A CESTODE PARASITE IN THE FLESH OF THE BUTTERFISH.

By EDWIN LINTON, Ph. D.

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HISTORICAL ACCOUNT.

During the summer of 1904, at the laboratory of the Bureau of Fisheries at Woods Hole, Mass., while I was engaged in the study of helminth parasites of fishes, a particular case of parasitism was called to my attention by Dr. Lynd Jones, who had observed the frequency of a parasite in the flesh of butterfish, *Poronotus, triacanthus,* which he had been feeding to terns.

The parasites occur in the muscle tissue of their host in the form of small cysts usually less than 1 millimeter in length. Each cyst consists of a connective-tissue envelop surrounding a plerocercus (blastocyst) in which is the scolex of a cestode worm. In most of the cases examined the scolex was found to be sufficiently developed to admit of its being referred to the species *Otobothrium crenacolle.* The adult of this species, first found by me in the spiral valve of the hammerhead shark (*Sphyrna zygæna*), was made the type of a new genus.[a]

The genus *Otobothrium* is distinguished from *Rhynchobothrium* by the presence of two supplemental eversible organs on each of the two bothria. These supplemental organs are covered with minute spine-like bristles, and appear either as small pits or small papillæ, depending on whether they are inverted or everted. In 1901 I recorded from the muscles of the butterfish cestodes that should have been referred to this species, but, their real nature not being recognized at that time, they were wrongly placed in the genus *Rhynchobothrium.*[b] For the purpose of comparison with observations recorded for the first time in this paper, I make the following extract from the record cited:

> On August 26, 1899, 2 butterfish * * * were submitted to me by Dr. C. Judson Herrick. * * * The muscles between the ribs contained great numbers of small cysts. When one of these was compressed, a blastocyst was liberated, from which, upon further pressure, a larval cestode * * * could be obtained. Forty of these cysts were counted in a space 4 millimeters square.
>
> Similar conditions were observed in a butterfish brought to me by Mr. E. E. Tyzzer August 17, 1900, and in another examined the following day.

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a Linton, Notes on Entozoa of marine fishes of New England. Report of the Commissioner of Fish and Fisheries for 1887, p. 849–853, pl. XIII, fig. 9–15, and pl. XIV, fig. 1–4.

b Linton, Parasites of fishes of the Woods Hole region. U. S. Fish Commission Bulletin for 1899, vol. XIX, p. 453–454, pl. XXIII, fig. 255–256a, and pl. XXIV, fig. 265.

In these cases enormous numbers of cysts were seen in the muscles. They were most abundant on the ventral side of the vertebral column, between the subvertebral spines. They were also scattered through the dorsal region, lying deep among and near the dorsal vertebral spines. The cysts are small, oval, about 1 mm. in length and somewhat less in shorter diameter. * * * Dimensions of larva in millimeters: Length, 0.7; bothria nearly circular, 0.3 in diameter; diameter of neck, 0.1. Contractile bulbs very short.

Since the foregoing record was made I have found this parasite in a number of different hosts at Beaufort, N. C.[a], Woods Hole, Mass., and in Bermuda. Details of these finds are given in my reports on these localities and a list of the hosts is given later in this paper.

Beginning with August 8, 1904, a systematic search was made for these parasites in the flesh of the butterfish and examinations were made on nine different dates that season, the last on October 12. The fish came from Buzzards Bay, near the village of Woods Hole; Nomans Land, a small island which lies some five miles at sea off the western end of Vineyard Sound; Montauk, Long Island, and Barnegat, N. J. In all, 188 fishes were examined, of which only one-half of 1 per cent were without parasites in the flesh, and 75 per cent were badly infested. Prior to August 8 a few butterfish had been examined, but search was made only on and in the viscera. Of these examinations I find in my notes on the dates July 20 and 25 mention of finding on the viscera small cysts containing living blastocysts, which, though not sufficiently developed for certain identification, are very probably *Otobothrium crenacolle*. It is somewhat surprising in the light of the subsequent discovery of the prevalence of this parasite in the flesh of the butterfish, and in the intestinal walls of many other fish, that the viscera of the butterfish should be so free from it.

During the summers of 1905 and 1906 the search for parasites was continued and a total of 331 fish were examined. Of these 42 per cent were badly infested, and only 11 per cent revealed no parasites.

DESCRIPTION OF SCOLEX, CYST AND BLASTOCYST.

Scolex.—In most cases where the cysts were opened the scoleces were found to be sufficiently developed to admit of identification. So far as can be determined from the scolex alone the species is *Otobothrium crenacolle*. The bothria agree closely with those of the adult as found in the spiral valve of the hammerhead. The proportions of the head and neck, the blunt salient angles, and the crenulate border of the posterior end of the neck produced by the diverging posterior ends of the contractile bulbs are all in close agreement with similar features in the adult. The hooks on the proboscides, although seen to present considerable variety, are not in disagreement with what I have observed in the adult (fig. 12–16). The peculiar accessory organs on the bothria were found to be present in all scoleces that possessed well-developed proboscides, and they were found to have longer bristles than was noted in the original descriptions (fig. 10, 11). They are eversible, and together with the proboscides often showed signs of life where the scolex was otherwise quiescent.

[a] Linton, Parasites of fishes of Beaufort, North Carolina. Bulletin Bureau of Fisheries, vol. XXIV, 1904, p. 321–428, pl. I–XXXIV.

Cyst and blastocyst.—The walls of the cysts are comparatively thin, and in sections are seen to be made up of a few concentric layers of connective tissue.

The plerocercus or blastocyst has a large number of comparatively coarse calcareous bodies in the parenchyma; abundant contractile fibers occur in its wall, whose outer layer is a dense cuticle. Each blastocyst contains a single scolex.

The cysts lie both in the connective tissue septa and in the midst of the muscle bundles. While the usual shape is oval, with longer diameter about 1 millimeter or less, and the shorter diameter approximately two-thirds of the longer, a considerable variety may be found where a large number of cysts is examined. For example, among cysts removed from a fish in the lot from Barnegat, N. J., the following dimensions, in millimeters, were recorded:

	Longer diameter.	Shorter diameter.
	mm.	*mm.*
1...	0.57	0.57
2...	0.75	0.52
3...	0.90	0.75
4...	1.12	0.75
5...	1.35	0.75
6...	1.65	0.45

In this lot the following additional measurements were made: Diameter of proboscis, with hooks, 0.023; without hooks, 0.014; length of longer hooks, 0.008. Figures 12–16 show more variation in size and shape of hooks in different parts of the proboscis than has been hitherto recorded for this species.

DISTRIBUTION AND NUMBER OF CYSTS IN BUTTERFISH.

The distribution of the cysts in the body of the fish is determined, in some degree at least, by the position of the principal blood vessels. This is indicated by the great uniformity which is maintained in the areas of infection. In all cases where fish were found to be badly infested the greatest number of cysts was found on the ventral side of the backbone, approximately halfway between the abdominal cavity and the base of the caudal fin as in figure 1. While this drawing was made from an actual dissection, it might well be a generalized sketch or composite of all the more badly infested fish.

There are in general four areas of greatest infection. Named in the order of the greatest number of cysts in each they are:

1. Below the backbone between the abdominal cavity and the caudal fin.
2. Below the backbone and above the caudal third of the abdominal cavity.
3. Above the backbone and opposite area 1.
4. Above the backbone, opposite area 2, about halfway between the backbone and the dorsal surface.

There was also observed, in a considerable number of the more badly infested fish, a cluster of cysts close behind the caudal border of the skull (fig. 1). Not all the fish opened were examined for parasites in this position, but enough to make the conclusion very probable that all badly infested fish have this cluster of cysts behind the skull. None were found to occupy this position except in fish which harbored large numbers of parasites, and they were found in all the badly infested fish in which special search was made for them.

If these cysts are present in the muscles of a fish they are easily found by splitting the fish and removing the flesh from one side of the skeleton. If the fish is badly infested it will be found to present some such appearance as that shown in figure 1. When an infested fish has been opened in this manner, while many cysts may be found in the muscle tissue which has been removed, a much larger number will be found on the skeletal portion, where they lie in greatest numbers between the vertebral spines. Masses of cysts completely filling the interspinous spaces, especially on the ventral side of the vertebræ, were of common occurrence. Some of these masses were as much as 5 and 10 millimeters in length and 3 and 4 millimeters thick. Since an interspinous space is not far from 5 millimeters wide it may be seen, allowing a cyst to occupy a space equivalent to a sphere 1 millimeter in diameter, that from 120 to 400 cysts may be found in a single interspinous space. This theoretical estimate was abundantly verified by calculations based on actual count. Many of the badly infested fish also had numerous cysts lateral to the centra of the vertebræ, especially in that part of the backbone lying dorsal to the abdominal cavity.

The cysts are easily recognized without the aid of a lens. Their outline is usually short oval. Their color is in some cases a translucent bluish white, in others ivory white, in others yellowish white.

DETAILS OF EXAMINATIONS OF BUTTERFISH FOR CYSTS.

August 8, 1904.—One. Cysts very numerous in the flesh. This specimen was submitted to me by Dr. Lynd Jones, who stated that he had noticed these small cysts in the flesh of butterfish which he had been feeding to terns, while he had seen nothing of the kind in other fish which he had been cutting up for the same purpose.

On the same date two other fish were examined. Cysts were found in large numbers in each. While these cysts were somewhat variable in size, they did not exceed 1 millimeter in length. Measurements of a typical one yielded the following results in millimeters: Length 0.75, breadth 0.60; the blastocyst when liberated from the cyst contracted and extended itself actively and varied from 0.4 to 0.7 in length; the larva, liberated from the blastocyst, also active, measured 0.67 in length.

August 13.—Six fish were examined for parasites in the muscle tissue and were all found to be infested. Two had few parasites, one had many, and each of the other three had enormous numbers. The cysts were oval and 0.8 by 0.7 millimeter in the two principal diameters. The favorite resting place of the cysts is on the ventral side of the vertebral column, between and near the ventral spinous processes. In the most highly parasitized fish the underside of the backbone from a point opposite the insertion of the pectoral fin to the tail was thickly beset with

cysts. The maximum number occurred in a region between the seventh and twelfth vertebra from the tail. It was estimated that 1,200 cysts were exposed in a fish 21 centimeters in length laid open as shown in fig. 1, but since many of the cysts could not be seen, the actual number in the fish was much greater than this. The region above the backbone, while not having so many cysts as the ventral region, still had large numbers. These were most abundant between the dorsal spinous processes of about the seventh to the tenth or twelfth vertebra from the tail, and in the thoracic region, about halfway between the backbone and the dorsum. Both above and below the backbone cysts were scattered more or less thickly for a distance of 25 to 30 millimeters from the vertebræ. In those fish which had but few parasites the cysts were widely scattered both above and below the backbone. In some places cysts were seen lying as close as it was possible for them to lie in spaces as much as 5 millimeters square, the clusters having a thickness of 2 or 3 millimeters.

August 17.—Two fish, 187 and 200 millimeters in length, respectively, were examined and each found to be badly infested. Another, 75 millimeters in length, was examined at the same time, but no cysts were found in its flesh.

August 18.—Eight fish examined. Two of these, 50 and 75 millimeters in length, respectively, had no cysts in the flesh. The others, 125 to 175 millimeters in length, each had cysts in the flesh. These cysts, as in other instances observed, were most abundant about the posterior third on the ventral side of the backbone between the ventral spines.

August 24.—Fourteen fish from 175 to 206 millimeters in length, and one 106 millimeters in length, were examined. Cysts were numerous in all the larger fish, and very numerous, i. e., several thousand, approximately, in all but two or three of the fourteen. In the small specimen only two cysts were found, although careful search was made. One of these was a little back of the middle and near the ventral side of the backbone; the other was at about the posterior third and halfway between the backbone and the dorsal surface of the body. These two cysts were ivory white. One of them contained a scolex; in the other a scolex had not yet developed.

In the badly infested fish cysts were most abundant along the backbone between the vertebral spines. The cysts were most abundant on the ventral side of the backbone in most of the fish. A few of the fish had the cysts massed in a space two or three centimeters in extent on the ventral side of the backbone, a short distance behind the abdominal cavity. The cysts in a few other instances were most abundant about the middle of the body—as many above as there were below the backbone. The color of the cysts, except in the case cited above, was yellowish, enough to make a fairly sharp contrast with the flesh of the host. Apparently the larger fish had been affected with these flesh parasites for some time. Most of them were in rather poor condition. So far as examined it was found that the usual immature nematodes were present on the abdominal viscera, but not in unusual numbers.

August 26.—Seventy-three fish examined. Of these, 57 ranged in length from 190 to 210 millimeters; the remaining 14 were from 146 to 162 millimeters in length. Cysts were found in the flesh of every one of the 73. They were very numerous in 51 of the 57 larger fish. Even those of the 51 which were least infected still harbored approximately several thousand cysts. The remaining 6 of the larger fish had few cysts—that is to say, upon splitting one of them only a few scattering cysts were seen, or, in a few cases, clusters with the cysts somewhat scattered. The number of cysts visible in a split fish, in these slightly parasitized specimens, varied from a dozen or less to 50 or more.

The distribution of cysts was in general in agreement with what has been given under previous dates. In the worst cases the cysts were collected in dense granular masses which filled completely several of the interspinous spaces both above and below the backbone. In those which were most infested there were also clusters of cysts in the head just behind the skull. A few cysts were seen below the ventral end of the abdominal cavity, and a few also on the viscera. In the larger fish the cysts were usually yellowish, and contained mature scoleces; in the smaller fish they were for the most part white, and, so far as examined, with immature scoleces. In cases of slight infection the cysts were found scattered at irregular intervals above and below the backbone, prevailingly behind the abdominal cavity. In many of the fish which were only slightly parasitized, clusters of cysts, 20 or 30 in each cluster, were lodged above the body cavity but below the backbone.

Of the 14 smaller fish, 4 had many cysts in the flesh; the remaining 10 had few. One of them, the smallest in the lot, was at first thought to be free of cysts, but upon a careful examination one cyst was found below the backbone about the posterior third.

The scoleces from cysts in the smaller fish, so far as examined, were immature, most of them with hooks not yet developed on the proboscides, nor accessory organs on the bothria; scoleces from cysts in the larger fish had hooks on the proboscides and accessory organs on the bothria.

The cysts vary somewhat in size, but the usual diameter was from 0.5 to 0.7 millimeter. The blastocysts have the parenchyma filled with relatively coarse calcareous bodies. The calcareous bodies in the scoleces are numerous, but very much smaller than those of the blastocysts.

August 30.—Sixty-nine fish were examined. These were taken in a fish pound at Nomans Land on the 29th. Each fish in this lot was split open so as to expose the vertebræ with the dorsal and ventral vertebral spines. Details of infection are given in the table below. In general, it may be said that practically every fish harbored parasites in the flesh. In the few cases where no parasites were seen, it is to be noted that what is meant is that no parasites were seen in the median section of the fish. In a few of the fish in which at first no cysts were seen, further search by scraping off some of the flesh brought one or more cysts into view. The smallest fish had fewest cysts, and the cases of most numerous cysts occurred among the largest fish.

The number of cysts visible in a single interspinous space was found to be from 100 to 150 in two of the worst cases of infection. In such cases from 10 to 12 contiguous interspinous spaces contained each approximately the same number of cysts. This does not represent the actual number of cysts, but only those which could be seen without further dissection than is involved in laying the fish open in the manner described above.

The following table contains a record of cysts seen on the exposed surface of each of the 69 fish of this lot opened as above described. The number, where not specifically stated, is indicated approximately by the words "few," "several," "scattering," "many," "numerous," and "very numerous." In a few cases the parasites occurred in a single cluster, consisting of from 12 to 30 or more cysts. It should be noted that in all the badly infested fish cysts occurred, often in large numbers, lateral to the backbone, and immediately behind the skull. The fourth specimen in the list had also a few cysts on the viscera. The viscera of only a few of this lot, however, were examined.

TABLE SHOWING DISTRIBUTION OF CYSTS IN THE PRINCIPAL REGIONS OF INFECTION IN A LOT OF 69 BUTTERFISH.

	Length of fish.	Cysts above backbone.		Cysts below backbone.	
		Anterior.	Posterior.	Anterior.	Posterior.
	cm.				
1	11	None	None	None	None.
2	11	do	do	do	do.
3	11	do	do	One	do.
4	11	do	do	Few	do.
5	13-14	Few	Two	Several	One.
6	13-14	None	None	One	None.
7	13-14	do	Several	None	Three.
8	13-14	do	None	Several	Several.
9	13-14	do	do	One	None.
10	13-14	do	do	None	Two.
11	13-14	do	do	Cluster	do.
12	13-14	do	do	do	do.
13	13-14	do	do	One	None.
14	13-14	Few	do	Cluster	Two.
15	13-14	do	do	Many	Many.
16	13-14	do	do	None	None.
17	13-14	Several	do	do	do.
18	13-14	Few	Few	Few	Few.
19	13-14	None	do	do	None.
20	13-14	do	Two	None	do.
21	13-14	do	Few	Few	do.
22	13-14	Few	do	Many	Many.
23	13-14	do	None	None	None.
24	13-14	do	do	Many	do.
25	13-14	Many	Many	Numerous	Numerous.
26	13-14	do	do	Very numerous	Very numerous.
27	13-14	None	Few	Many	Many.
28	13-14	Few	do	do	do.
29	13-14	do	None	None	None.
30	13-14	do	do	do	One.
31	13-14	do	do	Many	Few.
32	13-14	do	do	do	do.
33	13-14	do	do	Cluster	None.
34	13-14	Many	Few	Very numerous	Very numerous.
35	13-14	Few	do	Cluster	Few.
36	13-14	None	One	Few	do.
37	13-14	do	None	Several	do.
38	13-14	Few	Few	Many	Many.
39	13-14	One	do	do	None.
40	13-14	Few	do	Several	Several.
41	13-14	Numerous	Many	Very numerous	Very numerous.
42	13-14	None	do	Two	One.
43	13-14	do	One	None	None.
44	13-14	do	None	Few	Few.
45	13-14	do	do	do	do.
46	13-14	Few	Few	Many	Many.
47	13-14	do	do	do	do.
48	13-14	Many	Numerous	Very numerous	Very numerous.
49	13-14	None	None	None	Few.
50	18-21	Numerous	Numerous	Very numerous	Very numerous.
51	18-21	None	None	Two	None.
52	18-21	Scattering	Scattering	Many	Many.
53	18-21	Few	Two	do	Few.
54	18-21	Many	Many	Numerous	Numerous.
55	18-21	Few	Few	Many	Many.
56	18-21	None	None	Several	None.
57	18-21	Few	Few	Many	Many.
58	18-21	Many	Numerous	Numerous	Very numerous.
59	18-21	Scattering	Scattering	do	Many.
60	18-21	Many	Many	do	Numerous.
61	18-21	do	do	do	do.
62	18-21	do	do	do	Very numerous.
63	18-21	do	do	do	do.
64	18-21	do	Few	Many	Many.
65	18-21	Numerous	Many	Numerous	Very numerous.
66	18-21	Few	Few	Many	Many.
67	18-21	do	do	Numerous	do.
68	18-21	do	Very numerous	Very numerous	Very numerous.
69	18-21	do	Few	Many	Many.

September 20.—Twelve fish examined. These were taken at Montauk, Long Island, and sent to me from Blackford's, Fulton Market, New York. Cysts were found in 11 of the 12 fish, distributed in general as has been described in preceding cases.

TABLE SHOWING OCCURRENCE OF CYSTS IN FLESH OF 12 BUTTERFISH FROM MONTAUK, LONG ISLAND.

	Length of fish.	Cysts above backbone.		Cysts below backbone.	
		Anterior.	Posterior.	Anterior.	Posterior.
	cm.				
1	20.0	Numerous	Numerous	Numerous	Very numerous.
2	20.0	Many	Many	Many	Numerous.
3	20.0	None	None	None	Few.
4	20.0	Few	Few	Few	Very numerous.
5	20.0	None	None	None	Few.
6	18.5	.....do	.....do	.....do	do.
7	16.5	One	.....do	Numerous	Very numerous.
8	16.5	Numerous	Many	.....do	do.
9	16.5	.....do	Very numerous	.....do	do.
10	16.5	Many	Numerous	Many	Numerous.
11	15.0	Few	Few	Very numerous	Very numerous.
12	15.0	None	None	None	None.

In no. 9 cysts were also very numerous lateral to the backbone in the middle of the body, and a few were seen in the ventral muscles of the post-abdominal region. The usual immature nematodes were abundant on the viscera, but no cysts were noted in the body cavity.

October 12.—Twelve fish examined. These were caught at Barnegat, N. J., and were sent to me from Blackfords, Fulton Market, New York.

TABLE SHOWING DISTRIBUTION OF CYSTS IN 12 BUTTERFISH FROM BARNEGAT, N. J.

	Length of fish.	Cysts above backbone.		Cysts below backbone.	
		Anterior.	Posterior.	Anterior.	Posterior.
	cm.				
1	17.0	Few	Few	Many	Very numerous.
2	17.0	.....do	.....do	Very numerous	do.
3	17.0	.....do	.....do	Numerous	do.
4	17.0	.....do	.....do	Many	Many.
5	17.0	.....do	.....do	Numerous	Very numerous.
6	18.0	.....do	.....do	Many	Many.
7	19.0	.....do	.....do	.....do	do.
8	19.5	.....do	Many	Very numerous	Very numerous.
9	20.0	.....do	Few	Numerous	do.
10	20.0	Numerous	Numerous	Very numerous	do.
11	21.0	Many	Many	Many	Numerous.
12	22.0	Numerous	Numerous	Very numerous	Very numerous.

Most of these fish had many cysts also along the lateral borders of the vertebræ. In no. 12 there were enormous numbers of cysts below the backbone caudad of the abdominal cavity, where they were scattered through the muscles generally. A cluster of about 100 cysts lay immediately behind the skull.

Some blastocysts with the contained scoleces were removed from their cysts and found to be still living. A number of cysts were placed in normal salt solution and examined from day to day for over a week. They were found to show signs of life on the evening of the 19th. The last signs of activity were seen in the proboscides.

Summers of 1905 and 1906.—The results of the examination of butterfish for parasites during these periods are given in the following table:

TABLE SUMMARIZING RESULTS OF THE EXAMINATION OF BUTTERFISH FOR FLESH PARASITES AT WOODS HOLE, MASS., IN THE SUMMERS OF 1905 AND 1906.

Date.	Number of fish.	Length.	Number of fish showing—			
			No cysts.	Few cysts.	Many cysts.	Numerous cysts.
1905.		cm.				
July 14	1	16.5	1			
	1	18.4			1	
	1	22.7		1		
July 15	1	15.5				1
	4	20.7			1	3
	1	21.2				1
July 17	1	16	1			
	1	18				1
	7	21–22		6		1
	8	23–26		6	1	1
July 18	23	20–25		14	4	5
July 22	1	15				1
	1	19				1
	9	20		4	3	2
	1	25	1			
July 24	1	16				1
	3	17				3
	17	21–22	1	10		6
	2	24		2		
July 27	1	15	1			
	7	20–21		1	4	2
	1	23				1
August 3	4	12	2	2		
	1	13		1		
	1	14		1		
	4	15		2		2
	1	17				1
	1	21		1		
	1	22				1
	1	23		1		
August 4	1	15			1	
	2	18		1		1
	4	20		1	1	2
	2	21			1	1
	1	22		1		
August 5	5	20	1		2	2
August 7	1	17				1
	5	21–22		2	1	2
	2	22		1		1
August 8	3	13	2	1		
	1	15			1	
	9	20	1	1	1	6
	3	17		1	1	1
	12	21	1	2	2	7
August 10	1	23				1
	1	26				1
August 14	1	11	1			
	1	20		1		
	1	21			1	
August 15	1	10	1			
	1	15				1
	6	17–18		1	2	3
	12	20–21		2	2	8
	8	23–24	1	5		2
August 18	4	11	3	1		
	4	15		1		3
	3	17		2		1
	12	20		1	1	10
	4	21		1	1	2
August 21	3	11	2	1		
	1	12			1	
	2	17	1	1		
	2	19			1	1
	4	20			1	3
	5	22		3		2
August 22	7	11	2	5		
	3	15	1	2		
	2	17				2
	3	18		3		
	13	20–21		3	1	9
	1	22		1		
1906.						
July 26	1	17				1
	2	21		1		1
July 27	1	16		1		
	3	18			2	1
	9	21	1	2		6
	1	22				1
August 2	2	19				2
	2	20				2
	2	22				2
August 4	1	18				1
	1	21				1
	4	22			1	3
August 7	3	15	1	1	1	
	3	17	1	2		
	1	19				1
August 8	2	16	1	1		
	2	19		1		1
	2	21				2
August 9	1	14	1			
	1	15			1	
	3	20			2	1
	1	21				1
August 10	4	10	4			
	2	15	2			
	1	16		1		
	1	19				1
	3	21		2		1
August 11	2	10	2			
	3	15	1	1	1	
	1	19				1
	1	20				1
	1	22				1
Total	331		38	110	44	139

HABITATS OF THE PARASITE.

The following list of hosts in which this species has been found is a compilation of both published and unpublished notes of my collections made at Woods Hole, Mass., Beaufort, N. C., Tortugas, Fla., and in Bermuda.

ADULT STAGE.

In spiral valve of the following hosts:

Carcharhinus obscurus (?). Dusky Shark.

Beaufort, N. C.:
1902—Aug. 26, few.

Carcharhinus platyodon.

Tortugas, Fla.:
1906.—July 12, two small specimens.

Scoliodon terræ-novæ. Sharp-nosed Shark.

Beaufort, N. C.:
1901.—July 16, one, length 10 mm.; free segments, length 3 mm.
July 18, two.
July 22, six, length 4 to 7 mm.; posterior segments easily detached.
July 22, three.
August 15, one.
1902.—July 11, twenty-nine from one shark; also numerous cysts with scoleces in stomach wall.

This shark was examined on 18 other occasions when this parasite was not found. All the sharks of this species which were examined were, with one exception, small, 25 to 30 cm.; one measured about 100 cm.

Sphyrna zygæna. Hammerhead.

Woods Hole, Mass.:
1886.—July 28, one hundred and fifty.
1887.—July 18, one hundred.
Chyle swarming with free proglottides in each case.
1898.—July 21, three.

A small hammerhead was examined on August 5, 1898, another on August 18, and another on July 31, 1899. *Otobothrium crenacolle* not found on either date.

ENCYSTED STAGE.

Balistes carolinensis. "Turbot."

Bermuda:
1903.—July 14, a few small cysts in walls of stomach and intestines.
July 22, a few cysts in intestinal wall.

The closely related species *Balistes vetula* was examined also. There were numerous cysts in the intestinal wall, but all that were opened contained only chalky, degenerate tissue, with no trace of parasite.

Bairdiella chrysura. Yellow-tail.

Beaufort, N. C.:

1901.—Aug. 12, small cysts on viscera; scoleces immature and not certainly identifiable.

Aug. 15, scoleces in cysts on viscera.

1902.—July 17, cysts on viscera.

July 19, cysts on viscera and in mesentery.

Aug. 8, cysts on viscera and in mesentery few.

This host was examined on 4 other occasions in 1901 and on 12 other occasions in 1902 when these parasites were not found.

Carcharhinus obscurus (?). Dusky Shark.

Beaufort, N. C.:

1902.—July 11, several noted in ellipsoidal cysts in stomach wall between submucous and muscular coat.

July 26, immense numbers encysted in stomach wall. Dimensions in millimeters, specimen slightly compressed: length of blastocyst, 1.5; breadth, 0.9; larva, length, 0.41.

Woods Hole, Mass.:

1905.—Aug. 11, one shark examined. Numerous cysts were found between the mucous and muscular layers of the stomach wall.

Coryphæna hippurus. Dolphin.

Beaufort, N. C.:

1902.—Aug. 1, very numerous, encysted in submucous coat of stomach.

Cynoscion nebulosus. Speckled Trout.

Beaufort, N. C.:

1901.—July 15, cysts very numerous between muscular coat and submucosa of stomach.

July 22, large numbers of cysts in stomach wall.

Aug. 28, numerous cysts in stomach wall.

This species examined on 4 other occasions in 1901 and once in 1902, when these cysts were not found.

Cynoscion regalis. Gray Trout, Squeteague, Weakfish.

Beaufort, N. C.:

1902.—Aug. 18, few cysts in stomach wall.

Aug. 19, few cysts in wall of alimentary tract.

Cysts not found in the three other examinations of this fish in 1902.

Woods Hole, Mass.:

1903.—Aug. 20, encysted in stomach wall.

1904.—July 8, small cysts on viscera.

Aug. 6, two small cysts from viscera. One of these cysts, measuring 1.8 and 1.12 millimeters in the two principal diameters, contained three blastocysts (fig. 6). The blastocysts were actively contracting and extending themselves, and the bothria of the scoleces were also active. The walls of the cyst were transparent.

1905.—July 8, one. One cyst in stomach wall.

July 14, one. Few cysts in stomach wall.

July 17, six. Few cysts in stomach wall.

July 19, ten. Cysts on mesentery.

Associated with cysts of *Tetrarhynchus bisulcatus.*

Diplodus sargus. Bream.

Bermuda:

1903.—July 14, two cysts in mass of brown pigment on serous coat of viscera.

This fish examined on 5 other occasions and the parasite not found.

Galeichthys milberti. Fork-tailed Catfish.

Beaufort, N. C.:

1901.—July 8, numerous cysts under serous coat of stomach and intestine. Dimensions in millimeters: length of cyst, 2.5; blastocyst, length, 1; breadth, 0.3; numerous calcareous bodies in parenchyma, the largest 0.08, and 0.11 in the two principal diameters; then, with almost no intermediate sizes, more numerous and smaller ones 0.015 and less in diameter.

Aug. 5, one cyst.

Examinations of this fish made on 7 other occasions in 1901 and on 2 in 1902; this parasite not noted.

Lagodon rhomboides. Pinfish.

Beaufort, N. C.:

1901.—Aug. 21, one cyst from viscera.

Pinfish examined on 12 other occasions in 1901 and on 10 in 1902 and this parasite not found.

Micropogon undulatus. Croaker.

Beaufort, N. C.:

1901.—Aug. 6, few cysts found in a cluster of cysts of the genus *Rhynchobothrium* in mesentery.

1902.—Aug. 11, one.

These cysts not noted on the other occasions of examining this fish, which were 15 in 1901 and 12 in 1902.

Ocyurus chrysurus. Yelting.

Bermuda:

1903.—July 22, few small cysts in mesentery.

No cysts found on the 2 other occasions of examining this fish.

Opsanus tau. Toadfish.

Beaufort, N. C.:

1901.—Aug. 30, few cysts on viscera.

Examinations of this fish made on 19 other occasions in 1901 and on 23 in 1902; this parasite not noted.

Orthopristis chrysopterus. Hogfish.

Beaufort, N. C.:

1901.—Aug. 6, one cyst, 2 millimeters in diameter, with two blastocysts containing scoleces on viscera.

This fish examined on 15 different dates in 1901 and on 25 in 1902; this parasite found on only one occasion.

Paralichthys albiguttus. Mud Flounder.

Beaufort, N. C.:

1901.—Aug. 21, cysts very numerous in stomach wall.

This flounder examined on 14 different dates in 1901 and on 17 in 1902. These cysts recorded on one occasion only.

Pomatomus saltatrix. Bluefish.

Beaufort, N. C.:
1901.—July 30, cysts in stomach wall.
Aug. 28, numerous cysts in stomach wall.
None found in the 9 other examinations of this fish made in 1901, nor in the 14 made in 1902.

Poronotus triacanthus. Butterfish.

Woods Hole, Mass.:
1899.—Aug. 26.
1900.—Aug. 17.
1904.—Aug. 8, 13, 17, 18, 24, 26.
1905 and 1906.—See page 120 for details.
Nomans Land, Mass.:
1904.—Aug. 30.
Montauk, Long Island:
1904.—Sept. 20.
Barnegat, N. J.:
1904.—Oct. 12.
Large numbers of cysts in flesh found on each occasion.

Scoliodon terræ-novæ. Sharp-nosed Shark.

Beaufort, N. C.:
1902.—July 11, numerous cysts in stomach wall between muscular coat and submucosa. Many of the cysts were filled with degenerate tissue.

Scomberomerus regalis. Cero.

Beaufort, N. C., 1901.—Aug. 23, enormous numbers of cysts in stomach and intestinal walls, for the most part in the submucosa. Some of the cysts were amber-colored, owing to the waxy degenerate tissue with which they were filled; some contained blastocysts in which scoleces had not yet developed far enough to be identifiable, while others contained scoleces which could be identified through the transparent walls. Dimensions, life, under pressure, in millimeters: length of cyst 1, shorter diameter, 0.8; length of larva, 0.32; bothria, length 0.16, breadth 0.12. An amber-colored, thick-walled cyst measured 1.54 and 1.09 in the two principal diameters; the blastocyst was 0.52 long and 0.28 broad, and the length of the larva was 0.28.

Trichiurus lepturus. Cutlass-fish.

Woods Hole, Mass., 1903.—July 6, several clusters of small cysts from body cavity, collected by Vinal N. Edwards. Some of the cysts were pedicelled; black pigment associated with some. These cysts were evidently from the mesentery or serous covering of the viscera. Dimensions in glycerin, compressed, in millimeters: cyst, 1.35 by 0.9; blastocyst, 0.75 by 0.63; larva, length 0.37; breadth of head, 0.22.

Xiphias gladius. Swordfish.

Woods Hole, Mass., 1904.—July 15, a few small cysts from the serous coat of the pyloric cœca, associated with small waxy cysts. Dimensions in millimeters: blastocyst, length 1.6, breadth 1; larva, length 0.67; length of head and neck, 0.60; breadth of head 0.21, of neck at base 0.16.

Mustelus canis. Dog Shark.

Woods Hole, Mass., 1905.—July 31, two sharks examined. Cysts were found in the stomach wall, many in one, few in the other.

Sarda sarda. Bonito.

Woods Hole, Mass., 1905.—July 24, five fish examined. July 27, one fish examined. Numerous cysts were found in the stomach wall of two, and few in each of the others.

Alutera schœpfi. Filefish.

Woods Hole, Mass., 1905.—Aug. 7, one. Cysts in walls of stomach and intestine. Associated with cysts containing a larval *Dibothrium.*

Paralichthys dentatus. Summer Flounder.

Woods Hole, Mass., 1905.—Aug. 18, two. Cysts found in stomach wall and in mesentery, associated with cysts of *Tetrarhynchus bisulcatus.*

EFFECT OF THE PRESENCE OF CYSTS ON WEIGHT OF HOST.

In order to ascertain how much, if any, the weight of fish was affected by the presence of cysts in the flesh, the following weights were obtained of fish belonging to the lot which was examined on August 26, 1904.

1. Three fish were chosen with care so as to agree with three others of equal length and depth. The length of these fish was 215, 215, and 200 millimeters, respectively. Three of these fish, each of which had very numerous cysts in the flesh, together weighed 672 grams; three others of similar dimensions, but with relatively few parasites, weighed 686 grams.

2. Another lot of three fish, each 200 millimeters in length, each with very numerous cysts in the flesh, together weighed 644 grams; three others chosen so as to agree in length and depth with them, but with less numerous parasites, weighed 658 grams.

3. Three fish measuring 190, 200, and 210 millimeters, respectively, each with very numerous cysts in the flesh, together weighed 630 grams; three others of the same lengths and corresponding depths, but with very few (12, more or less) cysts in the flesh, together weighed 700 grams.

4. Three measuring 150, 162, and 146 millimeters, respectively, each with many parasites, together weighed 280 grams; three others of similar length and depth with but very few (less than 12 seen) cysts, together weighed 294 grams.

TABLE SHOWING EFFECT OF THE PRESENCE OF CYSTS IN THE FLESH ON WEIGHT OF FISH, MADE BY COMPARING FISH OF THE SAME LENGTH AND DEPTH.

	Length of fish.	Condition.	Weight of the lot of three in grams.	Approximate loss.
	mm.			*Per cent.*
1	215, 215, 200	Cysts very numerous	672	2
	215, 215, 200	Cysts relatively few	686	
2	200, 200, 200	Cysts very numerous	644	2.1
	200, 200, 200	Cysts less numerous	658	
3	190, 200, 210	Cysts very numerous	630	10
	190, 200, 210	Cysts very few	700	
4	146, 150, 162	Many cysts	280	4.8
	146, 150, 162	Very few cysts	294	

It is a significant fact that in all cases where a comparison was made between fish of the same length and depth, the one with numerous parasites and the other with few, the result was a less weight for the fish having the greater number of parasites. It seems reasonable to conclude, therefore, from this loss of weight, that the vitality of the fish is affected by the presence of cysts in the flesh.

LIFE HISTORY OF THE PARASITE.

The round of life of this parasite may be epitomized thus:

The adult stage is passed in the spiral valve of some shark. Ripe proglottides containing large numbers of eggs escape from the intestine of the shark along with the feces, and are eaten by various fishes. The eggs give rise to embryos, which make their way into the body of the intermediate host, where they become encysted. The encysted embryo ultimately develops into a scolex with characteristic sucking disks and proboscides armed with hooks. When a fish that has these cysts in its tissues is swallowed by a shark which is adapted to become the final host of this tapeworm the connective tissue cyst is digested off, the scolex is liberated, and attaches itself to the mucous membrane of the shark's intestine. It there grows to the adult tapeworm, producing segments which separate easily from the strobile as they ripen, and pass off with the feces bearing eggs to begin another generation.

SPECIAL CASE OF BUTTERFISH AND HAMMERHEAD SHARK.

Food of the hammerhead shark.—A more particular consideration of the case afforded by the butterfish is justified by the high percentage of fish which were found to be infected. That the butterfish is the principal source from which the adult tapeworm of the hammerhead comes is based on the following considerations:

The hammerhead is carnivorous; fish and squid are the only food which I have found in the stomachs of those which I have examined. Butterfish are abundant, and, being good eating, are doubtless often eaten by the hammerhead.

Practically all of the butterfish which were examined for cysts in the flesh, except small specimens, were found to be infested, and a large proportion of them harbored enormous numbers of cysts. Although special search for these cysts was confined to the past season, there is reason for believing that the large proportion of parasitized fish then found is not exceptional. My notes made at the time of collecting in 1899 and 1900 show the same distribution of cysts in the flesh of this fish as was found in 1904, and there is no reason for thinking that they would not have been found in abundance in other butterfish in previous years if search had been made for them.

Sharks and butterfish are taken together in the fish traps, thus showing an association in their natural surroundings sufficiently close to permit their being final and intermediate host, respectively, of the same cestode parasite.

In view, therefore, of the very large proportion of butterfish which harbor cysts of *Otobothrium crenacolle*, the conclusion is justified that the butterfish is the principal source from which the supply of adult tapeworms is kept up.

It may be mentioned here for the comfort of eaters of fish that parasites in the flesh of food-fish are of very unusual occurrence. I had looked for them repeatedly in most of the food-fish of the Woods Hole region for many years without finding

any, but had never happened to examine the flesh of the butterfish. Even those butterfish with cysts in the flesh which were brought to my attention did not at first suggest anything to me other than that they were cases of exceptional and accidental infection.

Food of the butterfish.—Turning now to the other phase of the subject, it may be inquired, What is the source of the cysts in the flesh of the butterfish?

Any persistent and regularly recurring case of parasitism when a cestode is the parasite is usually possible only where the final and intermediate hosts are related to each other as eater and eaten. Furthermore, they must be so closely associated in habitat that the intermediate host in the natural performance of its feeding activities will become infected. In the absence of opportunities to study the habits of the butterfish in its natural surroundings recourse must be had to an examination of the stomach contents in order to ascertain the nature of the food, since it is with the food that cestode eggs and embryos gain admission to the body of the intermediate host.

The following notes on the food of the butterfish were published in my report, "Parasites of Fishes of the Woods Hole Region" (Bull. U. S. Fish Commission, 1899, vol. XIX, p. 453):

> Stomachs of larger fish usually empty, but a few fragments of fish occasionally seen. In the alimentary tracts of smaller specimens copepods, annelids, and small fish were found. Sept. 1, 1900, 25 small fish were examined. The food consisted principally of amphipods.

In the latter part of August, 1903, a few butterfish were examined on three occasions by my assistant, Mr. G. F. Englesby. The stomachs were empty in two of the lots; in the other fragments of fish were found. In July and August, 1904, butterfish were examined on several occasions by my assistant, Mr. M. B. Swift. In most cases the stomachs were reported to be empty. In a few cases I examined the digested material with the aid of a microscope and found the setæ and jaws of annelids. Pieces of green algæ were found on two occasions. Mr. Vinal N. Edwards examined butterfish on October 7, 9, and 16 and found ctenophores in the stomachs on each of these dates and annelids on the 9th. On May 10 he found shrimp. Mr. Edwards states that the butterfish does not take the hook, but is caught only in traps.

It is evident, I think, even from the above rather meager food notes, that the butterfish eats any small floating or swimming animals which it encounters in the water.

It should be remembered also that the chyle in the intestines of those hammerheads in which *Otobothrium crenacolle* was found in considerable numbers contained large numbers of ripe segments of this tapeworm, which, moreover, continued active for many hours in sea water. Also the segments contained enormous numbers of eggs. It follows from this condition of things that segments containing eggs with embryos are being continually discharged into the water along with the feces from those sharks which harbor this worm in the intestine. Butterfish encountering these free segments would naturally catch and swallow them, as they would any small swimming worm, crustacean, or the like. This is also indicated by the fact that those butterfish which were found to be infected in most cases carried large

numbers of the cysts, which would not be the case if infection came only from the accidental swallowing of eggs which had escaped from the segment and become disseminated through the water. The evidence thus becomes strong enough to fasten upon the butterfish, with a high degree of probability, the reputation of habitually seeking these cestode segments where they are most likely to be found, viz, in the feces of the hammmerhead shark.

ECONOMIC CONSIDERATIONS.

It has been asked, What is the effect of the presence of this flesh parasite on the value of the butterfish as a food fish?

So far as the writer's knowledge goes, no very satisfactory answer can yet be made to this question. It will require observations extending over several years to ascertain whether the large proportion of butterfish found to be infected in the summers of 1904, 1905, and 1906 is normal or exceptional. If the number of butterfish on the coast remains fairly constant year after year and sharks are migratory, so that while there are large numbers one season there are few another, this would undoubtedly have an effect on the degree of parasitism in the butterfish in successive years.

It is not likely that the parasites themselves have any effect on the nutritive value of the flesh in which they are encysted, neither could their presence be detected by the palate. That they work some disadvantage to the vitality of the fish is shown by the results given above of the experiments in comparative weights. I am not aware that the eating of butterfish has been followed by any after effects which may not be experienced from the eating of any fish. Neither has it been shown that the presence of these cysts in the flesh is accompanied with toxic products of any kind. Of course there is no danger whatever that these cysts can give rise to adult tapeworms in warm-blooded man, even if he were in the habit of eating fish which were only partly cooked, or even uncooked.

The principal objection which can be made against the use, as food, of fish in which cestode cysts are probably present is the very natural one which is based on the popular prejudice against measly meat of any kind. This prejudice is not only natural but doubtless rests on deep-seated racial experience. A recent communication from Mr. M. B. Swift furnishes a good illustration of this prejudice, as well as a confirmation of the unblissful state of the knowing.

At his boarding place, a short time ago, butterfish were served, and he, after surreptitiously inspecting the fish and finding in them the familiar cysts in large numbers, decided that he would not take fish that day; but he neglected to state his reason until after his table companions had partaken freely of the fish. He then generously imparted to them his knowledge and demonstrated his lecture by showing to his attentive audience the real presence of the subject of his discourse. The result was immediate, startling, and in two cases disastrous to the intended destination of the breakfast.

Again, since we have here a food fish which apparently is almost invariably infested with tapeworm cysts in the flesh, and often in great numbers, it is natural that inquiry should be made for some remedy for this affliction under which a particular part of creation is groaning. Just how far man's interference with the

balance of nature in his search for food among the fishes of the sea enters as a factor tending toward the extinction of any species is hard to estimate. Theoretically his mightiest efforts are, in the aggregate, so slight that they appear to my mind to be a negligible quantity. If the economic use of fish by man does enter as an appreciable factor in the struggle for existence, then anything which will open up uses to which sharks may be put will be in the way of restoring the balance which has been disturbed and of correcting this particular evil of cestode parasites in the flesh of food fish.

The skin of the shark has some commercial value as shagreen, glue may be made of some of the waste parts, oil from the liver, etc. In addition to these uses the use of sharks as food is a matter of considerable economic importance. Young sharks are quite as good eating as many of the fish which are sold in our markets and, indeed, they themselves form an important addition to the food fishes in some countries. Unfortunately there is a strong prejudice against shark meat, especially in this country, and when it is called dogfish the prejudice is intensified, although dogfish, in the opinion of many who have tried it, is quite as good eating as squeteague. Properly prepared it would be hard to tell it from canned salmon. It must be admitted, however, that old shark is not good eating.

If, then, an industry could be built up which would make it worth while for fishermen to expend the same energy and develop the same ingenuity in the capture of sharks as is done in the capture of fish which are now used as food, there would result a means of profit where there is now actual loss. A factor would also be introduced in the life experience of sharks which might tend toward reducing their numbers. If the number of sharks were reduced there would follow a corresponding reduction in the amount of such parasitism among teliosts as is caused by cestode worms.

PROBLEMS SUGGESTED.

A few problems are suggested by the occurrence of these parasites in the flesh of the butterfish for which no final solutions are proposed in this paper.

1. Time required for the development of a mature scolex.

It is possible that this may be ascertainable by means of feeding experiments, although there are many practical difficulties in the way. Some information is probably obtainable by a very careful examination with the aid of the microscope of small butterfish of known age. Small fish were found to be free from cysts in the flesh, or to have very few and those immature. The larger fish were for the most part found to have many parasites. Furthermore, the cysts in the smaller fish were white, those from the larger fish yellowish, showing thus a difference in age.

2. Distribution of the cysts in the flesh.

The rather uniform distribution of cysts in certain favored locations is doubtless dependent primarily on the vascular system, and particularly on the arterial circulation.

When liberated from the egg shells by the action of the digestive juices the embryos are very small and, upon penetrating the mucous membrane of the stomach and intestine and entering lymph spaces or capillaries, would be carried in the circulation as easily as blood corpuscles. The distribution of the cysts indicates

that the embryos have entered the circulation by way of the intestino-portal vessels and have been carried to the heart, thence through the capillaries of the gills, and have, for the most part, reached their final resting place by way of the dorsal aorta and its continuation in the caudal aorta. As the blood current is checked in the small arterial branches and capillaries the embryos make their way into the adjacent muscular and connective tissue.

3. Susceptibility of the butterfish to the encystment of *O. crenacolle* in the flesh, and immunity of other fish from the same.

It is possible that a comparative study of the circulation and the splanchnic anatomy of the butterfish and one of the species of fish in which cysts were found in large numbers on and in the abdominal viscera may yield data for the solution of this problem.

EXPLANATION OF PLATES.

KEY TO LETTERING.

b, bothrium.
bl, blastocyst (plerocercus).
c, cyst.
ca, calcareous body.
cb, contractile bulb of proboscis.
ct, connective tissue.
m, muscle tissue.
o, accessory bothrial organ.
p, proboscis.
sc, scolex or larva.
sh, proboscis sheath.
st, beginning of strobile.

PLATE I.

FIG. 1. Specimen of butterfish (*Poronotus triacanthus*) laid open to show cysts of *Otobothrium crenacolle*. The principal regions of infection are shown somewhat diagramatically. The number of cysts shown in the sketch is far less than may be seen in a badly parasitized fish. Sketch made from a fish 22 centimeters in length, from Barnegat, N. J.

FIG. 2. From life. Cluster of cysts from the butterfish. The cluster measured 2.1 by 1.2 millimeters in the two principal diameters. The scoleces were active, their average length about 1 millimeter.

FIG. 3. A blastocyst from cluster shown in figure 2, compressed so as to show the distinctive features of the species; length of larva 0.8 millimeter.

FIG. 4. Another cyst from same host. The blastocyst, which does not completely fill the cyst, measured 1.24 by 0.8 millimeter in the two diameters.

FIG. 5. Blastocyst of figure 4 removed from the cyst. The head and part of the neck of the scolex is emerging from the blastocyst and the proboscides are everted.

FIG. 6. Cyst with three blastocysts containing scoleces, from serous coat of intestine of squeteague (*Cynoscion regalis*). The walls of the cyst were transparent; blastocysts and scoleces active. Cyst 1.8 by 1.12 millimeters in the two diameters.

PLATE II.

FIG. 7. Cyst, blastocyst, and scolex from butterfish, life. Diameter of cyst, 0.5 millimeter.

FIG. 8. Blastocyst with scolex emerging—removed from cyst shown in figure 7.

FIG. 9. Scolex (larva) removed from blastocyst.

FIG. 10. Part of bothrium highly magnified, showing the accessory organs retracted.

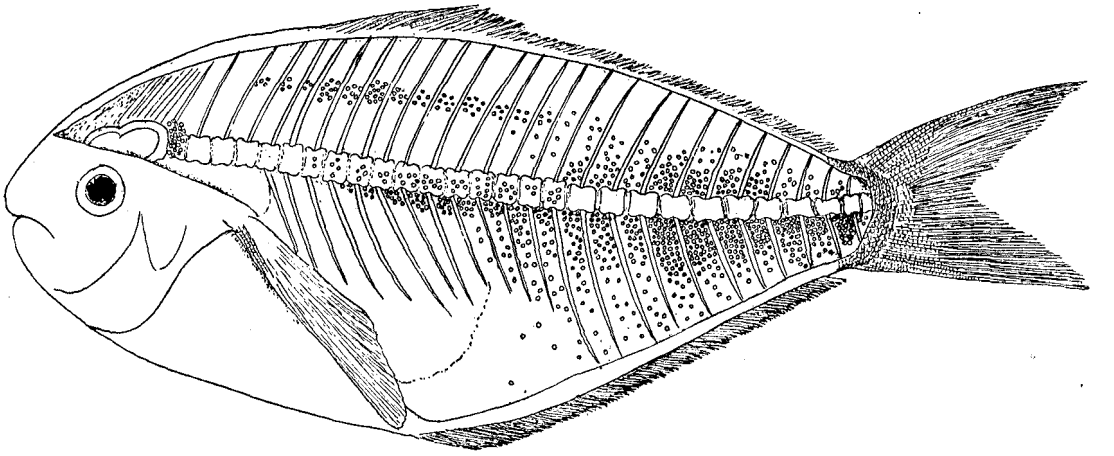
FIG. 11. One of the accessory organs, everted, still more highly magnified.

FIG. 12–16. Different views of proboscides highly magnified. Figures 12 and 13 are views of portions of the proboscis near the base. The sketches were made with the aid of a camera lucida, 1-inch eyepiece and one-twelfth objective, and represent an enlargement of about 720 diameters.

FIG. 17. Cyst, blastocyst, with scolex and muscle tissue of host, compressed; sketched from specimen mounted in balsam, × about 60.

FIG. 18. Section of muscle tissue with fifteen cysts, × about 6. The muscle fibers are cut transversely in the upper and longitudinally in the lower part of the figure.

FIG. 19. Section of muscle tissue with ten cysts, × about 60. *a*, empty cysts; blastocysts with larvæ appear in other sections of the series; *d*, neck of scolex cut transversely, showing the four proboscides; *e*, scolex cut nearly longitudinally; *f*, bothria cut nearly transversely; *g*, section passes through the bothria and two of the contractile bulbs nearly longitudinally; the neck of the larva has been bent and is largely missing from this section; *h*, diagonal section of neck of larva—at one end of section the proboscides are cut transversely, at the other two of them appear but cut longitudinally; *i*, section shows blastocyst but misses the larva, which may be seen in another section of the series.



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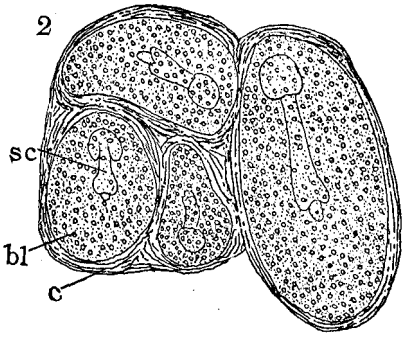

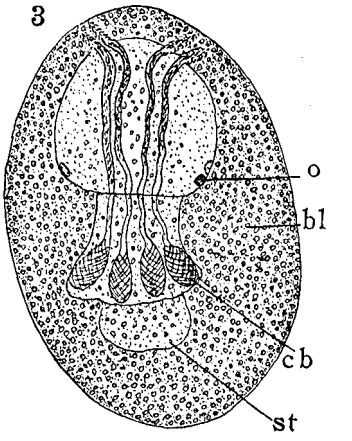

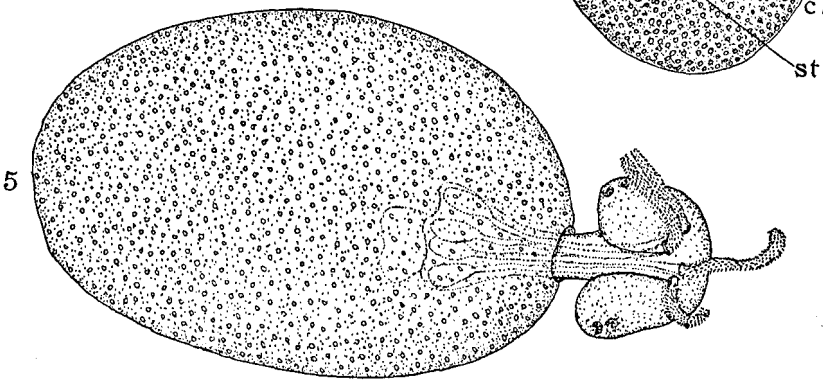

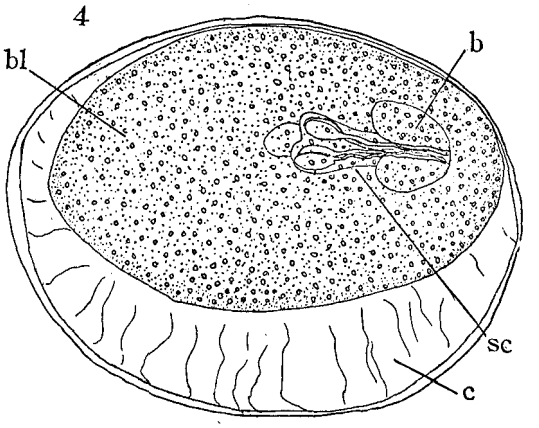

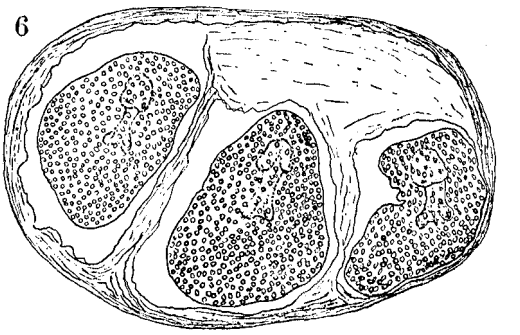

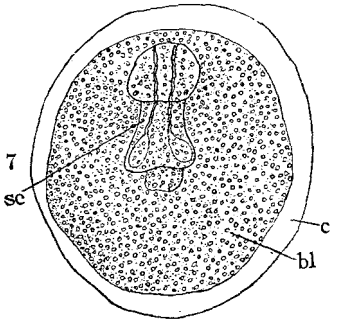
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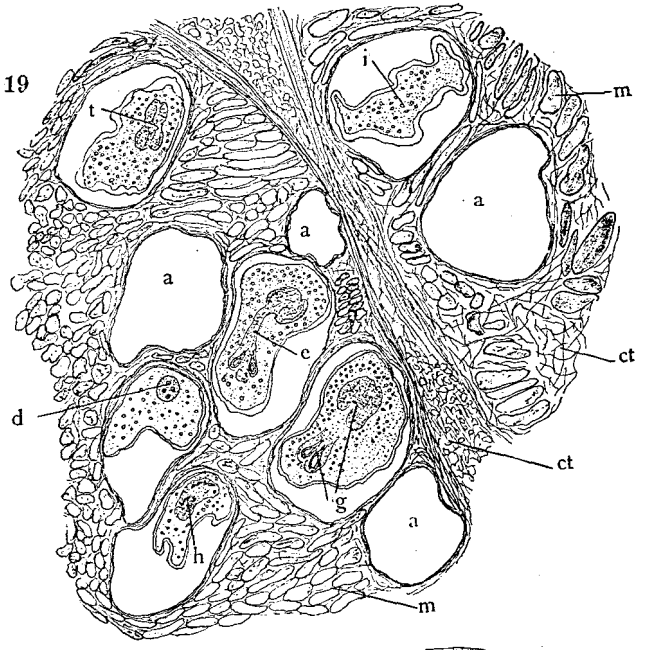
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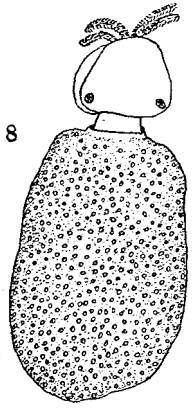
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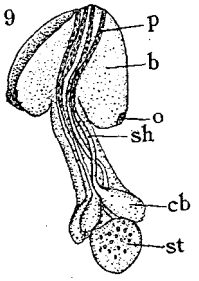
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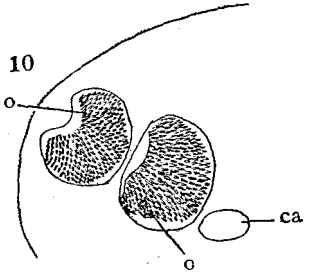
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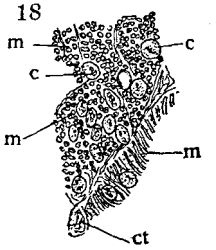
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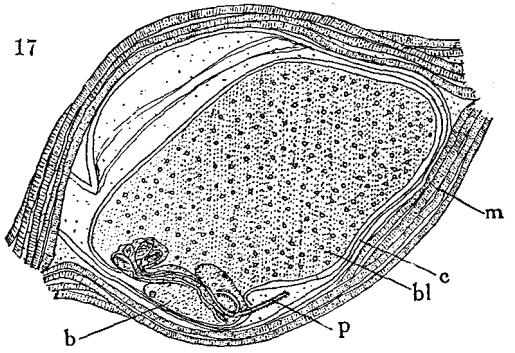
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