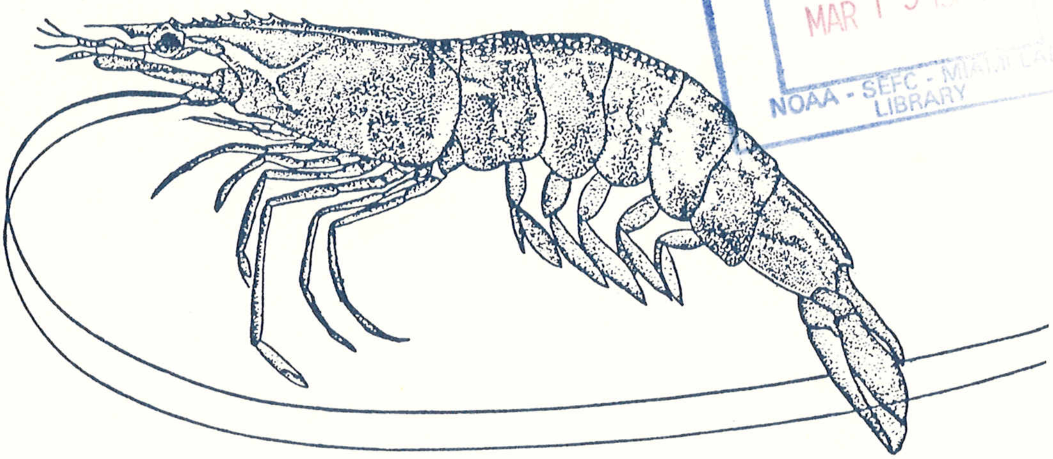
NOAA Technical Memorandum NMFS-SEFC-169

A Survey of Potential Disease-Causing Organisms in Bait Shrimp from West Galveston Bay, Texas

NATIONAL MARINE FISHERIES
MAR 1 9 1986
NOAA - SEFC - MIAMI LAB
LIBRARY



U. S. DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration

National Marine Fisheries Service

Southeast Fisheries Center
Galveston, Laboratory
Galveston, Texas 77550

DECEMBER 1985

NOAA Technhical Memorandum

NMFS-SEFC-169

A Survey of Potential Disease-Causing Organisms in Bait Shrimp from West Galveston Bay, Texas

BY

Clark T. Fontaine

U.S. Department of Commerce
Malcolm Baldrige, Secretary

National Oceanic and Atmospheric Administration
Anthony J. Calio, Acting Administrator

National Marine Fisheries Service
William G. Gordon, Assistant Administrator for Fisheries

DECEMBER 1985

This Technical Memorandum series is used for documentation and timely communication of preliminary results, interim reports, or similar special-purpose information. Although the memorandums are not subject to complete formal review, editorial control, or detailed editing, they are expected to reflect sound professional work. Any errors or omissions are solely the responsibility of the authors.

A SURVEY OF POTENTIAL DISEASE-CAUSING ORGANISMS IN BAIT SHRIMP FROM WEST GALVESTON BAY, TEXAS

CONTENTS

A SURVEY OF POTENTIAL DISEASE-CAUSING ORGANISMS IN BAIT SHRIMP FROM WEST GALVESTON BAY, TEXAS

ABSTRACT

Data are presented from a one year survey of potential disease-causing organisms in white shrimp, *Penaeus setiferus*, and brown shrimp, *P. aztecus*, collected by commercial bait dealers in West Galveston Bay, Texas. The shrimp examined were purchased from bait dealers at 12 to 18 day intervals beginning on November 19, 1973 and continuing until November 22, 1974.

Bacteria isolated from the blood of shrimp were predominately of the genera *Vibrio*, *Aeromonas*, and *Pseudomonas*. *Vibrio* occurred most often during July, August, and September, *Aeromonas* in the spring and fall, and, *Pseudomonas* in September, October, and November. One imperfect fungus of the genus *Fusarium* was isolated in March.

An unidentified suctorian was observed attached to shrimp gills from May through December, while the peritrichous ciliate, *Lagenophrys*, was on the gills during all months except August and was most frequent in May and June. Two species of the stalked, peritrichous ciliates *Epistylis* and *Zoothamnium* were observed attached to the gills. *Epistylis* occurred in March and September, while *Zoothamnium* was widespread, occurring in every month with the highest incidence in May, June, and July.

The gregarine, *Nematopsis penaeus*, was observed in the digestive tract of shrimp throughout the study. Only two shrimp exhibiting microsporidosis were found: *Nosema nelsoni* in April and *Thelohania* sp. in May.

Larval nematodes were found in 10 to 100% of all samples except in November 1973. Seasonally, the incidence was highest during January through March. Numerous unidentified cestode procercoid larvae were observed in the midgut. The highest incidence occurred in August and September.

The incidence of the larval Trypanorhynchid cestode, *Prochristianella hispida*, remained fairly constant with little difference occurring between brown and white shrimp. Several unidentified Cyclophylidean larvae were observed encysted in the wall of the midgut of one shrimp and a metacercaria of *Opeocoeloides fimbriatus* was observed in the hepatopancreas of brown shrimp.

SURVEY OF POTENTIAL DISEASE-CAUSING ORGANISMS IN BAIT SHRIMP FROM WEST GALVESTON BAY, TEXAS

INTRODUCTION

The objectives of the survey reported herein were to document the incidence, seasonal abundance, and recognition of the major parasites and diseases of white shrimp, Penaeus setiferus and brown shrimp P. aztecus, from West Galveston Bay, Texas. Species utilized in this one-year (Nov. 1973-Nov. 1974) survey were obtained from commercial bait dealers. The resulting data and figures should aid in the recognition and diagnosis of pathological conditions encountered in other natural shrimp populations. All penaeid shrimp morphological terms used follow those presented by Young (1959).

Contributions of diseases to the mortalities of shrimp in natural populations currently are poorly understood. Additionally, helminth and protozoan parasites occur in natural populations of shrimp and may contribute to low survival of juvenile shrimp in estuarine areas. Excellent surveys and reviews of diseases and parasites of penaeid shrimp have been presented by Couch (1978) and Overstreet (1978). The majority of their work, however, was done on shrimp from areas in the northeastern Gulf of Mexico. Further, Johnson (1978) reported his observations in a handbook of shrimp diseases, and Sindermann (1970) has documented a synopsis of principal diseases of marine fish and shellfish.

In nature, diseases probably weaken some shrimp making them easy prey of their many enemies (Neal, 1974). Currently, five major diseases are recognized in penaeid shrimp (Lightner, 1975): (1) mycosis of larval shrimp caused by a Lagenidium sp.; (2) mycotic infection of juvenile shrimp with Fusarium spp.; (3) bacterial infection caused by Vibrio spp. and Benekea spp.; (4) a complex of several gill diseases the causes of which individually or collectively result in respiratory failure; and (5) the "cotton" shrimp group of diseases caused by several species of Microsporida.

MATERIALS AND METHODS

Live shrimp were purchased from commercial bait dealers at 12 to 18 day intervals. All shrimp were collected by trawl from West Galveston Bay waters within easy access to the bait camps. At the time of purchase, the water temperature at a given bait camp was taken with a stem thermometer, and the salinity with a hand-held refractometer (Table 1). The live shrimp were placed in an ice chest, and upon arrival at the laboratory 10 animals were removed for examination; the remainder of the shrimp were maintained in a 1,000-liter holding tank. All shrimp taken for examination were measured (total length, tip of rostrum to tip of telson) and sexed before being processed (Table 1).

There were eight tissue groups observed: (1) blood, (2) gills, (3) hindgut and gland, (4) midgut, (5) foregut, (6) dorsal gland, (7) hepatopancreas, and (8) gross examination of musculature, heart, and appendages.

Blood samples (ranging in volume from 0.1 cc to 0.5 cc) were drawn with a tuberculin syringe directly from the heart after first swabbing the cuticle with 70% alcohol. The blood was then placed on the surface of plates of tryptic soy agar containing 2.5% NaCl and incubated 24 hr at 28°C. All transfers and isolations were done using the same media. Pure cultures of bacteria were inoculated into slant tubes containing tryptic soy agar containing 2.5% NaCl and sent to D. H. Lewis (Texas A&M University, College of Veterinary Medicine, Department of Microbiology, College Station, Texas) for identification. All biochemical characterizations presented herein follow those presented by Lewis (1973) for aerobic bacteria of fish and shellfish. Routine antibiotic sensitivities were performed by Dr. Lewis on all bacterial isolates made during this study.

The gills were examined by first removing the right branchiostegite with scissors and then excising the gill processes with forceps. A wet mount of the gill tissue was made using sterile seawater and examined microscopically. The exoskeleton and musculature overlying the digestive tract was removed by making two lateral incisions with scissors and lifting the tissue away with forceps. The gut was then removed intact and placed in sterile seawater in a glass petri dish. The hindgut gland, hindgut, and dorsal gland were placed on individual glass slides with seawater and flattened with a glass cover slip. The midgut and foregut were handled similarly, but were stripped with the edge of the coverslip to remove all fecal material and parasites.

A preliminary gross examination was made of heart, musculature, and appendages for clinical signs of disease. The hepatopancreas was examined using procedures described by Aldrich (1965). The connective tissue sheath covering the hepatopancreas plus some additional hepatopancreatic tissue were examined microscopically.

Tissue specimens were periodically taken from bait shrimp and prepared for histological examination. The tissue specimens were fixed in 10% phosphate buffered formalin and prepared routinely for sectioning. The tissue sections, cut at 7-8 μ, were stained with Harris's hematoxylin and counterstained with eosin. All micrographs of fresh whole mounts and prepared histological sections were made with a Zeiss Photomicroscope II[1/].

Tissue smears were made from shrimp with clinical signs of microsporidian infection and stained with Giemsa stain. Parasites were identified following observations previously published by Overstreet (1973), Sprague and Couch (1971), Corkern (1970), Kruse (1959), and Hutton et al. (1959).

RESULTS

A. Bacteria

There were 17 species of bacteria represented in the isolates, predominantly the genera *Vibrio* (42.3%), *Aeromonas* (23.6%), and *Pseudomonas* (22.8%). Cultures of *Lucibacterium harveyi*, *Gaffyka homari*, *Chondrococcus columneris*, *Bacillus* sp., and *Enterobacter* sp. also occurred.

1/Mention of trade names or commercial products does not constitute endorsement by the National Marine Fisheries Service, NOAA.

1. Vibrio

The species of Vibrio isolated during this study were V. alginolyticus, V. anguillarum, V. algosus, and V. parahaemolyticus. All four species of Vibrio were positive for indole production and were swarmers on the medium used for isolation (tryptic soy agar containing 2.5% NaCl). Some isolates of V. anguillarum had an acidic reaction with lactose while other species were alkaline. Some species were positive in the Voges-Proskaur test while other species were negative, and some isolates were phosphorescent and others not. The antibiotic sensitivity of V. alginolyticus and V. angullarum is shown in Table 2.

The percentage of shrimp from which Vibrio spp. were isolated per month is graphically represented in Figure 1. There were 57 isolates of Vibrio spp. (often more than one Vibrio sp. was isolated per animal) of which 44% were made during July, August, and September.

2. Aeromonas

There were only two species of Aeromonas isolated from bait shrimp: A. shigelloides and A. formicans. A. shigelloides was separated from A. formicans by non-utilization of gelatin. A. formicans was charaterized by production of gelatinase, non-aerogenic, and did not form acetylmethylcarboniol from dextrose (Voges-Proskaur test). The antibiotic sensitivity of the two species is shown in Table 2.

The occurrence of Aeromonas spp. by months is shown in Figure 1. The two species of Aeromonas occurred predominately in the spring and fall and both species were isolated from white shrimp but only A. shigelloides was isolated from brown shrimp.

3. Pseudomonas

Six species of Pseudomonas spp. were isolated from bait shrimp: P. piscicida, P. dentrificans, P. stutzeri, P. fluorescens, P. alcaligenes, and P. diminuta. The six species produced a wide variety of biochemical reactions, and the antibiotic sensitivity of two of the more common species is shown in Table 2.

The monthly occurrence of Pseudomonas spp. is shown in Figure 1. Pseudomonas spp. were isolated primarily in the fall with approximately 48%

of all isolations made in September, October, and November. The species of P. dentrificans, P. fluorescens, and P. alcaligenes were isolated only from white shrimp, while P. diminuta was isolated only from brown shrimp, and P. piscicida and P. stutzeri were isolated from both shrimp.

B. Fungi

The only fungus isolated during this study was an imperfect fungus of the genus Fusarium. This Fusarium sp. occurred on the gills of one white shrimp in March 1973 and was associated with numerous ciliates and an unidentified filamentous organism (Fig. 2).

The affected white shrimp showed gross clinical signs of black gill disease (Lightner et al., 1976). The Fusarium was isolated in Cantino PYG broth supplemented with 2% NaCl and treated with penicillin and streptomycin to inhibit bacterial growth. The culture was maintained on Sabouraud dextrose agar supplemented with 2% NaCl and with shrimp homogenate (SSS medium - Lightner and Fontaine, 1975). The Fusarium sp. produced micro- and macro-conidia both in artificial media and in shrimp tissues.

C. Protozoa

1. Suctoria

One species of suctorian was observed attached to the gills of bait shrimp (Fig. 3). The organism was attached to the gills by a disk, with a stout stalk, lorica, and suctorial and penhensile tentacles present. Unconfirmed tentative taxonomic descriptions (Kudo, 1954) place the organism in the family Ephelotidae and the genus Ephelota.

The monthly incidence of this organism is presented in Figure 4. The suctorian was not observed on the gills of shrimp from January through April 1974. Microscopic examinations of fresh whole mounts of affected gill tissue indicated that no histological damage was caused by the suctorian.

2. Ciliata

a. Peritricha

Only one peritrichous ciliate with a pseudochitinous lorica was observed in the gills of bait shrimp. This ciliate was tentatively identified (Kudo, 1954) as a species of *Lagenophrys* (Fig. 5) having the peristomal margin connected with the inner margin of the lorica aperture and a stalked disk extending out of the lorica. The lorica also possessed a flattened adhering surface and a short neck with a convex surface.

The seasonal incidence of *Lagenophrys* sp. is presented in Figure 4. *Lagenophrys* sp. occurred in shrimp during all months except August and was most frequent in May and June. All of the shrimp examined during June showed this organism. Unlike other ciliates observed in association with shrimp, *Lagenophrys* sp. does cause tissue damage, evoking a strong cellular response from the host (Fig. 6). *Lagenophrys* sp. appears to digest the cuticle of the gills and often will become encysted in the underlying tissue. A strong host response is indicated by congestion of hemocytes in the affected gill filament and formation of copious amounts of melanin. The melanin imparts a grossly observable brown discoloration to the gills.

Two species of stalked, non-loricated peritrichous ciliates, *Epistylis* sp. (Fam. Epistylidae) and *Zoothamnium* sp. (Fam. Vorticellidae), were observed attached to the gills. *Epistylis* sp. is normally on dichotomous, non-contractile stalks, while in *Zoothamnium* sp. (Fig. 7) the myonomes of all stalks of a colony are continuous so that the entire colony contracts or expands simultaneously (Kudo, 1954).

Epistylis occurred in only four of the white shrimp examined (two in March and two in September), while *Zoothamnium* sp. (Table 3) occurred in every month with the highest incidence in May, June, and July 1974. No histological damage attributable to *Zoothamnium* sp. was demonstrated (Fig. 8); however, heavy infestation of the gill imparted a grossly observable brown discoloration.

3. Sporozoa

a. Gregarinida

The gregarine observed in the digestive tract was identified as Nematopsis penaeus Kruse (1959). The incidence of N. penaeus ranged from a low of 80% in August and September to 95 or 100% in all other months. The occurrence in all shrimp examined was 95.8% (Table 4).

The sporozoite stages of N. penaeus were observed in the gastric mill and midgut (Fig. 9). The gametocyte stages were only found in the hindgut or hindgut gland (Fig. 10). No evidence of intracellular invasion nor of other histological damage was observed.

The abundance of N. penaeus in brown and white shrimp is presented in Table 5. The data indicate that the gregarine is much more abundant in the digestive tract of white shrimp during the months of December to March. Although incidence was comparable between the two shrimp species (Table 5), the gregarine was more abundant in the white shrimp than in the browns.

b. Microsporidia

During this study, only two shrimp exhibited microsporidosis. The first was a white shrimp examined in March 1974 that was determined to be infected with Nosema nelsoni. The second microsporozoan occurred in a brown shrimp examined in May 1974 and was identified as Thelohania sp. The spores of Thelohania sp. were not confined to the ovarian tissue but were widespread throughout the musculature. Both animals displayed the classic white musculature or "cotton" appearance characteristic of microsporidosis.

D. Helminths

1. Nematoda

The larval nematodes observed in shrimp were initially identified in shrimp from Texas coastal waters as Contracecum habena by Corkern (1970). Recently, however, Overstreet (1973) in closer taxonomic examinations of the nematodes places them in the genus Thynascaris. Because of the differences in opinion of the taxonomic classification, observations presented here will refer to the organisms simply as nematodes.

Nematodes were found in 10 to 100% of all samples except in November (Table 6). The larvae were observed in all tissues or organs examined except the musculature, with the highest incidence occurring in the dorsal gland (Table 7). Seasonally, the percent occurrence was highest during January through March.

The nematodes were also more abundant in February and March, and most were located in the dorsal gland (Table 8). For instance, 460 of the 500 total larval nematodes were observed in the dorsal gland of the 20 bait shrimp examined during March. The nematodes were not in the lumen of this gland, but were embedded in the connective tissue; no inflammatory response to any of the nematodes was ever observed (Fig. 11). The nematodes observed in the gills were located in hemolymph vessels, while those observed in the hindgut, hindgut gland, midgut, and foregut were in the lumen of the digestive tract.

2. Cestoda

Numerous unidentified Tetraphyllidean procercoid larvae (Kruse, 1959) were observed in the midgut of bait shrimp (Fig. 12). The highest incidence occurred in August and September in which 31.2% of the shrimp examined were infected. The numbers of cestode larvae in those shrimp infected ranged from 12 to 306. Unlike the gregarines and nematodes observed in the digestive tract, the procercoid larvae apparently became attached to the gut mucosa (Fig. 13).

The life cycle of the trypanorhynchid cestode, *Prochristianella hispida*, has been discussed in detail (Aldrich, 1965; Overstreet, 1978) as has the host reaction to larval stages (Sparks and Fontaine, 1973). The incidence of *Prochristianella* larvae (Fig. 14) in white and brown shrimp is presented in Table 9. The incidence in all shrimp remained fairly consistent during this study; likewise, little differences occurred in incidence between the two species of shrimp. The highest incidence was 100% of all white shrimp during July and August. The numbers of cestode larvae ranged from 1 to 35 in white shrimp and 1 to 31 in brown shrimp. The majority of the larvae were encysted in the fibrous connective tissue sheath that surrounds the hepatopancreas; however, larval cysts were observed in the hindgut, hindgut gland, and in the heart.

Several unidentified Cyclophylidean larvae (personal communication, William H. Wardel, Texas A&M University at Galveston) were observed encysted in the wall of the midgut of one shrimp. When dissected and placed on a glass slide, coverslip pressure was enough to evert the acetabulum (Fig. 15). These larvae were similar to those identified as Cyclophyllidea in brown and white shrimp by Corkern (1978).

3. Trematoda

A metacercaria identified as Opecoeloides fimbriatus by Kruse (1959) was observed in the hepathopancreas of one brown shrimp examined in June 1974. The trematode was non-encysted (Fig. 16) and appeared to move freely through the interstitial spaces in the hepatopancreas.

DISCUSSION

The observations on incidence and seasonal abundance of bacteria, commensals, and parasites of penaeid shrimp presented here should aid in future recognition and diagnosis of diseases encountered in natural shrimp populations. Many of the bacteria isolated from shrimp in this study have been shown to be pathogenic to penaeid shrimp (Lightner and Lewis, 1975); however, none of the shrimp from which these bacteria were isolated displayed the clinical signs of a bacterial septicemia as described by Lightner and Lewis (1975).

Additionally, many of the brown gill syndrome problems observed in shrimp during this study were not recognized by gross symptoms as are those published by Lightner et al. (1976). Often, no gross signs were observable in live bait shrimp, but closer examination of the gills showed them to be highly infested with the filamentous organism (Fig. 2). Possibly the brown gill syndrome may be a result of a synergistic complex of commensal and parasitic organisms, rather than one organism causing direct histopathological lesions.

Penaeid shrimp from naturally occurring populations are evidently subjected to a wide variety of parasites, potentially pathogenic bacteria, and commensals that may cause respiratory problems. Apparently, most of the wild shrimp are able to cope with these situations and should be the subject of detailed investigations to determine what, if any, immune or other responses are responsible for their apparent resistance. Such knowledge should form a basis for sound shrimp pathology investigations.

ACKNOWLEDGMENTS

I thank Don Lightner for his help and encouragement during this study. Also, Imogene "Sandy" Sanderson aided greatly during the study, particularly with histological preparations. Dan Pataln aided in preparation of the figures and Bea Richardson was the typist.

LITERATURE CITED

Aldrich, D. V. 1965. Observations on the ecology and life cycle of Prochristianella penaei (Cestoda: Trypanorhyncha). Journal of Parasitology, 51(3):370-376.

Corkern, C. C., Jr. 1970. Investigations of helminths from the hepatopancreas of the brown shrimp, Penaeus aztecus Ives, from Galveston Bay, Texas. Thesis submitted to Texas A&M University for M.S. degree, p. 51.

Corkern, C. C., Jr. 1978. A larval cyclophyllidean (Cestoda) parasite of brown and white shrimp. 2 pp. EDDLS-10. College Station: Fish Disease Diagnostic Laboratory, Texas Agricultural Extension Service, Department of Wildlife and Fisheries Sciences, Texas A&M University Extension System.

Couch, J. A. 1978. Diseases, parasites, and toxic responses of commercial penaeid shrimp of the Gulf of Mexico and south Atlantic coasts of North America. Fishery Bulletin 76 (1):1-44.

Hutton, R. F., Franklin Sogandares-Bernal, Bonnie Eldred, Robert M. Ingle, and Kenneth D. Woodburn. 1959. Investigation on the parasites and diseases of saltwater shrimp (Penaeidae) of sports and commercial importance to Florida. State of Florida, Board of Conservation, Marine Laboratory, Technical Series No. 26.

Johnson, S. K. 1978. Handbook of shrimp diseases. TAMU-SG-75-603 (revised ed.). 23 pp. College Station: Department of Marine Resources Information Center for Marine Resources, Texas A&M University.

Kruse, D. N. 1959. Parasites of the commercial shrimps, _Penaeus aztecus_ Ives, _P. duorarum_ Burkenroad, and _P. setiferus_ (Linnaeus). Tulane Studies in Zoology 7(4):123-144.

Kudo, R. R. 1954. Protozoology. 4th ed. Springfield, Ill., C. C. Thomas, 966 pp.

Lewis, D. H. 1973. Predominant aerobic bacteria of fish and shellfish. Sea Grant Publication, TAMU-SG-73-401.

Lightner, D. V and C. T. Fontaine. 1975. A mycosis of the American lobster, _Homarus americanus_, caused by _Fusarium_ sp. Journal of Invertebrate Pathology, 25:239-245.

Lightner, D. V. 1975. Some potentially serious disease problems in the culture of penaeid shrimp in North America. Proc. Third U.S.-Japan Meeting on Aquaculture, Tokyo, Japan. Spec. Pub. Fish. Agency, Japanese Govt. and Japan Sea Reg. Fish Res. Lab., pp. 75-97.

Lightner, D. V. and D. H. Lewis. 1975. A septicemic bacterial disease syndrome of penaeid shrimp. Marine Fisheries Review 37(5-6):25-28.

Lightner, D. V., C. T. Fontaine, and K. Hanks. 1976. Gill diseases in penaeid shrimp. World Mariculture Society Annual Workshop, Seattle, Washington.

Neal, R. A. 1974. Progress toward farming shrimp in the United States. Marine Fisheries Review 35(3-4):67-70.

Overstreet, R. M. 1973. Parasites of some penaeid shrimp with emphasis on reared hosts. Aquaculture (2-1973):105-140.

Overstreet, R. M. 1978. Marine maladies? Worms, germs, and other symbionts from the northern Gulf of Mexico. Mississippi-Alabama Sea Grant Consortium, MASF-78-021, Ocean Springs, Mississippi, 140 pp.

Sindermann, C. J. 1970. Principal diseases of marine fish and shellfish. Academic Press, 369 pp.,New York,

Sparks, A. K. and C. T. Fontaine. 1973. Host response in the white shrimp, Penaeus setiferus, to infections by the larval Trypanorthnchid cestode, Prochristianella penaei. Journal Invertebrate Pathology 22(2):213-219.

Sprague, V. and J. Couch. 1971. Annotated list of protozoan parasites, hyperparasites, and commensals of decapod crustacea. Journal of Protozoology 18(3):526-537.

Young, J. H. 1959. Morphology of the white shrimp, Penaeus setiferus (Linnaeus 1758). U.S. Fish and Wildlife Service, Fishery Bulletin, 145, vol. 59, 168 p.

LIST OF TABLES

Table 1. Temperatures, salinities, sex and average total length of bait shrimp (white and brown shrimp combined).

Date	Temperature (^oC)	Salinity (ppt)	Sex			Average Length (X,mm)
			Male	Female	Total	
Nov. 1973	24	15	2	6	8	102.5
Dec.	20	15	8	12	20	107.8
Jan. 1974	18	17	1	9	10	95.3
Feb.	18	15	8	12	20	99.1
Mar.	20	14	11	9	20	105.2
Apr.	24	20	10	10	20	103.8
May	28	18	7	13	20	81.4
June	28	20	11	9	20	95.3
July	30	27	10	10	20	98.2
Aug.	29	28	5	15	20	118.4
Sept.	24	22	10	10	20	114.6
Oct.	24	22	6	14	20	102.6
Nov.	20	19	6	14	20	106.0
Sum	307	252	95	143	238	1,330.2
Mean	23.6	19.4	7.3	11.0	18.3	102.3

Table 2. The antibiotic sensitivity of seven of the more common bacteria isolated from bait shrimp (brown and white shrimp combined).[a]

Isolate	A	C	Cl	Na	Gm	PB	L	T	N	Dm	F/M	OL
Vibrio alginolyticus	R[a]	S	R	R	S	R	R	R	R	R	S	R
Vibrio anguillarum	R	S	R	R	S	R	R	R	R	R	S	R
Aeromonas formicans	R	S	R	R	R	R	R	R	R	R	S	R
Aeromonas shigelloides	S[b]	S	S	S	S	S	R	R	R	R	S	R
Pseudomonas piscicida	R	S	S	R	S	S	R	R	R	R	R	S
Pseudomonas stutzeri	R	S	S	S	S	S	R	R	R	R	R	S
Lucibacterium harveyi	R	S	R	R	S	R	R	R	R	R	S	R

A - aureomycin; C - chloromycetin; Cl - colymycin; Na - nalidixix;

Gm - gentamycin; PB - polymycin; T - teramycin; N - neomycin;

Dm - demeclocycline; F/M - furadantin/ macrodantin; OL -oleandomycin

[a] R = resistant

S = sensitive

Table 3. Number of shrimp infected and incidence by month of Zoothamnium sp., Lagenophrys sp., suctorian, and an unidentified filamentous organism observed in gills of bait shrimp (white and brown shrimp combined).

	Zoothamnium			Lagenophrys		Suctorian		Filamentous Organism	
Date	Number of Shrimp Examined	Number of Shrimp Infected	Percent Occurrence	Number of Shrimp Infected	Percent Occurrence	Number of Shrimp Infected	Percent Occurrence	Number of Shrimp Infected	Percent Occurrence
Nov. 1973	8	6	75	5	62.5	4	50	0	0
Dec.	20	2	10	19	95	14	70	0	0
Jan. 1974	10	6	60	5	50	0	0	0	0
Feb.	20	13	65	8	40	0	0	0	0
Mar.	20	7	35	6	30	0	0	1	5
Apr.	20	8	40	4	20	0	0	0	0
May	20	16	80	17	85	2	10	1	5
June	20	20	100	20	100	9	45	3	15
July	20	17	85	5	25	2	10	8	40
Aug.	20	9	45	0	0	1	5	11	55
Sept.	20	13	65	4	20	0	0	0	0
Oct.	20	15	75	12	60	9	45	1	5
Nov.	20	12	60	10	50	11	55	4	20
Total	238	144	60.5	115	48.3	52	21.8	29	12.2

Table 4. Incidence of the gregarine Nematopsis penaeus in the digestive tract of bait shrimp (white and brown shrimp combined).

Date	No. of Shrimp Examined	No. and % of Shrimp Infected							
		Foregut		Midgut		Hindgut		Total	
		No.	%	No.	%	No.	%	No.	%
Nov. 1973	8	5	62	7	88	6	75	8	100
Dec.	20	19	95	19	95	20	100	20	100
Jan. 1974	10	5	50	10	100	8	80	10	100
Feb.	20	13	65	20	100	19	95	20	100
Mar.	20	7	35	17	85	18	90	19	95
Apr.	20	1	5	19	95	14	70	20	100
May	20	3	15	20	100	18	90	20	100
June	20	4	20	11	55	16	80	19	95
July	20	3	15	19	95	17	85	20	100
Aug.	20	0	0	11	55	13	65	16	80
Sept.	20	1	5	16	80	14	70	16	80
Oct.	20	1	5	18	90	17	85	20	100
Nov.	20	1	5	15	75	17	85	20	100
Total	238	63	26.5	202	84.9	197	82.8	228	95.8

Table 5. Numbers of *Nematopsis penaeus* observed in the digestive tract of bait shrimp (white shrimp and brown shrimp combined).

Date	White Shrimp			Brown Shrimp		
	Number of Shrimp Examined	Total Number of *N. penaeus*	Average Number of *N. penaeus* Per Shrimp	Number of Shrimp Examined	Total Number of *N. penaeus*	Average Number of *N. penaeus* Per Shrimp
Nov. 1973	8	4077	509.6	0	0	0
Dec.	20	8514	425.7	0	0	0
Jan. 1974	10	3890	389.0	0	0	0
Feb.	20	7335	366.8	0	0	0
Mar.	20	4906	245.3	0	0	0
Apr.	7	2051	293.0	12[a]	1515	126.2
May	1	505	505.0	19	6217	327.2
June	0	0	0	20	967	48.4
July	4	536	134.0	16	1612	100.8
Aug.	14	454	32.4	6	279	46.5
Sept.	18	1171	65.1	1[b]	205	205.0
Oct.	20	2798	139.9	0	0	0
Nov.	20	1722	86.1	0	0	0

a/- one pink shrimp, *P. duorarum*, was examined, not included.
b/- one seabob, *Xiphopeneus kroyeri*, was examined, not included.

Table 6. Occurrence of larval nematodes observed in bait shrimp (white and brown shrimp combined).

Date	Number of Shrimp Examined	Number off Larval Nematodes Observed							Percent Infected
		Gills	Hindgut	Midgut	Foregut	Hepato-pancreas	Dorsal Gland	Muscle	
Nov. 1973	8	0	0	0	0	0	0	0	0
Dec.	20	0	0	0	1	1	0	0	10
Jan. 1974	10	0	0	0	0	4	2	0	60
Feb.	20	0	0	2	0	0	15	0	85
Mar.	20	0	2	1	8	2	20	0	100
Apr.	20	0	2	0	5	3	11	0	55
May	20	0	0	0	1	2	1	0	15
June	20	0	0	1	0	0	0	0	5
July	20	0	0	0	0	4	10	0	50
Aug.	20	1	0	0	1	2	6	0	40
Sept.	20	0	0	0	0	1	5	6	30
Oct.	20	0	0	0	0	1	5	6	30
Nov.	20	0	0	0	1	1	9	0	45
Total	238	1	4	4	17	21	84	12	41.2
Frequency of Occurrence (%)		0.4	1.7	1.7	7.1	8.8	35.3	5.0	41.2

Table 7. The monthly incidence of larval nematodes in bait shrimp, *Penaeus setiferus* and *Penaeus aztecus*, with average number of worms per infected animal.

Date	No. of Shrimp Examined	No. of Shrimp Infected	% Infected	Average No. Nematodes in Infected Shrimp
		White Shrimp		
Nov. 1973	8	0	0	0
Dec.	20	2	10.0	1.0
Jan. 1974	10	6	60.0	4.3
Feb.	20	16	80.0	16.5
Mar.	20	20	100.0	25.0
Apr.	7	7	100.0	21.9
May	1	0	0	0
June				
July	4	2	50.0	1.5
Aug.	14	4	29.0	5.5
Sept.	18	6	33.3	1.7
Oct.	20	5	25.0	1.6
Nov.		10	50.0	3.5
Total	162	78	48.1	13.1
		Brown Shrimp		
Apr.	12	4	33.3	2.0
May	19	3	16.0	1.3
June	20	1	5.0	1.0
July	16	8	50.0	5.2
Aug.	6	4	67.0	4.0
Sept.	1	0	0	0
Total	74	20	27.0	3.2

Table 8. Number of larval nematodes in bait shrimp (white and brown shrimp combined).

Date	No. of Shrimp Examined	No. of Nematodes Observed						
		Gills	Hindgut	Midgut	Foregut	Hepato-pancreas	Dorsal Gland	Total
Nov. 1973	8	0	0	0	0	0	0	0
Dec.	20	0	0	0	1	1	0	2
Jan. 1974	10	0	0	0	0	10	15	25
Feb.	20	0	0	2	0	0	263	265
Mar.	20	0	2	1	35	2	460	500
Apr.	20	0	2	0	8	6	145	161
May	20	0	0	0	1	2	1	4
June	20	0	0	1	0	0	0	1
July	20	0	0	0	0	7	38	45
Aug.	20	1	0	0	1	2	26	30
Sept.	20	0	0	0	0	1	7	8
Oct.	20	0	0	0	0	1	7	8
Nov.	20	0	0	0	1	1	31	33
Total	238	1	4	4	47	33	993	1082
Frequencey of Occurrence (%)		0.09	0.36	0.36	4.34	3.05	91.77	

Table 9. Occurrence of the larval trypanorhynchid cestode, *Prochristianella penaei*, in bait shrimp, *Penaeus setiferus* and *Penaeus aztecus*.

Date	Penaeus setiferus			Penaeus aztecus		
	Infected	No. Examined	%	Infected	No. Examined	%
Nov. 1973	5	8	62.5	0	0	0
Dec.	12	20	60.0	0	0	0
Jan. 1974	4	10	40.0	0	0	0
Feb.	15	20	75.0	0	0	0
Mar.	10	20	50.0	0	0	0
Apr.	3	7	42.8	1	12	8.3
May	0	1	0	8	19	42.1
June	0	0	0	10	20	50.0
July	4	4	100.0	10	16	62.5
Aug.	14	14	100.0	5	6	83.3
Sept.	13	18	72.2	0	1	0
Oct.	8	20	40.0	0	0	0
Nov.	6	20	30.0	0	0	0
Total	94	162	58.0	34	74	45.9

FIGURES

1. The incidence by months of Vibrio, Pseudomonas, and Aeromonas isolated from the hemolymph of bait shrimp.

2. Unidentified filamentous organism attached to the endite of basipodite of the first maxilla. Wet mount, no stain, X50.

3. Unidentified suctorian attached to tip of gill filament (F). Wet mount, no stain, X75.

4. The incidence of Zoothamnium, Lagenophrys, suctorian, and the filamentous organism observed attached to the gill of bait shrimp.

5. Lagenophrys sp. (L) encysted in gill filament. Note intense melanization of the filament by hemocytes. Wet mount, no stain, X50.

6. Histological section showing Lagenophrys (L) digesting into a gill filament (F). H&E, X50.

7. Heavy infestation of Zoothamnium on the gills. Wet mount, no stain, X50.

8. Histological preparation of Zoothamnium (Z) attached to the gills (G). Note no inflammatory response as with Lagenophrys. H&E, X75.

9. Nematopsis penaeus sporozoite in midgut of shrimp. Wet mount, no stain, X100.

10. Nematopsis penaeus gametocyte in hindgut of shrimp. Wet mount, no stain, X50.

11. Histological preparation of dorsal gland showing sections of larval nematodes (N). Note the larvae are in the connective tissue of the gland and not in the lumen (L). H&E, X125.

12. Unidentified cestode procecoid in midgut of shrimp. Wet mount, no stain, X200.

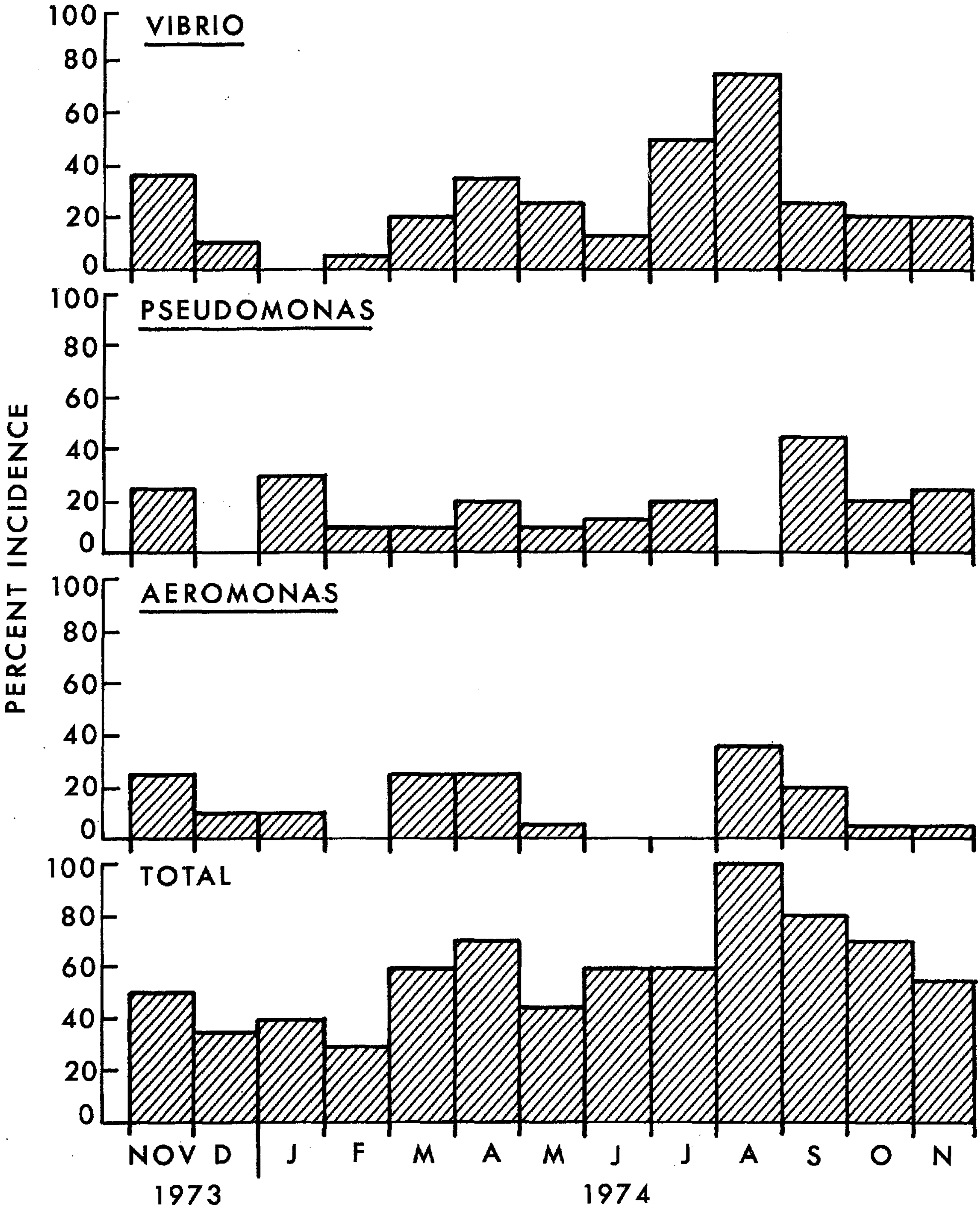
13. Histological preparation of midgut showing unidentified cestode attached to gut lining. H&E, X125.

14. Trypanorhynchid larvae, Prochristianella hispida, teased from a capsule on the hepatopancreas. Wet mount, no stain, X450.

15. Cyclophilidean larvae encysted in the wall of the midgut. Wet mount, no stain, X75.

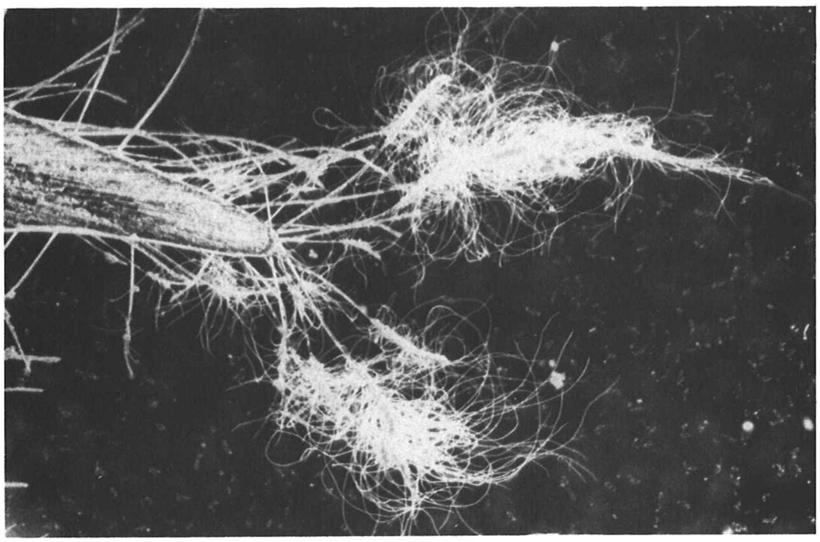
16. Trematode metacercaria from hepatopancreas. Wet mount, no stain, X125.

1. The incidence by months of *Vibrio*, *Pseudomonas*, and *Aeromonas* isolated from the hemolymph of bait shrimp.

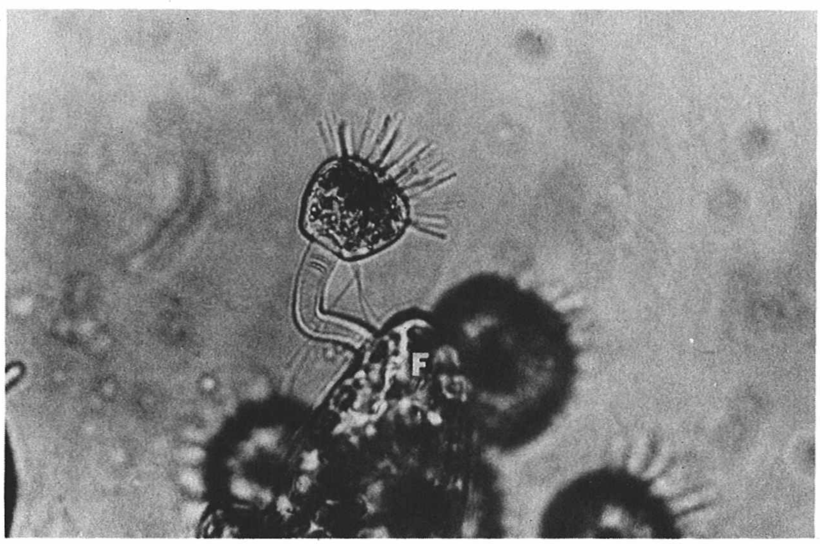


1. The incidence by months of *Vibrio*, *Pseudomonas*, and *Aeromonas* isolated from the hemolymph of bait shrimp.

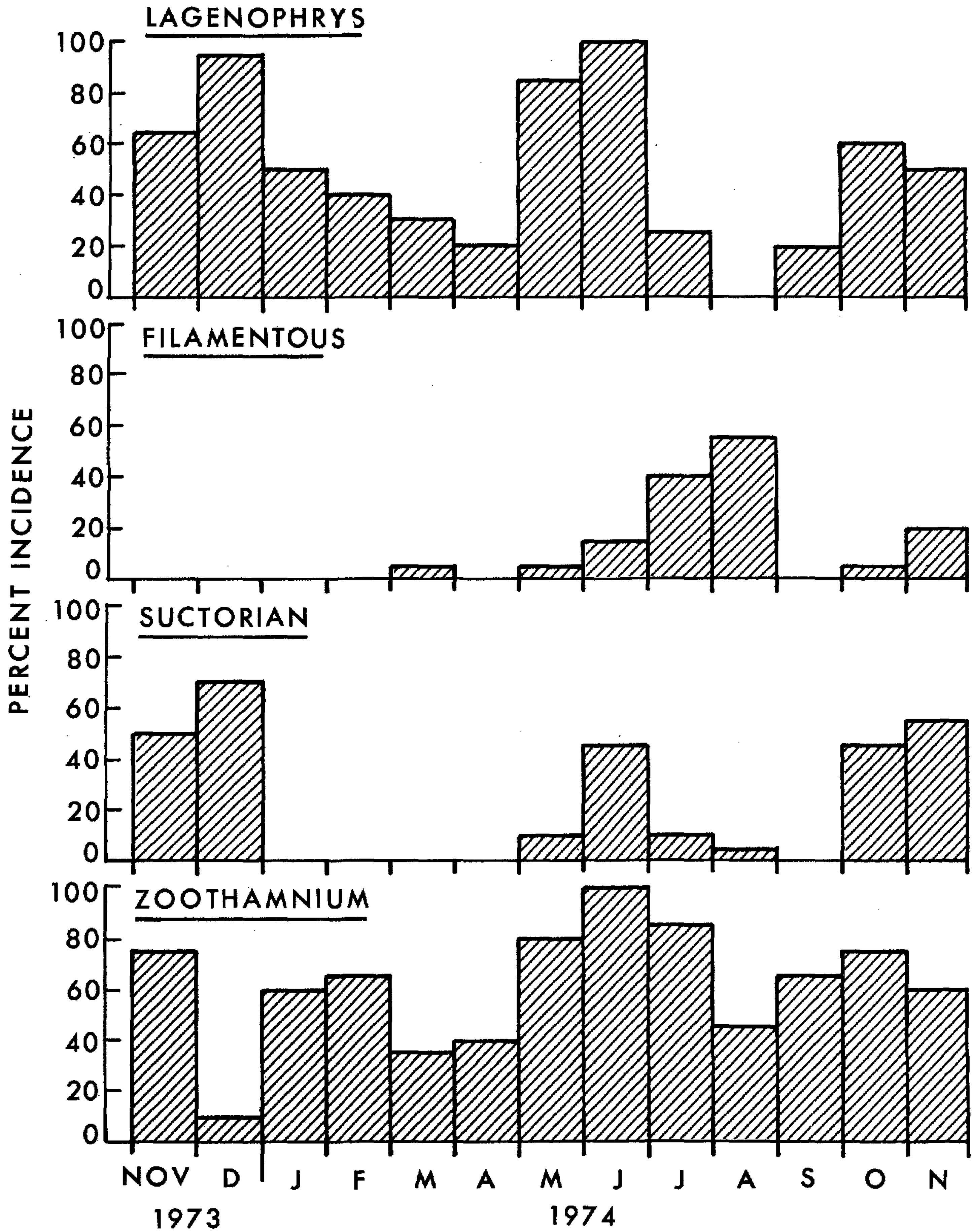
2. Unidentified filamentous organism attached to the endite of basipodite of the first maxilla. Wet mount, no stain, X50.



3. Unidentified suctorian attached to tip of gill filament (F). Wet mount, no stain, X75.

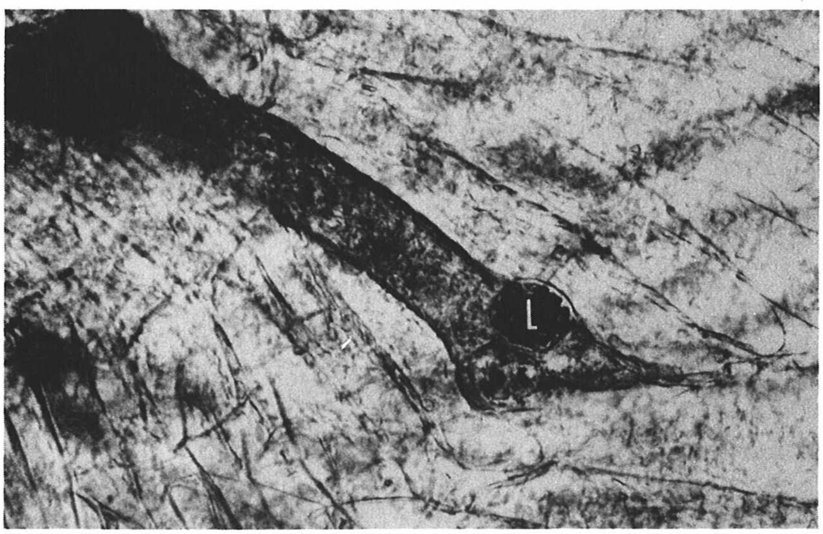

F

4. The incidence of *Zoothamnium*, *Lagenophrys*, suctorian, and the filamentous organism observed attached to the gill of bait shrimp.

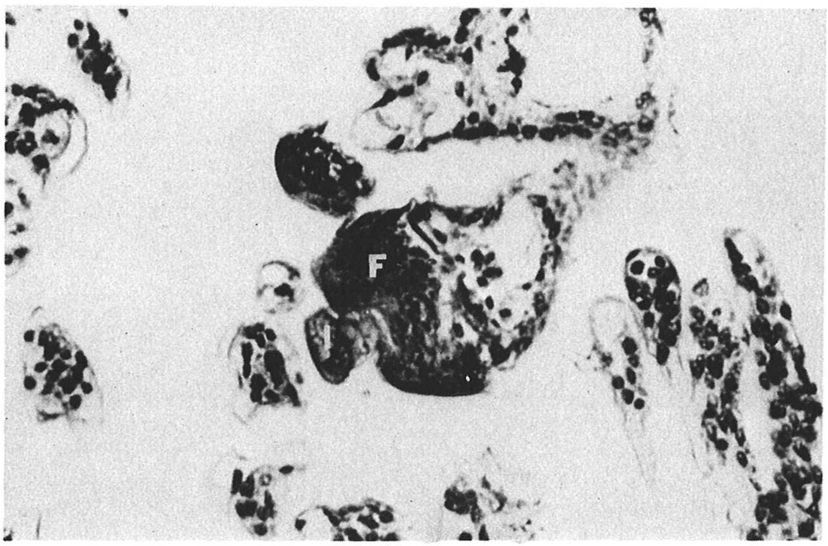


4. The incidence of Zoothamnium, Lagenophrys, suctorian, and the filamentous organism observed attached to the gill of bait shrimp.

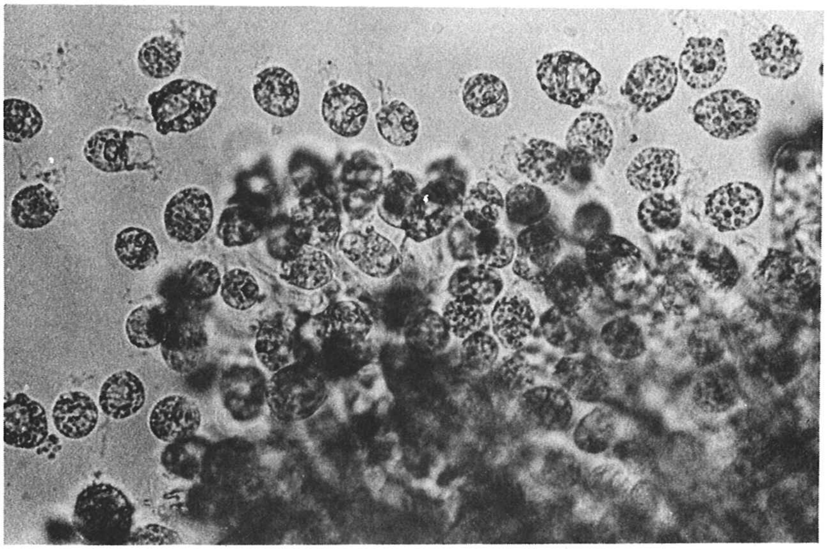
5. Lagenophrys sp. (L) encysted in gill filament. Note intense melanization of the filament by hemocytes. Wet mount, no stain, X50.


L

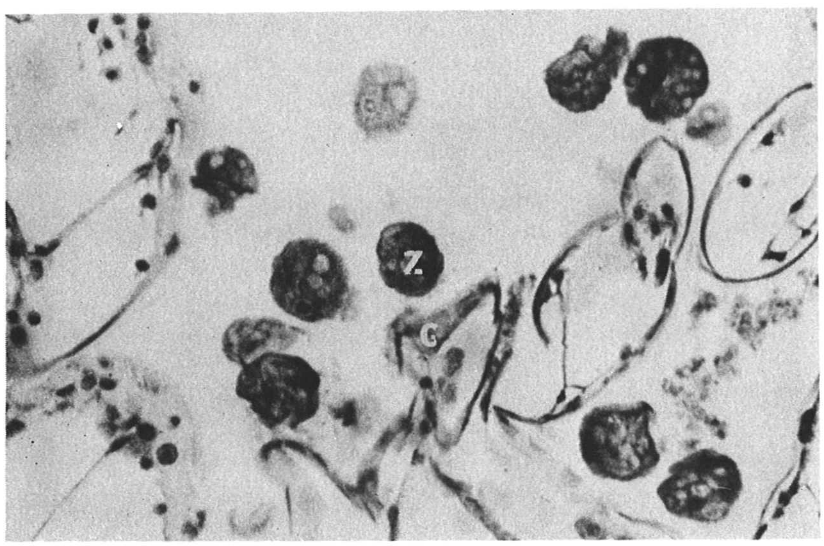
6. Histological section showing Lagenophrys (L) digesting into a gill filament (F). H&E, X50.


F

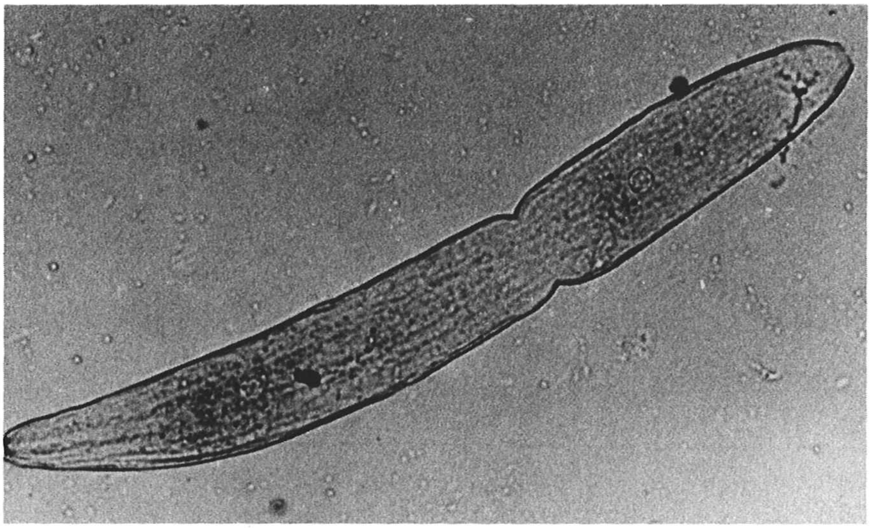
7. Heavy infestation of _Zoothamnium_ on the gills. Wet mount, no stain, X50.



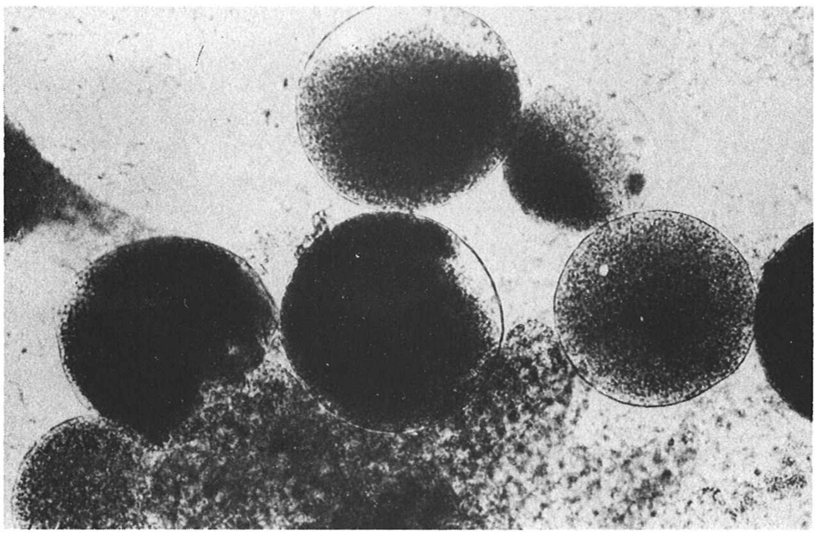
8. Histological preparation of *Zoothamnium* (Z) attached to the gills (G). Note no inflammatory response as with *Lagenophrys*. H&E, X75.


Z
G

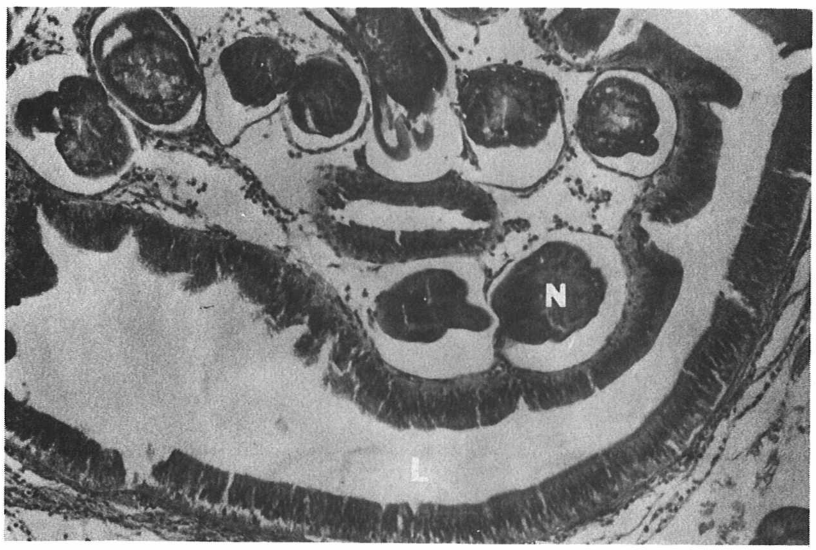
9. Nematopsis penaeus sporozoite in midgut of shrimp. Wet mount, no stain, X100.



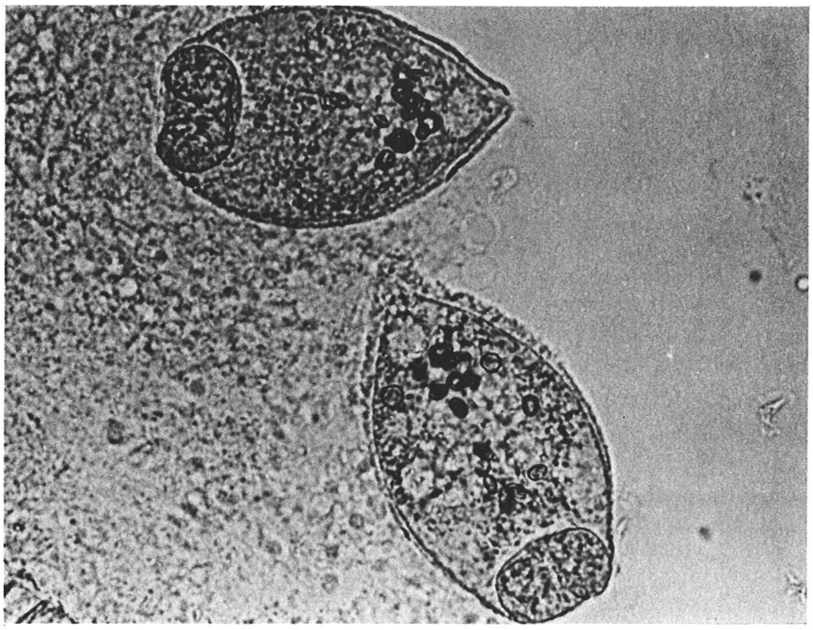
10. *Nematopsis penaeus* gametocyte in hindgut of shrimp. Wet mount, no stain, X50.



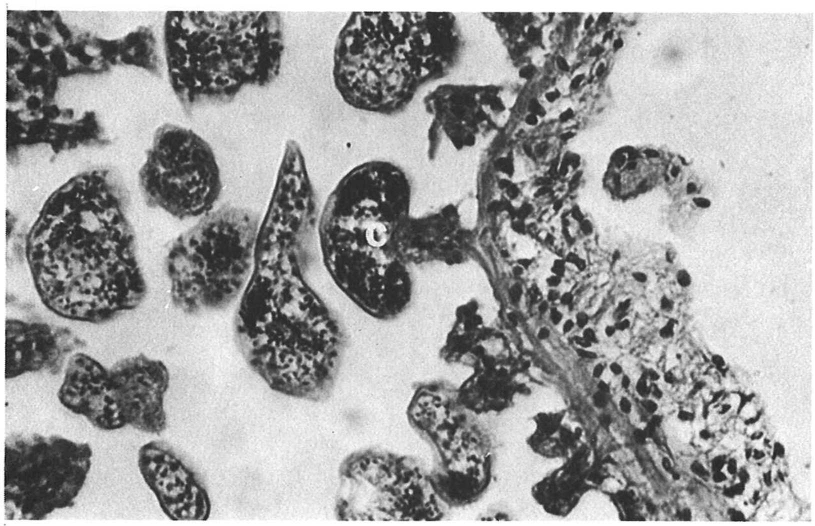
11. Histological preparation of dorsal gland showing sections of larval nematodes (N). Note the larvae are in the connective tissue of the gland and not in the lumen (L). H&E, X125.


N
L

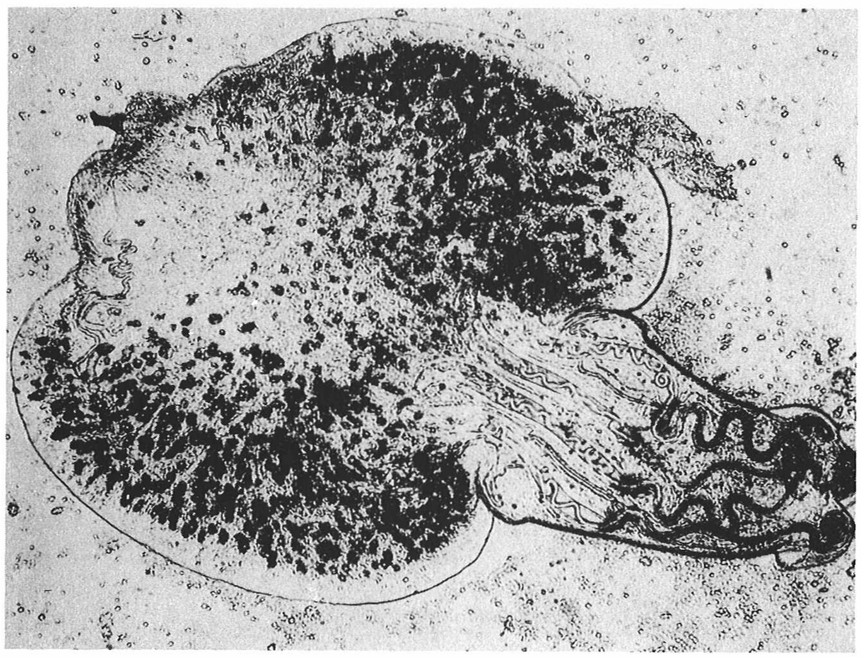
12. Unidentified cestode procecoid in midgut of shrimp. Wet mount, no stain, X200.



13. Histological preparation of midgut showing unidentified cestode attached to gut lining. H&E, X125.


C

14. Trypanorhynchid larvae, *Prochristianella hispida*, teased from a capsule on the hepatopancreas. Wet mount, no stain, X450.



15. Cyclophilidean larvae encysted in the wall of the midgut. Wet mount, no stain, X75.

16. Trematode metacercaria from hepatopancreas. Wet mount, no stain, X125.