'infestation est généralement très intense : plusieurs centaines

de kystes chez le même poisson. L'espèce voisine, *Atherina hepsetus* L., pêchée dans le golfe de Marseille, héberge également ces parasites, mais plus rarement et en moins grande quantité (une quinzaine au maximum). Le cycle évolutif semble donc s'accomplir plus facilement dans les collections d'eau restreintes. Cette métacercaire se présente sous forme de kystes arrondis, mesurant 150μ à 280μ de diamètre; leur paroi est très mince et permet de distinguer par transparence les organes de la larve. Dans les cas de parasitisme très intense, il peut exister jusqu'à cinq métacercaires dans le même kyste. On trouve déjà les caractères très accusés de la forme adulte : corps globuleux, de 360μ à 500μ sur 210μ à 350μ ; organe adhésif de 80μ à 120μ ; pharynx latéral de 32μ à 40μ ; ébauches très nettes des testicules (85μ), de la poche du cirre (110μ sur 40μ) de l'ovaire et du tube utérin. La progénèse n'a jamais été observée, le parasite dégénère au bout d'un certain temps.

Cette métacercaire a pu évoluer expérimentalement chez *Labrax lupus* C. V., par ingestion de foie d'*Atherina*. Au bout de cinq à six jours on trouve des Trématodes à œufs déjà formés et d'autres à divers stades de développement. Un début d'infestation a été aussi réalisé chez la grenouille *Hyla arborea* (L.).

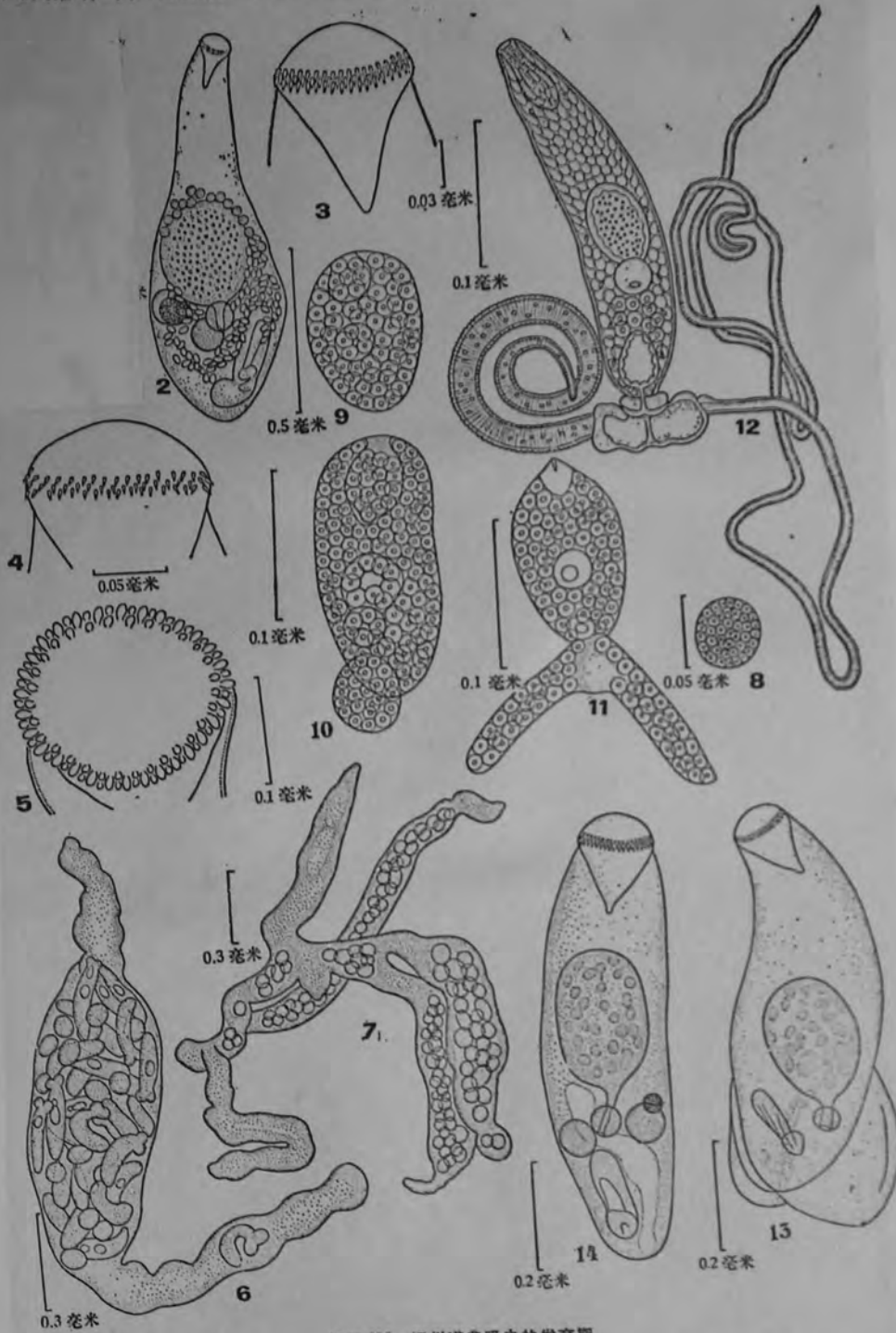
Atherina mochon et *A. hepsetus* hébergent aussi dans leur musculature une autre métacercaire que je rattache aux ^{Char} ~~Acanthosomidae~~ ^{Soraa, 1901} ~~Ryukyu~~ ~~Yasuk~~. Kyste ovalaire, mesurant 250^μ à 380^μ sur 160^μ à 240^μ. Métacercaire allongée (700^μ à 1100^μ sur 200^μ à 260^μ). Ventouse orale : 140^μ en moyenne, portant une couronne de 18 épines céphaliques de 30^μ à 40^μ. Deux taches oculaires très apparentes (même dans le kyste), situées à droite et à gauche du pharynx, mais rarement symétriques. Ventouse ventrale : 80^μ à 90^μ. Je n'ai pu obtenir jusqu'à présent qu'un début de développement chez *Hyla arborea*, les circonstances ne m'ayant pas encore permis d'utiliser des poissons carnassiers neufs pour cette série d'expériences.

(Extrait des *Comptes rendus des séances de l'Académie des Sciences*,
t. 204, p. 1086, séance du 5 avril 1937.)

Dollfustrema foochowensis Tang and Tang, 1963

唐崇惕、唐仲璋：福建腹口吸虫种类及生活史的研究

图版 IV



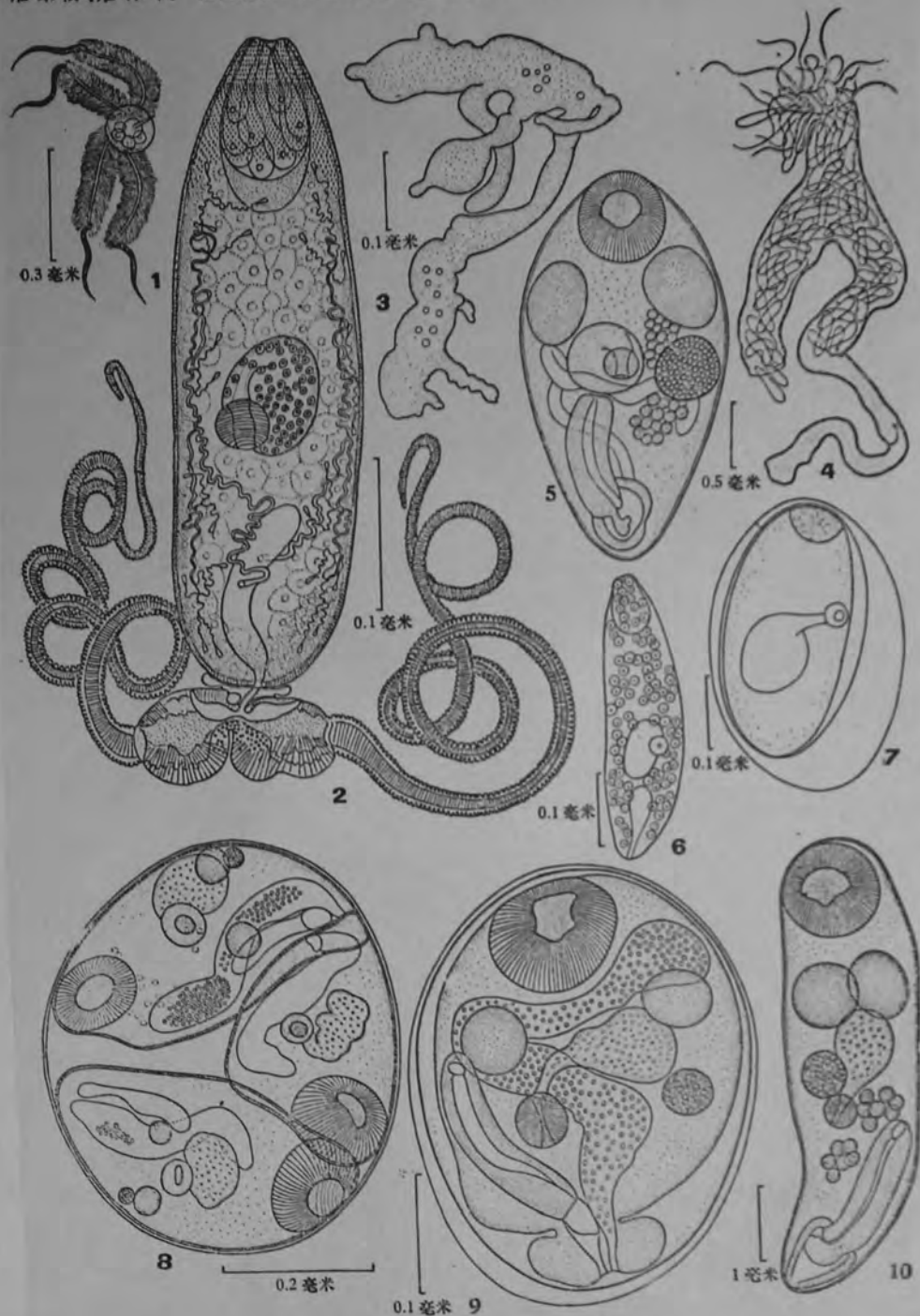
图版 IV 福州道弗吸虫的发育期

- | | | |
|---|-------------------|---------------|
| 1. 成虫。 | 2. 提早发育的成虫。 | 3. 成虫的前吸器。 |
| 4. 人工感染的46天后期尾蚴的前吸器。 | | |
| 5. 范尼氏道弗吸虫成虫的前吸器上的棘圆(用以与福州道弗吸虫前吸器上的棘圆对照)。 | | |
| 6. 子胞蚴。 | 7. 子胞蚴。 | 8. 尾蚴胚球。 |
| 9. 尾蚴胚体示头器和咽。 | 10. 尾蚴胚体示头器、咽和尾球。 | 11. 尾蚴胚体。 |
| 12. 成熟尾蚴。 | 13. 46天脱囊的后期尾蚴。 | 14. 52天的后期尾蚴。 |

From Tang and Tang, 1976

唐崇惕、唐仲璋：福建腹口吸虫种类及生活史的研究

图版 III



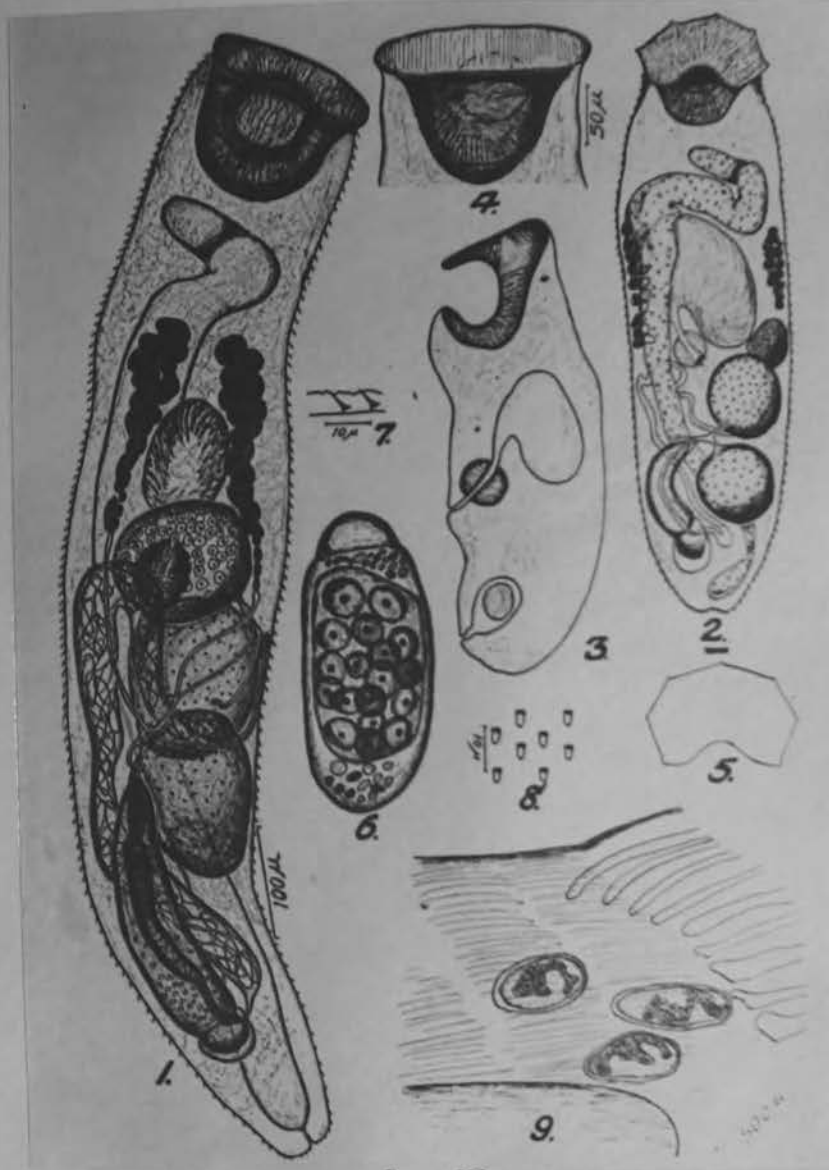
图版 III 前靠近似牛首吸虫的发育期

- | | | |
|-------------------|-------------|---------------|
| 1. 毛蚴。 | 2. 尾蚴。 | 3. 子胞蚴。 |
| 4. 子胞蚴。 | 5. 天然感染的童虫。 | 6. 39 小时的后尾蚴。 |
| 7. 9 天的囊蚴。 | 8. 42 天的囊蚴。 | 9. 47 天的囊蚴。 |
| 10. 人工感染的 10 天童虫。 | | |

From Tang and Tang, 1976

Bucephalidae

Rhipidocotyle septapapillata Krull, 1934



Final host: Eupomotis gibbosus (experimental)
Intermediate hosts: 1. (?)
2. Fundulus diaphanus diaphanus; Eupomotis gibbosus.
metacercariae encysted in muscles and caudal fin.

Reference: Krull, Wendell H. 1934. Trans. Amer. Micros. Soc., 53:408-415

from Kniskern, 1952

Trans. Amer. Micros. Soc.
61(4):317-340.

Rhipidocotyle septapapillata Krull, 1936

Final host: Micropterus dolomieu

First intermediate host: Lampsilis alliquoidea

Cercaria basi Woodhead, 1936 develops in branching sporocysts.

Second intermediate hosts: small fishes

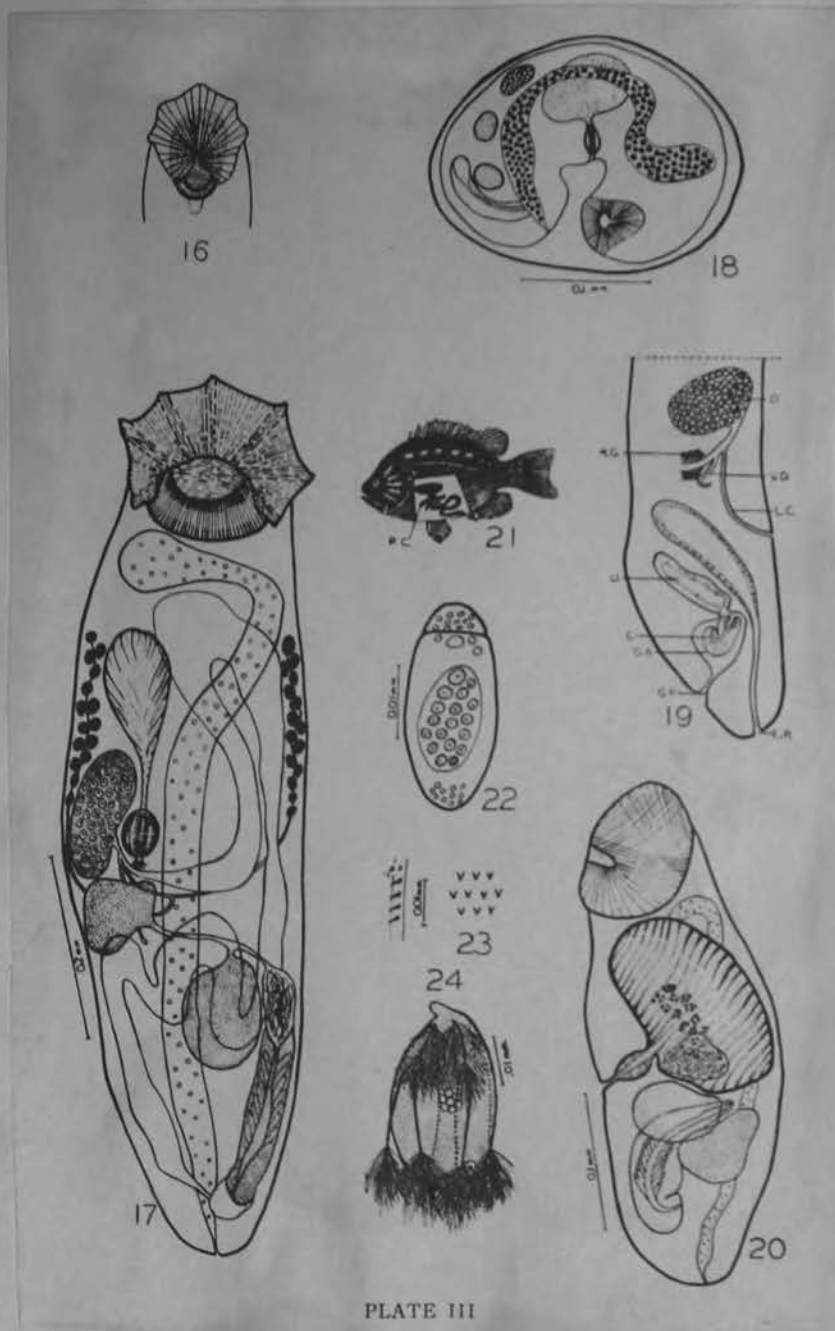


PLATE III

BUCEPHALIDAE