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Parasites of the Inshore Lizardfish, *Synodus foetens*, from South Florida, Including a Description of a New Genus of Cestoda

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PARASITES OF THE INSHORE LIZARDFISH, *SYNODUS FOETENS*, FROM SOUTH FLORIDA, INCLUDING A DESCRIPTION OF A NEW GENUS OF CESTODA[1]

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ABSTRACT

The parasites of the inshore lizardfish, *Synodus foetens*, were studied from collections taken from an estuarine canal in south Florida between January 1963 and December 1964. A new genus of Cestoda (Bothriocephalidae) has been erected with the proposed name *Anantrum*. Several larval and adult helminths and a dinoflagellate were studied from monthly samples of *Synodus*. Incidence of infection, intensity of infection, location of parasites in the host, and associations among parasites are discussed. Extensions of ranges for parasites in *S. foetens* and parasites heretofore not recorded from *S. foetens* are noted.

INTRODUCTION

Little attention has been paid to fluctuations in abundance of parasites of marine fishes according to host species. Most of the parasitological work on marine fishes of Florida has been taxonomic in nature, with some discussion concerning the zoogeography. The important surveys were made by Linton (1910), Manter (1934, 1947), Ward (1954), Sogandares-Bernal & Hutton (1959 a, b, c), and Nahhas & Short (1965). Noble (1960) and V. A. Dogiel and his associates (1958), working in other regions, have emphasized the importance of ecological studies of parasites.

The approach selected for use in this study is to investigate one species of fish from a single area on a seasonal basis. The faunal parasites of *Synodus foetens* (Linnaeus) 1776, the inshore lizardfish, were studied from collections taken from the Buttonwood Canal from January, 1963, through December, 1964. *S. foetens* is a productive species to study because it feeds on a variety of prey and it can withstand a wide range of environmental conditions.

In Florida there are two rainy seasons, usually occurring in May–June and September–October, in which the salinity of the water is strongly influenced by the amount of rainfall. The high water table in the rainy seasons of 1963 maintained a relatively low salinity through March, 1964. Less rain in 1964 caused subsequent higher salinities.

Buttonwood Canal is located in the southern part of the Florida main-

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land, in the Everglades National Park. It is a 3-mile-long tidal canal which was opened in November, 1957, to connect Coot Bay with Florida Bay. It is approximately 60 feet wide and 8 feet deep. Collections were made about one-half mile from Florida Bay, under the canal's only bridge, located near the entrance to Flamingo, Florida.

Studies were made on a dinoflagellate protozoan from the gills, digenetic trematodes and a nematode from the stomach, a cestode and a digenetic trematode from the intestine, acanthocephalan and nematode cysts from the body cavity, and larval cestodes from various body locations.

Methods and Materials

Specimens of *S. foetens* were taken from samples obtained for a juvenile-shrimp project being carried out for the Bureau of Commercial Fisheries by the Institute of Marine Sciences, University of Miami. Collections were made with a nylon channel net with three-quarter inch stretch mesh, which completely blocked the canal. They were usually made for two nights during both new and full moon. Continuous collections were made every half hour during ebb tides which occurred between sunset and sunrise.

Most samples of *Synodus* were placed in 15 per cent formalin–fresh water, and the fish were later transferred to 40 per cent isopropyl alcohol. Other specimens of *Synodus* were kept alive until an examination was made for parasites. These parasites were fixed in Bouin's solution and stored in 70 per cent ethyl alcohol.

Two larvae of *S. foetens* from R/V Gerda collections made in the vicinity of Great Bahama Bank were also examined for parasites, as were two adults from Biscayne Bay, Florida. Notation of the parasites found in the latter fish is in Table 2.

About 11 fish were autopsied for each monthly period (Table 1). During the first portion of this study, the skin was removed from the flesh, and the muscle fibers were inspected. The brain and the rest of the nervous system were carefully examined. Blood smears were made from fresh material. These procedures were discontinued after negative results were obtained from randon samples, and full attention was given to examination of the gills and the visceral organs. Bacterial, viral, and fungal organisms were excluded from this study.

The parasites were removed and counted, and, on some occasions, the length, maturity, and exact location of the parasite in a host's organ noted. Representative parasites were stained and mounted, and the rest placed into vials containing alcohol.

Salinity and temperature measurements of the water were recorded hourly at the time of collection.

Partial correlation coefficients (Steel & Torrie, 1960: 285) were computed to look for relationships between monthly mean numbers of stomach

TABLE 1
MONTHLY TOTALS OF AUTOPSIED *Synodus foetens* COLLECTED FROM BUTTONWOOD CANAL DURING 1963 AND 1964

Month	1963 Number of fish	1964 Number of fish
January	11	3
February	13	6
March	12	11
April	13	6
May	11	11
June	10	11
July	–	12
August	11	8
September	8	1
October	2	11
November	11	11
December	11	11
Total	103	102

parasites and other variables. They were also computed to find the environmental factor affecting the site of an intestinal cestode.

To examine possible associations between the abundance of different parasitic species, the chi-square test was applied, using 2 × 2 and 2 × 4 contingency tables. The short method of chi-square technique was applied to 2 × 2 contingency tables (Simpson *et al.*, 1960: 318; Noble *et al.*, 1963: 302), applying the small-sample adjustment (Simpson *et al.*, 1960: 189) when the smallest observed frequency was fewer than ten.

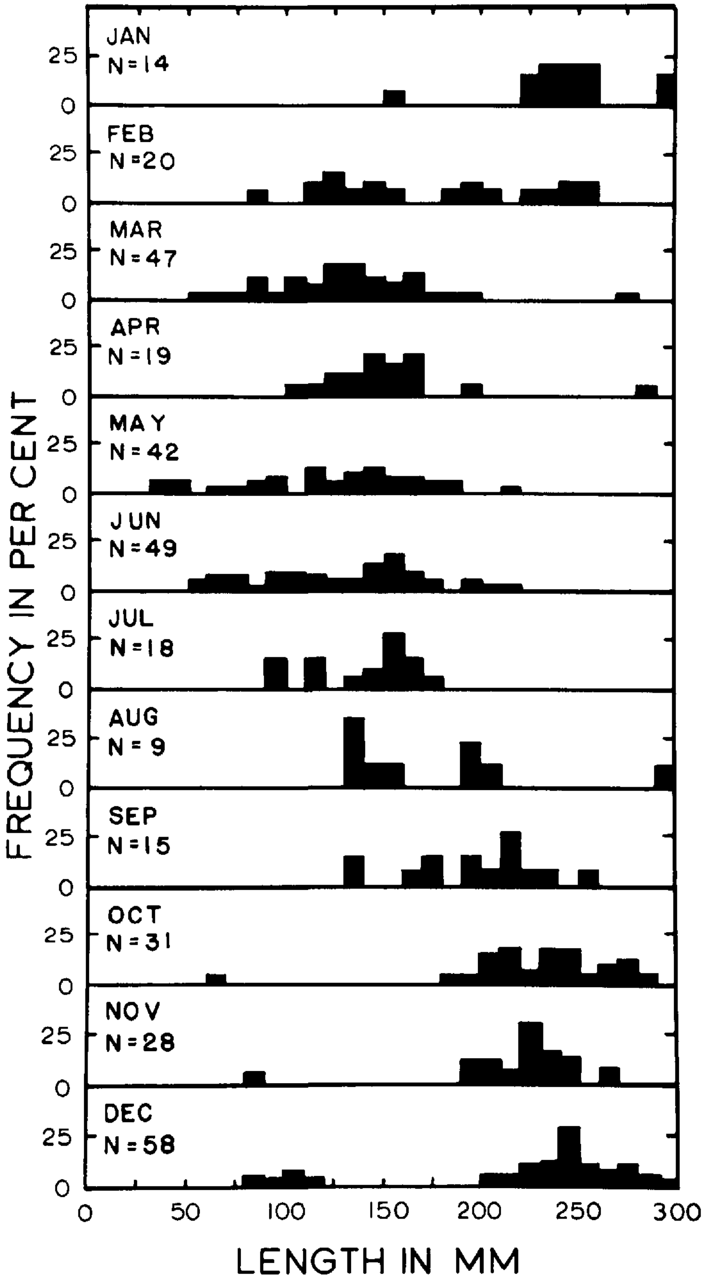
ECOLOGY OF *Synodus foetens*

S. foetens is the commonest shallow-water myctophiform fish of Florida. A review of the family Synodontidae by Anderson, Gehringer, & Berry (1966) has an excellent coverage of the systematics and biology of *S. foetens*. An extensive synonymy and list of references are included.

The inshore lizardfish is found from Cape Cod to Brazil, over various bottoms such as sand, mud, and marl, and in salt-water creeks, rivers, bays, sounds, and outer beaches. It has been found in waters with temperatures ranging from 8.3 to 31.7°C (Reid, 1954: 19), and salinities ranging from 1.9 (Schultz, 1962: 4) to 60‰ (Simmons, 1957: 182).

Inshore lizardfish in the northern part of the geographic range appear to have a seasonal migration. Anderson *et al.* (1966) found no records of *S. foetens* being taken north of North Carolina for January through

FIGURE 1. Monthly length-frequency of *S. foetens* in Buttonwood Canal with data for 1963 and 1964 combined. N is sample size.


JAN
N = 14
FEB
N = 20
MAR
N = 47
APR
N = 19
MAY
N = 42
JUN
N = 49
JUL
N = 18
AUG
N = 9
SEP
N = 15
OCT
N = 31
NOV
N = 28
DEC
N = 58
FREQUENCY IN PER CENT
25
0
0
50
100
150
200
250
300
LENGTH IN MM

←

May. The situation in southern waters is more complex. Hildebrand (1954: 290) reported no seasonal trends in abundance for *S. foetens* along the Texas coast, while Gunter (1945: 41) found no specimens during the winter.

Since the length-frequency data for the fish during the two-year study were similar, the data were combined and are presented in Figure 1. The average number of inshore lizardfish taken monthly in standard half-hour samples showed several characteristics: the abundance was usually less than one fish per sample, there was no apparent seasonal trend in abundance, and there was not an obvious difference between 1963 and 1964.

It has been recorded that younger *S. foetens* are generally found in inshore waters, while larger ones are taken offshore (Anderson *et al.*, 1966). The findings of this study tend to substantiate this assumption, in that smaller fish are in shallow water and members of a year class disappear from the canal waters after about a year (Fig. 1). This disappearance corresponds with an increase in temperature and salinity.

S. foetens feeds voraciously from the bottom in a lurching manner. It apparently feeds during the day (Hildebrand, 1954: 290). This is also indicated in the present study by the examination of a large number of empty stomachs in lizardfish that were collected at night. In those stomachs that had food, the contents were usually partially digested. Items found included: *Penaeus duorarum*, a palaemonid shrimp, several species of small crustaceans, and the fishes *Synodus foetens, Anchoa mitchilli, Lagodon rhomboides, Eucinostomus argenteus, Sphaeroides* sp., *Cyprinodon variegatus, Poecilia latipinna, Gobionellus* sp., a cyprinodontid, an atherinid, and others that were too digested to identify. There are records of shrimp, crabs, squid, sea urchins, and annelids in the stomach of *Synodus*, but fish are the principal food. Anderson *et al.* (1966) listed several fishes other than those found by the author. These records show that *S. foetens* has a diversified diet.

PARASITES OF *Synodus foetens*

The parasite-mix of *S. foetens* from Buttonwood Canal will be discussed according to taxonomic groupings. Table 2 lists the parasite-mix of *S. foetens* as reported in the literature by site of infection in the fish, geographic locality, and reference to the study. There were no external parasites except a dinoflagellate found on the gill filaments. This lack of ectoparasites might be due to a burying behavior displayed by *S. foetens*. *Synodus* buries itself in sandy bottoms, leaving only its eyes exposed.

The majority of the parasites from this study are found in the stomach, intestine, gall bladder, mesentery and gills.

TABLE 2
REFERENCES FOR ALL SPECIES OF PARASITES REPORTED FROM *Synodus foetens*

Parasite	Site	Geographic locality	Reference
Dinoflagellata			
Oodinium sp.	gills	Buttonwood Canal, Florida	present study
Digenea			
Plagioporus truncata	intestine	Woods Hole region, Mass.	Linton, 1940
Tubulovesicula pinguis	stomach	Beaufort, North Carolina;	Linton, 1905
		Woods Hole region, Mass.	Linton, 1940
Distomum fenestratum	stomach	Buttonwood Canal, Florida	present study
Hemiurus appendiculatus	stomach	Woods Hole region, Mass.	Linton, 1940
Lecithochirium mecosaccum	stomach	Dry Tortugas, Florida;	Manter, 1947
		Apalachee Bay, Florida	Nahhas & Short, 1965
L. parvum	stomach	Dry Tortugas, Florida	Manter, 1947
L. synodi	stomach	Dry Tortugas, Florida;	Manter, 1947
		Grand Isle, Louisiana;	Sparks, 1958
		Beaufort, North Carolina	Manter, 1931
Ectenurus americanus	stomach, gills	Dry Tortugas, Florida;	Manter, 1947
		Biscayne Bay, Florida	present study
Parahemiurus merus	stomach	Dry Tortugas, Florida	Manter, 1947
Sterrhurus musculus	stomach	Dry Tortugas, Florida;	Manter, 1947
		Grand Isle, Louisiana;	Sparks, 1958
		Apalachee Bay, Florida;	Nahhas & Short, 1965
		Buttonwood Canal, Florida;	present study
		Biscayne Bay, Florida	present study
S. monticellii	stomach	Beaufort, North Carolina	Linton, 1905
Stomachicola rubea	stomach	Beaufort, North Carolina	Linton, 1905
S. magna	stomach	Beaufort, North Carolina;	Manter, 1931
		Grand Isle, Louisiana;	Sparks, 1958
		Freeport, Texas;	Sparks, 1960
		Buttonwood Canal, Florida	present study
Genolopa ampullacea	intestine	Nassau and/or Eleuthera, Bahamas;	Sparks, 1957
		Dry Tortugas, Florida	Manter, 1947

TABLE 2 (CONTINUED)

Parasite	Site	Geographic locality	Reference
Opegaster synodi	intestine	Dry Tortugas, Florida	Manter, 1947
Opecoeloides polyfimbriatus	intestine	Galveston Bay, Texas	Read, 1947
Opecoeloides sp.	intestine	Buttonwood Canal, Florida	present study
Cestoda			
Anantrum tortum	intestine	Beaufort, North Carolina;	Linton, 1905
		Biscayne Bay, Florida;	present study
		Buttonwood Canal, Florida	present study
tetraphyllidean larvae	cystic duct, gall bladder, stomach wall, pyloric caeca	Beaufort, North Carolina;	Linton, 1905
		Buttonwood Canal, Florida;	present study
		Biscayne Bay, Florida	present study
tetrarhynchid larvae	intestine, body cavity	Buttonwood Canal, Florida;	present study
		Biscayne Bay, Florida	present study
Rhynchobothrium sp.	intestine	Beaufort, North Carolina	Linton, 1905
Acanthocephala			
Serrasentis socialis	body cavity	Beaufort, North Carolina	Linton, 1905
Pomphorhynchus laevus	intestine	Beaufort, North Carolina	Linton, 1905
acanthocephalan larva	body cavity	Buttonwood Canal, Florida	present study
Nematoda			
ascarid larva	viscera	Beaufort, North Carolina	Linton, 1905
Contracaecum spp.	viscera, body cavity	Buttonwood Canal, Florida	present study
Goezia minuta	stomach	Buttonwood Canal, Florida	present study
Isopoda			
Livoneca texana	gills	Padre Island, Gulf of Mexico	Pearse, 1952
Copepoda			
Abasia pseudorostris	mouth cavity	Beaufort, North Carolina;	Wilson, 1908
		Biscayne Bay, Florida	present study
Naobianchia spinosa	gills	Port Aransas, Texas	Pearse, 1952

Phylum PROTOZOA
Class *MASTIGOPHORA*
Order DINOFLAGELLATA
Family Blastodiniidae
Oodinium sp.

This dinoflagellate was found attached to the gill filaments by means of cytoplasmic processes. Shapes varied from spherical to pyriform. The measurements ranged from 100μ by 50μ to 500μ by 450μ.

This species could be *O. ocellatum* Brown, 1931, but the "flagellum" and stigma described by Nigrelli (1936: 137) were not apparent. *O. ocellatum* is the only known parasitic flagellate on marine fishes. *O. limneticum* Jacobs, 1946, is parasitic on freshwater fishes and does not have the "flagellum" or stigma. Both described species are smaller than the dinoflagellates on *Synodus*. A more elongated species, *O. cyprinodontum* Lawler, 1967, is found on estuarine fishes of Virginia.

Phylum PLATYHELMINTHES
Class *TREMATODA*
Order DIGENEA
Family Hemiuridae
Sterrhurus musculus Looss, 1907

The hemiurid *S. musculus* was found in large numbers in many of the inspected fish. It is attached to the stomach epithelium, causing lesions, and found free in the contents of the stomach. Extended adults are about 1 cm in length, but when contracted are generally about 2 mm long. Manter (1934: 305) includes an adequate modern account for this species under the synonym, *S. floridensis*.

The identity of many of the hemiurids examined is tentative, since most of the slides were not prepared from fresh material. All the identifiable specimens have proved to be *S. musculus*. Individual *S. foetens* from another area, however, are reported as being infected by three hemiurid species simultaneously (Manter, 1934: 307).

The data presented here concerning incidence and intensity treat all the digenetic trematodes that appear to be *S. musculus* as such.

Stomachicola magna (Manter, 1931) Manter, 1947

S. magna is a large hemiurid which can extend well over 2 cm in length. It is usually attached to the stomach epithelium, leaving large protuberances and lesions. All identified specimens are *S. magna*. Several immature forms were observed which also appeared to be *S. magna*.

This infection extends the geographical range of *S. magna* in *S. foetens* from North Carolina to Florida. It has also been found in Texas and Louisiana (Table 2).

A few tailed hemiurids with undeveloped vitellaria were also found in the stomach. Possibly, these parasites were passing through the gut, and may be unable to mature in *Synodus*.

Family Didymozoidae
Distomum fenestratum Linton, 1907

This immature didymozoid was found in the stomachs of only three specimens of *Synodus*. The infection is a new host record for *D. fenestratum*. It might be just an accidental infection, but this species is known to infect other species of *Synodus*. The mature form is not known. Cable & Nahhas (1962: 34) found that small fishes may acquire immature didymozoids by eating crustaceans such as the barnacle *Lepas*. The adult forms are found in large pelagic fishes. Apparently, these definitive hosts may acquire the parasite from either crustaceans or small fishes.

Family Opecoelidae
Opecoeloides sp.

This trematode is placed in *Opecoeloides* because the caeca connect with the outside after joining with the excretory vesicle. It is probably *O. fimbriatus* (Linton, 1934) Sogandares-Bernal & Hutton, 1959, which was originally described in Manter (1934), but additional parasitic material is necessary to confirm this.

The trematode was found only in the intestines of those fish sampled from February through June of 1964. Most fish infected during this period had one parasite; the heaviest infection was three.

Before this study, the only *Opecoeloides* known from *S. foetens* was *O. polyfimbriatus*.

Class *CESTODA*
Order PSEUDOPHYLLIDEA
Family Bothriocephalidae

The following cestode is an atypical member of the family Bothriocephalidae Blanchard, 1849, of Yamaguti (1959). It differs from other genera in the following characteristics: absence of bothria, presence of neck, strobila without distinct segmentation, and proglottids not craspedote. At present I do not think that erection of a new family is justified because the family Bothriocephalidae already encompasses a wide variation in characteristics. As an example, *Bothriocephalus scorpii* Mueller, 1776, does not have complete segmentation between successive proglottids or even between pairs of proglottids. The neck on the species of this description is recognized because of the complete lack of segmentation. Therefore, until the family Bothriocephalidae is reviewed, I think that the following genus should be placed in this family and that it is most closely related to the genus *Bothriocephalus*.

Anantrum, n. g.

Diagnosis.—Bothria absent. Strobila without external segmentation. Vitellaria cortical.

Description.—The scolex is elongate, clavate, without bothria, and unarmed. Neck is present. Strobila is lacking external segmentation, but proglottisation is evident. Anterior region of strobila is without reproductive organs. Marginal surfaces are truncatedly oval. Proglottids are anapolytic, wider than long in relaxed worm. Longitudinal excretory ducts and nerve canals are in medulla. Parenchymal musculature is well developed. Testes are centrally located in lateral medulla. Cirrus pouch is oval, at right angles to dorsal surface, and surrounded by several small prostatic cells. Cirro-vaginal atrium is dorsal and median. Ovary is bilobed in the ventral and central median medulla. Seminal receptacle is present. Vitellaria are cortical, extending from proglottis to proglottis, the same as the testes. Uterus consists of winding uterine duct enlarging into an elongated sac beginning posteriorly to female pore. Uterine pore is ventral, alternating irregularly from one side of the median line to the other. Eggs are thin-shelled, operculated, and not embryonated when laid.

Type-species.—Dibothrium tortum Linton, 1905.

Discussion.—The name *Anantrum* is from *an* (= without) and *antron* (= cavity), and refers to the lack of bothria on the scolex.

Anantrum tortum (Linton, 1905), n. comb.

Fig. 2

Dibothrium tortum Linton, 1905: 354, figs. 119-124.

Description.—Total length of gravid strobilae ranges from about 1 to over 15 cm. Proglottids vary greatly. A proglottis 2.30 mm wide was 0.27 mm long, and a proglottis 0.35 mm wide was 0.49 mm long. Width of a relaxed proglottis ranges from 0.3 to 5.0 mm. A worm 161.5 mm in length had 422 proglottids, 321 of which contained eggs. The strobilae are usually twisted or spiralled, with the lateral edges curled in varying directions. Scolex is a club-shaped organ which can contract, appearing as a nipple on the end of the strobila. The scolex varies between 0.6 and

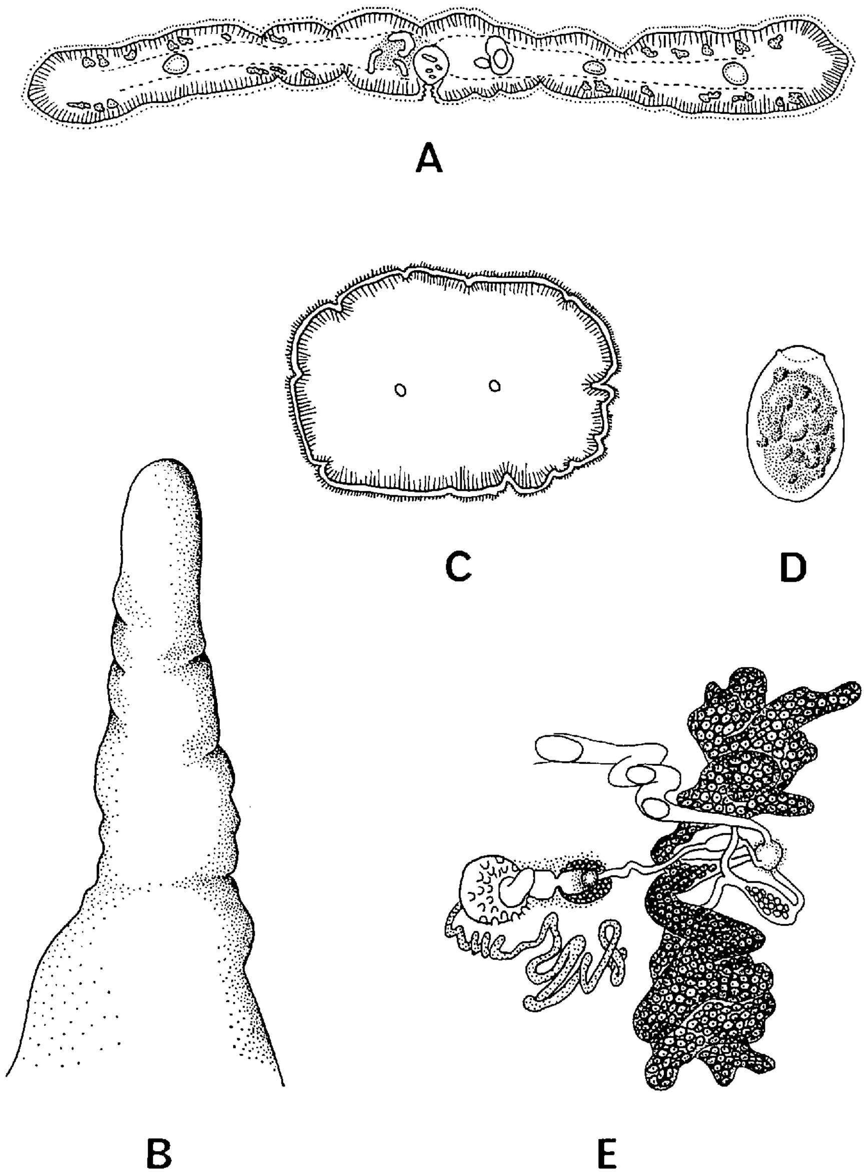


FIGURE 2. *Anantrum tortum* n. comb. A, cross section of proglottis through the cirrus position. B, anterior end. C, cross section of anterior end. D, egg. E, reproductive organs. All figures except B were drawn with the aid of a camera lucida.

1.5 mm in length and 0.2 and 0.8 mm in diameter. Dorsal and ventral masses of parenchymal muscles originate about midway down the length of the scolex. Testes are spherical to lobed, ranging from 25 to 57μ across the greatest diameter. The sperm duct is convoluted and without enlarged external seminal vesicle. The duct becomes more narrow in diameter as it approaches the cirrus pouch. The greatest diameter of the cirrus pouch, in dorsal view, ranges from 50 to 76μ. The pouch is oval in cross section, 72μ long for 61- and 58-μ-diameter pouches. The cirro-vaginal atrium has approximately 30 papillae which are placed roughly in four circular rows. There is a large internal seminal vesicle. The ejaculatory duct is moderately coiled. The ovary consists of two laterally lobated, wing-like extensions. The seminal receptacle is oblong, and the seminal canal is generally short. The two major vitelline ducts form a common duct which enlarges into a reservoir before joining the fertilization canal. The insertion of the ducts from the ovary, seminal receptacle, and vitellary are usually located one upon the other when viewed superficially. Vitelline glands are located in the cortex, with the greatest diameter ranging from 18 to 43μ. A cross section with four medullary testes on one side of the worm will have approximately 24 vitelline glands, of which half are located dorsally and half ventrally. Eggs are thin-shelled, operculated, and not embryonated when laid. The eggs measure 48 to 58μ by 27 to 34μ. The operculum, unless opened, can be observed only as a slight ridge at the anterior curvature.

Discussion.—The specimens described differ from those described by Linton (1905: 354) only by usually having an oval rather than spherical cirrus pouch. Linton originally described the cestode from *S. foetens* collected in North Carolina. Buttonwood Canal is a southern extension of the geographical range for this cestode.

The worm is twisted along the intestinal tract of its host, either singly or in groups of up to eight. It is usually located in the intestinal loops or with its scolex doubled over on the strobila in a pyloric caecum.

A specimen was deposited in the U. S. Nat. Mus. Helm. Coll. (No. 71122).

Orders Tetrarhynchidea and Tetraphyllidea

Larvae of tetrarhynchidean and tetraphyllidean species were found in the intestines of *S. foetens*. Plerocercoid larvae were both free and embedded in the epithelium. A tetraphyllidean species was found in the pyloric caeca of every fish inspected. Another tetraphyllidean species was found in the gall bladder and cystic duct, frequently filling these structures. Linton (1905: 354) reported "*Scolex polymorphus*" from the cystic duct and stomach tissue of *S. foetens*. Buttonwood Canal is an extension of the range for larval tetraphyllideans in *S. foetens*.

Phylum NEMATODA
Class *SECERNENTEA*
Order ASCARIDIDA
Family Group Stomachinae
Goezia minuta Chandler, 1935

This is an adult nematode which can form a cyst in the stomach wall, often in the vicinity of the pyloric sphincter. As many as ten worms were seen partially extended from a single cyst. The length of the worm ranges from less than 1 mm to greater than 8 mm. *S. foetens* is a new host record for *G. minuta*.

LARVAL NEMATODES AND ACANTHOCEPHALANS

The mesenteries were usually infected with larval nematodes and acanthocephalans, especially in the larger fish. There were two different larval nematodes. *Contracaecum* sp., which fits the description of *C. collieri* Chandler, 1935, was occasionally found on the stomach wall or the gonads. This worm attains a length of over 2 cm.

Another species of *Contracaecum* was prominent in many of the *S. foetens*. Most specimens are 3 to 4 mm in length. They were found in both coiled and extended positions. Linton (1905: 354) also mentions an *Ascaris* infection in *S. foetens*, but the larvae could easily be a different species.

A larval acanthocephalan was found in most of the fish studied. All specimens were probably the same species, but identification was impossible since the proboscises were never extended fully. The cysts could be found in all sizes up to 4 mm. A few worms had migrated through the intestinal wall. Linton (1905: 353) found two species of Acanthocephala in *S. foetens*. He found an adult of *Pomphorynchus laevus* in the intestine and a larva of *Serrasentis socialis* in the body cavity. Neither of these was found in *S. foetens* from Buttonwood Canal.

ECOLOGY OF THE PARASITES

Noble *et al.* (1963: 303) stated that to understand the ecological relationships between parasites and their micro- and macroenvironment, a large number of fish must be examined over a long period of time. In the present study, the number of specimens of fish is small, owing to the limited number available in the particular habitat being studied. Statistical approaches, for the most part, were curtailed by the variation

TABLE 3

THE INCIDENCE OF INFECTION FOR SEVERAL SPECIES OF PARASITES IN SPECIMENS OF *Synodus foetens* WHICH ARE UNDER 10 CM IN LENGTH FROM BUTTONWOOD CANAL[1]

Length of *S. foetens* (mm)	*Oodinium*	*Stomachicola*	*Sterrhurus*	*Goezia*	*Anantrum*	Intestine, cestode larvae	Pyloric caeca, cestode larvae	Gall bladder, cestode larvae	Mesentery, parasites
37	0	0	0	0	0	0	x	0	0
40	x	0	0	0	0	x	x	0	0
51	0	0	0	0	0	x	x	0	0
56	x	0	0	0	0	–	x	x	0
62	0	0	0	0	x	x	x	0	0
66	0	0	0	0	0	x	x	0	0
66	–	0	0	0	0	x	x	0	0
76	0	0	0	0	x	–	x	0	x
79	0	0	0	0	0	x	x	0	0
80	0	0	x	x	0	x	x	0	0
80	x	0	x	0	0	x	x	0	x
81	0	0	x	x	0	x	x	0	0
81	x	0	x	0	x	x	x	x	0
83	x	0	0	0	0	x	x	x	0
89	x	0	0	0	0	x	x	x	0
90	0	0	x	0	x	x	x	0	x
90	x	0	0	x	0	x	x	0	0
91	–	0	0	0	0	x	x	x	x
92	x	0	x	x	0	x	x	0	x
94	–	0	x	0	0	x	x	x	x
95	–	0	x	0	x	x	x	x	x

[1] x = infected, 0 = not infected, and – = not examined.

in intensity of parasite number per fish and the low number of monthly samples of *S. foetens*.

Incidence of Infection.—All the autopsied specimens of *S. foetens* from the Buttonwood collections were found to be infected by one or more species of parasite. Two 37-mm larvae of *S. foetens* collected from the R/V GERDA, station number G-516, which is located at the tip of Great Bahama Bank, were examined to see if larval *Synodus* were infected. They were not infected.

Small individuals of *Synodus* were examined to determine at what length they were first infected by different parasitic species. A 37-mm transformed lizardfish collected from Buttonwood Canal, 3 March, 1965, had an infection of larval cestodes in the pyloric caeca. The smallest

TABLE 4

NUMBER OF *Synodus foetens* OF SPECIFIC LENGTHS FROM BUTTONWOOD CANAL, AND THEIR MINIMAL AND AVERAGE NUMBER OF PARASITIC SPECIES

Synodus length (cm)	Minimum number of parasitic species									Average number of species
	2	3	4	5	6	7	8	9	10	
4	–	1	–	–	–	–	–	–	–	3.0*
5	–	1	–	1	–	–	–	–	–	4.0
6	2	–	1	–	–	–	–	–	–	2.7
7	1	–	1	–	–	–	–	–	–	3.0
8	–	1	2	2	1	–	–	–	–	4.5
9	–	–	3	1	2	–	–	–	–	4.8
10	–	3	–	1	2	1	–	–	–	4.7
11	–	–	–	1	2	1	1	–	–	6.4
12	–	–	1	1	3	5	2	–	–	6.5
13	1	–	1	2	5	1	3	2	–	6.3
14	–	–	1	2	6	6	3	2	–	6.7
15	–	–	2	1	8	2	3	1	–	6.4
16	–	–	1	2	2	7	2	–	–	6.5
17	–	–	–	1	1	1	2	–	1	7.3
18	–	–	–	–	–	–	1	1	–	8.5
19	–	–	–	4	2	3	1	2	–	6.6
20	–	–	–	1	2	2	4	–	–	7.0
21	–	–	–	1	5	5	–	–	–	6.4
22	–	1	–	1	3	4	3	1	1	6.9
23	–	–	–	3	2	1	5	1	–	6.9
24	–	–	3	–	1	5	3	1	–	6.6
25	–	–	–	–	–	3	1	2	1	8.1
26	–	–	–	–	1	1	–	–	–	6.5
27	–	–	–	–	–	–	–	1	–	9.0*
28	–	–	–	1	–	1	–	1	–	7.0
29	–	–	–	–	1	–	–	2	–	8.0

* Only one fish.

fish, which was 40 mm in length, examined from the two-year collection had five *Oodinium* sp. and several cestode plerocercoids in both the pyloric caeca and the intestine. The smallest fish in which other parasites were first recorded were the following (Table 3): gall bladder cestode at 56 mm, *Anantrum tortum* at 62 mm, acanthocephalan at 76 mm, *Sterrhurus musculus* and *Goezia minuta* at 80 mm, *Stomachicola magna* at 106 mm, and other parasites in larger fish. Table 3 also reveals the negative results for the fish under 10 cm in length.

A low incidence of *Stomachicola* in small fish, accompanied by a higher incidence in the larger *Synodus* collected at the same time, suggests that the parasite is acquired from an intermediate host not normally fed on by small individuals of *S. foetens*.

The number of parasitic species present increased with increase in the

TABLE 5
INCIDENCE OF PARASITIZED *Synodus foetens*, BY PARASITE SPECIES, DURING 1963 AND 1964

Parasite	1963 No. of fish examined	1963 Incidence (percentage)	1964 No. of fish examined	1964 Incidence (percentage)	Combined incidence (percentage)
Oodinium	55	74.5	73	79.5	77.3
Sterrhurus	103	99.1	102	72.5	85.9
Stomachicola	103	63.1	102	32.4	47.8
Goezia	103	66.0	102	33.3	49.8
Anantrum	103	76.6	102	55.8	66.4
Opecoeloides	103	0	102	9.8	4.9
Intestinal plerocercoids	74	80.0	86	65.2	72.5
Pyloric caeca plerocercoids	91	100.0	99	100.0	100.0
Gall bladder plerocercoids	99	85.9	102	67.6	76.6
Mesentery cysts	103	95.2	102	83.3	89.3

length of fish up to about 11 cm, and above that length, a relatively constant number was retained (Table 4). The number of parasitic species for each length-grouping indicated in the table is minimal. This was done for several reasons. First, the numbers are not exact because only 128 fish were inspected for *Oodinium* and, second, distinction between different cestode larvae was not recorded for a few fish. Also, microparasites were probably present in some of the fish, and more than one species of digenetic trematode were probably present in the stomach of some fish. It is believed, however, that the table indicates the overall increase in incidence.

Only one species of parasite infected every fish, and that was the cestode larva located in the pyloric caeca (Table 5).

The incidence of species of parasites present was higher in 1963 than in 1964 for all but two species (Table 5). There was a slight difference between the incidence in 1964 and in 1963 for the *Oodinium* sp. *Opecoeloides* sp. was recorded during 1964 only. Considering only the five months in which *Opecoeloides* was observed, 22 per cent of the fish were infected. The reasons for the yearly incidence differences were not evident. There is probably a relationship between infection rate of the intermediate hosts and incidence. Dr. Durbin Tabb (personal communication) found that there were smaller populations of several invertebrates in 1964 than in 1963. This decrease in number of invertebrates in 1964 could indicate there was a decline of potential intermediate hosts, or

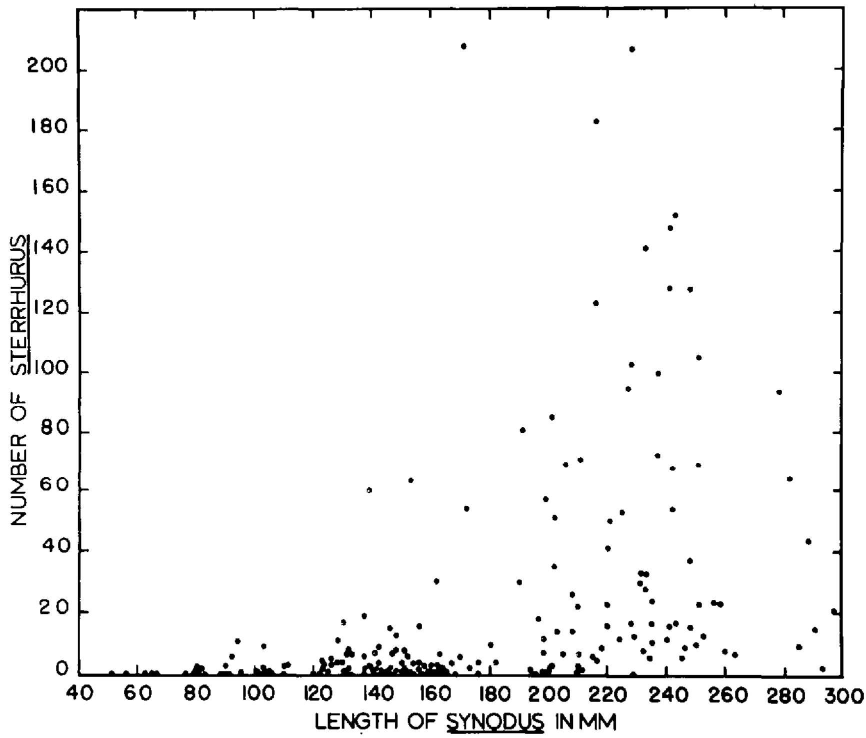


FIGURE 3. Variation in number of *Sterrhurus* with length of 205 specimens of *Synodus foetens* during 1963 and 1964, with the exception of 614 and 346 *Sterrhurus* in *Synodus* at 193 and 238 mm respectively.

that both the incidence of parasites in the lizardfish and the availability of the invertebrates were dependent on the same factor. The yearly differences could also be related to the difference in average length of *Synodus* between the two years. The average length in 1963 was 179.7 mm, compared with 167.3 mm for 1964.

Intensity of Infection.—Intensity of infection, as well as incidence, is a function of both micro- and macroenvironment. Lack of understanding of all the contributing factors, the interrelationships of these factors, and the small sample sizes permit only indications concerning the parasite and its environment. Only monthly means were used for analysis because of the small sample sizes (Table 1).

There appear to be relationships between monthly mean numbers of *Sterrhurus* and monthly mean salinity values, and between monthly mean numbers of body-cavity cysts and monthly mean length of host values.

TABLE 6
PARTIAL CORRELATIONS ON MONTHLY OBSERVATIONS

Variables†	Correlation coefficients
$r_{bd \cdot c}$	−0.540*
$r_{cd \cdot b}$	−0.086
$r_{bd \cdot a}$	−0.481*
$r_{ad \cdot b}$	+0.103
$r_{ae \cdot c}$	+0.695**
$r_{ae \cdot b}$	+0.608**
$r_{ce \cdot a}$	+0.231
$r_{be \cdot a}$	+0.083

† a = mean length of *Synodus foetens*; b = mean salinity; c = mean temperature; d = mean number of *Sterrhurus* per *S. foetens*; e = mean number of body cavity cysts per *S. foetens*.
* $P < 0.05$.
** $P < 0.01$.

Figure 3 illustrates that the number of *Sterrhurus* increases with increase in length of *Synodus*. Wide variation in number of parasites per fish occurs for fish over 16 cm in length. The number of parasites per *Synodus* reaches a peak around 23 cm, and then the number tends to diminish.

There are, perhaps, several factors contributing to this variation in intensity. Different year classes of fish may have a variation in number of parasites. The fish were broken down into three groups, and the averages of the fish over 16 cm in these groups were compared. These groups constituted samples from January through June, 1963, July, 1963 through June, 1964, and July through December, 1964. The mean numbers of worms for these periods were 58.5, 73.2, and 10.9 *Sterrhurus* per *Synodus* for sample sizes of 20, 42, and 34 respectively. These figures do not entirely represent the group, however, because one fish in each of the first two groups strongly affects the means. The means excluding those two fish were 27.8, 64.9, and 10.9 parasites per fish. Variations in number per fish within these three groups suggest further controlling factors. Only the two previously mentioned fish revealed large deviations from the means. One fish, 193 mm long, collected in April, 1963, had 614 *Sterrhurus,* 395 of which contained eggs. This was the largest number of trematodes found in a single fish during the study.

Partial correlations were calculated for monthly means of salinity, temperature, length of *Synodus,* and numbers of *Sterrhurus* for the 19 months that had over five fish per month. There is a significant inverse correlation between the number of *Sterrhurus* and salinity, but not temperature, keeping constant the length of *Synodus* (Table 6). The correlation between the mean number of parasites and length is not significant with salinity kept constant. Figure 4 illustrates the variation of monthly

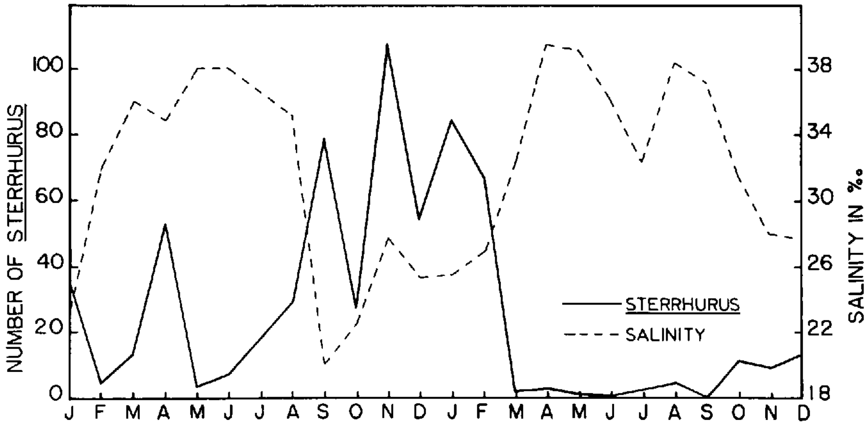


FIGURE 4. Monthly variations of mean number of *Sterrhurus* and mean salinity of Buttonwood Canal during 1963 and 1964.

mean number of *Sterrhurus* and monthly mean salinity. The results of the correlations and the graph do not necessarily mean that the salinity directly influences the number of *Sterrhurus*. *Sterrhurus* is probably acquired through intermediate hosts, and those hosts could be affected by the salinity of the water. The intermediate host or hosts might be present or infective only during low-salinity–low-temperature periods. Copepods and chaetognaths have been reported as the second intermediate hosts of hemiurid trematodes (Dawes, 1956: 481). It also appears that some species of hemiurids have free-living larvae (Dawes, 1956: 481; Noble *et al.*, 1963: 301).

The salinity of the water might have had a direct effect upon the intensity of infection of *Sterrhurus*. *Sterrhurus* is normally found in the stomach. The presence of the worms in the intestine suggests that they are being discharged from the fish. *Sterrhurus* were found in the intestines of 12 *Synodus,* and their presence might be attributed to the salinity of the water. When the monthly mean salinity is relatively high, the parasitic infection rate is relatively low, and vice versa. Seven of the *Synodus* with *Sterrhurus* in their intestines were fish that had a much greater infection than the average infection for the month in which they were collected. Eight *Synodus* with *Sterrhurus* in their intestines were collected during January, April, September, and November of 1963. These were months after which there was a large decline in the average infection in the following month (see Figure 4). All 12 fish were included in one or both of the two groups mentioned above. It is also important to realize that other physical or chemical factors could be affecting the infection rate of *Sterrhurus*.

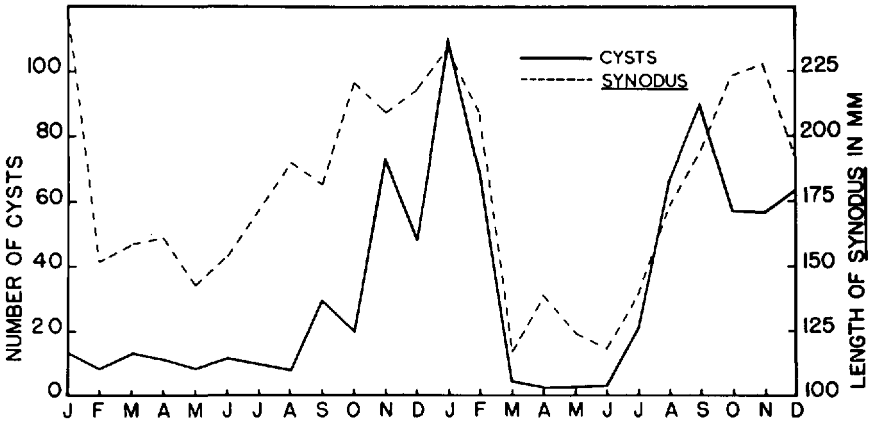


FIGURE 5. Monthly mean variations in length of *Synodus foetens* and mean number of body cavity cysts during 1963 and 1964.

Interaction between different parasitic species could also contribute to the variability in number of *Sterrhurus* present in individual fish. Possibly, the presence of another parasitic species within the same stomach increases or enhances the potential for infection. This will be discussed in a later section.

Cysts from the body cavity do not show the same relationship as *Sterrhurus*. The mean numbers of cysts from the fish over 16 cm divided into the same groups as before, are 18.8, 56.2, and 68.9 cysts per fish. There is some variation in each group, but not as pronounced as for *Sterrhurus*.

The mean number of cysts has a positive correlation with length of *S. foetens* (Fig. 5). Partial correlations were calculated, using the monthly mean numbers of cysts per fish, length of *Synodus*, salinity, and temperature (Table 6). The mean number of cysts showed a significant positive correlation with length of *S. foetens*, when salinity or temperature was kept constant. There was no relationship between number of cysts and salinity or temperature.

Potential for accumulating parasites increases with the amount of food a fish eats. This accumulation of encysted larval stages is typical of most intermediate hosts. Generally, acanthocephalan and nematode larvae do not leave the host as long as the host remains alive.

Probably more than one factor is involved in cyst infections. The intermediate hosts for both acanthocephalans and nematodes are crustaceans such as copepods and amphipods. The lack of a relationship between salinity or temperature and mean number of cysts suggests that they are accumulated throughout the year and that the presence of the

TABLE 7

MONTHLY MEAN NUMBER OF PARASITES PER *Synodus foetens*, AND MEAN TEMPERATURES AND SALINITIES DURING 1963 AND 1964

Month	Temperature (°C)	Salinity (‰)	*Sterrhurus*	*Stomachicola*	*Goezia*	*Anantrum*	Gall bladder cestode	Body cavity cysts	*Oodinium*
1963									
January	19.0	23.3	37.2	2.4	4.5	3.3	8.9	13.3	30.3
February	19.8	32.0	4.9	1.0	2.4	1.7	12.0	8.4	8.0
March	21.3	36.1	13.7	0.8	1.9	1.8	23.6	13.0	12.5
April	24.1	34.9	53.3	1.8	2.8	2.0	22.4	11.4	6.2
May	28.0	38.1	3.8	1.8	2.1	1.7	10.1	88.5	6.8
June	28.5	38.2	7.1	1.7	0.5	2.1	6.6	11.5	4.0
July	—	—	—	—	—	—	—	—	—
August	26.0	35.3	30.0	1.0	2.0	1.0	16.0	8.0	16.0
September	25.5	20.0	79.0	1.1	3.5	1.0	24.3	29.5	9.8
October	24.5	22.6	28.0	2.3	0.0	2.5	2.0	20.0	54.0
November	23.8	27.7	108.3	2.1	1.2	3.5	13.7	72.9	1.0
December	18.0	25.4	55.3	0.9	0.6	1.6	18.1	48.3	0.3
1964									
January	20.0	25.6	84.7	2.0	0.0	6.7	0.7	110.3	6.3
February	16.6	26.9	66.7	1.2	0.0	2.2	3.7	68.0	3.2
March	26.2	32.4	2.4	0.0	0.5	2.9	8.8	4.5	1.7
April	27.1	39.6	2.8	0.2	0.7	1.2	3.5	2.7	5.2
May	26.5	39.4	1.2	0.3	0.6	0.9	2.0	2.7	4.8
June	28.3	36.3	0.5	0.4	0.1	0.2	0.9	3.5	12.3
July	29.7	32.5	2.8	1.2	1.3	0.6	1.4	20.3	24.4
August	30.2	38.5	4.9	0.2	2.9	1.3	3.4	66.4	2.5
September	31.1	37.3	0.0	0.0	1.0	0.0	9.0	90.0	12.0
October	25.8	31.7	10.6	0.6	1.3	1.7	5.2	57.0	5.5
November	23.8	28.2	9.3	1.1	0.5	0.5	13.5	56.3	26.3
December	21.3	27.7	13.1	0.9	0.9	1.8	12.5	63.4	13.3

appropriate intermediate hosts is not related to fluctuations of either salinity or temperature.

Such clear relationships are not indicated by the monthly means of the other parasites. Table 7 includes the monthly variations for several parasites, accompanied by the salinity and temperature.

The intestinal opecoelid infected *Synodus* from February through June of 1964, only. This infection probably corresponds to the infection of the intermediate host. Hutton *et al.* (1959: 19) have reported *Opecoeloides fimbriatus* from *Penaeus duorarum*, a dietary item of *Synodus*, in Buttonwood Canal.

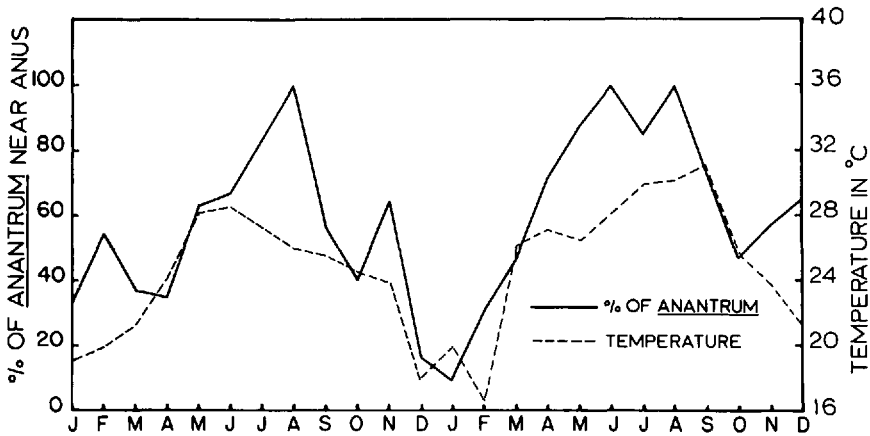


FIGURE 6. Monthly variations in the percentage of *Anantrum tortum* located near the anus of *Synodus foetens* and the mean temperature of Buttonwood Canal during 1963 and 1964.

Cestode larvae were grouped separately into high, medium, and low infection rates. There was no indication of a relationship among any of the measured variables and the infection rates.

Inspection of the raw data revealed no obvious relationships between parasitic species or numbers with sex of fish. Further examination of variations of parasites with sex of fish was not carried out. There were 74 males, 107 females, and 23 immature and undetermined specimens of *Synodus*.

Variation of Parasite Position.—The site of a parasite within a host can be affected by the external environment. Specimens of *Anantrum* were recorded from near the pyloric caeca, in the center of the intestine, and near the anus. When the salinity of the water is held constant and an inverse sine transformation (Steel & Torrie, 1960: 158) is applied to percentage data, there is a correlation at the 99 per cent level of significance between the percentage of worms located near the anus and the temperature of the water. Figure 6 illustrates the relationship between the location of the worms and the temperature of the water, not accounting for the salinity of the water.

Interrelationships.—The presence of one or more parasitic species may influence the presence of other species. For this study, two statistical associations were revealed by using contingency tables. All combinations of stomach parasites were assessed (Tables 8 and 9). The data, however, are taken from a heterogeneous sample. The specimens of fish have a wide range of length and are from different months. The frequency of

TABLE 8

OBSERVED NUMBERS OF 185 SPECIMENS OF *Synodus foetens* OVER 10 CM IN LENGTH INFECTED WITH COMBINATIONS OF *Sterrhurus* (S), *Stomachicola* (SC), AND *Goezia* (G), DURING 1963 AND 1964

	S	No S	G	No G
Sc	94	4	52	46
No Sc	74	13	47	40
G	92	7	—	—
No G	76	10	—	—

	Sc		No Sc	
	G	No G	G	No G
S	51	43	41	33
No S	1	3	6	7

absence of parasites is influenced by the smaller *Synodus*. Only 9.8 per cent of the fish were under 10 cm, while 61.1 per cent of the fish not infected by any parasites in the stomach were under 10 cm. The data for the fish under 10 cm were omitted because they would suggest a much more significant association than the data for the range of length of fish in which infection was common.

The level of significance for the *Sterrhurus-Stomachicola* and the *Sterrhurus-Stomachicola-Goezia* associations were both significant (Table 9). The relationships are both positive. This means that there are more worms present in association with each other than would occur on a random basis.

The presence of a species of parasite may increase or decrease the possibility of the presence of other parasitic species. One species might be beneficial to another because it produces a metabolite essential for the second species, or because the reactions of the host against the

TABLE 9

STATISTICAL EVALUATION OF COMBINATIONS OF *Sterrhurus* (S), *Stomachicola* (SC), AND *Goezia* (G) INFECTING 185 SPECIMENS OF *Synodus foetens* FROM BUTTONWOOD CANAL DURING 1963 AND 1964

Parasites	Degrees of freedom	Chi-square value
SSc	1	5.278*
GSc	1	0.017
SG	1	0.664
ScGS	3	8.099*

* $P < 0.05$.

parasitic species provide essential substances for the second species. It is not known if beneficial metabolites are produced by any of the parasites of *Synodus*. The three parasites of the stomach, however, do cause host reactions which might be beneficial to the infection by a certain parasitic species. Both *Stomachicola* and *Sterrhurus* form lesions in the stomach which must heal after the parasite changes its site. The cysts of *Goezia* are accompanied by considerable mucus. These associations, however, might be a reflection of the availability of the intermediate hosts only.

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Sumario

Parasitos del Pez Lagarto Costero, *Synodus foetens,* del Sur de la Florida, Incluyendo la Descripcion de un Nuevo Genero de Cestoda

Se estudiaron los parásitos de *Synodus foetens* procedentes de colecciones cogidas en el Canal Buttonwood, entre enero de 1963 y diciembre de 1964. Los peces fueron encontrados todos los meses excepto en julio de 1963. Ellos constituían las clases de un año, que permanecieron en el canal aproximadamente por un año. La dieta de *S. foetens* incluyó el camarón rosado, *Penaeus duorarum,* y un camarón palaemónido, y los peces *S. foetens, Anchoa mitchilli, Lagodon rhomboides, Eucinostomus argenteus, Sphaeroides* sp., *Cyprinodon variegatus, Poecilia latipinna, Gobionellus* sp., un ciprinodóntido, un anterínido y otros demasiado digeridos para poder ser identificados.

Se ha hecho un nuevo género de Bothriocephalidae con el propuesto nombre de *Anantrum*. Una nueva combinación es *A. tortum,* que previamente era *Dibothrium tortum* Linton, 1905. Se da una redescripción de la especie.

El pez lagarto estaba infectado por *Oodinium* sp., *Sterrhurus musculus, Distomum fenestratum, Stomachicola magna, Goezia minuta, Anantrum tortum, Opecoeloides* sp., varios plerocercoides cestodes larvales, dos diferentes *Contracaecum* spp. larvales y un acantocéfalo larval. Todos éstos constituyen reportes de nuevas localidades.

Oodinium sp., *D. fenestratum, G. minuta, Opecoeloides* sp., *Contracaecum* sp. y las larvas de acantocéfalos y tetrarinchoideos se reportan en un nuevo huésped. Se reporta extensión en la distribución geográfica de la infección de *S. foetens* en el Canal Buttonwood por *Stomachicola magna,*

Anantrum tortum y larvas de tetrafilideos. Las infecciones encontradas en *S. foetens* procedentes de Biscayne Bay extienden el alcance de *Sterrhurus musculus, Ectenurus americanus* y *Abasia pseudorostris.*

Hay un aumento en el número de especies parasíticas con longitudes que van desde la de *S. foetens* hasta alrededor de unos 11 cm.

La incidencia de infección fue mayor en 1963 que en 1964 para todos excepto *Oodinium* sp. y *Opecoeloides* sp. La diferencia entre los dos años fue poca en el caso de *Oodinium*. *Opecoeloides* infectó *Synodus* sólamente desde febrero hasta junio de 1964. El único parásito que infectó todos los peces fue una larva plerocercoidea de tetrafilideos encontrada en el ciego pilórico.

Varios factores parecen jugar un papel en la intensidad de los grados de infección. Hay una diferencia en los grados de infección entre las clases de cada año. El promedio mensual de *Sterrhurus* por pez está en correlación negativa con la salinidad media cuando la longitud de *Synodus* se mantiene constante. El número promedio de quistes en la cavidad del cuerpo está en correlación positiva con la longitud de *Synodus* cuando la salinidad se mantiene constante. Se discuten las posibles razones para las relaciones entre estos y otros factores que actúan entre sí.

Hay una relación positiva entre la temperatura del agua y el por ciento de *Anantrum tortum* localizado en el extremo posterior del intestino.

Pruebas eventuales indican asociaciones positivas entre la presencia de *Sterrhurus* y *Stomachicola* y entre *Sterrhurus, Stomachicola* y *Goezia*. Hasta ahora no hay explicación para estas asociaciones.

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