

5.—ON FISH ENTOZOA FROM YELLOWSTONE NATIONAL PARK.

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This paper makes the third which the author has prepared for the U. S. Fish Commission on entozoa collected in the Yellowstone National Park. The first of these papers contained a report on two species of larval cestods, *Ligula catostomi* from the sucker (*Catostomus ardens*), and *Dibothrium cordiceps* from the trout (*Salmo mykiss*), collected by Dr. David S. Jordan in September and October, 1889. The second paper was a special report on the life history of *Dibothrium cordiceps*, being the result of the author's investigations, in July and August, 1890, into the cause of the excessive parasitism among the trout of Yellowstone Lake. The present paper contains descriptions of other fish entozoa which were obtained incidental to the inquiry into the life history of *D. cordiceps*.

Aside from the trout parasite (*D. cordiceps*), perhaps the most interesting form encountered was the monobothrium from the sucker; this appears to be an undescribed species, and I have given it the name *Monobothrium terebrans*, from its habit of boring a pit in the mucous membrane of its host. I have thought it best also to give a brief account of the anatomy of this singular worm. Some additional notes on the ligula of the sucker have been given. These are based on observations made in July, 1890. That part of the report which relates to the nematods is necessarily imperfect, owing to the fact that, with the exception of the species *Dacnitis globosa* from the trout, the specimens were all immature and for the most part few in number.

CESTODA.

Ligula catostomi Lt., Bull. U. S. F. C., ix, for 1889, pp. 66-72, pl. xxiii-xxv.

An account of this parasite, based upon specimens found by Dr. David S. Jordan in the sucker (*Catostomus ardens*), of Witch Creek, a tributary of Heart Lake, Wyoming, was published in the Bulletin of the United States Fish Commission, cited above. It is not proposed to give any further account of the anatomy of this species here, but simply to record a few notes and observations.

On July 28, 1890, I found in a young sucker, captured in a small warm stream near our camp on Heart Lake, a ligula, in the abdominal

cavity. The length of the fish was about 75 mm., that of the parasite 400 mm. The greatest breadth, near the anterior end, was 6 mm. For the first 75 mm. it was thick and stout, the remainder was slender and tapered slowly to the posterior end, near which the breadth was about 2 mm. Several large suckers from the lake were examined, but no ligulae were found in them. The water of the lake is quite cold, the temperature 40° F. having been found at a depth of 124 feet.

On July 29, I examined a number of suckers collected in Witch Creek. The fish were taken in a seine from a warm branch of the main stream. The temperature of the water in which the fish were swimming was 95° F. A school of fish were observed in the warm stream where it joined with a cold stream, 46° F. The fish showed no tendency to enter the cold water, even when frightened by the presence of the seine. Two species of fish were secured from this school, viz: *Catostomus ardens* and *Leuciscus atrarius*. The specimens were all young or half grown. No trout were seen in the warm water, although they appeared to be rather abundant in the cold stream.

The larger suckers were nearly all infested with these parasites; the smaller ones not so much, and the smallest scarcely at all. Of 30 fish, ranging from 14 to 19 centimeters in length, only one or two were without parasites. Of 45 specimens averaging about 10 centimeters in length, 15 were infested and 30 were not. Of 65 specimens, averaging about 9 centimeters in length, 10 were infested and 55 were not. Of 62 specimens less than 9 centimeters in length, 2 were infested and 60 were not.

I insert the following notes made at the time of collecting:

1. Fish 19 cm. long, contained 1 parasite, length 39.5 cm., broadest at anterior end, where it measured 15 mm.
2. Fish 17 cm. long, 1 parasite 27 cm. long, 13 mm. broad near anterior end.
3. Fish 15 cm. long, 4 parasites, 12, 13, 13, and 20 cm. long, respectively.
4. Fish 13.7 cm. long, no parasites.
5. Fish 13 cm. long, 3 parasites.
6. Two fish 13 and 14 cm., respectively, no parasites.
7. Fish 11 cm. long, abdominal region flabby and collapsed, a hole beside and a little in front of vent from which a parasite had apparently escaped. One free ligula was found with the fish when they were brought in. The fish may have been injured in seining. The intestine was congested.
8. Two fish 10 and 11 cm. long, respectively, more than one parasite in each; put in alcohol entire.
9. Fish 10 cm. long, no parasites.
10. Two fish 10 cm. long, no parasites, intestine and peritoneum congested.
11. Fish 10 cm. long, no parasites; intestine and peritoneum black and unhealthy looking.
12. Fish 10 cm. long, one parasite 39 cm. long.
13. Three fish each 10 cm. long, two with 2 and one with 3 parasites.
14. Two fish, 8 and 9 cm., respectively, one with 3 and the other with 4 parasites.

The parasitized fish are perhaps a little lighter in color than the non-parasitized ones.

The admirable researches of Donnadieu on the ligula of the European tench show that the time during which the parasite lives in the abdominal cavity of the fish is variable, but is generally limited to two years. Most frequently it attains its maximum development at the end of the second year.

The fact that the specimens of *L. catostomi* showed comparatively slight difference in apparent age points to the conclusion that the period of infection is brief. It is probable that the final host is one, or possibly more than one, of the migratory aquatic birds, such as the heron, pelican, larus, merganser, etc., which are summer residents or visitors in this region. The abundance of the parasites is doubtless due to the warm water in the streams fed by thermal springs, which furnishes conditions favorable to the development of the embryos from the egg. If these parasites ever normally make their escape from their intermediate host the fish, as stated by European observers, the chances of their being swallowed by a bird are very few, since they are eaten with avidity by fish, in whose intestine, however, they do not mature.

On the evening of July 29 I threw into the lake a large number of these parasites, and on the following day, about noon, caught a chub (*Leuciscus atrarius*) near the place where the ligulae had been thrown. The alimentary canal of the chub was filled from one end to the other with ligulae in various stages of digestion. In the intestine they were reduced to a white chyle with recognizable fragments, and even in the stomach they were corroded and fragmental.

DIBOTHRUM CORDICEPS Leidy.

A description of this species by Dr. Joseph Leidy was published in the Preliminary Report of the U. S. Geological Survey of Montana and adjacent territory (Hayden, 1871, pp. 381, 382). Some account of the anatomy of the larval stage was given in my paper entitled, "On two species of Larval Dibothria from the Yellowstone National Park (Bull. U. S. Fish Commission, IX, for 1889, pp. 72-76, pls. XXV-XXVII); and of the adult stage in "A contribution to the life history of *Dibothrium cordiceps*," etc. (Bull. U. S. Fish Commission, IX, for 1889, pp. 337-358, pls. CXVII-CXIX.)

Larval stage: In the rocky mountain trout (*Salmo mykiss*), in cysts and free in the abdominal cavity; also often migrating into the flesh of these trout in the Yellowstone Lake.

Adult stage: Intestine of the American white pelican (*Pelecanus erythrorhynchos*).

MONOBOTHRUM TERREBRANS sp. nov.

[Plates 63, 64, 65; Figs. 1 to 21.]

Body elongated, somewhat flattened, linear, slightly enlarged at the extremities, which terminate in blunt points, opaque, white. Head variable, subsagittate, wedge-shape or bluntly rounded, a little broader and thicker than the body, somewhat depressed dorso-ventrally but without distinct bothria, translucent white with more delicate cuticle than body. Posterior end of the body with irregular prominences due to the development of ova in the uterus. Genital aperture ventral about the posterior fifth; testes in front of genital aperture occupying the greater part of the body; female genitalia behind the genital aperture. Largest specimen 28 mm. in length. Sometimes several with heads buried in common pit in mucous membrane of host.

Habitat: Intestine of *Catostomus ardens*, Heart Lake, Wyoming, July 28, 1890.

Diesing makes this genus the type of his family *Monobothria*. The genera included are *Caryophyllæus* Gmelin, *Monobothrium* Diesing, and *Diporus* Diesing. These cestods are peculiar in that the body is not segmented and contains but one set of genitalia. In other words a single individual corresponds to one proglottis of an ordinary tapeworm. The members of the group thus serve, in a measure, to connect the cestods and trematods.

Several large suckers which had been taken in a trammel net were examined and about a dozen specimens of this parasite were obtained from two of the fish. They were associated with *Echinorhynchus tuberosus*, and in each instance several of the individuals were found to be attached to the intestinal wall with their heads buried in a common pit in the mucous membrane. Some of these clusters were preserved entire with a portion of the intestine. Upon examining the alcoholic specimens one was found 7 mm. in length, which was wholly inclosed in a pit in the mucous membrane. The walls of the pit were thick and gristly and the head end of the parasite had nearly perforated the intestinal wall.

The longest living specimen measured 28 mm.; as an alcoholic specimen it measured nearly the same, presenting the following dimensions in millimeters: Length, 27; breadth, median, 2, expanding near anterior end to 2.5, and near the posterior end tapering rather abruptly to 1; thickness about 1, but increasing to 1.5 at the posterior end where there are two or three moderately swollen or nodular places.

The following observations are based on alcoholic specimens: A small specimen measured 17 mm. in length; median breadth, 25 mm.; breadth near extremities, 2 mm. The anterior end of this specimen was sagittate and thicker than the body, posterior end bluntly tapering, thicker than body, and somewhat swollen or nodular. Each end of the

larger specimens is rather sharply marked off from the body for a distance of 3 mm. or more. The anterior end is somewhat lighter colored than the body and suggests the head of some species of *Dibothrium*, but there are no bothria. The body, especially toward the posterior end, is yellowish-white.

ANATOMY.

The sections upon which the following account of the anatomy is based were made from specimens stained *in toto* in borax carmine.

Structure of the head.—Upon examining transverse and longitudinal sections of the head it is seen to consist of somewhat spongy tissue, in which there are a few longitudinal muscular and connective fibers and numerous protoplasmic granules and granular masses contained in a mesh of transverse connective fibers. There are also numerous small open spaces shown in the sections which are doubtless the fine and irregular branchings of the vessels of the water-vascular system. Figs. 9 and 10 show the structure of the head of a small specimen. In them it is seen that the cuticular layer is very thin and the subcuticular granulo-fibrous layer, which is clearly defined toward the middle of the body, is but faintly foreshadowed. The longitudinal muscular fibers are not collected into any definite area, but are distributed pretty uniformly among the other tissues. There is no indication of layers of any kind. If the entire section, from which Fig. 10 was sketched, had been figured it would have shown no peculiarities of structure that are not shown in the small portion which is represented.

No calcareous bodies were found in any of the sections. One of the smallest specimens was placed in hydrochloric acid, but no evidence of the presence of calcareous particles was educed.

Structure of the body.—There is a rather abrupt transition between the head and the body. When transverse sections made through the anterior part of the body immediately back of the head are compared with those of the head several differences may be observed. The cuticle is thicker and more sharply defined. In the center of the section the connective fibers assume a parallelism, especially in a direction from margin to margin, which is in marked contrast with the irregular course which they pursue in the head. The open spaces, which indicate the situation of longitudinal vessels, are collected towards the periphery. The protoplasmic granules in the center soon begin to collect into clusters, which represent the beginnings of the testes.

In a small specimen about 5 mm. long, which was cut into transverse sections, it was not until the middle, or a little back of the middle, counting from the head, that the longitudinal muscles began to collect into bundles to form a somewhat discontinuous layer surrounding the inner space.

In sections made in the vicinity of the reproductive aperture, back of the posterior fourth of the body, the cuticle was found to consist of two layers (Fig. 20, *e, c*). The outer or epidermal layer appears to be sloughing off from the inner, uniform cuticular layer. Within the cuticle is a very thin layer of fine longitudinal fibers. This is succeeded by a thick granulo-fibrous layer, which contains numerous granules and nuclear bodies, which latter stain deeply in carmine. There are also, especially in the older specimens, small clusters of longitudinal muscular fibers in this layer (Fig. 16, *l*). The inner portion of this layer is somewhat open or areolar. The water vascular system consists of an indefinite number of vessels not clearly defined and of various sizes, which, in the posterior part of the body, in the vicinity of the reproductive aperture, lie in the inner portion of the subcutaneous granulo-fibrous layer (Fig. 16, *w*). This characteristic branching of the water-vascular system appears to be identical with that observed by G. R. Wagener (Natuurk. Verh. Haarlem, XIII, 96; Tab. VII, 2). Next within the granulo-fibrous layer is a layer of longitudinal muscular fibers (Figs. 16, 17, 18, 20, *lm*). This does not constitute an unbroken layer, but consists of numerous clusters of longitudinal fibers which lie in the midst of the connective tissue and surround the central space. The latter contains the genital organs. A terminal pore leading into a short duct with thick walls was observed in transverse sections through the posterior end of a small specimen. The duct enters posteriorly from near one margin and not from the extreme tip, and continues anteriorly to the posterior vitelline gland. The same was observed in transverse sections of larger specimens, where it appeared first in the posterior sections as a pore entering one of the margins, and was soon seen, in succeeding anterior sections, toward the middle of the sections as an elongated opening with strong walls of connective tissue of irregular thickness. In the smaller specimens strong connective fibers run from the anterior end of this cul-de-sac. This organ is doubtless the terminal pulsating organ common to larval cestods.

Genital organs.—The testes begin a short distance back of the head. In a young specimen they began about the anterior third; in an older specimen they began almost immediately behind the head. They consist of globular masses (testicules) of granular protoplasm in the younger specimens. In the older specimens they are irregular in shape and relatively smaller. The granules are collected into minute globular clusters and appear in the sections as circular or oval nests of nuclei. The testes extend posteriorly nearly to the reproductive aperture, which is about the posterior fourth or fifth of the body.

In front of the genital aperture there is a voluminous tube which, after making numerous convolutions, communicates with the cirrus bulb. This tube is evidently the vas deferens (*vide* Figs. 13, 14, 15, 16). In sections of a large specimen it was seen to contain numerous masses

of minute, short filaments felted together (Fig. 21, s). These, when isolated, appear as slender filaments with a black speck at one end. They are presumably spermatozoa. I was not able to demonstrate any communication between the testes and the vas deferens from my sections. The wall of the cirrus-bulb is thick and well supplied with circular muscular fibers, and within there are numerous retractile muscular fibers. The cirrus was retracted in all the specimens. The aperture of the cirrus, as seen in section through the retracted organ, is quite irregular, with puckered walls and its longer axis transverse to the long axis of the body (Fig. 19, c i).

The germ gland or ovary lies transversely across the body about midway between the genital aperture and the posterior end (Figs. 13, 14, 15, g). It is a single organ, though comprising two marginal lobes with a narrower connecting part. The latter disappears in specimens which have become replete with ripe ova, while the marginal lobes still remain (Fig. 14, g). In such cases there appear to be two ovaries. In Fig. 13 there appear to be two ovaries. The sketch was made from a section which passes on the dorsal side of the part which connects the marginal lobes. It is thus seen that the marginal portions of the ovary extend farther toward the dorsal side than the part which connects them. The ovaries are made up of nucleated cells closely and uniformly packed together. They do not lie in clusters or nests like the granular nuclei of the testes and the vitelline glands. In the older specimens, however, the ovary appears to be broken up into lobular portions (Fig. 14, g). The ovary as a whole lies nearest the ventral face of the body.

The vitellaria (Figs. 13, 14, 15, vg) in the younger specimens are seen to consist of two marginal glands which connect with a posterior gland lying behind the ovary. In the adult specimens this organ may be divided into at least three distinct glands, one posterior and two marginal. The vitellarian gland differs from the ovary in being lobulated, and in the lobules there are numerous clusters of granules, appearing in section as circles or oval nests of nuclei. This organ is well developed along each margin in the vicinity of the cirrus bulb, extending forward of the cirrus bulb for a short distance and overlapping the testes. I observed small ducts leading from the marginal glands, but found nothing corresponding to the conspicuous marginal ducts noticed by Van Beneden in his account of the anatomy of the related genus *Caryophyllæus*.

The ducts from the vitellaria were in some cases crowded with small globular masses, which apparently originate from the disintegration of the nests of nuclei in the vitellaria. The exact relation of these ducts to the duct from the germ gland was not certainly made out, but they were so far traced as to show that they unite with that duct near the median line on the dorsal side of the germ gland not far from its posterior border.

The duct from the germ gland leaves that organ on its postero-dorsal side. Soon after leaving the gland it enlarges for a short space and appears to be lined in the enlarged portion with cilia.

The vagina opens immediately behind the cirrus in a common genital pore. In longitudinal sections parallel with the ventral surface and near the exterior it appears as a simple transverse slit smaller than the male orifice. The vagina pursues a somewhat tortuous course for a short distance behind the external opening, during which time it lies near the ventral surface. It then dips into the central region of the body and passes along the median region on the dorsal side of the germ gland. It enlarges at one point into a kind of seminal receptacle (Fig. 13, *v*). It appears to unite with the germ duct near the posterior edge of the germ gland and on its dorsal side.

The common duct formed by the union of the germ duct and vagina soon receives ducts from the vitelline glands. The common duct thus formed, and which is the beginning of the uterus, functions as a shell gland. In Fig. 13, *o, o* are ova which lie in the vicinity of the shell gland. See also Fig. 14 *u'* and the ideal sketch, Fig. 15 *sg*.

The product of the vitelline glands is added in the shape of small globules of protoplasmic matter. These masses do not, at least immediately, unite, and on that account the ova, even in the beginning of the uterus, have the appearance of undergoing segmentation. In some cases I observed ova that appeared to be in the process of formation. The shell was exceedingly thin and weak, and among the numerous non-nucleated masses, products of the vitelline gland, could be distinguished the nucleated germ cell (Fig. 12 *a*).

The uterus lies dorsally in the posterior part of the body. It is a voluminous organ and when full of eggs occupies the greater part of the body behind the cirrus bulb (Fig. 14 *u*). It is on account of the accumulation of eggs in the uterus that the posterior surface of the body is raised into irregular elevations (Figs. 1, 3, 7, 8). The uterus begins behind the ovary and appears to originate from the confluence of the vagina, germ duct, and vitelline ducts. The first folds in section present a reticulated appearance and contain numerous ova which have thin and membranous shells. These ova are very irregular in their outline and are invariably collapsed. Both shell and contents stain deeply with carmine. The perfect ova have shells that resist the action of the staining fluid.

From its origin on the postero-dorsal side of the germ gland the uterus proceeds by numerous folds anteriorly in the direction of the cirrus bulb. It appears to terminate, in the older specimens, in a pore immediately behind the cirrus, in close proximity with the vagina.

The ova are comparatively large, being 0.06 to 0.065 mm. in length and 0.03 to 0.035 mm. in breadth. The globular masses of which their protoplasmic contents are for the most part made up are 0.01 mm. and over in diameter.

TREMATODA.

ENCYSTED DISTOMA FROM *LEUCISCUS ATRARIUS*.

[Plate 65, Figs. 22-25.]

On July 30 I examined several small chubs (*Leuciscus atrarius*) from a warm branch of Witch Creek, and some larger fish of the same species from Heart Lake. In these fish the mesentery and serous covering of the viscera generally were thickly specked with minute white granules, which upon examination proved to be cysts containing larval trematods. In most cases each cyst contained but one larva, but in one instance, among cysts from a large chub, three larvæ were observed in one cyst, and in several others two. The larvæ lay in a transparent fluid which was inclosed in an oval sac with pellucid walls. The sac collapses when the larva is liberated. It is then seen to consist of interlacing fibers, the interstices of which are filled with granular parenchyma. The parasites are too immature to make their identification certain. I record, however, the following characters:

The average length of the cysts appears to be about 0.5 mm. An alcoholic cyst measured 0.7 mm. in length and 0.5 mm. in breadth, and contained a larval distomum 0.4 mm. long and 0.25 mm. broad. Another larva, liberated from a somewhat smaller cyst, measured 0.32 and 0.16 mm., and another 0.35 and 0.26 mm. in length and breadth, respectively. Another was 0.4 mm. long and 0.15 mm. thick.

These distoma are elliptical, oblong, or oval in outline when viewed dorsally or ventrally, but in marginal view are convex dorsally and concave ventrally. The two suckers have made their appearance, and also the muscular pharynx. These organs have about the same relative positions and proportions as the similar organs in *Distomum laureatum*, but there is no indication of the head papillæ of that species. The body is somewhat longitudinally striated behind the ventral sucker, an appearance which seems to be due to the branches of the water-vascular system. There is a posterior emargination which marks the position of the terminal pore of the water-vascular system. From a short median vessel connecting with the terminal pore a number of marginal vessels branch like the arms of a candelabra. The ventral sucker is well developed, the oral imperfectly so.

DISTOMUM LAUREATUM Zeder.

Rudolphi Entozoa Hist., II, 413; id., Synops., 113, 413; Diesing, Syst. Helminth., 380; Dujardin, Hist. Helminth., 435; Olsson, Bitrag till Skandinavians Helminthfauna, 1876, 24, Taf. IV, Figs. 52, 53, 54.

Body unarmed, depressed, oblong, with short neck. Head with four low, blunt, dorsal papillæ and two ventro-marginal lobes on oral sucker. Ventral sucker larger than mouth, sessile but prominent, with transverse cleft-like aperture. Pharynx globose near the mouth, with short

oesophagus. Intestinal crura continued almost to the posterior end. Vitelline glands numerous, not only occupying the margins of the body as far as the middle of the neck, but also all the region behind the testes. Transverse duct with vitelline receptacle in front of the testes. Testes two, subglobose, median, approximate with each other. Ovary globular, one-half the size of a testis, remote. Gyri of uterus few, situated in front of the testes. Genital apertures apposed in middle of neck. Bursa of penis long, smooth, cylindrical. Excretory vessel a median cæcum, desisting in front of testes and opening in a posterior caudal pore. Length 6 mm., breadth 1.5 mm.

This description is adapted, with a few changes, from Olsson, cited above.

Habitat: *Salmo mykiss*, rectum. Heart Lake and Yellowstone Lake, July and August.

A distomum which I have found frequently in the Rocky Mountain trout appears to be identical with *D. laureatum*, a parasite which infests several European fishes, e. g., *Thymallus vulgaris*, *Coregonus oxyrhynchus*, and *Salmo fario*.

The dimensions given by Dujardin for this species are: Length, 2 to 3.35 mm.; breadth, 1 to 1.22 mm.

My specimens, alcoholic, measure from 1.5 to 4 mm. in length and 0.5 to 1.5 mm. in breadth. The length is in most cases three or four times the breadth. The diameter of the ventral sucker is about twice that of the oral sucker. The transverse diameter of the aperture of the ventral sucker is three times its axial diameter. The eggs are yellow, elliptical, usually collapsed in alcoholic specimens from 0.07 to 0.085 mm. in length and 0.04 to 0.045 mm. in breadth.

In life the color is yellowish-white; with transmitted light the eggs, which are large and not numerous, appear golden-brown. In the living specimens there appeared to be about five low, blunt papillæ on the dorsal half of the circumference of the oral sucker. Subsequent study revealed the number and disposition given above and in the sketches. This parasite was noticed on several occasions, but usually there were but few—a dozen or two—in each host.

Detailed measurements of the specimen figured in Fig. 26. are as follows:

	Millimeters.
Length	3.50
Greatest breadth	1.00
Diameter of anterior sucker, interior, lateral	0.17
Diameter of anterior sucker, interior, axial	0.15
Diameter of anterior sucker, exterior	0.33
Diameter of ventral sucker, interior	0.30
Diameter of ventral sucker, exterior	0.43

ACANTHOCEPHALA.

ECHINORHYNCHUS GLOBULOSUS Rud.

[Plate 65, Figs. 31, 32.]

A fragment of an echinorhynchus from a trout (*Salmo mykiss*) collected by Dr. Jordan in Yellowstone Lake, in September, 1889, appears to belong to this species, or at least near it. The fragment is the anterior end of a female broken a short distance back of the proboscis sheath. The length of the fragment is 3 mm.; the length of the proboscis is 0.6, and of the sheath 1.2 mm.; the diameter of the proboscis at base is 0.27, at apex 0.16 mm.; length of hooks, 0.05 to 0.06 mm. There are about ten rows of hooks and about the same number in each spiral visible on a side, and about sixteen hooks in a vertical row. The specimen was put in glycerin to study, and the peculiar shape of the proboscis may be in part due to a collapse of its walls. The proboscis is cylindrical at base, tapers abruptly about the middle, and becomes cylindrical again towards the apex. The hooks on the slender part of the proboscis were somewhat distorted. This feature appears in the two upper right-hand hooks in Fig. 32. The lemnisci were not clearly made out, but they appear to be shorter than the sheath.

ECHINORHYNCHUS TUBEROSUS Zeder.

[Plate 66, Figs. 33-39; Plate 67, Fig. 40.]

Zeder, Naturg., 163; Rudolphi, Entoz. Hist., 11, 257; Synops., 65 and 312; Westrumb, Acanthoceph., 9; Creplin, Obs., 26; Wiegmann's Arch., 1846, 150, 152, 154, and 155; Dujardin, Hist. Nat. des Helminth., 538; Diesing, Syst. Helminth., 11, 33; Revision der Rhyngodeen, 29.

Proboscis short, clavate, or subglobose, with about three series of hooks; about six large hooks in outer series, hooks in other series diminishing in size and number toward base of proboscis. Hooks long, slender, recurved, but with slight outward curve toward the point. No neck. Proboscis sheath short. Lemnisci very long and slender, in the males sometimes equal to more than one-half the length of the body. Body elongated, attenuate at each end. Males with copulatory bursa. Length of males from 4 to 9 mm., of females from 10 to 15 mm.

Habitat: *Catostomus ardens*, *Leuciscus atrarius*, intestine; July 28, 1890; Heart Lake, Wyoming.

I refer to this species a lot of 75 echinorhynchi from the intestine of the sucker (*Catostomus ardens*). Eight large fish were examined and echinorhynchi were found in most of them. I also refer to the same species a single specimen from the intestine of a chub (*Leuciscus atrarius*). The majority of the specimens of the first lot were translucent

white or cream color, a few were lemon-yellow, and a few orange-yellow. The specimen from the chub was a male 6 mm. in length and of a rusty yellow color. In a few cases external pores, with elevated thickened borders, were observed, similar to what I have recorded in *E. agilis* (Report of Commissioner of Fish and Fisheries, 1886, p. 490). One of these is shown in Fig. 40. The bodies of the alcoholic specimens are arcuate; the proboscis is usually inclined nearly at right angles to the body; the terminal aperture of the female is lateral near the posterior end. The lemnisci are proportionally longer in the males than in the females. The length is not well shown in Fig. 38, which was sketched from a specimen in glycerin, in which the lemnisci did not show plainly. They frequently extend far beyond the first testis, and are, moreover, often more or less folded. The testes are large, oblong, and approximate. The vas deferens is large; the prostatic sacs appear to be represented by a single elongated gland lying parallel with the vas deferens; the ejaculatory duct and bursa are both relatively large.

The ovarian masses are ellipsoidal. The dimensions of a typical mass were, length .14 mm., other diameters about .07 mm. The fusiform embryos were .035 mm. in length, and .015 mm. in breadth. The outer cells of the ovarian masses are the largest and are nucleated.

The body wall near the anterior end is thin, as shown in Fig. 36. Towards the median and posterior region the subcuticular fibrous layer thickens greatly and contains the relatively large branching vessels of the water-vascular system. Some of the latter may be seen in optical section in Fig. 38.

The following measurements were obtained from typical alcoholic specimens:

Measurements.	Male.	Female.
Length	mm. 6.00	mm. 10.00
Length of proboscis	0.25	0.15
Diameter of proboscis	0.20	0.15
Length of proboscis sheath	0.50	0.40
Length of lemnisci	3.00	1.50
Length of largest hooks on proboscis	0.07	

NEMATODA.

The nematods infesting the fishes of the National Park do not appear to be very numerous either as to species or individuals. Moreover, the specimens which were found on the expedition were, with the exception of those of one species, encysted or otherwise immature forms. Since there is much consequent uncertainty attending their proper identification I shall refer to them somewhat cursorily under the head of the several hosts.

SALMO MYKISS.

A parasite which is found rather frequently in greater or less abundance, usually in the vicinity of the pyloric cæca of the trout; agrees very closely with *Dacnitis globosa* Dujardin, from *Salmo fario*.

The species *D. globosa* is not recognized by Von Linstow in his "*Compendium der Helminthologie*," but is apparently regarded by him as identical with *Cucullanus globosus* Zeder. On account of its close agreement with Dujardin's description of *D. globosa*, I have used that name in the explanation of the figures (Pl. 67, Figs. 41 to 46).

There appear to be two varieties of this worm, or at least of the females. In one the body is slender, almost filiform, the female being twice as long as the male. In the other the body is not so slender and there is not much difference between the sexes with respect to the length of the body. This feature, however, may be accidental.

This worm may be described as follows:

Body, white, usually slender, nearly linear, anteriorly narrowing into a neck, which expands into a head that is wider than the neck, marked with longitudinal striæ and with indistinct transverse striæ. Head subglobose, with two rather thin and corneous lips, the mouth a triangular slit narrowing dorsally. The head is usually deflected dorsally by a curve in the neck, which resembles a crosier. There is a small nodular eminence on the dorsal side of the head. Œsophagus with thick, strong walls. Female with body usually twice the length of the male; reproductive aperture with border raised into prominent folds, situated about the posterior third; posterior end acuminate. Male usually about half the length of the female, posterior end strongly recurved ventrally with a pair of sabre-shaped spicules and a short, blunt process behind the pair of spicules and a broad sucker-like depression in front of the spicules bearing the anal aperture near its anterior end.

Length of females, 8 to 15 mm.; of males, 7 mm.

One of the long, slender females was 12 mm. long and 0.2 mm. in diameter; one of the shorter kind was 8 mm. long and 0.3 mm. in diameter. A male, corresponding in appearance with the latter, was 7 mm. long and 0.27 mm. in diameter. These dimensions are of alcoholic specimens. The following additional measurements were made, also on alcoholic specimens. The dimensions are given in millimeters: Male, length

7.00; greatest diameter, 0.25; diameter of head, 0.20; diameter of neck, 0.13; length of neck, 1.00; length of caudal spine, 0.15. Female, length 15.00; greatest diameter, 0.40; diameter of head, 0.25; diameter of neck, 0.17; length of neck, 1.20. Genital pore, 5 mm. from posterior end.

These parasites were met with frequently in the trout of Heart Lake and in those of Yellowstone Lake and the river. Their favorite resting-place is in the alimentary canal in the vicinity of the pyloric cæca.

ENCYSTED SPECIMENS OF *D. GLOBOSA*.

This worm was also found in cysts which usually appeared as pediculated tumors within the body cavity of the trout. It frequently happened that among the cysts of *Dibothrium cordiceps*, found in the body cavity of the trout, there would be a few cysts which differed somewhat in appearance from the former. These, when opened, collapsed on account of the liberation of a thin, watery, granular fluid, in which there was invariably a small nematod worm. These proved, upon subsequent examination, to be specifically identical with the worms from the alimentary canal which I have referred to *D. globosa*.

These cysts are easily distinguished from the dibothrium cysts by their difference in color and resistance to pressure. The cysts of *Dibothrium cordiceps* are white, firm, and resistant. The nematod cysts are yellowish or flesh-colored, and are soft and yielding. Moreover, they are usually suspended by a peduncle and are covered by a layer of the peritoneum, which is richly supplied with blood vessels. The worm which is liberated from the cyst is altogether disproportionate in size to the containing cyst. The worm, even from a cyst 10 mm. in diameter, may be so small as to be easily overlooked amidst the granular fluid which escapes when the wall of the cyst is ruptured. These cysts usually occur on the rectum or along the course of the lower intestine. They are sometimes found, however, in the vicinity of the pyloric cæca.

A cyst measuring 15 by 9 by 7 mm. in its three dimensions, which had been preserved in alcohol, was opened. The walls were 0.5 mm. thick, and the contents were granular and whitish. The cyst was covered by a layer of peritoneum, which contained capillary blood vessels. The worm which was liberated was 8 mm. in length. Another cyst, 4 by 5 by 3 mm. in its three dimensions, contained a small male worm 4 mm. long. The nematods obtained from these cysts were all immature and belonged to the same species, *Dacnitis globosa*. Sections of these cysts show that their walls are made up of a number of concentric layers, rather loosely connected and often poorly defined, and with numerous nuclear granules in and among the layers.

In addition to *Dacnitis globosa*, and associated with it, I found a few forms that I have not been able to identify. One of these, a single specimen of which was found, is an immature form of a rather stout nematod, length 14 mm., breadth 0.5 mm. It tapers gradually toward

the anterior end and a little more rapidly toward the posterior end. The body is marked by five longitudinal striæ and a broad longitudinal-stripe on each side; there are a few transverse wrinkles for a distance of about 0.3 mm. from the anterior end. The mouth appears to be simple and there is no œsophagus. Another is a fragment, the posterior end of a female, length 11 mm., breadth 0.5 mm. This fragment is cylindrical; posterior end rather blunt. In optical section the body appears to be crenulated, owing to the deep transverse striæ. The intestine is dark brown and the anal aperture nearly terminal.

Another species, which bears some resemblance to *Ascaris tenuissima* Zeder, was found in the trout (Figs. 47-51). These are slender, white worms, tapering gradually towards the anterior end from about the posterior third; posterior end larger except at the extremity, where it tapers rather abruptly to a blunt, slightly-curved point, behind the anal aperture (Fig. 49). Head small, truncate, mouth apparently trilobed. Body marked by regular transverse striæ, making serrate margins in optical sections near anterior end, the serrations becoming crenulate posteriorly. The œsophagus is short, with what I take to be a chitinous ring at base. The few specimens which I have found are small. The following measurements were obtained from a female, dimensions given in millimeters: Length, 7; diameter of anterior end, 0.03; post anal diameter, 0.04; diameter immediately in front of anal aperture, 0.06; greatest diameter of body about 0.12; ova, 0.04 by 0.02 in diameter. The length of a male was found to be 4 mm. Spicules, 2, diverging. Genital aperture of female about posterior third, vulva prominent. My specimens do not present many characteristic details of structure, and I am not able, without more careful examinations of sections, to reach a satisfactory conclusion with regard to their classification.

Some small nematods encapsuled in the muscular walls of the intestine of the trout were found, some of which appear to be immature forms of the foregoing. These worms are very small, hardly exceeding 3 mm. in length, and many of them not more than 2 mm. long. One of them, which measured 2 mm. in length, was 0.06 mm. in diameter, and for the greater part of its length was filled with polygonal nucleated cells about 0.02 mm. in diameter. The body tapers abruptly at the posterior end, but more gradually towards the anterior end. The mouth appears to be three-lobed and surrounded by about five minute papillæ. The chitinous cuticle is uniformly and minutely marked with transverse striæ. This feature in optical section produces serrate margins, the teeth of which are about 0.01 mm. apart. In one the anal aperture was found to be 0.2 mm. from the posterior end. In another of these encapsuled nematods, which was stouter than the ones just described, the polygonal cells were present and also minute cells about 0.002 mm. in diameter, which filled a large part of the body. The length of this specimen was 3 mm., the diameter 0.2 mm. In this speci-

men the margins in optical section are crenulate and the body tapers towards each end. I can not refer this specimen to any species with any degree of certainty. The former encapsuled specimens are evidently young forms of those which I have referred provisionally to *Ascaris tenuissima*, although they present some resemblance to *Ascaris capsularia* Rudolphi.

LEUCISCUS ATRARIUS.

The nematods secured from this fish were few in number. They were found only in the body cavity, where they were coiled up under the external tunic of the viscera. They are all apparently larval ascaridæ, although on account of their rudimentary condition I have not been able to identify them with certainty.

One specimen obtained from the serous coat of the intestine of its host appeared to be near the stout nematod from *S. mykiss* mentioned above. It was 17 mm. in length. Its greatest breadth was 0.6 mm. near the posterior end. Its diameter at the anterior end was 0.25 mm. The living worm was for the most part brownish red in color. When the alcoholic specimen was examined it was found to be partly enveloped in a thin, transparent, chitinous investment, which, when removed, revealed a smooth cuticle, with a broad, prominent lateral line. The breadth of the lateral lines was about 0.07 mm. at the anterior end, increasing to 0.1 mm. toward the posterior end. The surface, except along the lateral regions, presented a reticulated or squamose appearance. When the specimen was placed in glycerin the reticulations were no longer visible. Fine transverse fibers and strong longitudinal fibers, however, became visible in the cuticle.

The neck is continuous with the body, the head narrow, truncate, mouth terminal, with rudimentary lips. The body is gradually attenuate anteriorly, but tapers abruptly and somewhat unequally on opposite sides to the rather blunt posterior end; anal aperture terminal. At the posterior end there is a minute, bluntly rounded, papillary spine, 0.012 mm. in length. Nothing could be made out with regard to the œsophagus or genital organs.

In addition to the above, some small white nematods were obtained from the mesentery. These were about 7 mm. long and 0.35 mm. in the greatest diameter. The anterior end is nearly truncate and 0.1 mm. in diameter. The body tapers nearly uniformly to each extremity, but in some more abruptly towards the posterior end. The lateral lines are prominent. The surface of the body is smooth, the longitudinal muscles well developed, giving a longitudinally striated appearance when magnified; transverse striæ are not visible in alcoholic specimens, but become visible when treated with glycerin. The number of oral lobes is not definite, but there are several small oral papillæ. The genital organs are rudimentary, the anal aperture terminal. These specimens resemble the larger specimen closely, but in life were white, while the

larger specimen was brownish red. They are also much like the specimens mentioned below from the sucker.

CATOSTOMUS ARDENS.

But one species of nematod was found in this fish. These were slender white worms, found in the intestine of their host, where they were associated with *Echinorhynchus globulosus* and *Monobothrium terebrans*. They were from 6 to 8 mm. long and about 0.3 mm. in diameter. They taper toward each end alike. The body in alcoholic specimens appears to be marked with fine longitudinal striæ. The lateral lines are prominent. When treated with glycerin fine transverse striæ became visible. The lips are not well defined, but are apparently three in number, with several minute papillæ. The reproductive organs are rudimentary.

In the absence of distinct characters, it is of necessity impossible to refer these larval nematods to established species.

WASHINGTON AND JEFFERSON COLLEGE,
Washington, Pa., April 3, 1891.

EXPLANATION OF PLATES.

PLATE 63.

Monobothrium terebraus sp. nov.

- Fig. 1. Adult; *a*, head; *b*, posterior end; *c*, genital pore, $\times 34$.
 Fig. 2. Smaller specimen, dorsal view, $\times 18$.
 Fig. 3. Posterior end of adult, ventral view; *a*, genital pore, $\times 14$.
 Fig. 4. Small specimen, dorsal view, $\times 14$.
 Fig. 5. Anterior end of adult, marginal view, $\times 14$.
 Fig. 6. Anterior end of adult, dorsal view, $\times 14$.
 Fig. 7. Posterior end of adult, dorsal view, $\times 14$.
 Fig. 8. Posterior end of adult, marginal view, $\times 14$.
 Figs. 5 to 8 are sketched from the same specimen.
 Fig. 9. Median longitudinal section of anterior end of small specimen, parallel with a dorsal surface, $\times 200$.
 Fig. 10. Transverse section near apex, of small specimen; *c*, cuticle; *w*, vessel of water-vascular system, $\times 200$.
 Fig. 11. Egg, sketched from section of young specimen, showing eggs in the uterus, $\times 375$.
 Fig. 12. Egg, from one of the posterior convolutions of the uterus of a young specimen; *a*, germ cell; the remainder of the contents consists of globular masses from the vitelline gland, $\times 375$.
 Fig. 13. Longitudinal section through the posterior region of a small specimen; *c*, cuticle; *ci*, cirrus and cirrus-pouch; *e*, epidermis; *g g*, marginal lobes of germ gland; *lm*, longitudinal muscles; *o o*, eggs in posterior convolutions of the uterus; *sc*, subcuticular fibro-granular layer; *t*, testes; *u u*, uterus; *v*, seminal receptacle of vagina; *vd*, vas deferens; *vg vg*, marginal and posterior vitelline glands, $\times 300$.

PLATE 64.

Monobothrium terebraus sp. nov.

- Fig. 14. Longitudinal section through the posterior region of an adult specimen, $\times 60$; *u*, shell gland; other letters as in Fig. 13.
 Fig. 15. Diagrammatic sketch showing position of genitalia; *v*, vagina; *v'*, seminal receptacle; *g*, shell gland; other letters as in Fig. 13.
 Fig. 16. Transverse section through body in region of cirrus bulb of adult, $\times 54$; *l*, longitudinal muscles in subcutaneous fibro-granular layer; *w*, vessels of water-vascular system; other letters as in Fig. 13.
 Fig. 17. Transverse section of body-wall in front of cirrus, $\times 210$; *l*, longitudinal subcutaneous fibers; other letters as in Fig. 13.
 Fig. 18. From transverse section in front of germ gland, $\times 210$; *v*, ciliated duct vagina; *g*, germ gland; *lm*, longitudinal muscles; *o*, egg in uterus; *u*, uterus.
 Fig. 19. Longitudinal section near ventral surface; *ci*, cirrus; *v*, vagina, $\times 300$.

PLATE 65.

Monobothrium terebrans sp. nov.

- Fig. 20. Longitudinal section of body wall near posterior end; *e*, epidermis; *c*, cuticle; *l*, longitudinal subcuticular fibers; *sc*, subcuticular fibrogranular layers; *n*, nucleated cell; *lm*, longitudinal muscle layer; *g*, nucleated cells of germ gland, $\times 300$.
- Fig. 21. Longitudinal section through vas deferens; *vd*, vas deferens; *s*, masses of spermatozoa, $\times 375$.

Encysted distomum from *Leuciscus atrarius*.

- Fig. 22. Young distomum in cyst, from body cavity of *Leuciscus atrarius*, $\times 60$.
- Fig. 23. Same liberated from cyst, $\times 60$; *w*, terminal pore of water vascular system.
- Fig. 24. Cyst with three distoma, from same host.
- Fig. 25. Cyst with two distoma, from same host.

Distomum laureatum Zeder.

- Fig. 26. Ventral view of specimen in carbolic acid and turpentine; $\times 24$, *a*, mouth and anterior sucker; *ph*, pharynx; *c*, cirrus; *b*, ventral sucker; *o*, eggs in uterus, walls of latter organ not clearly defined in specimen; *ov*, ovary; *vd*, vitelline duct; *t*, testes; *vg*, vitelline glands.
- Fig. 27. Marginal view of another specimen, $\times 22$.
- Fig. 28. Ventral view of anterior end.
- Fig. 29. Dorsal view of same specimen figured in No. 28.
- Fig. 30. Ventral view of anterior end of specimen 4.5 mm. in length, $\times 45$.

Echinorhynchus globulosus ? Rud.

- Fig. 31. Sketch of a fragment, the anterior end of an echinorhynchus from *Salmo mykiss*; length of fragment, 3 mm. Specimen in glycerin when sketched; anterior end of proboscis apparently collapsed.
- Fig. 32. Hooks of same near base of proboscis.

PLATE 66.

Echinorhynchus tuberosus Zeder.

- Fig. 33. *a*, Anterior end of ♀ $\times 12$; *d*, posterior end of same, $\times 12$; *b*, hooks of proboscis; *c*, same, specimen in caustic potash, showing basal supports, highly magnified.
- Fig. 34. Portion of proboscis of ♀ in glycerin.
- Fig. 35. Anterior end of ♀, optical section, *l*, lemnisci; *s*, sheath of proboscis; *a*, cuticular pore; *o*, eggs; *o*, ovarian masses, $\times 14$; *ova* \times about 30.
- Fig. 36. Transverse section through anterior end, *c*, cuticle; *l*, longitudinal subcuticular fibers; *sc*, subcuticular granulo-fibrous layer; *cm*, circular muscles; *lm*, longitudinal muscles forming a sheath for the lemnisci; *ll*, lemnisci; *v*, longitudinal vessel of same; *s*, wall of proboscis sheath; *ng*, nerve ganglion; *r*, retractor muscle of proboscis.
- Fig. 37. Transverse section through nerve ganglion, more highly magnified than Fig. 36; *ng*, nerve ganglion.
- Fig. 38. Optical section of ♂ in glycerin; *a*, *b*, *c*, hooks of proboscis. Other specimens were observed in which the lemnisci were relatively considerably longer than shown in this sketch. $\times 9$.
- Figs. 33 to 38 sketched from specimens from *Catostomus ardens*.
- Fig. 39. Head of ♂ from *Leuciscus atrarius*.

PLATE 67.

Echinorhynchus tuberosus Zeder.

Fig. 40. Anterior end of ♂ from *Catostomus ardens*.

Dacnitis globosa Dujardin.

Fig. 41. ♂ and ♀ × 3½.

Fig. 42. Side view of head of ♂, optical section; *o*, mouth; *ph*, pharynx, × 60.

Fig. 43. Anterior end of ♀; *a*, front view of head, × 60.

Fig. 44. Posterior end of ♂; *v*, vent; *st*, anal spines, × 60.

Fig. 45. Same, optical section, × 60.

Fig. 46. Vulva of ♀, highly magnified.

Undetermined species of Nematods.

Fig. 47. Small nematod, ♀, from *Salmo mykiss*, × 12.

Fig. 48. Anterior end of same, × 185.

Fig. 49. Posterior end of same, × 185.

Fig. 50. Same species, ♂, × 12.

Fig. 51. Posterior end of same, × 185.

Fig. 52. Small nematods from *Catostomus ardens*, × 3½.

Drawings by the author from alcoholic specimens.









