HELMINTH PARASITES OF THE CUNNER (TAUTOGOLABRUS ADSPERSUS (WALBAUM)) IN NEWFOUNDLAND

CHANDRA S. SANKURATHRI
B. Sc. (Hons.) (Andhra), M. Sc. (Andhra)

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by

© CHANDRA SEKHAR SANKURATHRI,
B.Sc. (Hons.)(Andhra), M.Sc. (Andhra)

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for the degree of Master of Science

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

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ABSTRACT

A total of 808 specimens of the labrid Tautogolabrus adspersus (Walbaum), obtained during the months of August 1967 to September 1967, and July 1968 to October 1968, from eight sampling areas around the Newfoundland coast were examined for helminth parasites.

Of the 21 different helminths recovered, 18 are from a new host. All species found are described and discussed. Data were analyzed quantitatively to note any variations in infection levels among the different sampling areas and locations within the areas.

The degree of infection with Cryptocotyle lingua (Creplin, 1825) metacercariae on various parts of the body was noted, so was the infection per unit area, and the incidence of parasitaemia in the different areas sampled.

An increase in the number of species of helminths and in the intensity of infection was found to parallel increasing age.

ACKNOWLEDGEMENTS

A study such as this is seldom the undertaking of a single individual. I express my sincere thanks to Dr. M. Laird, Head of the Biology Department, for providing the facilities in the Department where my work was carried out and to Memorial University of Newfoundland for awarding the fellowship which supported this work. I am deeply indebted to Dr. W. Threlfall, Biology Department, for his valuable guidance and constant source of inspiration throughout this work.

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INTRODUCTION

There is little information on the helminth parasites of Tautogolabrus adspersus (Walbaum), the cunner. The relevant papers are those of Cooper (1921), Johansen (1924), Linton (1899, 1901, 1911, 1940, 1941) and Ryder (1884). Most of the fish dealt with in these works were obtained near Woods Hole, Massachusetts, U. S. A.

This thesis presents the results of an ecologically oriented study of the helminth fauna of the cunner in Newfoundland waters.

Most of the dauntingly large literature on the helminths of marine fishes is concerned with taxonomy and morphology. Few papers give details of exactly where, when, and how the fish were caught, the number of fish examined, the number of parasites found and the location of the parasites within the host.

Before dealing with the parasitofauna of a particular host, it is essential to know something about its biology. Johansen (1924) and Naidu (1966) studied the biology of the cunner, Tautogolabrus adspersus (Walbaum)[1], a labrid fish of the order Perciformes.

In first describing the cunner from the coast of New England, Walbaum (1792) named it Labrus adspersus. Cuvier and Valenciennes (1839) provided the first definite record and description of a specimen taken

[1]Scientific names of fish mentioned herein are according to the usage of the American Fisheries Society special publication No. (2). 1960, "A List of Common and Scientific Names of Fishes from the United States and Canada", 2nd edition. Ann Arbor, Michigan.

from Newfoundland waters. Later, Agassiz and Whitman (1882) and Kuntz and Radcliff (1915 - 16) described the eggs and larval stages. The genus Tautogolabrus was erected by Guenther (1862).

T. adspersus is popularly known as the 'cunner'[1] and, also, as the perch, sea perch, blue perch, bergall, nipper, achigen de mer, tanche-tautogue and vieille[2]. Cunners are common along the Atlantic coastline from northern Newfoundland to Chesapeake Bay, including the Gulf of St. Lawrence (Johansen, 1924).

They live on or near the bottom, mostly within a few miles of the shore (Leim and Scott, 1966) and are common around wharves, wrecks and floats.

The body is more or less oblong and moderately compressed with a stout, deep caudal peduncle, equalling half the maximum body depth. The head is pointed with a terminal mouth bearing thick lips and a premaxillary bone that is protractile. The jaws are provided with several rows of teeth. The opercula are covered with fairly large scales. The preopercula, however, are characterized by smaller scales and the interopercula are naked. All the fins are naked, the body being covered with large, weakly ctenoid or cycloid scales (Naidu, 1966). The scales seem to be cycloid, as no ctenii were observed. The lateral line is continuous but arched, and normally bears sixty-four scales (Naidu, 1966).

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[1] See footnote on previous page.

[2] Common names are according to Leim and Scott, 1966. "Fishes of the Atlantic Coast of Canada." Queen's Printer, Ottawa.

The dorsal fin is made up of eighteen spiny rays and nine to ten soft rays, and extends from the posterior end of the head to the caudal peduncle. The caudal fin is heavy and rounded with soft rays, while the pectoral fin is rounded and composed of fourteen soft rays. The pelvic fin is composed of one spiny ray and seven soft rays. The anal fin is provided with three spiny rays and nine soft rays.

Cunners may reach a length of 17 inches but usually do not exceed 12 inches, and may weigh up to 3¼ pounds.

Cunners are variously coloured with red, brown and blue pigments, the actual colour depending on the prevailing background (Leim and Scott, 1966).

The internal anatomy is that of a typical perciform fish.

The spawning season extends from June to August in Newfoundland coastal waters (Naidu, 1966).

Cunners feed mostly on molluscs and crustaceans, such as limpets, mussels, periwinkles, crabs, shrimps, mysids and amphipods, and on other marine organisms such as sea urchins, fish eggs and worms (Leim and Scott, 1966).

Controversy exists over whether the cunners migrate into deeper waters in winter. They are found close to the shore during spring and summer. With the onset of winter, though, when the water temperature drops to about $5^{o}C$, they appear to move into deeper waters (Ambrose, 1866; Bigelow and Schroeder, 1953; Johansen, 1924). It should be mentioned that certain authors claim that cunners do not move into deeper waters (Smith, 1897; Sherwood and Edwards, 1901). At all events, these fish seem to be

present in the inshore waters of Newfoundland during the mid-winter period (J. Green, pers. comm.).

The cunner is of no economic importance in Newfoundland. Nevertheless, Jordan and Everman (1898) noted that its flesh is of excellent flavour, and Bean (1903) reported that it is highly esteemed in some parts of New England. In Newfoundland, the cunner is usually looked at with disgust and prejudice, this opinion appearing to be purely psychological and traditional.

It is best known for the entertainment it provides for those who fish from wharves around the Newfoundland coast.

MATERIALS AND METHODS

Random samples of fish were obtained from eight different areas around the Newfoundland coast during the months of August 1967 to September 1967, and July 1968 to October 1968 (Table 1, Fig. 1).

Most of the fish were caught using a rod and line baited with a small piece of meat or tomcod. Scuba divers using 'chem fish collector'* obtained a number of fish, while on other occasions a large prawn net (3' diameter) was used. Examples from St. Chad's, Bonavista Bay, were caught in lobster traps.

Fish from local sampling stations (1,8) were examined fresh, other specimens being stored in ice for three days. On a number of occasions, fish were kept alive in the laboratory for periods of up to three weeks using a circulating sea water system. Specimens from the more distant sampling sites were either deep frozen or placed in 10 per cent formaldehyde at the site of capture. The material from Gaultois was deep frozen in the local bait depot.

Prior to parasitological examination, the fish were weighed (g) and their total length measured (mm). They were then examined for both ecto- and endoparasites using conventional parasitological techniques.

Details of each fish including colour, sex and gut contents were kept on an autopsy record card (Fig. 2) which was modified from one described by Lagler (1959).

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*Chemical Insecticide Corporation, New Jersey.

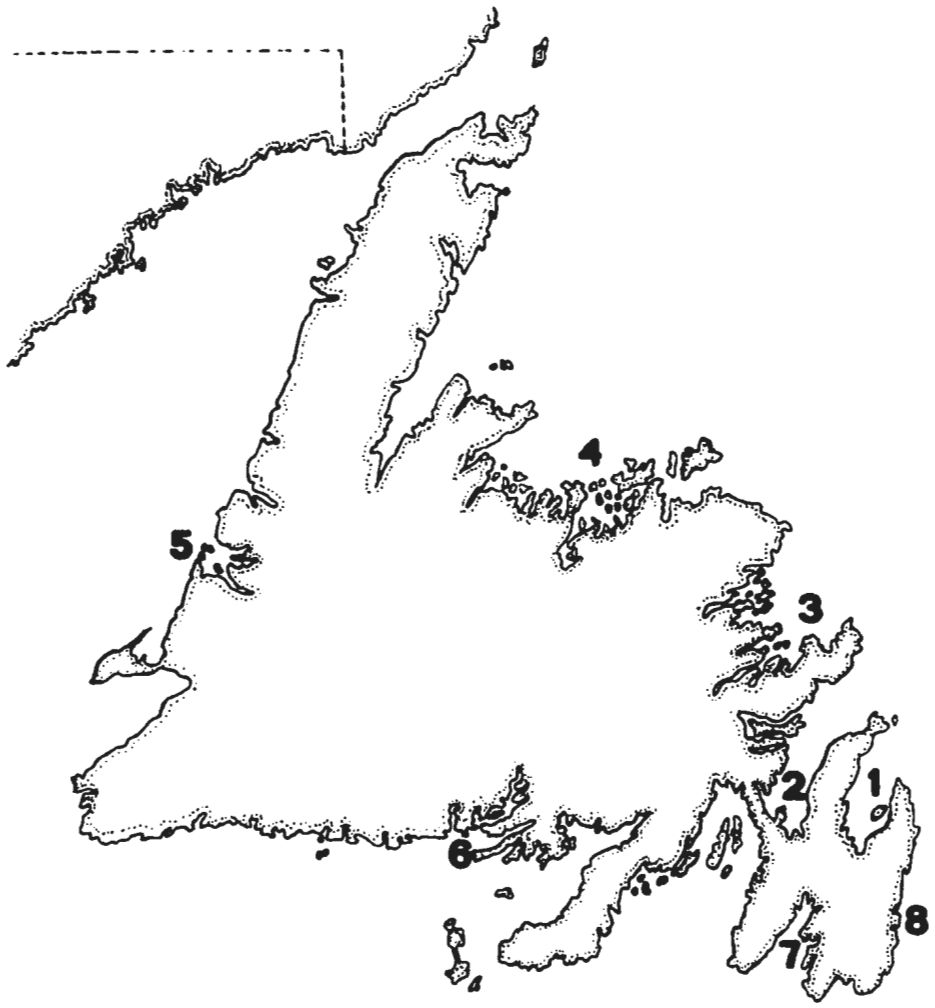

Fig. 1. Showing sampling areas.

1. Conception Bay
2. Trinity Bay
3. Bonavista Bay
4. Notre Dame Bay
5. Bay of Islands
6. Hermitage Bay
7. St. Mary's Bay
8. South Shore

TABLE 1

Listing sampling stations where specimens of *T. adspersus* were caught.

	Place	No. of fish examined
1.	Conception Bay	
	A. St. Phillips	52
	B. Portugal Cove	34
	C. Lake View	38
	D. Holyrood	42
	E. Total	166
2.	Trinity Bay	
	A. Norman's Cove	82
3.	Bonavista Bay	
	A. St. Chad's	77
	B. Sandy Cove	50
	C. Total	127
4.	Notre Dame Bay	
	A. Inspector Islands (Near Comfort Cove)	83
	B. Lewisporte	50
	C. Botwood	4
	D. Coal All Islands (Near Comfort Cove)	17
	E. Total	154
5.	Bay of Islands	
	A. Benoit's Cove	18
	B. Frenchman's Cove	34
	C. Lark Harbour	48
	D. Total	100
6.	Hermitage Bay	
	A. Gaultois	138
7.	St. Mary's Bay	
	A. Mt. Carmel	35
8.	South Shore	
	A. Cape Broyle	6
9.	Total	808

AUTOPSY RECORD CARD

NAME OF THE BAY -

PLACE -

HOST DATA: DATE - NO. - REF. NO. - TOTAL LENGTH - WEIGHT - SEX -

COLOURATION - GUT CONTENTS -

PARASITE DATA: HEAD - BODY - FINS: PECTORAL - PELVIC -

DORSAL - ANAL - CAUDAL - GILLS - ORAL CAVITY -

CORNEA - EYEBALL - GENERAL MUSCULATURE -

STOMACH - INTESTINE - ANTERIOR HALF -

INTESTINE - POSTERIOR HALF -

RECTUM - PERITONEAL CAVITY -

LIVER - GALL BLADDER -

KIDNEY - AIR BLADDER - GONAD -

PERICARDIAL REGION - STOMACH SURFACE - INTESTINE SURFACE -

REMARKS -

FIG. 2. AUTOPSY RECORD CARD

The degree of metacercarial infection of various parts of the left side of the body was noted and recorded in a way similar to that of Evans and Mackiewicz (1958) (Fig. 3). Infection was calculated per unit area of the zone examined for metacercariae, so was the percentage infection in different regions of each fish. Metacercarial infection on cunners from different areas in Newfoundland was established.

Living trematodes, cestodes and acanthocephalans were relaxed in either a 0.9 per cent sodium chloride solution or in a 1.0 per cent ethyl carbamate (urethane) solution at room temperature. Later, these specimens were fixed and stored in 5 per cent formaldehyde or in 70 per cent ethyl alcohol.

Encysted nematodes were removed from their cysts using a pair of fine needles and a fine drawing brush. Those still alive were fixed in either hot 70 per cent alcohol or in glacial acetic acid (Berland, 1961), and then stored in 70 per cent alcohol.

Parasites from frozen or preserved fish were placed directly into 5 per cent formaldehyde or 70 per cent alcohol. In many preserved acanthocephalans, it was found that the proboscis was retracted. By applying slight pressure to the anterior end with a thick needle, this organ was made to evert.

Free metacercariae were obtained using the excystment methods of Erasmus (1962), McDaniel (1966), and Stunkard (1930). These methods were tried on both living and preserved material (Appendix I).

To confirm the identity of the metacercariae, specimens were administered, orally, to twelve 21-day-old chickens and six 21-day-old

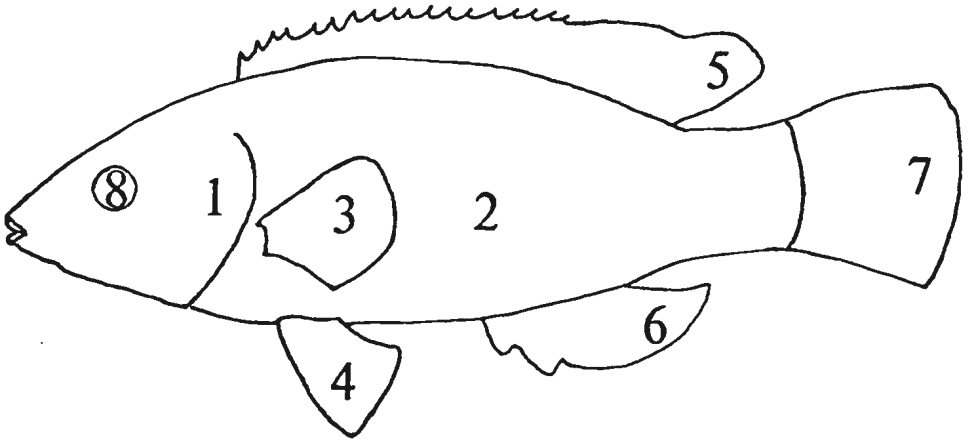

Fig. 3. Detailing the regions where the distribution of metacercarial cysts on the left side of fish were recorded. Infection with cysts was also noted on the gills, isthmus, eyeball and on the oral membrane.

mice. In each case, three controls were maintained. The infected animals and controls were divided into three groups, one of which was examined for parasites each week for three weeks.

Trematodes, cestodes and acanthocephalans were stained with acid carmine[1] and mounted in the conventional manner. A few trematodes were subjected to catechol incubation[1] (Johri and Smyth, 1956) to stain the vitellaria and eggs before counter-staining with acid carmine.

Nematodes were cleared in lactophenol[1] and mounted in glycerol-jelly[1] or cleared and mounted as in Rubin's (1951) method.[1]

In an effort to determine possible differences between the degree of infection of the two sexes, 2xx contingency tests were performed according to Simpson et al. (1960).

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[1]Appendix II.

RESULTS AND DISCUSSION

A total of 808 fish, ranging in length from 31 to 338 mm. (Fig. 4) were examined for helminth parasites. Twenty-one helminth species were recovered during the survey. These comprised 11 species of trematodes, including Cryptocotyle lingua (Creplin, 1825) metacercariae and immature digeneans; four species of cestodes (considering all types of Scolex pleuronectis bilocularis larvae as one species); five species of nematodes and one species of acanthocephalan.

Qualitative analyses of data

Details of infections with the helminth species found are given in Tables 2, 3 and 4.

No Monogenea, Hirudinea and Copepoda parasitica were found.

Of the 21 different helminths recovered, 18 are new host records.

Trematoda

Hemiurus levinseni Odhner, 1905

The present specimen fitted the original description closely. Hemiurus appendiculatus (Rudolphi, 1802) was reported from a wide variety of marine fishes by Linton (1899, 1940), including an immature specimen from cunners from the Woods Hole region. During the present study, specimens of H. levinseni, which differs from H. appendiculatus in having suckers of almost equal size, were recovered. Measurements are given in Table 5.

Fig. 4. Showing range of size of sample obtained.

TABLE 2

Infections with trematode (excluding C. lingua metacercariae) species recovered for 410 infected fish.

Name of the species	No. fish infected	Incidence (%)	Total No. recovered	Range of numbers	Mean No./ infected fish	Site of infection**
Hemiurus levinseni Odhner, 1905.*	36	8.78	70	1 - 6	1.94	1,2,3,6
Derogenes varicus (Mueller, 1784) Looss, 1901.*	79	19.27	105	1 - 5	1.33	1,2,3,6
Lecithaster gibbosus (Rudolphi, 1802) Lühe, 1901.*	118	28.78	210	1 - 16	1.78	1,2,3,6
Lepidapedon elongatum (Lebour, 1908) Nicoll, 1915.*	3	0.73	5	1 - 3	1.67	2,6
Podocotyle atomon (Rudolphi, 1802) Odhner, 1905.*	1	0.24	1	1	1	2
Podocotyle reflexa (Creplin, 1825) Odhner, 1905.*	2	0.49	2	1	1	2
Ptychogonimus megastomus (Rudolphi, 1819) Lühe, 1900.*	1	0.24	3	3	3	2
Metadena sp.*	1	0.24	2	2	2	2
Microphallus sp.*	2	0.49	13	1 - 12	6.5	1,2
Immature digenetic trematodes.*	2	0.49	24	3 - 21	12.0	1

*New host record.
**1 - Stomach, 2 - Anterior intestine, 3 - Posterior intestine, 4 - Rectum, 5 - Viscera, 6 - Gills.

TABLE 3

Infections with cestode species recovered for 410 infected fish.

Name of the species	No. fish infected	Incidence (%)	Total No. recovered	Range of numbers	Mean No./ infected fish	Site of infection**
Eubothrium parvum Nybelin, 1922.*	1	0.24	2	2	2	2
Eubothrium sp.*	4	0.98	4	1	1	2
Bothriocephalus sp.*	18	4.39	26	1 - 3	1.44	1,2
Larval pseudophyllidean	4	0.98	6	1 - 3	1.5	2
Scolex pleuronectis bilocularis Mueller, 1788.*	13	3.17	38	1 - 10	2.92	2,3

*New host record.
**1 - Stomach, 2 - Anterior intestine, 3 - Posterior intestine.

TABLE 4

Infections with nematode and acanthocephalan species recovered for 410 infected fish.

Name of the species	No. fish examined	Incidence (%)	Total No. recovered	Range of numbers	Mean No./ infected fish	Site of infection**
Cucullanellus minutus (Rudolphi, 1819) Törnquist, 1931.*	1	0.24	6	6	6	2
Contracaecum aduncum (Rudolphi, 1802) Railliet and Henry, 1912.*	1	0.24	1	1	1	2
Anisakis sp. larva*	180	43.90	438	1 - 13	9.98	2,3,4,5,6
Phocanema sp. larva*	45	10.98	68	1 - 3	1.51	1,3,5
Phocascaris sp. larva*	40	9.76	79	1 - 12	1.98	1,2,3,4,5
Contracaecum sp. larva*	23	5.61	32	1 - 2	1.39	1,2,3,4,6
Echinorhynchus gadi Zoega in Mueller, 1776	125	30.49	481	1 - 54	3.85	1,2,3,4

*New host record.
**1 - Stomach, 2 - Anterior intestine, 3 - Posterior intestine, 4 - Rectum, 5 - Viscera, 6 - Gills.

TABLE 5

Measurements (mm) of 7 specimens of Hemiurus levinseni Odhner, 1905 (in balsam).

Morphological criteria	Average	Range
Length	1.32	0.90 - 2.16
Width	0.23	0.14 - 0.34
Oral sucker - length	0.12	0.10 - 0.14
width	0.12	0.10 - 0.14
Acetabulum - length	0.12	0.08 - 0.14
width	0.13	0.09 - 0.15
Pharynx - length	0.05	0.04 - 0.06
width	0.06	0.05 - 0.08
Testes - length	0.11	0.07 - 0.14
width	0.10	0.08 - 0.12
Ovary - length	0.09	0.06 - 0.11
width	0.10	0.07 - 0.13
Vitellaria - length	0.13	0.05 - 0.20
width	0.10	0.07 - 0.11
Eggs - length	0.023	0.017 - 0.025
width	0.010	0.008 - 0.013

TABLE 6

Measurements (mm) of 6 specimens of Derogenes varicus (Mueller, 1784) Looss, 1901 (in balsam).

Morphological criteria	Average	Range
Length	1.71	1.32 - 2.14
Width	0.44	0.34 - 0.55
Oral sucker - length	0.19	0.15 - 0.23
width	0.19	0.17 - 0.21
Acetabulum - length	0.34	0.29 - 0.39
width	0.32	0.24 - 0.36
Oral sucker to acetabulum	0.67	0.50 - 0.84
Acetabulum to posterior tip	0.65	0.46 - 0.94
Pharynx - length	0.06	0.05 - 0.08
width	0.08	0.07 - 0.09
Testes - length	0.12	0.11 - 0.13
width	0.11	0.11 - 0.12
Ovary - length	0.12	0.11 - 0.13
width	0.11	0.11 - 0.12
Vitellaria - length	0.17	0.15 - 0.20
width	0.13	0.07 - 0.16
Eggs - length	0.06	0.04 - 0.06
width	0.03	0.02 - 0.04

TABLE 7

Measurements (mm) of 12 specimens of Lecithaster gibbosus (Rudolphi, 1802) Lühe, 1901 (in balsam).

Morphological criteria	Average	Range
Length	1.23	0.82 - 1.59
Width	0.39	0.27 - 0.48
Oral sucker - length	0.12	0.09 - 0.15
width	0.13	0.10 - 0.16
Acetabulum - length	0.23	0.17 - 0.29
width	0.22	0.15 - 0.29
Oral sucker to acetabulum	0.27	0.16 - 0.34
Acetabulum to posterior tip	0.62	0.43 - 0.94
Pharynx - length	0.09	0.05 - 0.11
width	0.09	0.07 - 0.11
Eggs - length	0.024	0.020 - 0.025
width	0.016	0.013 - 0.018

Derogenes varicus (Mueller, 1784) Looss, 1901

This species is characterized by an extremely wide host spectrum and wide geographical distribution. It is found in the stomachs of more than 50 species of fish belonging to many different families and has been recorded from all the major seas and oceans (Dogiel, Petrushevski and Polyanski, 1958). The maximum egg size in the present specimen was larger than that recorded by Linton (1940) (0.06 x 0.0425; 0.054 x 0.036, respectively). Measurements are given in Table 6.

Lecithaster gibbosus (Rudolphi, 1802) Lühe, 1901

Lecithaster confusus Odhner, 1905, has been reported from many species of marine fish, including cunners (Linton, 1940). During the present survey, L. gibbosus was recovered. This species being distinguished from L. confusus in possessing roundish ovarian lobes, finger-like vitelline lobes, a vesicula seminalis dorsal to, and not extending beyond the ventral sucker and larger ova. In the present case, the ova were slightly smaller than those of Linton (1940) (0.024 - 0.036 x 0.015 - 0.018 mm). Measurements are given in Table 7.

Lepidapedon elongatum (Lebour, 1908) Nicoll, 1915

Lepidapedon elongatum has been reported from 13 species of fish belonging to four families. Manter (1934) recovered specimens from fish obtained at depths of 140 - 367 fathoms. This species has been reported from the Atlantic Ocean (Nicoll, 1915; Linton, 1940). It has also been reported from the Black Sea, from the Pacific Ocean near Panama, Japan and Puget Sound. It differs from other species in the genus in having a long

prepharynx and oesophagus and an intertesticular space equal in size to a testes lobe and filled with vitellaria. Only three specimens were recovered from the cunners examined, the helminths having larger eggs than those recovered by Linton (1940) (0.054 - 0.07 x 0.03 - 0.04 mm.). Measurements are given in Table 8.

Podocotyle atomon (Rudolphi, 1802) Odhner, 1905

The only specimen of Podocotyle atomon that was recovered contained larger eggs (0.08 - 0.093 x 0.033 - 0.038 mm.) than those measured by Linton (1940) (0.07 - 0.084 x 0.03 - 0.05 mm.).

Podocotyle reflexa (Creplin, 1825) Odhner, 1905

This trematode has been reported from the sea raven, hake and tomcod (Miller, 1941; Yamaguti, 1958). Two specimens were recovered from cunners, constituting a new host record.

Ptychogonimus megastomus (Rudolphi, 1819) Lühe, 1900

Slightly elongate, plump trematodes with a non-spinous cuticle which is thrown into large, irregular, transverse folds. Two well-developed, muscular and closely adjacent suckers anteriorly situated. Oral sucker subterminal and slightly larger than acetabulum. Pharynx well developed, goblet shaped. Prepharynx and oesophagus absent, Caeca wide and convoluted, originating directly from pharynx, extending anteriorly, and then turning and running posteriorly to the tip of the body. Testes median, one behind the other in posterior region. Ovary, pretesticular and median. There is a well-developed, muscular genital

TABLE 8

Measurements (mm) of 3 specimens of Lepidapedon elongatum (Lebour, 1908) Nicoll, 1915 (in balsam).

Morphological criteria	Average	Range
Length	4.20	2.83 - 5.28
Maximum width (neck)	0.29	0.26 - 0.36
(body)	0.26	0.22 - 0.30
Oral sucker - length	0.10	0.07 - 0.11
width	0.11	0.10 - 0.13
Acetabulum - length	0.10	0.09 - 0.11
width	0.11	0.09 - 0.12
Pharynx - length	0.09	0.09
width	0.07	0.07 - 0.08
Prepharynx	0.18	0.15 - 0.20
Testes - length	0.19	0.15 - 0.21
width	0.19	0.16 - 0.21
Ovary - length	0.19	0.14 - 0.21
width	0.17	0.15 - 0.18
Eggs - length	0.073	0.055 - 0.088
width	0.043	0.028 - 0.060

sucker which opens anterior to the acetabulum. Vitellaria follicular, arranged in lateral fields and extending from the posterior border of the acetabulum, almost to the tip of the body. All the specimens recovered during the present survey were immature and did not contain eggs. Measurements are given in Table 9.

To date, only two species are found in the genus Ptychogonimus Lühe, 1901, one of which is from fresh water fishes (Lyster, 1939) and the other, P. megastomus, from marine elasmobranchs. All the specimens (3) of P. megastomus recovered were immature and lacked eggs. This constitutes a new host record of particular interest due to the fact that the parasites were present in a teleost.

Metadena sp.

Two specimens were found, one with a round and the other with an oblong, thick spinulate body (length - 1.13 and 1.61 mm.; Width - 0.86 and 1.08 mm.).

Spines more prominent in anterior half of body (length - 5 - 7.5 μ), and gradually decreasing in size towards posterior end. Oral sucker terminal and larger (length - 0.09 and 0.14; width - 0.26 and 0.27 mm.) than acetabulum (length - 0.13; width - 0.14 mm.), which is embedded within an encircling fold of the body wall. Prepharynx and oesophagus absent while the pharynx is not clear in the specimens obtained. Intestinal caeca extending posterior to the testes. Two large oval shaped testes arranged diagonally in posterior half of body. Deeply lobed pretesticular ovary, situated between testes. Prostatic complex

TABLE 9

Measurements (mm) of 3 specimens of Ptychogonimus megastomus (Rudolphi, 1819) Lühe, 1900 (in balsam).

Morphological criteria	Average	Range
Length	1.68	1.32 - 2.40
Width	0.44	0.29 - 0.66
Oral sucker - length	0.27	0.21 - 0.33
width	0.29	0.25 - 0.36
Acetabulum - length	0.26	0.22 - 0.33
width	0.26	0.20 - 0.33
Pharynx - length	0.13	0.11 - 0.14
width	0.11	0.11
Testes - length	0.14	0.14 - 0.15
width	0.18	0.18
Genital sucker - length*	0.09	-
width*	0.09	-
Ovary - length*	0.08	-
width*	0.10	-

*Measurements obtained from only one specimen.

and cirrus lacking. Large, dorsal, preovarian vitelline follicles from a band across the body in front of acetabulum. Uterine coils, containing numerous, small eggs, occupy most of space between posterior end of body and vitelline band. Eggs (length - 0.035 - 0.040 (average - 0.038); width - 0.020 - 0.025 (average - 0.023)) are dark brown in colour.

Manter (1947) reviewed the genus Metadena Linton, 1910, and recognized four valid species in North American marine fishes. Two of the specimens obtained in the present study appear different from the previously described species. The present forms differ from M. globosa (Linton, 1910) in not having a very large oral sucker. Their uterus extends to the vitellaria which separates them from Metadena adglobosa Manter, 1947. They resemble Metadena crassulate Linton, 1910, in many respects but possess eggs that are much larger than those found in M. crassulata. In all the four species described, the eggs were 0.014 - 0.022 x 0.008 - 0.013 mm., while in the present specimens, they were much larger (0.035 - 0.04 (average - 0.038) x 0.02 - 0.025 (average - 0.023 mm.). The vitelline follicles formed a definite band across the dorsal side of the digenean. Although the specimens recovered from cunners differ from the known species, it is thought unwise to describe a new species based on measurements of only two examples.

Microphallus sp. (Fig. 5)

Small trematodes with a smooth, pyriform body. Oral sucker well developed and subterminal. A distinct prepharynx leading into a small pharynx. Oesophagus very long while short caeca do not extend

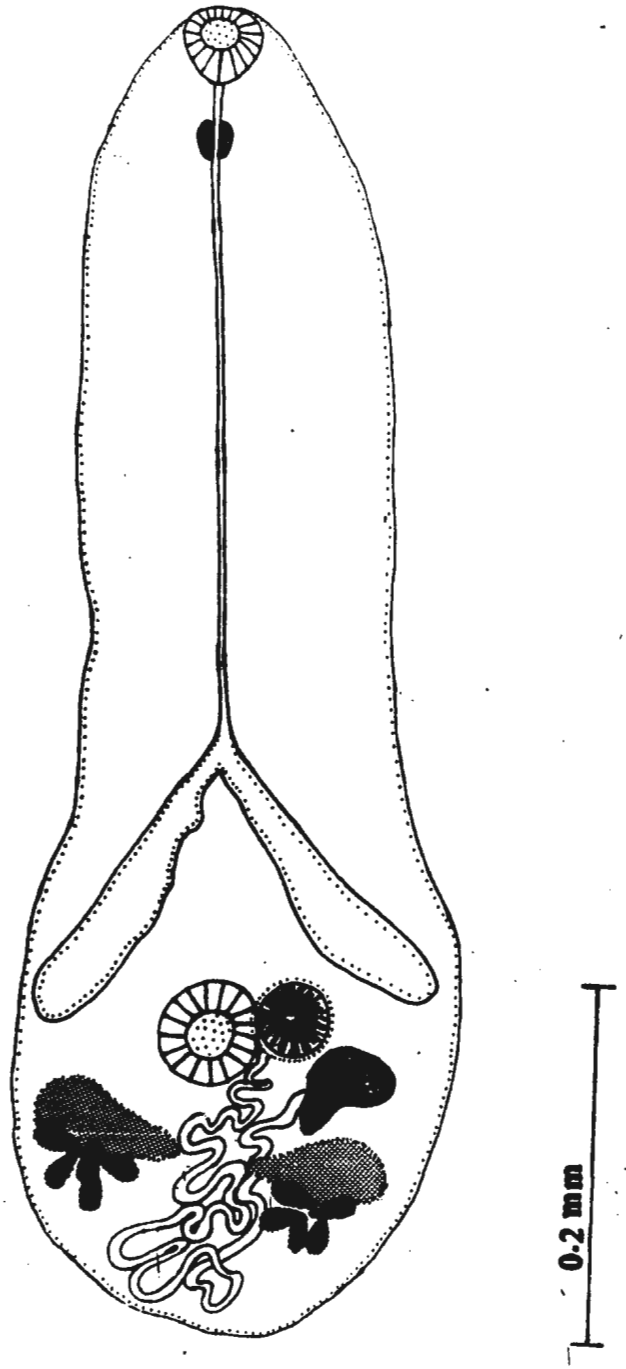


Fig. 5. Microphallus sp. recovered from T. adspersus.

beyond acetabular region. Acetabulum equal in size to oral sucker, situated in posterior third of body. Testes symmetrically placed, postacetabular. Cirrus sac absent. Genital atrium well developed, opening on right side of acetabulum. Ovary postacetabular, lying in front of right testis. Vitellaria composed of five lobes symmetrically placed on either side of the creature's midline and almost overlapping the testes. Postacetabular uterus which, in the specimens examined did not contain eggs. Measurements of 13 specimens are given in Table 10.

To date, Microphallus opacus (Ward, 1894) Ward, 1901, is the only species of microphallid reported from fishes (Rausch, 1947; Strandine, 1943). Microphallus ovatus Osborn, 1919, syn. of M. opacus was reported to infect turtles (Rausch, 1946a) and a Microphallus sp. was reported from raccoons (Rausch, 1946b). Rausch (1947) performed laboratory experiments which indicated a broad spectrum of definite hosts for M. opacus. However, no Microphallus species have been reported from marine fishes. During the present study, 13 specimens of Microphallus sp. were recovered from two fish caught in Notre Dame Bay. All the specimens were immature and lacked eggs. They differed from M. opacus in general body proportions, especially the position of the acetabulum and caeca. Due to the lack of eggs, it was decided that no specific diagnosis would be made until further more mature specimens were obtained.

It is of interest to note that M. opacus metacercariae were obtained from crayfish, Cambarus sp. (Rausch, 1947) while, in both the

TABLE 10

Measurements (mm) of 13 specimens of *Microphallus* sp. (in balsam).

Morphological criteria	Average	Range
Length	0.64	0.50 - 0.79
Width	0.25	0.20 - 0.38
Oral sucker - length	0.07	0.05 - 0.08
width	0.07	0.06 - 0.08
Acetabulum - length	0.07	0.06 - 0.08
width	0.07	0.05 - 0.08
Pharynx - length	0.04	0.03 - 0.04
width	0.03	0.02 - 0.04
Prepharynx	0.04	0.03 - 0.06
Oesophagus	0.26	0.21 - 0.31
Testes - length	0.06	0.05 - 0.08
width	0.10	0.07 - 0.12
Ovary - length	0.05	0.045- 0.05
width	0.06	0.05 - 0.07
Genital atrium - length	0.06	0.04 - 0.08
width	0.06	0.04 - 0.07

fish parasitised by Microphallus sp., crab appendages were found in the gut contents.

Immature digenetic trematodes (Fig. 6)

Long, slender trematodes with a slightly subterminal oral sucker. Well-developed pharynx and conspicuous prepharynx. Oesophagus prominent, bifurcating into caeca before reaching acetabulum, which is slightly smaller than oral sucker. Caeca reach posterior end of the body. A pair of pigmented (black) eye spots present in front of pharynx. Two postacetabular testes, almost round in shape and arranged diagonally. All the specimens recovered seem to belong to the same species. Measurements of six specimens are given in Table 11.

The small, immature digenetic trematodes recovered from the stomachs of two fishes exhibited only rudiments of the testes. Moreover, the presence of a pair of black eye spots suggested that they were late stage metacercariae that had only recently entered the fish host. As the internal organs were incompletely developed, no generic diagnosis was attempted.

Metacercariae of Cryptocotyle lingua (Creplin, 1825) Fischoeder, 1903

These represent the infective stage of C. lingua. The metacercariae lie in small, double-walled, spherical cysts, 0.36 mm in diameter, mainly on the scales. The outer cyst wall is thick (0.082 - 0.125 mm.) and fibrous, while the inner wall is thin and smooth. Each cyst usually encloses one metacercaria, which is free to move within its enclosing wall. The cysts were found on all sizes of fish and on

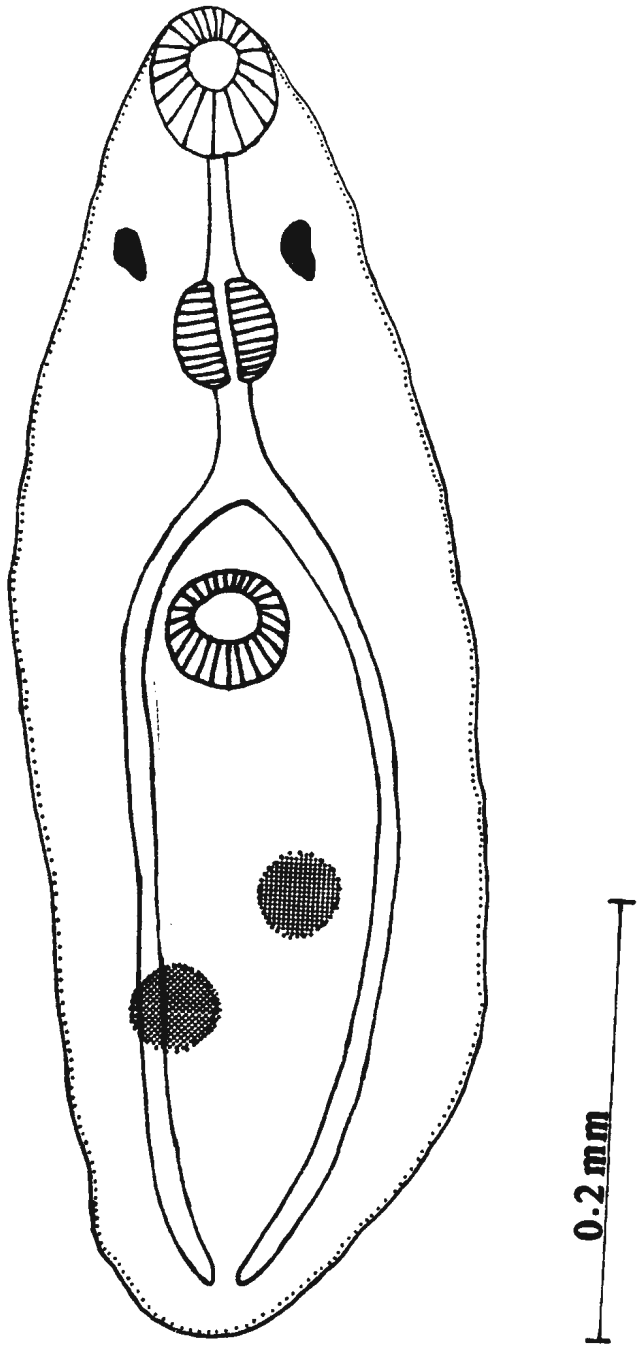


Fig. 6. Immature digenetic trematodes obtained from stomach of T. adspersus.

TABLE 11

Measurements (mm) of 6 immature digenetic trematodes (in balsam).

Morphological criteria	Average	Range
Length	0.47	0.40 - 0.59
Width	0.20	0.14 - 0.24
Oral sucker - length	0.08	0.07 - 0.08
width	0.07	0.07 - 0.08
Acetabulum - length	0.06	0.05 - 0.08
width	0.07	0.05 - 0.08
Oral sucker to acetabulum	0.20	0.18 - 0.24
Acetabulum to posterior tip	0.21	0.16 - 0.29
Pharynx - length	0.03	0.02 - 0.05
width	0.04	0.03 - 0.05
Prepharynx	0.08	0.07 - 0.09
Oesophagus*	0.05	-
Testes - length	0.03	0.03 - 0.04
weight	0.04	0.03 - 0.05

*Measurement obtained from only one specimen.

all external parts of the body including paired fins, unpaired fins, cornea, gill and on the oral membrane (Figs. 7 and 8). All the cysts were surrounded by melanophores, except those that were found on the gills. Hence, heavy infections give a dark appearance to the body regions affected. In a few cases, the cornea was completely covered with black pigment due to metacercarial invasion. Individual scales bore 1 - 45 cysts (Fig. 9) depending on the degree of infection.

Live metacercariae were obtained from cysts utilizing the excystment methods of Erasmus (1962), McDaniel (1966) and Stunkard (1930). Measurements of five specimens (Fig. 10) are given in Table 12.

The identity of the metacercariae was confirmed by feeding living metacercariae to parasite-free chickens and mice. Autopsy of the first group of infected animals after seven days revealed the presence of one adult C. lingua in two mice and 12 in three chickens. The single specimen recovered from the mice was poorly developed and contained only a few eggs. Those from chickens were well developed and contained several eggs. In the next two groups, no adult specimens were recovered from mice, while numerous well-developed adults were obtained from chickens. Only one specimen containing only a few eggs was recovered from a chicken that was kept and then examined 35 days after the administration of the metacercariae.

Metacercarial infection of cunners has been recorded on many occasions (Chapman and Hunter, III, 1954; Hunter, III, 1940; Linton, 1899, 1911, 1940; Ryder, 1884; Stunkard, 1930). Ryder (1884) thought that the cysts were due to the presence of cercariae. Linton (1899)

Fig. 7. Showing gills of T. adspersus with heavy infection of C. lingua metacercariae (A) and without infection (B).

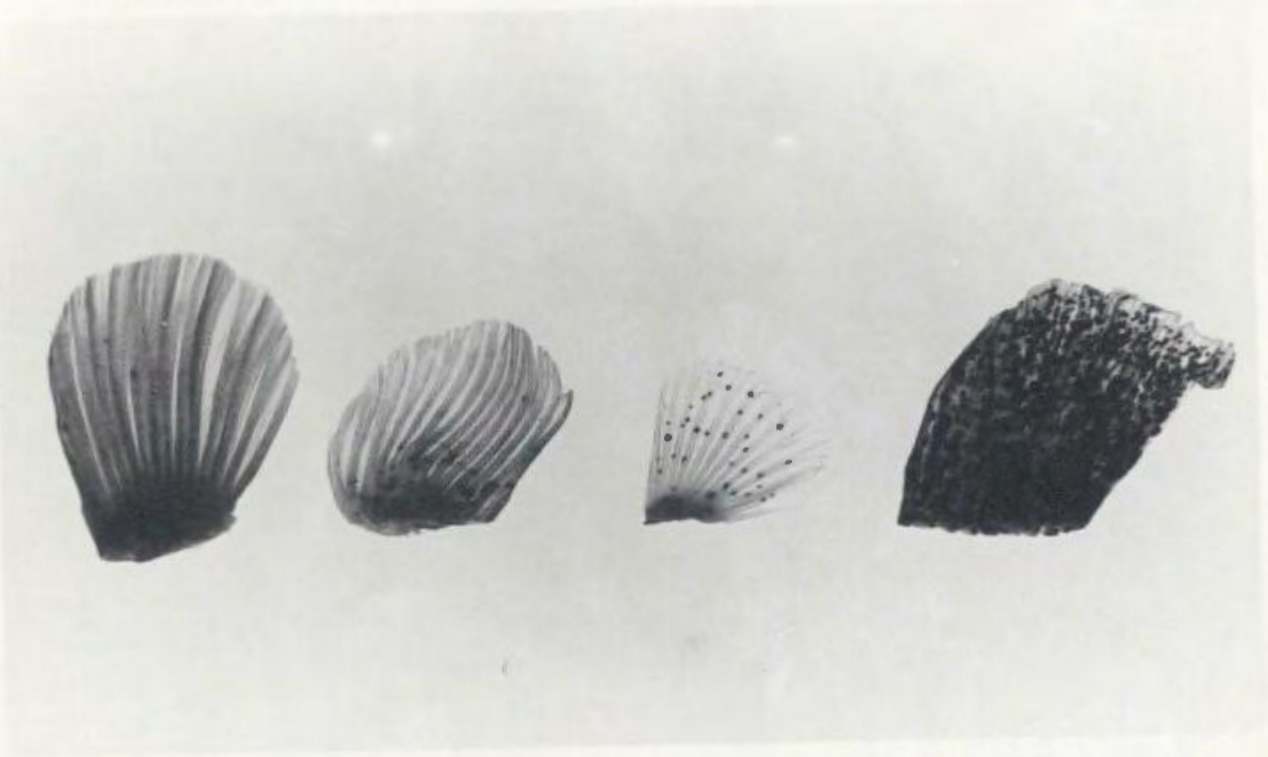


Fig. 8. Showing range of infection with C. lingua metacercariae on fins.

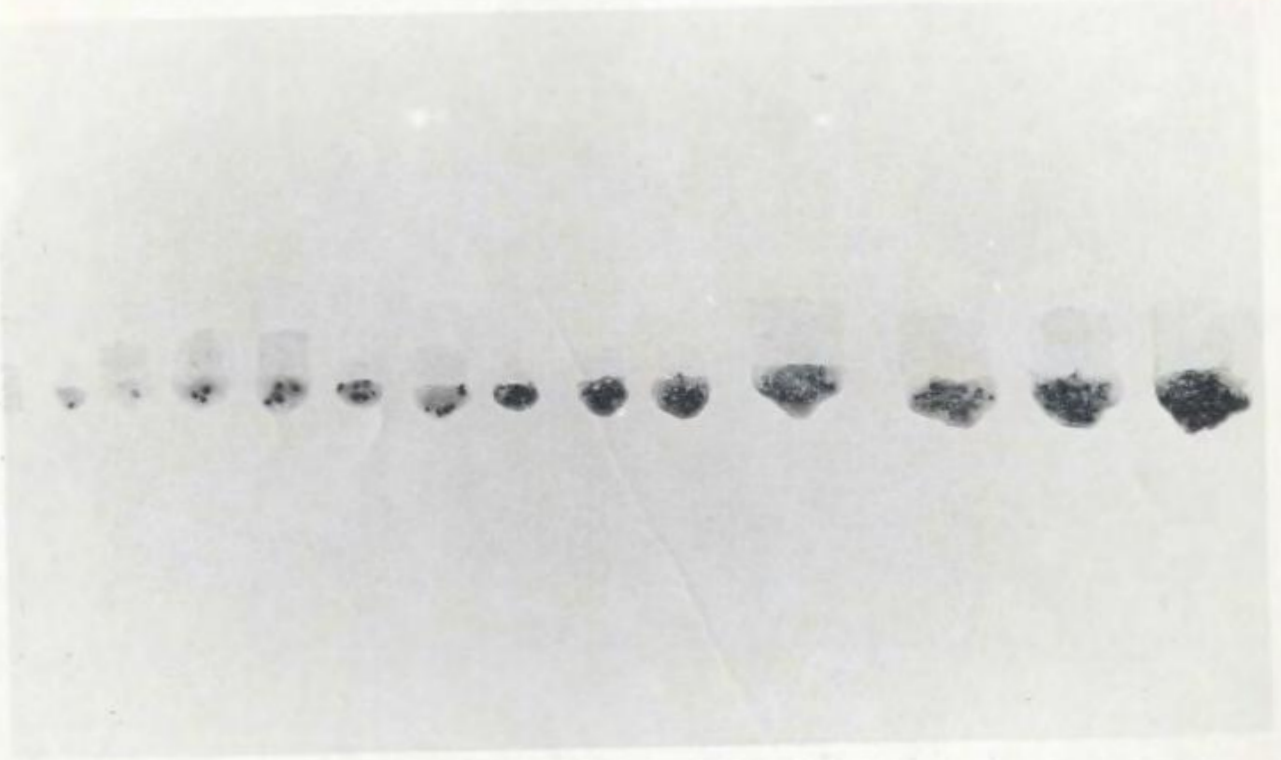


Fig. 9. Indicating the range of infection with C. lingua metacercariae on scales of T. adspersus.

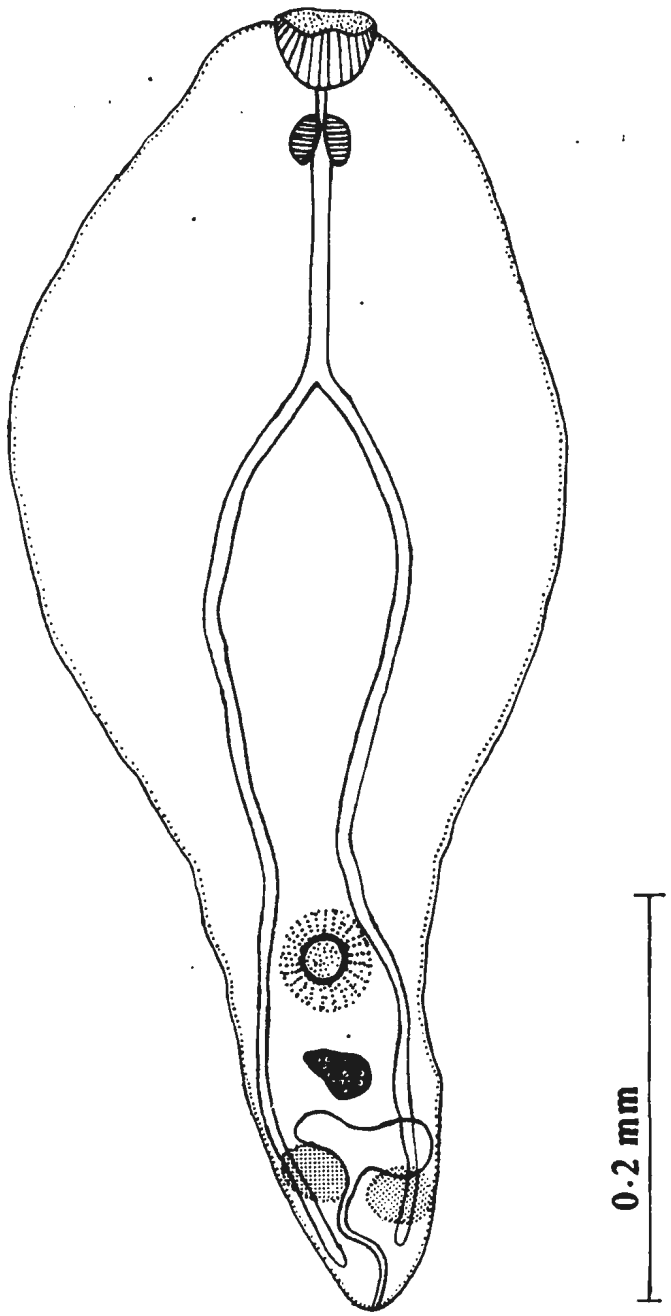


Fig. 10. Showing excysted metacercariae of Cryptocotyle lingua (Creplin, 1825).

TABLE 12

Measurements (mm) of 5 metacercariae of Cryptocotyle lingua (Creplin, 1825) Fischoeder, 1903 (in balsam).

Morphological criteria	Average	Range
Length	0.57	0.45 - 0.69
Width	0.21	0.14 - 0.27
Oral sucker - length	0.06	0.05 - 0.07
width	0.07	0.06 - 0.08
Pharynx - length	0.05	0.04 - 0.05
width	0.04	0.04 - 0.05
Prepharynx	0.03	0.02 - 0.04
Oesophagus	0.09	0.07 - 0.11
Genital atrium - length	0.04	0.04 - 0.06
width	0.03	0.02 - 0.04
Testes - length	0.05	0.04 - 0.07
width	0.04	0.03 - 0.08
Ovary - length	0.03	0.03 - 0.04
width	0.04	0.03 - 0.05

obtained immature trematodes from cysts by opening the cyst walls and later obtained adult stages from the intestine of loons (Linton, 1911). The same worker (Linton, 1915) linkes the metacercariae with the adults on the basis of morphological evidence. Stunkard (1930) confirmed Linton's (1915) ideas by demonstrating the complete life cycle of C. lingua, and by establishing T. adspersus as a common second intermediate host.

Living, excysted metacercariae were obtained only when McDaniel's (1966) method was used. Both the metacercariae and cyst walls were digested when Erasmus' (1962) or Stunkard's (1930) methods were employed. Of the two different solutions used in McDaniel's method, solution A released a greater number of metacercariae from their cysts than solution B. None of the three methods utilized released metacercariae from preserved material.

During the excystment experiments (Appendix II) when preserved material was used, the cyst walls were not dissolved away and the metacercariae were not freed. Only when living material was used, were free metacercariae obtained. This supports Howell's (1968) contention that excystment is an active process rather than the mere digestion of the cyst wall. This would also explain the lack of success with preserved material.

Of the 6 mice that had been fed living metacercariae of C. lingua, only one adult C. lingua containing a few eggs was recovered, whereas the infected chickens yielded many mature C. lingua containing numerous eggs.

The poor development of the examples from mice may simply be due to the fact that rodents are not the normal definitive hosts for this trematode. The normal definitive hosts for C. lingua are piscivorous birds and mammals (Stunkard, 1930). Rothschild (1942) failed to obtain adult C. lingua from laboratory-reared white rats, domestic ducks and black-headed gulls which had been fed living metacercariae. When metacercariae were fed to gulls on a vitamin deficient diet, poorly developed adults containing a maximum of 30 thin-shelled eggs each were obtained. The development of adults in the vitamin deprived gulls was probably due to a lack of resistance brought on by stresses imposed by the inadequate diet (Rothschild, 1942).

During the present project, all the adult flukes from chickens were well developed and contained numerous eggs, with the exception of the lone individual obtained from the bird autopsied 34 days after infection. The poor condition of this example may have been due to the development of resistance by the host as pointed out by Ackert, Edgar and Frick (1939) and Frick and Ackert (1948).

Cestoda

Eubothrium parvum Nybelin, 1922 (Fig. 11)

Cestodes with a subglobular scolex (length - 0.34 - 0.50 (average - 0.42); width - 0.47 - 0.52 (average - 0.50) mm.) bearing a pair of simple bothria and a small but conspicuous apical plate (length - 0.12; width - 0.25 mm.). There is no conspicuous neck. Strobilus distinctly segmented with a dorsal and a ventral median furrow.

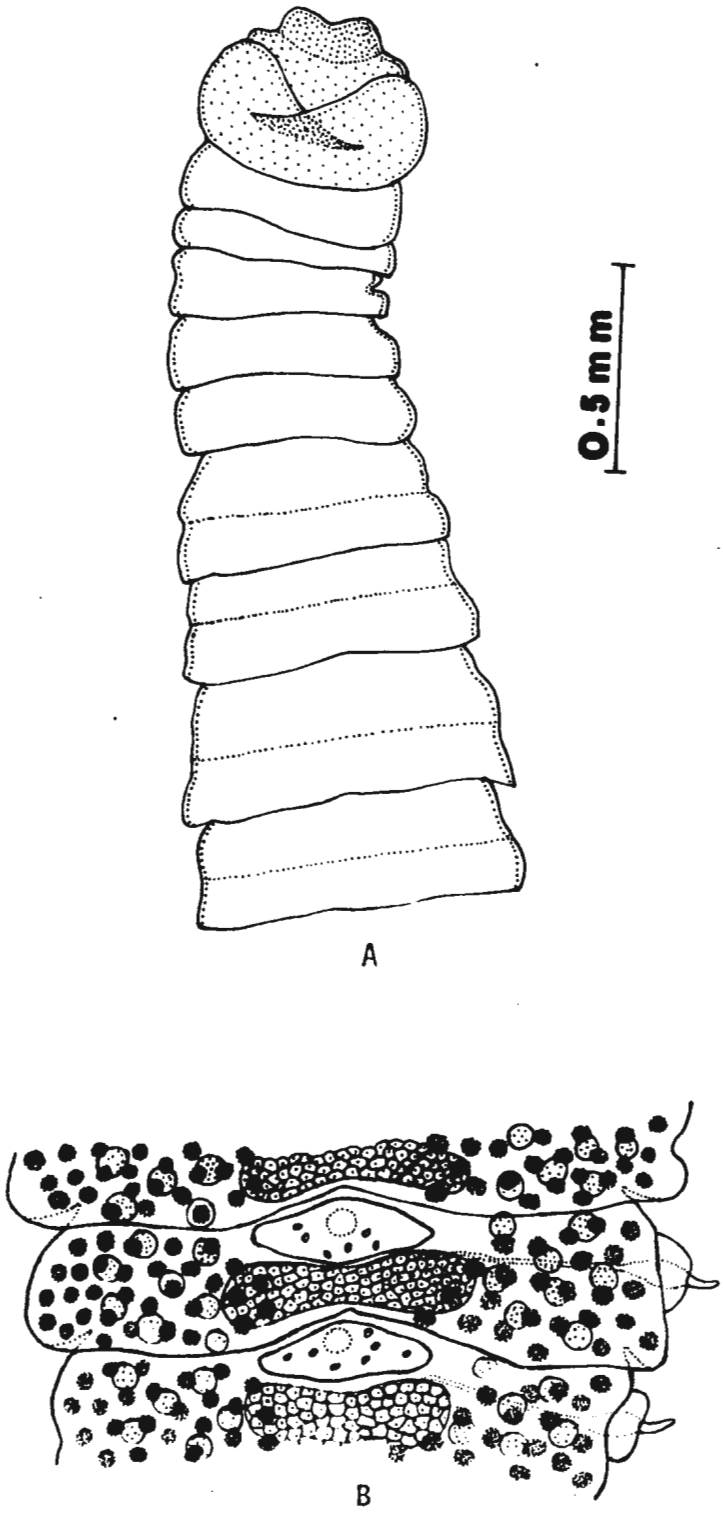


Fig. 11. Showing scolex (A) and mature proglottid (B) of Eubothrium parvum.

Proglottides craspedote, varying much in length and width (0.18 - 0.43 and 0.50 - 1.75 mm., respectively), and often showing secondary segmentation. Testes follicular, numerous, arranged in two separate lateral fields. Ovary kidney-shaped, not lobulated, and situated in the middle of the proglottid (length - 0.20; width - 0.55 mm.). Vitellaria follicular, numerous follicles interspersed among the testicular follicles. Vitellaria of successive proglotticles are distinct. Uterus preovarian and sac-like, containing a few small eggs (length - 0.027 - 0.040 (average - 0.034); width - 0.015 - 0.02 (average - 0.019) mm.). Cirrus sacs well developed (length - 0.18 - 0.25; width - 0.14 - 0.16 mm.) as are the cirri (length - 0.20 mm.).

During the present study, two mature specimens of E. parvum containing only a few eggs in each uterus were recovered from T. adspersus. This constitutes a new host record. Nybelin (1922), after a critical examination of European material, recognized seven valid species, while Wardle and McLeod (1968) described a total of eight European and North American species. E. parvum was described by Nybelin (1922) from Mallotus villosus caught in Norway. Only three species, namely, E. parvum, E. fragile Rudolphi, 1802, and E. arcticum Nybelin, 1922, have been recovered from marine fishes. Of the three species, E. fragile can be distinguished by the presence of a transverse row of testicular follicles between the lateral fields of testes, a feature lacking in the present specimens which were characterized by the presence of numerous vitelline follicles, a simple uterine sac and a relatively small holdfast.

This record is of interest as it is the first from the Western North Atlantic.

Eubothrium sp. (Fig. 12)

Small (length - 0.86 - 2.52 (average - 1.49); width - 0.25 - 0.34 (average - 0.30) mm.) worms with a subglobular scolex (length - 0.18 - 0.25; width - 0.2 - 0.32 mm), bearing simple bothria and a small but conspicuous apical disk (length - 0.09; width - 0.21 mm.). Strobilus distinctly segmented with no neck between scolex and proglottidles. Only immature specimens were found.

The immature Eubothrium sp. that were recovered possessed a scolex similar to that described for E. parvum. However, in all the four specimens found, the genitalia had not developed. It was felt that it would be unwise to assign a specific name to them. They were in all probability immature E. parvum.

Bothriocephalus sp. (Figs. 13, 14)

Many immature specimens of Bothriocephalus sp. were recovered, ranging in length from 1.25 to 9.63 mm. (average - 3.34), and in width from 0.14 to 0.46 mm. (average - 0.22). Body composed of an elongate scolex (length - 0.50 - 1.47 (average 0.81); width - 0.14 - 0.29 (average - 0.23) mm.), followed by a strobilus. Neck absent. Bothria long and shallow posteriorly with indented edges. Scolex provided with an apical disk. Segmentation complete, often with secondary segmentation Proglottidles craspedote, the anterior ones funnel shaped, posterior ones rectangular. Genitalia had not developed in any of the specimens recovered.

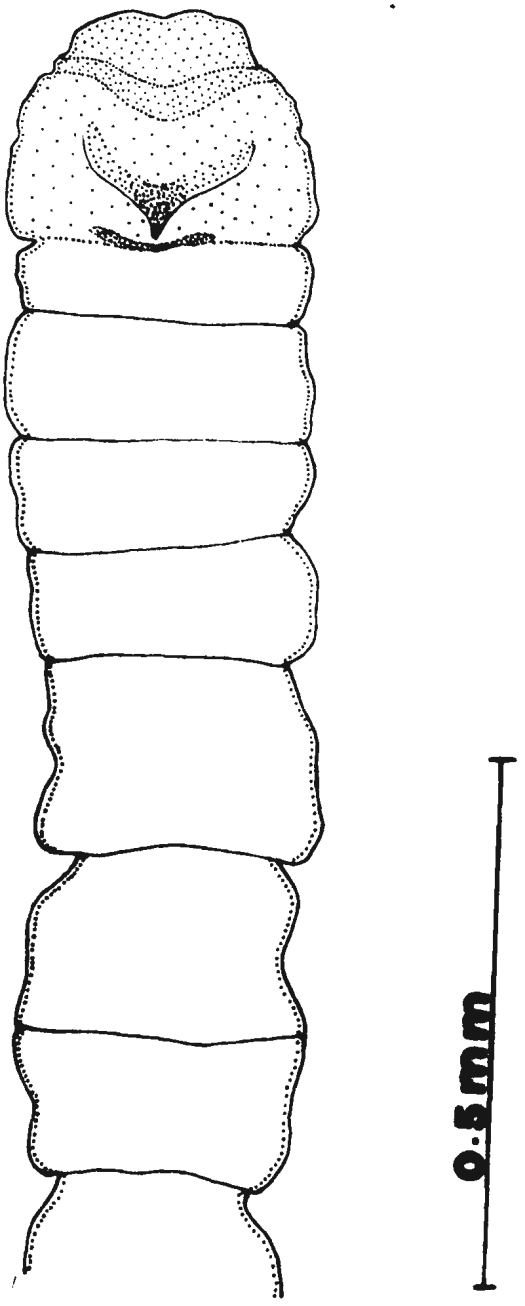


Fig. 12. Showing the anterior end of an immature Eubothrium sp.

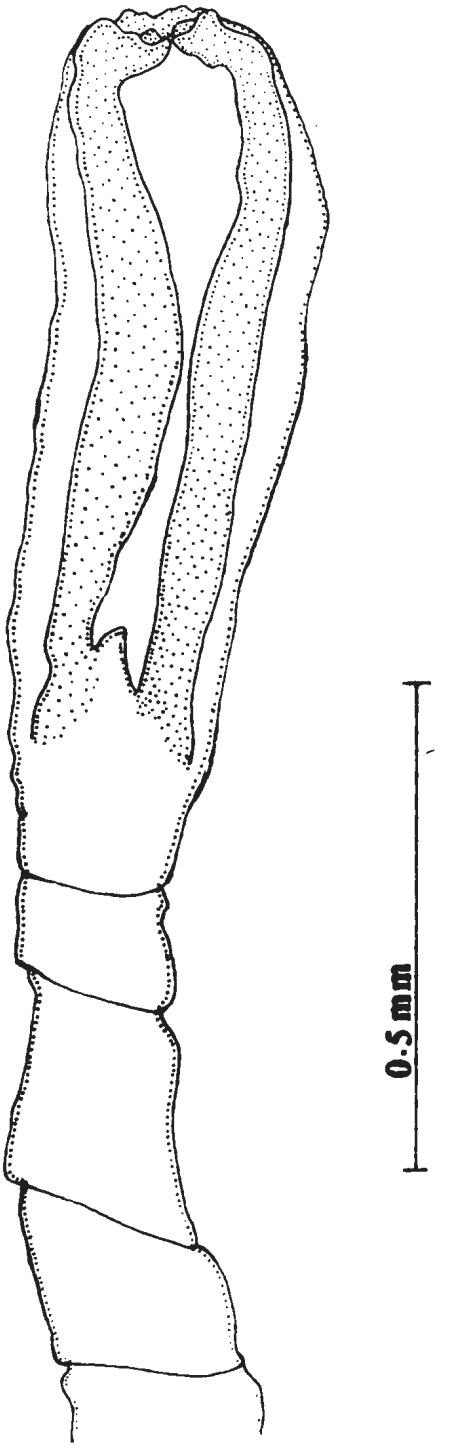


Fig. 13. Showing the scolex of an immature Bothriocephalus sp. (Lateral view).

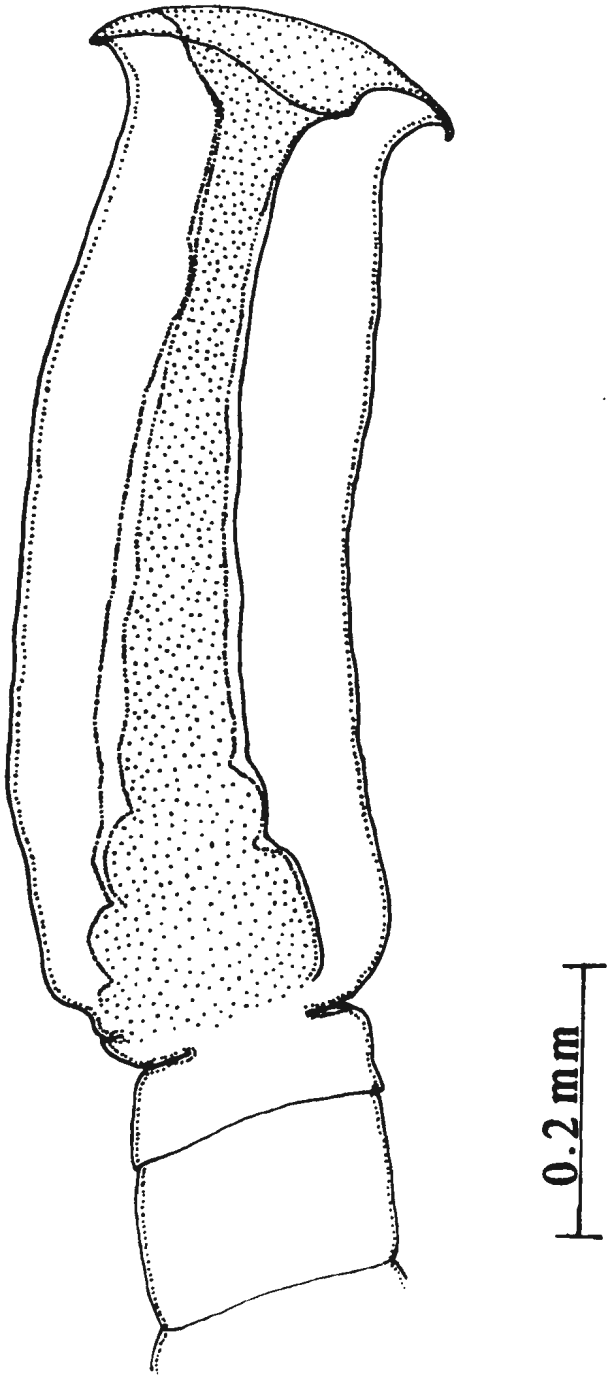


Fig. 14. Showing the scolex of an immature Bothriocephalus sp. (Dorso-lateral view).

The scolex was that of a typical bothriocephalid while the genitalia had not differentiated. A specific diagnosis was not possible. Two of the most common species of this genus from North American marine fish (Linton, 1941) are B. scorpii (Mueller, 1776) and B. claviceps (Geze, 1782) Rudolphi, 1810.

Larval pseudophyllidean (Fig. 15)

Small, white helminths (length - 0.28 - 0.52 (average - 0.37); width - 0.15 - 0.27 (average - 0.19) mm.) with a long, slender or oval body. Anterior end of body invaginated to form a cup-shaped vesicle containing a well-developed muscular sucker (length - 0.09 - 0.11 (average - 0.091) width - 0.10 - 0.15 (average - 0.12) mm.). There is no trace of any other structures.

A total of six larval pseudophyllideans were collected, all of which were found free in the anterior half of the intestine. Linton (1941) described larval (plerocercoid) stages of the genus, Bothriocephalus, from a wide variety of marine fishes of North America. The cestodes are normally encysted on the viscera. Linton (1941) described one such larval form (length - 2.0 mm.) from T. adspersus, and indicated that it possessed short spines on its anterior end and large calcareous bodies internally. The larvae were assigned to the genus, Bothriocephalus, with no reasons given for such a designation. The present specimens have the same basic shape as those described by Linton (1941), but differ in that they are much smaller in size and lack spines on the anterior end and the internal calcareous bodies. It is probable that the present

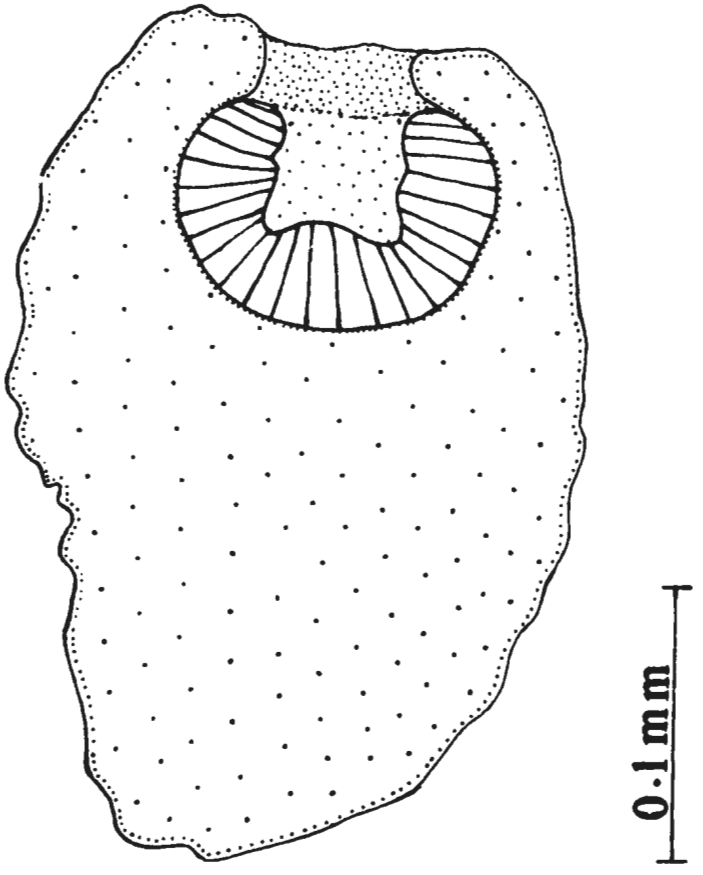


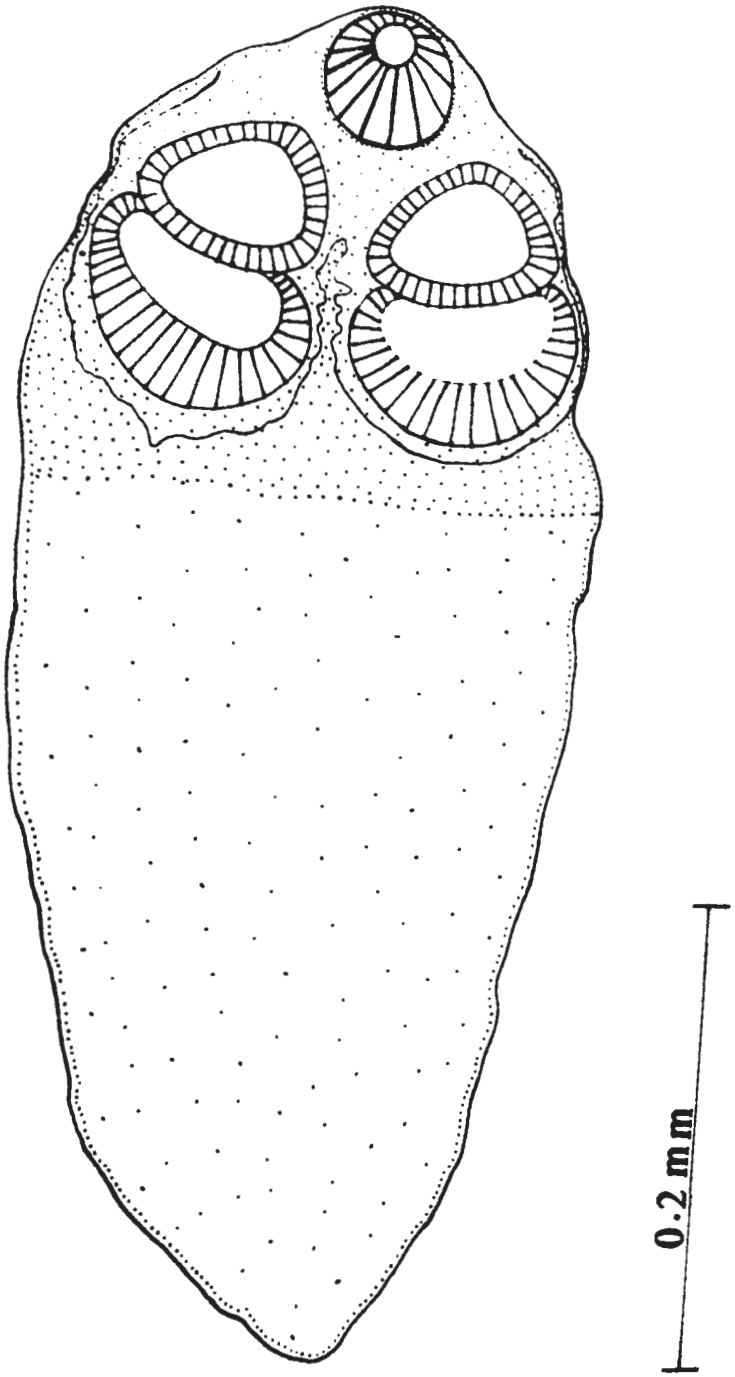
Fig. 15. Showing larval pseudophyllidean obtained from T. adspersus.

parasite is an earlier stage of the larval form found by Linton (1941).

Scolex pleuronectis bilocularis Mueller, 1788 (= S. polymorphus Rudolphi, 1819 = S. delphini Stossich, 1898). (Figs. 16, 17, 18)

Small larval cestodes with an oval or long, slender body. In some specimens, the scolex region was clearly demarcated from the rest of the body by a narrow constriction. Scolex with four well-developed bothridia and a small apical sucker. Each of the four bothridia divided by a transverse septum to give the appearance of two loculi in each bothridium. In some cases, the transverse septum was not very well developed, appearing as only a thin line crossing the sucker (Fig. 18). The apical sucker was either lying in a small pit or it was everted, forming a small globular structure at the apex of the scolex. In a few instances, live larvae were found to bear two conspicuous orange-red pigment spots in the neck region. Measurements of 26 specimens are given in Table 13.

A variety of tetraphyllidean larvae from a wide range of marine hosts, both vertebrate and invertebrate, have been referred to Scolex pleuronectis (Dollfus, 1964; Linton, 1901; Ninburg, 1963). Linton (1899 - 1941) has reported this organism from at least 60 species of marine teleosts from North American Atlantic waters. All the varieties described so far differ from one another in the size of the apical sucker, number of loculi in each bothridium, size and shape of the bothridia, and the presence or absence of pigmentation on the neck. The present plerocercoids were of three types, differing mainly in the



. 16. Showing Scolex pleuronectis bilocularis from T. adspersus.

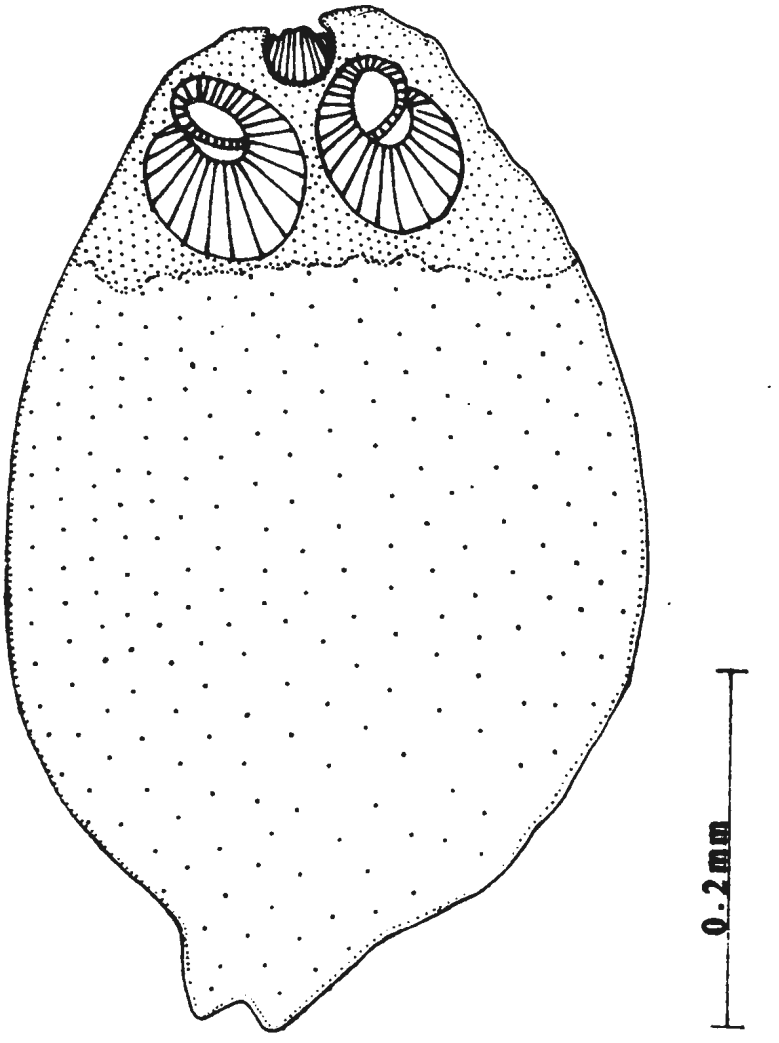


Fig. 17. Showing Scolex pleuronectis bilocularis from T. adspersus.

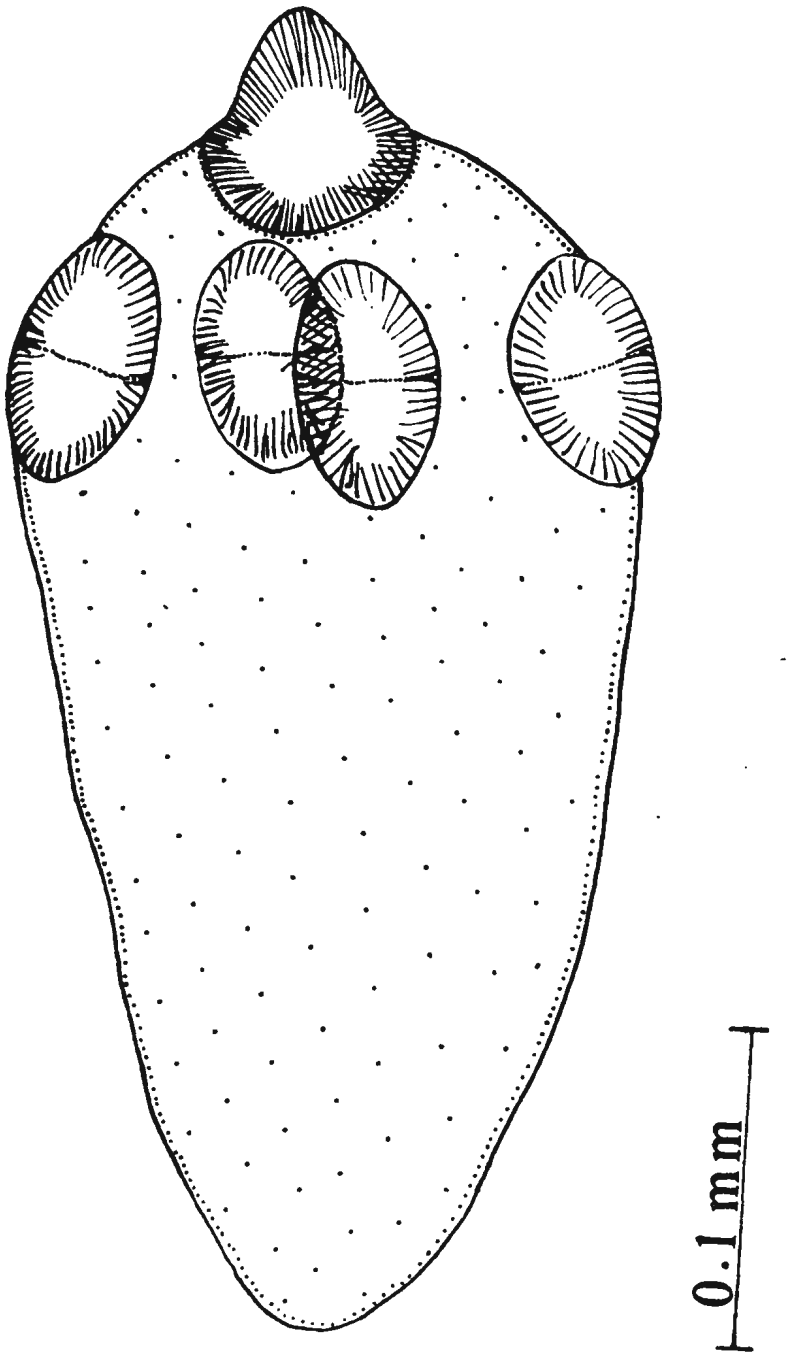


Fig. 18. Showing Scolex pleuronectis bilocularis from T. adspersus.

TABLE 13

Measurements (mm) of 26 specimens of Scolex pleuronectis bilocularis Mueller, 1788 (in balsam)

Morphological criteria	Average	Range
Length	0.55	0.34 - 0.88
Width	0.28	0.17 - 0.47
Sucker - length	0.18	0.13 - 0.22
width	0.12	0.09 - 0.17
Anterior locule - length	0.08	0.07 - 0.11
width	0.11	0.08 - 0.15
Posterior locule - length	0.09	0.06 - 0.13
width	0.12	0.09 - 0.17
Apical sucker - length	0.08	0.05 - 0.15
width	0.08	0.06 - 0.11

nature of the loculi in the bothridia. Basically, all three types were alike with two loculi in each bothridium. Hence, they were all grouped under the one name, S. pleuronectis bilocularis. The anterior end of the bothridia showed no accessory sucker. Present organisms closely resemble those described by Dollfus (1964) from cephalopods, but differ in being much smaller. Several bore a pair of red pigment spots on their necks, resembling the ones described by Ninburg (1963) from Murman pink salmon.

Linton (1899) reported an encysted larval Rhynchobothrium sp. on the viscera of a cunner. Since that time, nobody has reported them from this fish. During the present survey of 808 fish, not a single specimen was discovered. Johansen (1924) recorded a single adult specimen of Abothrium rugosum from T. adspersus. A. R. Cooper examined and identified the helminth but considered the infection an accidental one.

Nematoda

Adult nematodes have not been reported from this fish before. Johansen (1924) and Linton (1901) both reported encysted, immature Ascaris sp. from the viscera.

Cucullanellus minutus (Rudolphi, 1819) Törnquist, 1931

Extremely small nematodes with a slender, fusiform body without lateral alae. Mouth opening anteriorly and provided with a short, cuticular transverse ridge. Oesophagus simple and not divided into muscular and glandular portions. A buccal capsule is formed by a dilation of the anterior end of the oesophagus. A single intestinal caecum is present on the ventral side.

Male -

Preanal sucker present. Tail pointed. Caudal alae absent, but several pairs of caudal papillae present. Three of these adjacent to cloacal aperture. Spicules equal in length, but indistinct.

Female -

Tail pointed, vulva opening posteriorly. Only a single immature female found, with indistinct genitalia.

Measurements of six specimens are given in Table 14.

A total of five male and one female were recovered, while the specimens appeared to be immature as no eggs were present in the lone female. This species was reported from the intestine of sculpins and plaice in the U.S.S.R. (Bykhovskaya, 1962).

Contracaecum aduncum (Rudolphi, 1802) Railliet and Henry, 1912

Only one poorly preserved male (length - 19.08; width - 0.51 mm.) was recovered. As the specimen was incomplete, no description or measurements are given.

C. aduncum appears to be a cosmopolitan, and has been reported from a wide variety of marine fishes (Berland, 1961; Yamaguti, 1961).

Anisakis sp. larva

These helminths were generally found encysted on the viscera. The larvae were always coiled in either a single or a double spiral. On nine occasions, worms were found free in the intestine.

Anisakis sp. larvae are well known from cod (Dollfus, 1953; Grainger, 1959) and several other marine fish species (Berland, 1961).

TABLE 14

Measurements (mm) of 5 male and 1 female Cucullanellus minutes (Rudolphi, 1819) Törnquist, 1931 (in Rubin's medium).

Morphological criteria	Male		Female
	Average	Range	
Length	2.07	1.89 - 2.34	1.47
Width	0.23	0.21 - 0.25	0.24
Length of the oesophagus	0.4	0.38 - 0.42	0.37
Maximum width of the anterior bulb	0.12	0.11 - 0.13	0.12
Maximum width of the posterior bulb	0.09	0.09 - 0.11	0.08
Length of the preanal sucker	0.09	0.06 - 0.11	-
Spicule	0.30	0.288 - 0.32	-
Thickness of the cuticle	0.011	0.007 - 0.015	0.01 - 0.018
Cloaca to the tip of the tail	0.10	0.09 - 0.11	0.13

The latter author described two types of larvae, larva (I) and larva (II), based on small morphological differences. During the present work, no morphological differences were observed in the larval Anisakis sp. recovered.

Measurements of nine specimens are shown in Table 15.

Phocanema sp. larva

These larvae were found encysted on the viscera in a capsule formed by the host. On four occasions, worms were found lying free in the intestine. The larvae were coiled in either a single or a double spiral. A few examples were found to be actively penetrating the body wall.

Phocanema sp. larvae have been reported from a large number of hosts by various workers (Berland, 1961; Dollfus, 1953; Grainger, 1959). Baylis (1944) stated that, in this genus, an intestinal caecum was present in specimens above 28 mm. length. Hence, the larvae, which were less than 28 mm. were hard to distinguish from Anisakis sp. larvae (II) of Berland (1961). In one instance, a larva of 21.36 mm. length was found to possess a small bud-like outgrowth at the junction of the glandular oesophagus and the intestine. This observation supports Baylis' (1944) contention that a caecum is present only in large larvae. Measurements are given in Table 16.

Phocascaris sp. larva

These larvae were found lying free in the alimentary canal, except for two specimens which were encysted on the viscera. Unlike

TABLE 15

Measurements (mm) of 9 specimens of Anisakis sp. larvae (in Rubin's medium).

Morphological criteria	Average	Range
Length	24.32	15.6 - 31.2
Width	0.42	0.25 - 0.66
Muscular oesophagus	1.88	1.46 - 2.52
Glandular oesophagus	0.84	0.72 - 0.96
Anus to tip of tail	0.11	0.08 - 0.16
Thickness of cuticle	0.006	0.004 - 0.008

TABLE 16

Measurements (mm) of 6 specimens of Phocanema sp. larvae (in Rubin's medium).

Morphological criteria	Average	Range
Length	27.66	21.96 - 34.32
Width	0.53	0.39 - 0.77
Muscular oesophagus	1.68	1.61 - 3.4
Glandular oesophagus	1.08	0.81 - 1.8
Caecum	0.48	0.21 - 0.96
Anus to tip of tail	0.15	0.08 - 0.26
Thickness of cuticle	0.01	0.005 - 0.018

Anisakis and Phocanema, they were not coiled. Berland (1961) described Phocascaris sp. larva from the viscera of marine fish as Contracaecum sp. due to the presence of opposed caeca at the oesophagointestinal junction. Later (Berland, 1963), he worked out the life cycle of Phocascaris cystophorae Berland, 1963, and noticed similarities between the Contracaecum larva he had described before and larvae from hooded seals. These larvae (Phocascaris sp.) can easily be distinguished from Contracaecum sp. larvae by the presence of a thick, straight body, which is never coiled, and which bears regular transverse striae on the cuticle. They also lack definite lips and have a posterior end that is more or less pointed. All the larvae belonging to this genus, except one, were found free in the intestine. Measurements are given in Table 17.

Contracaecum sp. larva

These larvae were found free in the alimentary canal. Of the 32 specimens recovered, only one was in good enough condition to be measured.

All the Contracaecum sp. larvae (IV stage) recovered were lying free in the intestine. This stage is characterized by the absence of a boring tooth and by the presence of definite lips and a "cactus-tail".

Acanthocephala

Echinorhynchus gadi Zoega in Mueller, 1776

All these acanthocephalans fitted the original descriptions closely. Measurements are given in Table 18.

TABLE 17

Measurements (mm) of 11 specimens of Phocascaris sp. larvae (in Rubin's medium).

Morphological criteria	Average	Range
Length	10.76	6.49 - 15.17
Width	0.42	0.19 - 0.62
Length of muscular oesophagus	0.84	0.54 - 1.27
" " glandular oesophagus	0.14	0.1 - 0.23
" " anterior caecum	0.6	0.36 - 0.95
" " posterior appendix	0.81	0.68 - 1.08
" " anus to tip of tail	0.13	0.10 - 0.20
Thickness of cuticle	0.006	0.004 - 0.010
Distance between transverse striae		
(i) at apex of anterior caecum	0.013	0.010 - 0.015
(ii) at glandular oesophagus	0.02	0.01 - 0.03
(iii) at apex of appendix	0.03	0.02 - 0.04
(iv) at middle of body	0.04	0.03 - 0.05

TABLE 18

Measurements (mm) of 8 male and 10 female Echinorhynchus gadi Zoega in Mueller, 1776 (in balsam).

Morphological criteria	Male		Female	
	Average	Range	Average	Range
Length	15.14	9.8 - 22.56	28.39	19.8 - 37.2
Width	0.89	0.64 - 1.15	0.97	0.84 - 1.58
Length of the head	0.69	0.49 - 0.91	0.66	0.48 - 1.2
Length of the hooks	0.05	0.033 - 0.063	0.05	0.03 - 0.06
Testes - length	1.41	1.08 - 2.16	-	-
width	0.42	0.23 - 0.65	-	-
Cement glands - length	0.62	0.40 - 1.13	-	-
width	0.37	0.22 - 0.74	-	-
Eggs - length	-	-	0.092	0.06 - 0.137
width	-	-	0.016	0.01 - 0.025

Echinorhynchus gadi was recorded from cunners by Johansen (1924). A specimen was sent to H. J. Van Cleave who wrote the following comments:

> "The specimen you sent ..... belongs to the species Echinorhynchus gadi Muell.
>
> Your statement of infrequent occurrence in Tautogolabrus adspersus is borne out by own records. The individual is an immature female, probably resulting from an accidental introduction into this host, either through feeding upon some fish which carried the parasite normally, or taken in the larval stage along with some unusual invertebrate, not ordinarily occurring in the diet of the cunner."

This species has been reported from several marine fish species from the Western North Atlantic (Linton, 1900, 1901, 1933), from the Canadian Arctic (Van Cleave, 1920) and from the Pacific(Ekbaum, 1938). Dollfus (1953) collected together many of the records of this species from marine fishes. During the present survey, an intensity of infection of 30.5 per cent and the presence of well-developed females indicates that infection is not accidental, as Van Cleave thought, but that T. adspersus is a host for this species of helminth, which has a wide host spectrum. The range of egg sizes in the present specimens is somewhat larger than that given by Yamaguti (1963).

Quantitative analysis of data

C. lingua metacercariae were the most commonly found parasite in the cunners examined, 89.6 per cent of the fish being infected (the mean number per infected fish, 965). Details of infections with metacercariae at the different sampling stations are shown in Table 19.

Among the seven sampling stations, area 5 (Bay of Islands) and 7 (St. Mary's Bay) showed 100 per cent infection and the maximum mean number of metacercariae per infected fish. The lowest incidence was recorded from area 2 (Trinity Bay).

Fish from locations within sample areas 1 and 5 (Conception Bay and Bay of Islands) showed differences in the intensity of infection (Table 20).

It is of interest to note that, even though 88 per cent of the fish from Bonavista Bay were infected, specimens from there showed the lowest intensity of infection (134 metacercariae per infected fish). The maximum intensity of infection was recorded on fish from St. Mary's Bay (2541 metacercariae per infected fish).

Metacercarial infection on different parts of the fish varied considerably (Table 21). Of the total number of metacercariae recovered, 63.5 per cent were found on the body. The remaining 36.5 per cent were distributed on the other external parts of the host. Even though the percentage infection is greatest on the body, the maximum intensity of infection per unit area is found on the anal fin, followed by the caudal fin (Table 22). The infection per unit area on different parts of the body in the different sampling areas and locations within the areas are

TABLE 19

Giving details of *C. lingua* metacercarial infection in different sampling areas.

Origin	No. fish examined	Length* (mm)	No. fish infected	Percentage infection	Mean No. metacercariae /infected fish	Range**
1. Conception Bay	104	117 - 338	101	97.1	785.9	3 - 6,725
2. Trinity Bay	82	163 - 322	44	53.7	455.3	1 - 5,160
3. Bonavista Bay	50	152 - 284	44	88.0	134.0	1 - 1,770
4. Notre Dame Bay	133	85 - 334	129	97.0	616.1	3 - 14,030
5. Bay of Islands	100	91 - 267	100	100	2,469.7	14 - 10,690
6. Hermitage Bay	138	122 - 273	122	88.4	281.0	1 - 5,375
7. St. Mary's Bay	35	112 - 211	35	100	2,541.0	510 - 5,775
8. Total	642	85 - 338	575	89.6	965.3	1 - 10,690

*Range in total length of the fish sample.
**Range in no. of metacercarial cysts on the left side of the fish.

TABLE 20

Giving details of C. lingua metacercarial infection in different locations within the sampling areas.

Origin	No. fish examined	Length** (mm)	No. fish infected	Percentage infection	Mean No. metacercariae /infected fish	Range**
Conception Bay						
A. St. Phillips	8	117 - 276	8	100	275	22 - 765
B. Portugal Cove	16	16.9 - 31.4	15	93.8	75.5	9 - 205
C. Lake View	38	145 - 257	36	94.7	108.4	3 - 488
D. Holyrood	42	132 - 338	42	100	171.5	17 - 6,725
Notre Dame Bay						
A. Inspector Islands	83	85 - 334	81	97.6	667.0	3 - 14,030
B. Lewisporte	50	135 - 247	48	96.0	530.7	16 - 3,365
Bay of Islands						
A. Benoit's Cove	18	93 - 233	18	100	482.1	14 - 3,137
B. Frenchman's Cove	34	136 - 253	34	100	890.3	18 - 4,695
C. Lark Harbour	48	91 - 267	48	100	4,333.8	433 - 10,690

*Range in total length of the fish sample.
**Range in no. of metacercarial cysts on the left side of the fish.

TABLE 21

Giving the details of C. lingua metacercarial infection on different parts sampling areas and locations within the areas

Origin	Head			Body			
	Total	Average	%	Total	Average	%	Total
Conception Bay							
A. St. Phillips	167	20.9	7.6	557	69.6	25.3	242
B. Portugal Cove	42	2.8	3.7	445	29.7	39.3	101
C. Lake View	81	2.3	2.1	1,208	33.6	31.0	465
D. Holyrood	1,640	39.0	2.3	48,045	1,144.0	66.6	4,554
E. Total	1,930	19.1	2.4	50,255	497.6	63.3	5,362
Trinity Bay							
A. Norman's Cove	597	13.6	3.0	11,562	263.0	57.8	1,121
Bonavista Bay							
A. Sandy Cove	380	8.6	6.4	1,364	31.0	23.1	770
Notre Dame Bay							
A. Inspector Island	2,218	27.4	4.1	31,774	392.3	58.8	4,853
B. Lewisporte	1,105	23.0	4.3	9,597	200.0	37.7	2,605
C. Total	3,323	25.8	4.2	41,371	320.7	52.1	7,458
Bay of Islands							
A. Benoit's Cove	550	30.6	6.4	3,595	199.7	41.4	686
B. Frenchman's Cove	1,380	40.6	4.6	14,258	419.4	47.1	2,815
C. Lark Harbour	5,855	122.0	2.8	147,700	3,077.0	71.0	10,390
D. Total	7,785	77.9	3.2	165,553	1,655.5	67.0	13,891
Hermitage Bay							
A. Gaultois	882	7.2	2.6	22,493	184.4	65.6	2,095
St. Mary's Bay							
A. Mt. Carmel	1,805	52.0	2.0	59,800	1,709.0	67.3	4,505

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ın on different parts of the fish from different

ıns within the areas

	Pectoral			Pelvic			Dorsal	
%	Total	Average	%	Total	Average	%	Total	Average
25.3	242	30.3	11.0	140	17.5	6.4	415	51.9
39.3	101	6.7	8.9	52	3.5	4.6	153	10.2
31.0	465	12.9	11.9	232	6.4	5.9	641	17.8
66.6	4,554	108.4	6.3	2,190	52.0	3.0	5,182	123.4
63.3	5,362	53.1	6.8	2,614	25.9	3.3	6,391	63.3
57.8	1,121	25.5	5.6	604	13.7	3.0	2,450	55.7
23.1	770	17.5	13.1	330	7.5	5.6	1,037	23.6
58.8	4,853	59.9	9.0	1,811	22.4	3.4	3,894	48.1
37.7	2,605	54.3	10.2	2,024	42.2	8.0	3,268	68.1
52.1	7,458	57.8	9.4	3,835	29.7	4.8	7,162	55.5
41.4	686	38.1	7.9	427	23.7	4.9	930	51.7
47.1	2,815	82.8	9.3	1,413	41.6	4.7	3,137	92.3
71.0	10,390	216.5	5.0	5,630	117.3	2.7	11,955	249.0
67.0	13,891	138.9	5.6	7,470	74.7	3.0	16,022	160.2
65.6	2,095	17.2	6.1	1,001	8.2	2.9	2,638	21.6
67.3	4,505	129.0	5.1	5,070	145.0	5.7	5,200	149.0

Dorsal			Anal			Caudal		
Total	Average	%	Total	Average	%	Total	Average	%
415	51.9	18.9	173	21.6	7.9	495	61.9	22.5
153	10.2	13.5	87	5.8	7.7	249	16.6	22.0
641	17.8	16.4	370	10.3	9.5	878	24.4	22.5
5,182	123.4	7.2	3,653	87.0	5.1	6,566	156.3	9.1
6,391	63.3	8.1	4,283	42.4	5.4	8,188	81.1	10.3
2,450	55.7	12.2	1,131	25.7	5.6	2,392	54.9	12.1
1,037	23.6	17.6	693	15.8	11.8	1,275	29.0	21.6
3,894	48.1	7.2	2,791	34.5	5.2	6,478	80.0	12.8
3,268	68.1	12.8	2,122	44.2	8.3	4,531	94.4	17.8
7,162	55.5	9.0	4,913	38.1	6.2	11,009	85.3	13.8
930	51.7	10.7	727	40.4	8.4	1,730	96.1	19.9
3,137	92.3	10.4	2,517	74.0	8.3	4,600	135.3	15.2
11,955	249.0	5.7	9,085	189.3	4.4	16,475	343.2	7.9
16,022	160.2	6.5	12,329	123.3	5.0	22,805	228.1	9.2
2,638	21.6	7.7	1,989	16.3	5.8	3,084	25.3	9.0
5,200	149.0	5.9	3,935	113.0	4.4	8,045	230.0	9.1

Caudal		Cornea			Total	
Average	%	Total	Average	%	Total	Average
61.9	22.5	10	1.3	0.5	2,199	275.0
16.6	22.0	4	0.3	0.4	1,133	75.5
24.4	22.5	29	0.8	0.7	3,904	108.4
156.3	9.1	305	7.3	0.4	72,135	1,717.5
81.1	10.3	348	3.4	0.4	79,371	785.9
54.9	12.1	175	4.0	0.9	20,032	455.3
29.0	21.6	43	1.0	0.7	5,892	134.0
80.0	12.8	184	2.3	0.4	54,003	666.7
94.4	17.8	222	4.6	0.9	25,474	530.7
85.3	13.8	406	3.1	0.7	79,477	616.1
96.1	19.9	32	1.8	0.4	8,677	482.1
135.3	15.2	150	4.4	0.5	30,270	890.3
343.2	7.9	934	19.5	0.5	208,024	4,333.8
228.1	9.2	1,116	11.2	0.5	246,971	2,469.7
25.3	9.0	94	0.8	0.3	34,276	281.0
230.0	9.1	569	16.0	0.6	88,929	2,541.0

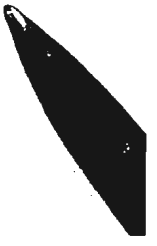

TABLE 22

Giving details of infection with C. lingua metacercariae on different parts of the body for the whole sample (642 fishes).

	Head	Body	Pectoral	Pelvic	Dorsal	Anal	Caudal	Cornea	Total
Total number of metacercariae	16,702	352,398	35,202	20,924	40,900	29,273	56,798	2,751	554,948
Average infection	29.1	612.9	61.2	36.4	71.1	51.0	98.8	4.8	965.3
Percentage of total metacercariae recovered	3.1%	63.5%	6.3%	3.8%	7.4%	5.3%	10.2%	0.5%	-
Number of units*	19.72	69.48	7.23	5.76	14.81	5.29	10.04	1.0	133.33
Infection per unit area**	1.5	8.8	8.5	6.3	4.8	10.6	9.8	4.8	-

*No. units per body regions based on cornea equalling 1 unit.
**Error min. ± .35
max. ± 1.8

shown in Table 23. Generally, the belly and the isthmus were not heavily infected.

Metacercarial infection in different length classes is shown in Table 24. The mean number of metacercariae per infected fish and infection per unit area on different parts of the body show an increase with increase in length (age) of the fish.

Host-parasite relations are the end products of a variety of complex factors, as pointed out by La Rue (1951) and many others. Hence, any attempt to explain a given relationship must include the interactions of many complex and often hidden ecological and physiological mechanisms.

Intensity of infection of the intermediate host with metacercariae depends on two main factors: namely, the behaviour of the cercariae and that of the fish. The cercariae of C. lingua lack an acetabulum, hence penetration into the fish is a difficult process, especially if the fish is swimming. The sluggish nature of cunners provides sufficient time for penetration to occur (Stunkard, 1930). During the present study, cunners were observed on a number of occasions lying motionless over seaweeds or other substrates for considerable periods of time. This behaviour may account for the high intensity of infection with metacercariae of C. lingua.

The occurrence of C. lingua metacercariae on fish from all the areas studied indicates the presence of infected birds (Threlfall, 1968a, 1968b) of a suitable molluscan first intermediate host, and of conditions necessary for the development of asexual, larval stages of the parasite within the mollusc(Sindermann and Farrin, 1962).

TABLE 23

Showing the intensity of infection with C. lingua metacercariae per unit area on different parts of the body in the different sampling areas and locations within the areas.

Origin	Head	Body	Pectoral	Pelvic	Dorsal	Anal	Caudal	Cornea
Conception Bay								
A	1.10	1.0	4.2	3.0	3.5	4.1	6.2	1.25
B	0.14	0.43	0.93	0.61	0.7	1.1	1.7	0.27
C	0.12	0.50	1.80	1.10	1.2	1.2	2.4	0.80
D	2.00	16.50	15.00	9.00	8.3	16.4	15.6	7.30
E	0.97	7.16	7.34	4.50	4.27	8.01	8.08	3.40
Trinity Bay								
A	0.70	3.80	0.40	2.40	3.80	4.90	5.5	4.00
Bonavista Bay								
A	0.44	0.45	2.42	1.30	1.60	3.00	2.9	0.98
Notre Dame Bay								
A	1.40	5.60	8.30	3.90	3.20	6.50	8.0	2.30
B	1.20	2.90	7.50	7.30	5.00	8.40	9.4	4.60
C	1.30	4.60	8.00	5.20	3.70	7.20	8.5	3.10
Bay of Islands								
A	1.60	2.90	5.30	4.10	3.50	7.60	9.60	1.80
B	2.10	6.00	11.50	7.20	6.20	14.00	13.00	4.40
C	6.20	44.30	23.90	20.40	16.80	35.80	34.20	19.50
D	3.90	23.80	19.20	13.00	10.80	23.30	22.70	11.16
Hermitage Bay								
A	0.37	2.65	2.40	1.40	1.50	3.10	2.5	0.77
St. Mary's Bay								
A	2.64	24.60	17.84	25.20	10.10	21.40	22.9	16.00
Total	1.50	8.8	8.5	6.3	4.8	10.6	9.8	4.8

TABLE 24

Showing mean number of C. lingua metacercariae per infected fish (a), % infection (b), and infection/unit area(c) in the different length classes of fishes.

Length intervals (mm)		Head	Body	Pectoral	Pelvic	Dorsal	Anal	Caudal	Cornea
0 - 50	(a)	0.94	2.12	0.41	0.06	0.06	0.65	0.35	0
	(b)	13.78	31.09	6.01	0.88	9.53	5.13	33.58	0
	(c)	0.05	0.03	0.06	0.01	0.04	0.07	0.23	0
60 - 100	(a)	35.0	85.83	46.67	18.44	60.0	39.83	91.06	5.39
	(b)	9.16	22.46	12.21	4.82	15.70	10.42	23.82	1.41
	(c)	1.77	1.24	6.46	3.20	4.05	7.53	9.07	5.39
110 - 150	(a)	33.98	428.85	68.22	34.53	82.09	58.01	122.11	6.67
	(b)	4.07	51.39	8.18	4.14	9.84	6.95	14.63	0.80
	(c)	1.72	6.17	9.44	5.99	5.54	10.97	12.16	6.67
160 - 200	(a)	28.63	707.02	71.91	42.37	75.28	55.19	108.12	5.25
	(b)	2.62	64.64	6.57	3.87	6.88	5.05	9.88	0.48
	(c)	1.45	10.18	9.95	7.36	5.08	10.43	10.77	5.25
210 - 250	(a)	21.93	431.84	45.36	25.30	55.78	39.03	75.83	3.50
	(b)	3.14	61.82	6.49	3.62	7.98	5.59	10.86	0.50
	(c)	1.11	6.22	6.27	4.39	3.77	7.38	7.55	3.50
260 - 300	(a)	30.83	876.63	63.33	36.30	80.81	53.04	86.52	4.39
	(b)	2.50	71.16	5.14	2.95	6.56	4.31	7.02	0.36
	(c)	1.56	12.62	8.76	6.30	5.46	10.03	8.62	4.39
310 - 350	(a)	105.0	3,637.86	223.14	87.0	114.57	170.0	289.29	6.86
	(b)	2.27	78.51	4.82	1.88	2.47	3.67	6.24	0.15
	(c)	5.32	52.36	30.86	15.10	7.74	32.14	28.81	6.86

The intensity of metacercarial infection on different parts of the fish varied considerably. Miller and McCoy (1930), working with metacercaria of another species, showed that the pectoral and caudal fins, which are usually in constant motion, are more heavily infected than any other part.

The head of the cunner is hard and bears only a few small scales, conditions which may not be very favourable for cercarial penetration. Concequently, only a few metacercariae are found in this region. Similarly, intensity of infection on the dorsal fin proved lower than on the anal and caudal fins. At least half of the dorsal fin is composed of spiny rays, metacercariae being distributed mostly on the soft rayed portion. Infection was invariably lowest on the belly and isthmus, which may be due to the lack of a proper substratum for penetration or to the behavioural pattern of the cercariae. Rothschild (1939) studied the swimming behaviour of C. lingua cercariae. Studies on the penetration patterns of cercariae might throw some light on the question of unequal distribution of the metacercariae on the various parts of the body.

The data also suggest that, as the fish grows older, more and more cysts are accumulated. Johansen (1924) indicated that the cunners become infected with metacercariae at 2 years of age. However, in the present investigations, fish from area 4 (D) were infected with metacercariae, even though they were only one year old.

The incidence of infection with trematodes, cestodes, nematodes and acanthocephalans is shown in Tables 25 - 29.

TABLE 25

Giving details of trematode (excluding C. lingua metacercariae)infections in different sampling areas and locations within the areas

Origin	No. fish examined (Total infected fish)	No. fish infected	Percentage infection of		Total no. worms recovered	Range (Min. - Max.)	Mean No./ infected fish
			total fish sample	infected fish			
Conception Bay							
A	52(26)	14	26.9	53.9	27	1 - 6	1.93
B	34(30)	12	35.3	40.0	35	1 - 9	2.92
C	38(20)	17	44.7	85.0	32	1 - 5	1.88
D	42(22)	16	38.1	72.7	24	1 - 5	1.50
E	166(98)	59	35.5	60.2	118	1 - 9	2.00
Trinity Bay							
A	82(77)	46	56.1	59.7	113	1 - 8	2.46
Bonavista Bay							
A	77(29)	15	19.5	51.7	25	1 - 4	1.67
B	50(35)	13	26.0	37.1	22	1 - 4	1.69
C	127(64)	28	22.1	43.8	47	1 - 4	1.68
Notre Dame Bay							
A	83(22)	16	19.3	72.7	56	1 - 16	3.50
B	50(15)	5	10.0	33.3	5	1	1.00
C	4(3)	1	25.0	33.3	1	1	1.00
D	17(-)	-	-	-	-	-	-
E	154(40)	22	14.3	55.0	62	1 - 16	2.82
Bay of Islands							
A	18(4)	1	5.6	25.0	1	1	1.00
B	34(13)	2	5.9	15.4	2	1	1.00
C	48(16)	3	6.3	18.8	3	1	1.00
D	100(33)	6	6.0	18.2	6	1	1.00
Hermitage Bay							
A	138(77)	16	11.6	20.8	19	1 - 3	1.19
St. Mary's Bay							
A	35(15)	8	22.9	53.3	26	1 - 16	3.25
South Shore							
A	6(6)	6	100.0	100.0	44	1 - 25	7.33

TABLE 26

Giving details of cestode infections in different sampling areas and locations within the areas.

Origin	No. fish examined (total infected fish)	No. fish infected	Percentage infection of		Total no. worms recovered	Range (Min. - Max.)	Mean No./ infected fish
			total fish sample	infected fish			
Conception Bay							
A	52(26)	4	7.7	15.4	7	1 - 3	1.75
B	34(30)	9	26.5	30.0	22	1 - 6	5.78
C	38(20)	2	5.3	10.0	2	1	1.00
D	42(22)	1	2.4	4.6	1	1	1.00
E	166(98)	16	9.6	16.3	32	1 - 6	2.00
Trinity Bay							
A	82(77)	2	2.4	2.6	2	1	1.00
Bonavista Bay							
A	77(29)	1	1.3	3.5	1	1	1.00
B	50(35)	-	-	-	-	-	-
C	127(64)	1	0.8	1.5	1	1	1.00
Notre Dame Bay							
A	83(22)	-	-	-	-	-	-
B	50(15)	10	20.0	66.7	16	1 - 3	1.60
C	4(3)	-	-	-	-	-	-
D	17(-)	-	-	-	-	-	-
E	154(40)	10	6.5	25.0	16	1 - 3	1.60
Bay of Islands							
A	18(4)	-	-	-	-	-	-
B	34(13)	1	2.9	7.7	2	2	2
C	48(16)	1	2.1	6.3	1	1	1
D	100(33)	2	2.0	6.1	3	1 - 2	1.5
Hermitage Bay							
A	138(77)	-	-	-	-	-	-
St. Mary's Bay							
A	35(15)	-	-	-	-	-	-
South Shore							
A	6(6)	4	66.7	66.7	22	1 - 14	5.5

TABLE 27

Giving details of nematode infections in different sampling areas and locations within the areas.

Origin	No. fish examined (total infected fish)	No. fish infected	Percentage infection of		Total no. worms recovered	Range (Min. - Max.)	Mean No./ infected fish
			total fish sample	infected fish			
Conception Bay							
A	52(26)	5	9.6	19.2	10	1 - 4	2
B	34(30)	26	76.5	86.7	91	1 - 15	3.5
C	38(20)	4	10.5	20.0	4	1	1
D	42(22)	6	14.3	27.3	8	1 - 2	1.33
E	166(98)	41	24.7	41.8	113	1 - 15	2.76
Trinity Bay							
A	82(77)	57	69.5	74.0	227	1 - 17	3.98
Bonavista Bay							
A	77(29)	15	19.5	51.7	19	1 - 3	1.25
B	50(35)	19	38.0	55.4	35	1 - 6	1.84
C	127(64)	34	26.8	53.1	54	1 - 6	1.59
Notre Dame Bay							
A	83(22)	4	4.8	18.2	5	1 - 2	1.25
B	50(15)	3	6.0	20.0	3	1	1
C	4(3)	-	-	-	-	-	-
D	17(-)	-	-	-	-	-	-
E	154(40)	7	4.6	17.5	8	1 - 2	1.14
Bay of Islands							
A	18(4)	2	11.1	50.0	4	2	2
B	34(13)	9	26.5	69.2	13	1 - 5	1.44
C	48(16)	13	27.1	81.3	16	1 - 2	1.23
D	100(33)	24	24.0	72.7	33	1 - 5	1.38
Hermitage Bay							
A	138(77)	69	50.0	89.6	161	1 - 11	2.33
St. Mary's Bay							
A	35(15)	5	14.3	33.3	8	1 - 4	1.6
South Shore							
A	6(6)	6	100.0	100.0	20	1 - 10	3.33

TABLE 28

Giving details of acanthocephalan infections in different sampling areas and locations within the areas.

Origin	No. fish examined (total infected fish)	No. fish infected	Percentage infection of		Total no. worms recovered	Range (Min. - Max.)	Mean No./ infected fish
			total fish sample	infected fish			
Conception Bay							
A	52(26)	15	28.9	57.7	33	1 - 6	2.2
B	4(30)	12	35.3	40.0	41	1 - 12	3.42
C	38(20)	6	15.8	30.0	8	1 - 3	1.33
D	42(22)	4	9.5	18.2	5	1 - 2	1.25
E	166(98)	37	22.3	37.7	87	1 - 12	2.35
Trinity Bay							
A	82(77)	52	63.4	67.5	278	1 - 54	5.35
Bonavista Bay							
A	77(29)	3	3.9	10.3	4	1 - 2	1.33
B	50(35)	9	18.0	25.7	10	1 - 2	1.11
C	127(64)	12	9.4	18.8	14	1 - 2	1.17
Notre Dame Bay							
A	83(22)	5	6.0	22.7	5	1	1
B	50(15)	-	-	-	-	-	-
C	4(3)	3	75.0	100.0	4	1 - 2	1.33
D	17(-)	-	-	-	-	-	-
E	154(40)	8	5.2	20.0	9	1 - 2	1.13
Bay of Islands							
A	18(4)	1	5.6	25.0	1	1	1.00
B	34(13)	3	8.8	23.1	9	1 - 5	3.00
C	48(16)	2	4.2	12.5	4	1 - 3	2.00
D	100(33)	6	6.0	18.2	14	1 - 5	2.33
Hermitage Bay							
A	138(77)	3	2.2	3.9	5	1 - 2	1.67
St. Mary's Bay							
A	35(15)	6	17.1	40.0	70	1 - 2	1.17
South Shore							
A	6(6)	1	16.7	16.7	4	4	4.00

TABLE 29

General numerical data of infections of 808 fish with Trematoda (excluding *C. lingua* metacercariae), Cestoda, Nematoda and Acanthocephala.

	No. fish infected	Incidence (%)	Total no. parasites	% of total no. of all parasites	Range of numbers	Mean no./ infected fish
Trematoda	191	23.6	435	26.9	1 - 25	2.28
Cestoda	35	4.3	76	4.7	1 - 14	2.17
Acanthocephala	125	15.5	481	29.8	1 - 54	3.85
Nematoda	243	30.1	624	38.6	1 - 17	2.57
All parasites	410	50.7	1,616	100.0	1 - 54	3.94

Of all the helminths found, nematodes were the most frequently recorded group, followed by trematodes, acanthocephalans and cestodes.

Among the individual species, Anisakis sp. larvae were the most commonly found parasites (excluding C. lingua metacercariae), followed by E. gadi and L. gibbosus. The mean number of Anisakis sp. larvae per infected fish was greater than any other species of helminth.

The intensity of helminth infection was not uniform in all the sampling areas, nor at the different locations within a given area (Table 30).

Intensity of trematode infection varied considerably in different areas, while cestodes were absent from areas 6 and 7 (Hermitage Bay and St. Mary's Bay). Nematodes and acanthocephalans were distributed unequally in the different areas and locations within the areas.

The fish from Coal All Islands, Notre Dame Bay (area 4, location D) did not contain any helminth parasites.

No difference was noticed in the incidence of helminth parasites in male and female fishes ($P > 0.05$). This suggests that there are few or no differences in the feeding habits of the male and female fishes.

The intensity of infection with helminths in different length classes of fishes may be seen in Table 31. A gradual increase in the incidence of infection and in the mean number of helminths per infected fish was noted as the length of the fish increased. The degree of infection with different groups of helminths and the incidence of infection with the different numbers of species in relation to the length classes were tabulated (Tables 32 - 35).

TABLE 30

Showing incidence of infection with helminths (excluding C. lingua metacercariae) in different sampling areas and locations within the areas.

Origin	No. fish examined	No. fish infected	% infection
Conception Bay			
A	52	26	50.0
B	34	30	88.2
C	38	20	52.6
D	42	22	52.4
E	(166)	(98)	(59.0)
Trinity Bay			
A	82	77	93.9
Bonavista Bay			
A	77	29	37.7
B	50	35	70.0
C	(127)	(64)	(50.3)
Notre Dame Bay			
A	83	22	26.5
B	50	15	30.0
C	4	3	75.0
D	17	-	-
E	(154)	(40)	(25.1)
Bay of Islands			
A	18	4	22.2
B	34	13	38.2
C	48	16	33.3
D	(100)	(33)	(33.0)
Hermitage Bay			
A	138	77	55.8
St. Mary's Bay			
A	35	15	42.9
South Shore			
A	6	6	100.0
Total	808	410	50.7

TABLE 31

Giving details of infection with helminths (excluding *C. lingua* metacercariae) in the different length classes of fishes.

Length intervals (mm)	No. fish examined	No. fish infected	Incidence (%)	Total No. helminths recovered	Mean No./ infected fish	Range of numbers
0 - 50	17	-	-	-	-	-
60 - 100	17	1	5.9	1	1	1
110 - 150	131	25	19.1	44	1.76	1 - 6
160 - 200	272	119	43.7	235	1.97	1 - 8
210 - 250	273	180	65.9	606	3.37	1 - 31
260 - 300	83	71	85.5	501	7.06	1 - 63
310 - 350	15	15	100.0	229	15.27	2 - 30

TABLE 32

Showing details of infection with the different groups of helminths (excluding *C. lingua* metacercariae) recovered in the different length classes of fishes.

Length intervals (mm)	Trematodes		Cestodes		Nematodes		Acanthocephalans	
	Incidence (%)	Mean No./ infected fish	Incidence (%)	Mean No./ infected fish	Incidence (%)	Mean No./ infected fish	Incidence (%)	Mean No./ infected fish
0 - 50	-	-	-	-	-	-	-	-
60 - 100	5.9	1	-	-	-	-	-	-
110 - 150	9.9	1.92	-	-	7.6	1.4	3.8	1
160 - 200	20.2	1.45	4.4	1.42	19.9	1.44	10.3	1.93
210 - 250	27.5	2.40	4.0	2.0	40.3	2.23	19.8	2.87
260 - 300	42.2	2.17	8.4	2.0	68.7	3.68	36.1	7.07
310 - 350	80.0	6.17	33.3	4.6	80.0	6.42	53.3	6.88

TABLE 33

Showing the number of species of trematodes* recovered from fishes of different length classes.

Length intervals (mm)		No. species					
		0	1	2	3	4	5
0 - 50	No.	17	-	-	-	-	-
	%	100	-	-	-	-	-
60 - 100	No.	16	1	-	-	-	-
	%	94.1	5.9	-	-	-	-
110 - 150	No.	118	12	1	-	-	-
	%	90.1	9.2	0.7	-	-	-
160 - 200	No.	217	50	5	-	-	-
	%	79.8	18.4	1.8	-	-	-
210 - 250	No.	196	65	10	1	1	
	%	71.8	24.0	3.7	0.4	0.4	
260 - 300	No.	48	25	9	1		-
	%	57.8	30.1	10.8	1.3		-
310 - 350	No.	3	3	5	4	-	-
	%	20.0	20.0	33.3	26.7	-	-

*(Excluding C. lingua metacercariae)

TABLE 34

Showing the number of species of cestodes recovered from fishes of different length classes.

Length intervals (mm)		No. species				
		0	1	2	3	4
0 - 50	No.	17	-	-	-	-
	%	100	-	-	-	-
60 - 100	No.	17	-	-	-	-
	%	100	-	-	-	-
110 - 150	No.	131	-	-	-	-
	%	100	-	-	-	-
160 - 200	No.	258	14	-	-	-
	%	94.9	5.15	-	-	-
210 - 250	No.	262	11	-	-	-
	%	96.0	4.0	-	-	-
260 - 300	No.	76	7	-	-	-
	%	91.6	8.4	-	-	-
310 - 350	No.	9	3	2	1	-
	%	60.0	20.0	13.3	6.7	-

TABLE 35

Showing the number of species of nematodes recovered from fishes of different length classes.

Length intervals (mm)		No. species				
		0	1	2	3	4
0 - 50	No.	17	-	-	-	-
	%	100	-	-	-	-
60 - 100	No.	17	-	-	-	-
	%	100	-	-	-	-
110 - 150	No.	121	8	2	-	-
	%	92.4	6.1	1.5	-	-
160 - 200	No.	218	52	2	-	-
	%	80.2	19.1	0.7	-	-
210 - 250	No.	163	88	19	3	-
	%	59.7	32.2	7.0	1.1	-
260 - 300	No.	26	33	21	3	-
	%	31.3	39.8	25.3	3.6	-
310 - 350	No.	3	4	5	3	-
	%	20.0	26.7	33.3	20.0	-

The results indicate that, with increase in length, the number and variety of helminth species increases.

The distribution of different groups of helminths in different areas and locations within the areas was not homogeneous. This is probably related to movements of the hosts, both final and intermediate, and may also be associated with the distribution of the intermediate hosts. The life cycles of only a few of the helminths recovered have been elucidated. Until more is known about the cycles, and about the ecology of the intermediate hosts, little can be said about the patchy distribution of these parasites.

Dogiel and Bykhovsky (1939) were pioneers in attempts to study local populations of fishes from a parasitological point of view. Considerable differences in the parasite fauna of fish stocks from several areas in the White Sea were found by Shulman and Shulman-Albova (1953).

With increase in age, there is an increase in the variety of species and an increase in incidence and intensity of infection with helminths, a fact previously noted by Dogiel (1961). One year old fish were not infected with helminths.

Some observations were made on site preference of the helminths within the host. Trematodes and cestodes were normally recovered from the stomach and the anterior intestine, while the acanthocephalans preferred the posterior and anterior regions of the intestine. Most of the nematodes found were encysted on the viscera, particularly the liver, testes and mesenteries around the rectum.

In conclusion, it can be said that the composition of the parasite fauna, age dynamics and geographical variations are due mainly to the mode of life of the host, and a complex series of relationships that, to date, are not fully understood. The parasite fauna of a particular host species provides clues to the ecology of the animal, particularly its feeding habits. These results provide further support for the promising role of parasites as "living tags" in fish studies.

Stomach analyses

The cunner is an omnivore, a wide variety of food items being found in the stomach contents of the fishes examined. Items found included: larvae and pupae of Coelopa sp.; larvae of Chironomidae; adult Tipula sp.; ostracods; Balanus balanoides; unidentified copepods and amphipods; appendages of decapod crustaceans; mysids; polychaetes; hydroid colonies; Acmaea testudinalis; Lacuna vincta; Mytilus edulis; Ischnochiton albus; pieces and spines of Strongylocentrotus droebachiensis; pieces of Opiophalinus aculeata; small specimens of Asterias vulgaris; fish bones and eggs; algae; sand; pebbles and pieces of carrot.

Such a wide variety of food may be responsible for the variety of species of helminths recovered, even though in small numbers.

Experiments with leeches

Early in the work, it was noted that no leeches were found on T. adspersus, despite the fact that they lived in close proximity to the longhorn sculpin, Myoxocephalus octodecemspinosus (Mitchill), and shorthorn sculpin, Myoxocephalus scorpius (Linnaeus), which almost always carry leeches on their gills or body surface (W. Threlfall, pers. comm.).

Consequently, eight heavily infected sculpins were kept in a tank of running sea water at the Marine Sciences Research Laboratory with ten cunners in an attempt to determine if the leeches would move from the sculpins onto the cunners. (In the events, the leeches moved from one species of sculpin to another and actively crawled and swam around the tank.) (W. Threlfall, pers. comm.).

In the experiment, no leeches had moved onto the cunners after two weeks exposure. On one occasion, two cunners were observed lying along side and almost touching the body of an infected sculpin. During a period of 30 minutes, leeches moved their anterior ends on the external surface of the cunners, but did not move onto them (W. Threlfall, pers. comm.). This behaviour strongly suggests that there is some barrier, either physiological or morphological, preventing them from such transfer. Further experiments may reveal the nature of the barrier(s).

CONCLUSIONS

To meet the increasing demands on natural resources imposed by the population explosion, efforts to increase our knowledge of natural resources should be intensified. Marine resources are of considerable importance, yet little is known about the dynamics of marine production.

Fisheries are among the main resources which may yield a radically increased abundance of food and consumer goods. The control of diseases and parasites of fish is clearly of great significance in restoring and increasing depleted reserves. Diseases are multifactorial in origin, the development and progress of such conditions being enhanced by factors such as, unfavourable environmental conditions, pollution or physiological insufficiencies.

The effects of diseases on fishes was discussed by Cox (1916), Sindermann (1956, 1966), and Williams (1961, 1962, 1967). Parasites considerably lower the growth rhythm of the host (Williams, 1961), affect the quality of flesh (Mann, 1954), and often lead to death (Sindermann and Rosenfield, 1954). Diseases and parasites may cause severe economic losses to the fishing industry, as pointed out by Hargis (1958) and many of the above workers.

The study of fish parasites with a view to the elimination of the conditions they cause is of great practical import. Some helminths are transmitted from fish to man and to fish-eating domestic and non-domestic animals (Alicata, 1965; Kuipers, 1964; Rosen et al., 1961, 1962; van Thiel et al., 1960; Williams, 1965). Early discovery of such parasites

in the fish and their life cycles makes it possible to control the infection of man and other animals. Eventually, it may even lead to the devising of practical prophylactic measures.

The study of fish parasites helps in developing standards for grading fish products, in the reduction of unwarranted losses due to improper sorting of fish products, and in the elimination of unjustified interruptions of exploitation caused by fish parasites (Markevich, 1951).

Ichthyoparasitological studies have been neglected when compared to the advances made in other fields of parasitology such as the study of the parasites of domestic animals (Cameron, 1951; Lapage, 1968).

Dogiel, Petrushevski and Polyanski (1958) gave a comprehensive account of the problems encountered in both fresh water and marine fish parasitology. Their work was the first attempt to bring these problems into perspective and to the attention of their co-workers. Some of the more important works on the helminths of marine fish are those of Dawes (1946, 1947), Dogiel and Bykhovskii (1934, 1939), Euzet (1959), Hoffman and Sindermann (1962), Linton (1887 - 1941), Manter (1934, 1947), Mola (1928), Nicoll (1907 - 1915), Polyanski (1953), Strelkov (1960), Williams (1961, 1967), and Zhukov (1953).

Earlier, research was often biased towards the taxonomy and morphology of the helminths. Pavlovski (1934), however, pioneered an ecological approach to the study of parasitism. Dogiel and his pupils later incorporated many of Pavlovski's ideas into their studies of fish parasites. This school of workers postulated many of the principles

that underlie the relationship of a parasite faunule to the conditions of the host's life, its ecology and physiology. These principles, apart from theoretical interest, are of great importance in practice. They form the scientific basis for rational measures of prophylaxis and treatment of parasitic diseases.

Dogiel (1932) stated (in Russian), "When we have at our disposal not only dry lists and description of new species, but when we get to know the entire life of the parasite fauna in any locality, we shall have a powerful weapon with which to fight outbreaks of parasitic diseases. This thorough knowledge of the biology of the whole parasite fauna will suggest the most effective means of combating them. At present, we must tackle this problem, as it were, blindfolded."

Pavlovski (1934) pointed out the dual nature of the environment of parasites, namely the micro-environment, a term referring to their immediate habitat, the host, while the host's habitat, with which the parasites are associated indirectly, is the macro-environment. Dogiel (1962) considered the micro-environment with its parasite fauna as an ecological unit. As the environment of parasites is formed by other animals, Pavlovski (1937) coined the term 'parasitocoenosis', to embrace the complex of relationships between parasites, their hosts and their environments. Theodorides (1954) described this double environment as the 'law of the double biotope'.

To date, an ecological approach to the study of parasites has been sadly neglected. The concepts of ecology are, however, essential to a clear understanding of parasitism. Baer (1952) pointed out that

'parasites are subjected to the same general laws that govern all free-living organisms'. The necessity for an ecological approach to the study of parasites was noted by Noble (1960), while Noble and Noble (1961) emphasized the community concept and pointed out that 'When a parasite is studied by itself, apart from its environment, only a part, and often a small part, of its total biology can be understood'. Present research trends are towards a study of the ecological complex formed by the parasite, its intermediate hosts, and definite host, and various features of the host's environment. This complex is often known as a 'Parasite-Mix' (Noble, 1960) or a 'parasitocoenosis' (Pavlovski, 1937) and is far more than the sum of its parts.

The parasite fauna of fish represents the end results of the interrelationships between the parasites and their various interdependent influences of both the macro- and micro-environment. In addition, zoogeographical and historical factors play a significant part in determining the parasite burden. Factors of importance in the macro-environment and microenvironment include, physiological and biological features of the host such as the type of food eaten, type and speed of locomotion, immunity, time of spawning and migrations, if any, and the influence of man. Other factors influencing the helminth burden of a given host in a certain region are, the presence or absence of suitable intermediate hosts, temperature, and other environmental conditions. The presence or absence of certain marine fish parasites may be related to the zonation of marine animals (Ichihara, 1968).

The study of marine invertebrates, particularly those which may serve as intermediate hosts for helminth parasites, is vital to the study of marine fish parasitology (Uspenskaya, 1955; Chubrik, 1954; Zelikman, 1950). Without this knowledge, the complex relationships between the vertebrate hosts and their parasites remains incomplete.

The distribution of parasites within a host is controlled by the same basic forces that govern the distribution of the host. Temperature, mechanical barriers, chemistry of the surrounding medium, food supply and other ecological factors continuously restrict or encourage the movement, growth or development of parasites within a given region. The structure of various parts of the alimentary canal determines the composition of parasite fauna of the various parts (Brambell, 1963; Schad, 1963; Sommerville, 1963; Threlfall, 1967). Most of the intricate relationships between the parasites and their hosts are still not fully understood, and only in recent years has much physiological work been carried out, the majority of which was summarized by Rogers (1962), Soulsby (1966), and Von Brand (1966).

The present study may form a framework on which may be built further studies concerned with ecological parasitology and,in particular, the ecological community in which the cunner lives. Further ecologically oriented studies of the parasitofauna should be undertaken in various locations to unravel the nature of complex host-parasite interrelationships, such huge numbers of which remain to be elucidated.

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APPENDIX I

(i) Erasmus' method (1962).

(a) Digest solution (pH. 2.0) -

0.5 g. pepsin[1] + 0.75 ml. con. (35%)

Hydrochloric acid + 100 ml. 0.6 per cent sodium chloride.

(b) Hatching solution (pH. 8.0)

100 ml. 1.0 per cent sodium bicarbonate

+ 1.0 g. trypsin[2] + 0.5 g. sodium tauroglycocholate

Metacercariae on a small piece of skin were placed in the digest solution in a dish at 35°C. for 1½ hours. Later, the mixture was thoroughly shaken and washed repeatedly. The cysts were then transferred to the hatching solution and incubated for 1 hour at 35°C.

(ii) McDaniel's method (1966).

The metacercariae were removed from scales and fins with as little tissue as possible. These metacercariae were incubated in 1.0 per cent pepsin[1] solution (pH. 2.0) for 30 minutes at 37°C.

Later, the cysts were transferred to one of two solutions (pH. 7.0).

(a) 1.0 per cent trypsin[2] + 0.1 per cent sodium taurocholate[4] + 0.01 M cysteine[5].

[1,2,4,5]See next page.

(b) 0.1 per cent trypsin[2] + 0.02 per cent sodium taurocholate[4].

The cysts were incubated for 1 hour at 37°C.

The cysts were checked periodically after one hour in incubator.

(iii) Stunkard's method (1930).

Metacercarial cysts were treated with 0.3 per cent Hydrochloric acid containing pepsin[1] (pH. 2.5) at 35°C. for 30 minutes.

Later, the metacercariae were transferred to a solution of 0.5 per cent sodium carbonate saturated with pancreatin[6] (pH. 8.0) at 35°C. for 1 hour. The cysts were checked periodically after 1 hour.

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[1] Difco

[2] B.D.H.

[3] K & K Laboratories, Inc., New York

[4] Pfanstiehl Chemicals Co., Illinois

[5] Nutritional Biochemical Corporation

[6] Fisher Scientific Company

APPENDIX II

(i) Semichon's Acetic Carmine Stain.

Glacial acetic acid - 500 ml.

Distilled water - 500 ml.

Carmine powder, in excess.

The mixture was heated to 95°C. - 100°C. in a waterbath for 15 minutes. The flask was then cooled rapidly in cold water, any undissolved carmine settling in the bottom. The supernate was filtered.

The stock stain was diluted with 2 to 3 parts of 70 per cent alcohol before use.

(ii) Catechol technique (Johri and Smyth, 1956).

This technique was used on trematodes preserved in either 70 per cent alcohol or 5 per cent formaldehyde.

The specimens were washed in distilled water for 30 minutes and kept in 0.1 per cent catechol solution at 40°C for 1 hour or 4 hours at room temperature (15°C.).

The specimens were then washed in distilled water for 15 minutes and counterstained with acid carmine.

(iii) Lactophenol of Amann.

Refractive Index - 1.44

Pure phenol crystals - 10 g.

Lactic acid - 10 g.

Glycerol - 20 g.

Distilled water - 10 g.

Exposure to light makes this medium yellow. This can be prevented by keeping lactophenol in the dark, or in a brown glass bottle.

(iv) Glycerol Jelly

Refractive Index, circa 1.47

Gelatin - 10 g.

Distilled water - 60 ml.

Pure glycerol - 70 ml.

Phenol crystals - 0.25 g.

Dissolve the gelatin in the water in a beaker placed in a waterbath. When the gelatin has dissolved, add the glycerol and, finally, the phenol. Keep this medium either in a corked tube or in a thin-walled balsam bottle. To melt it, place the bottle in hot water or in an embedding oven.

(v) Rubin's Method.

Polyvinyl alcohol (Stock solution) - 56 ml.

Lactic acid - 22 ml.

Phenol crystals - 22 ml.

The stock solution was prepared by dissolving 15 g. of polyvinyl alcohol in 100 ml. distilled water. This was accelerated by using a waterbath at 80^{o}C. Lactic acid and phenol were added to the stock solution in the prescribed proportions.

The resultant solution was stored in a dark bottle and used as a mounting medium. Specimens from any fixative can be placed directly into this medium.