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Introduction

In 1953 it was observed that the fishes taken by anglers in Trumbull Lake, Clay County, Iowa, were "grubby" or wormy" and hence considered unfit for human consumption. This study was undertaken to ascertain in greater detail the parasite fauna of that area. Work was begun in the summer of 1954 and collections were made intermittently through the summers of 1954 and 1955. All fish were examined at the Iowa Lakeside Laboratory, Lake Okoboji, Iowa. Final identifications of the parasites were completed at Iowa State College during 1956 and 1957.

Trumbull Lake lies in the northeast corner of Clay County, Iowa, in sections 22, 23, 26, 27, 34, and 36 of Lake Township. Access to the lake is provided by an unimproved road on the east side between sections 22 and 27, by a similar road on the west side between sections 23 and 26, and by a county road at the south edge of the lake. The lake has an official area of 1190 acres and an average depth of five feet. Its watershed ranks as one of the largest in the state and while it is fed by a single mother stream, it drains approximately 40,000 acres of fertile farmland. Trumbull Lake lies in an area of terminal moraine and its shorelines are of fine gravel and small rocks. In recent years much of the bottom of the lake has become covered with silt resulting from erosion on the surrounding farms. Except for the mother stream and several farm drainage tiles which empty into the lake, there is little or no flow of water through the lake. In 1954 and 1955 no water flowed over the spillway during the months of July and August. In 1955 the lake was extremely low, no water was found in the marshes and it was midsummer before rooted vegetation appeared in the water. The extreme difference in the degree of parasitism between the summers of 1954 and 1955 may perhaps be attributed to this difference in the water table (see Table 1). Due to its shallow nature and its silty bottom, the lake warms rapidly in the summer and plant life flourishes. Much of the shallower water near the shore has abundant growths of *Sagittaria, Scirpus,* and *Typha.* Beds of *Potamogeton*

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occur just beyond their outermost limits. Around most of the lakeshore there is a thin stand of cottonwood, boxelder, and willow trees.

Materials and Methods

Most of the fish examined in this study were taken with a 30-foot seine having four meshes to the inch. The minnows and shiners were taken on consecutive Monday mornings during the months of July and August in 1954. Some of the larger fish such as northern pike and common white suckers were taken in gill nets set on August 2, 1954, and the remainder were taken in a test seining operation of the Iowa State Conservation Commission. This latter operation provided the largest specimens examined in this study. At irregular intervals during the summer of 1955, check surveys were made to determine any rise or fall in the amount of parasitism. Fish taken in a seine were transferred to large containers and carried back to the laboratory where they were placed into live tanks for holding until it was convenient to examine them during the following week.

During the process of examination, the age, length, weight, and sex of each fish were recorded. Scaled fish were aged by counting the annular rings on the scales. To age the bullheads, it was necessary to remove the six vertebrae just anterior to the dorsal spine. These vertebrae were then placed into an aqueous solution of 7 percent pepsin and 2 percent hydrochloric acid and incubated for 24 hours at 38° C. to digest the flesh from the bone. At the end of 24 hours the bones were removed from the solution, washed in tap water, and allowed to air dry. When sufficiently dry to permit handling, the annual rings on the centra were counted to determine the age of the fish. This was done for about five bullheads in each size group and these were then used as a standard to age the remainder of the bullheads in the catch.

The fish were placed into individual containers, given a host number, and examined in sequence. Scales were removed for aging and after an examination under a dissecting microscope to detect any external parasites, the fish were killed and dissected for internal study. As the various organs and vertebrae were removed, they were placed into separate containers of normal saline solution to help ascertain the sites of infection. Following removal of the viscera, a careful examination of the coelomic, oral, and cranial cavities was made to detect any parasites situated in these areas. As the fish were dissected the organs were separated into the following general groups: (a) eyes, (b) gills, (c) pyloric caeca, (d) liver, (e) anterior intestine, (f) posterior intestine, (g) urinary bladder, (h) swim bladder, and (i) skin and adjacent flesh. These organs were then shredded, examined, allowed to stand for a period of approximately one hour, and then re-examined for any parasites which might have been overlooked in the initial search. An additional group (j) was established to include those parasites which were found in the original container after the removal of the various organs. The eyes of the first dozen fish of each species were given a complete examination for helminths. Since none was found, eyes of subsequent individuals were given only a superficial examination under a binocular dissecting scope, then discarded. If an irregularity was noted, a more complete study of the eye was made. Later checks were made periodically in each collecting area in order to determine if any parasitic infections had occurred subsequent to the initial collections. Any helminths that were found were placed into an aqueous solution of 0.7 percent sodium bicarbonate to dissolve the mucous of the fish.

Fixation methods varied with the species of helminths involved. Most of the trematodes were flattened using coverslip pressure unless they were too small to warrant such handling. All were fixed in AFA. Large specimens of cestodes were wound around a beaker and then fixed in AFA. When they were sufficiently hardened to remain expanded, the tapeworms were then transferred to a larger container of AFA to complete the fixation process. Acanthocephala were first placed into distilled water to facilitate extrusion of the proboscis and then were placed into hot 70 percent ethyl alcohol. All nematodes were fixed by placing them in hot 70 percent ethyl alcohol.

Following fixation, all specimens were transferred to shell vials and labeled according to host number and site of infection. Thus, vial 117b contained a parasite found on the gills of host number 117. Reference to host cards (which had been prepared during the examinations and numbered with the corresponding host), made readily available all pertinent data concerning the fish and parasite.

Mayer's paracarmine was used to stain all trematodes, cestodes, and acanthocephala encountered in this study. Nematodes were left unstained. In preparing whole mounts of the latter, they were dehydrated in an alcohol series to 95 percent ethyl alcohol, then transferred to a 1:1 solution of ether-absolute alcohol, and later placed into thin celloidin. When the celloidin became firm (not hard), it was cut into individual pieces, each containing a worm, and then placed into 80 percent alcohol, 90 percent alcohol, and cleared in beechwood creosote. Later specimens treated in the same manner but cleared in terpineol provided much more satisfactory results. After clearing, all specimens were mounted in Fisher Permount.

All illustrations included in this report, unless otherwise indicated, were made with the aid of camera lucida. Photographs were taken with a 35 mm. Exacta camera.

Identifications of fish hosts were made by using Bailey's key in

Iowa Fish and Fishing, 3rd ed., Harlan and Speaker (1956). Molluscs and leeches were identified using *Taxonomic Keys to the Common Animals of the North Central States,* by Eddy and Hodson (1955). The following general texts proved helpful in identifying many helminths: Baer (1951), Baylis and Daubney (1926), Dawes (1946), Wardle and McLeod (1952), Yamaguti (1953), and Yorke and Maplestone (1926).

Fish Hosts and Degree of Parasitism by Helminths

All species of adult fish examined carried at least one type of parasite. Of the 1,433 adult fish examined, 845 carried helminths, with an overall rate of infection of 58.6 percent. All specimens of common white suckers, orange-spotted sunfish, black bullheads, northern pike, green sunfish, plain red shiners, carp, and sticklebacks were infected. Young of the year fish in every case were lightly infected (Table 2). A total of 16 species of trematodes was found in the 13 species of fish. Actively motile flukes were found in all species except carp, and were located in the eyes, liver, muscles, intestine, visceral mesenteries, coelom, peritoneum, hepatic bile ducts, and on the gills. Encysted forms were found in the visceral mesenteries, peritoneum, pericardium, in the heart muscle, beneath the skin, and in the oral cavity. Most of the trematodes recovered were metacercariae but adults of four species were found. Cysts surrounded by a heavy black pigment were exceedingly abundant in fathead minnows and special consideration was given the data concerning the occurrence of flukes causing this reaction. These will be discussed in a following section dealing with larval trematodes.

Six species of cestodes were encountered. These were found in seven species of fish but adult forms occurred only in the northern pike and common white sucker. Larval or immature forms were found in yellow perch, golden shiners, orangespotted sunfish, black bullheads, northern pike, and green sunfish. Nematodes found were primarily immature forms encysted in the visceral mesenteries, although a few were found in the intestine. Adult Acanthocephala occurred in the intestines of orangespotted sunfish and cystacanths were found in the adipose tissues of a bullhead. Leeches were seldom found on the fish, but when found were usually attached to the base of the caudal fin. An exception, however, was one individual found attached to the roof of the mouth of an orangespotted sunfish. Summaries of the host-parasite data are presented in Tables 3 and 4.

Collections were made from five major areas of the lake. The fish showed no preference for any particular area and most species were easily taken everywhere. Few differences occurred in the degree of parasitism in the various regions and as a result, the relation of parasitism to fish hosts and lake area is discussed only with regard to the most abundant fish, the fathead minnow, *Pimephales p. promelas* (see below).

TREMATODA: DIGENEA

Family Gorgoderidae

Phyllodistomum *sp. Braun,* 1899 (Fig. 7)

Host: *Catostomus c. commersoni.*

Site of infection: hepatic bile ducts.

One of the 18 common white suckers examined contained a number of active flukes moving about in the hepatic bile ducts. These specimens proved to be immature forms that were difficult to identify. The intestinal crura consisted of large voluminous pouches which were atypical of any familiar group. The bodies of these worms were soft and billowy and many collapsed during mounting. Since the hepatic bile ducts are an unusual site of infection, it was hoped that this might be of assistance in the identification. However, no single group of helminths localizes in this area, so further study was required. Specimens were shipped to Dr. J. H. Fischthal who identified them as immature worms of the genus *Phyllodistomum,* family Gorgoderidae, on the basis of the position of the vitelline glands. On this authority, the specimens have been reported as such in this study.

Species of *Phyllodistomum* usually inhabit the urinary tract of amphibians or fish. It was shown by Goodchild (1954) that bladder flukes are very specific as to the region of the body of the host in which they will develop. His attempts to transplant them to other body regions resulted in failure or impaired development. However, specimens were recovered from the digestive tract of several species of fish taken from Lake Oneida, New York, by Van Cleave and Mueller (1934). They considered the worms to be ectopic. Miller reported a new species of *Phyllodistomum* from the urinary tract of the common white sucker, *Catostomus c. commersoni,* which he named *Phyllodistomum lysteri.* The specimens in this collection may well belong to this species as they seem to fit this description in those instances where sufficient development has occurred to differentiate organ structures.

Family Clinostomatidae

Clinostomum Marginatum *(Rudolphi, 1819)* (Fig. 5)

Hosts: *Lepomis humilis, Ictalurus melas.*

Sites of infection: between the rays of the pectoral fins, at the base of all fins, in the flesh, beneath the skin, in the oral cavity, and in the pharynx.

All specimens of this parasite were metacercariae found in various stages of development and encysted in a great variety of body regions. All of the worms were very active and moved about vigorously when removed from their enclosing cyst walls. Orange-spotted sunfish were in all cases lightly infected, seldom carrying more than one or two of these metacercariae which are commonly called the "yellow grub." The black bullheads, however, were very heavily infected. In some bullheads more than a dozen worms were visible externally and upon removal of the skin, often as many more could be found distributed within the myotomes. Even though the yellow perch, *Perca flavescens,* was very abundant in the same area as the infected fish, not one perch was found to harbor the parasite. This is unusual because the yellow perch is considered to be the most common second intermediate host. Bangham (1944) and Edney (1940) have reported heavy infections of ictalurid fish with such metacercariae. In Lake Oneida, New York, according to Van Cleave and Mueller (1934),

> *C. marginatum* is in no way limited to the perch as a second intermediate host. It can infect nearly all species of scaled fish, it would appear, but . . . hosts other than the perch can be dismissed as of very slight or merely accidental importance.

Bullheads taken from every sampling area of Trumbull Lake were found to carry this parasite, indicating a fairly uniform distribution of the helminth throughout the lake.

Late in the summer of 1955, permission was received to collect a limited number of the protected species of birds found in the area. On August 14, 1955, a young great blue heron, *Ardea herodias,* was shot on a sandbar along the west shore of the lake. A thorough examination of the mouth, tongue, and beak failed to indicate the presence of any parasites of this species. When metacercariae, however, were found in the flesh of an undigested fish removed from the crop of the heron, a closer check was initiated. This time 11 specimens were found attached and active half way down the trachea. None of these was mature.

Family Macroderoididae

Alloglossidium corti *(Lamont, 1921)* (Fig. 3)

Synonyms: *Plagiorchis corti* Lamont, 1921; *Plagiorchis ameiurensis* McCoy, 1928; *Alloglossidium kenti* Simer, 1929.

Host: *Ictalurus melas.*

Site of infection: intestine.

A single adult specimen of *Alloglossidium corti* was recovered from the intestine of a northern black bullhead *(Ictalurus melas)* and represented the only collection of this species from Trumbull Lake. The specimen was very active and appeared normal. Positive identification was difficult due to the large number of eggs in the uterus which tended to obscure much of the structural detail.

Plagiorchis corti (family Plagiorchiidae) was originally reported by Lamont (1921) from *Noturus gyrinus,* the tadpole madtom, and constituted the first report of a species of *Plagiorchis* from a fish. McCoy (1928) reported what he considered to be a new species from the yellow bullhead, *Ictalurus natalis.* Having found the cysts of a styleted xiphidiocercaria in a crayfish, McCoy fed them to a bullhead and recovered adult worms which he named *Plagiorchis ameiurensis.* This new species was based upon dimensional differences and upon what McCoy considered to be discrepancies with Lamont's (1921) generic description. Simer (1929) described a similar species from a bullhead which he named *Alloglossidium kenti* (family Allocreadiidae). It was shown by Mueller (1930) that *P. corti* and *P. ameiurensis* were synonyms and by Van Cleave and Mueller (1934) that *P. corti* and *A. kenti* were also synonymous. However, on the basis of the shape of its excretory bladder, Van Cleave and Mueller transferred this species to the genus *Alloglossidium* (family Allocreadiidae). Thus *P. corti, P. ameiurensis,* and *A. kenti* became synonyms of *Alloglossidium corti.*

McMullen (1935) pointed out that members of the genus *Alloglossidium* resemble flukes of the family Plagiorchiidae in most adult structures, but in regard to the form of the excretory bladder are more similar to members of the family Allocreadiidae. He was also able (1937) to show a wide degree of variation in the transitional stages of the excretory bladders of plagiorchid trematodes and hence proposed that *Alloglossidium* be returned to the family Plagiorchiidae because he felt the excretory bladder was no longer a valid character. Hence, in 1937, McMullen proposed a complete reorganization of the superfamily Plagiorchiodea and established a new family, Macroderoididae, to include this controversial genus and a closely related genus, *Macroderoides.*

The life cycle as described by McCoy involves a crayfish as the second intermediate host. McMullen (1935) reported that dragon fly and mayfly naiads may also serve in this capacity. Crawford (1937), too, found these hosts to be involved in the life cycle.

Family Allocreadiidae

Flukes of the family Allocreadiidae constitute a rather controversial group, as was noted in the discussion of *Alloglossidium corti* earlier in this report. Debate has continued concerning the genera to be included in this family. For a more detailed discussion of this problem, such works as Peters (1957), Seitner (1951), Arnold (1934), and Hunter and Bangham (1932) will prove helpful.

ALLOCREADIUM ICTALURI *Pearse, 1924* (Fig. 6)

Synonyms: *Allocreadium halli* Mueller and Van Cleave, 1932.

Host: *Ictalurus melas.*
Site of infection: intestine.

Large robust worms of the genus *Allocreadium* were found in the intestines of three black bullheads. Each fish carried only a few specimens which in every case were adult worms measuring 4.5-5.0 mm. x 1.2-1.7 mm. These allocreadid flukes closely fit the descriptions of the species, *Allocreadium ictaluri,* and fulfill the requirements as set forth by Pearse (1924) and Mueller and Van Cleave (1932). Mueller and Van Cleave believed they had found a new species and described it as *A. halli.* After a more careful comparison, they reduced *A. halli* to synonymy with *A. ictaluri* in a later paper (1934). However, the description of the species in their 1932 paper is excellent. In the specimens taken from Trumbull Lake, a variation in the appearance of the vitelline glands in the region anterior to the acetabulum is apparent. Those vitellaria located in the lateral and posterior regions are comparatively ovoid and follicular in nature, while those located anterior to the acetabulum are distinctly tear-shaped and much less compactly arranged. None of the previous descriptions mentions such a characteristic.

FAMILY LISSORCHIIDAE

In early reports and descriptions of those flukes now considered to belong to the family Lissorchiidae, they were listed as part of the family Allocreadiidae. Magath's (1918) description of *Lissorchis fairporti* represented the initial separation of one of these from the Allocreadiidae. McMullen (1937) completed the division when he established the family Lissorchiidae.

TRIGANODISTOMUM ATTENUATUM *Mueller and Van Cleave, 1932* (Fig. 8)

Host: *Catostomus c. commersoni.*
Site of infection: intestine.

A total of eleven worms of this species was recovered from three common white suckers. The largest number encountered in an individual fish was seven and all fish carried at least two of the helminths. All of the parasitized fish were large suckers taken in gill nets set late in the summer of 1954. Young suckers examined throughout the course of the two summers, however, failed to reveal any additional flukes. Van Cleave and Mueller (1934) reported this parasite from the same host, but suggested it was perhaps most abundant in young suckers. Even though the specimens included in this report fit the generic description as given by Mueller and Van Cleave (1932) and are identified as *Triganodistomum attenuatum* in the key provided by Fischthal (1942), they do not correspond precisely with the figures provided in these reports. Notably, in the illustrations provided by Mueller and Van Cleave, the cirrus and vagina open on the left ventral surface at the level of the acetabulum. The specimens from Trumbull Lake have the cirrus pouch and vagina at the same level except that they open on the right ventral surface of the body.

Haderlie (1950) described a new species, *T. polylobatum,* based primarily upon the number of ovarian lobes. His report did not mention whether or not pressure was used in flattening the worms prior to mounting. This is significant because in mounting worms from the Trumbull Lake collection, all specimens were flattened by coverslip pressure during fixation. In the worms taken from Trumbull Lake it is possible to count from three to seven lobes on the ovary even though the worms are so similar in other respects that it is certain that only one species is involved. Changes which might appear in the shapes of organs as a result of pressure have been clearly illustrated in a report by Ulmer (1950). In his report, it was shown that pressure can sufficiently distort organs so that normally ovoid shapes can become very lobate. On this evidence, it should be apparent that it is most important that mention be made of any pressure used during mounting processes, especially when decribing new species.

To date, the life cycle of one species of *Triganodistomum* is known. Wallace (1941) was able to work out the life history of *T. mutabile* and found that an oligochaete, *Chaetogaster* sp., serves as the second intermediate host. The snails found in Trumbull Lake had many oligochaetes inhabiting the mantle chamber but none of these was identified.

FAMILY BUCEPHALIDAE

BUCEPHALOPSIS PUSILLUM *Diesing (Stafford, 1904)* (Figs. 2 and 4)
Synonyms: *Gasterostomum pusillum* Stafford, 1904; *Bucephalus pusillus* Woodhead, 1930.

Hosts: *Perca flavescens, Lepomis humilis, Lepomis cyanellus, Esox lucius, Ictalurus melas, Pimephales promelas.*

Sites of infection: intestines, gills, intestinal mesenteries.

Since clams were extremely abundant in Trumbull Lake, it was expected that some representatives of the family Bucephalidae, which normally utilize clams as an intermediate host, would occur in the fish. Flukes were found in the digestive tract of six species of fish. The most heavily parasitized species was the yellow perch, but orangespotted sunfish, green sunfish, northern pike, black bullheads, and fathead minnows were also infected. All specimens were minute worms, measuring 0.558-0.713 mm. x 0.184-0.310 mm. when flattened. Although all of the worms appeared to be adults, only those recovered from the intestines of yellow perch, orangespotted sunfish, and black bullheads contained eggs. Van Cleave and Mueller (1934) believed that those species of fish harboring worms devoid of eggs were merely accidental hosts. They reported that *Ictalurus nebulosus* was one such host. In Trumbull Lake, *Ictalurus melas* contained not only mature flukes but was also infected with metacercariae on the gills and in the intestinal mesenteries. Van Cleave and Mueller (1934) refer to personal communications with Woodhead in which Woodhead emphasizes the host specificity of the genus *Bucephalopsis*. On the basis of the variety of hosts listed above, however, it is unlikely that *Bucephalopsis pusillum* is as host specific as was originally suspected. All three of the fish containing mature worms constitute new host records for this species.

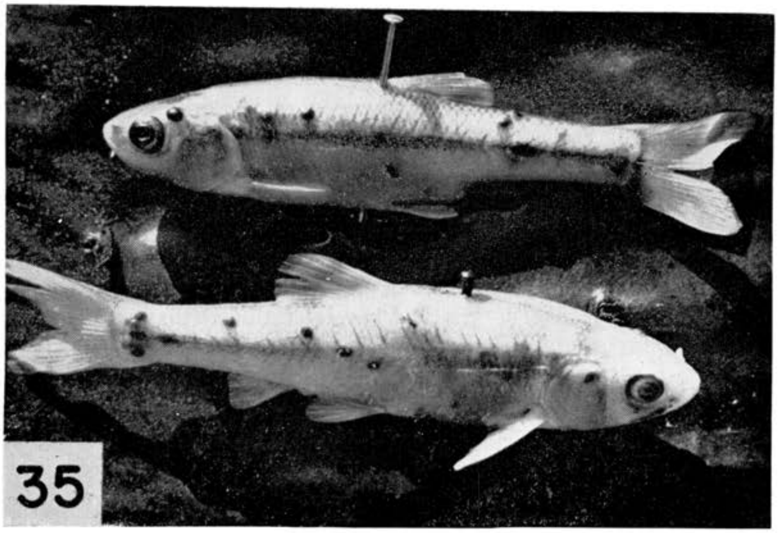
The life cycles of many American bucephalid flukes are unknown. It was reported by Kniskern (1952b) that the freshwater clam, *Anodonta grandis,* serves in the capacity of first intermediate host for *Rhipidocotyle septpapillata*. Clams of the genus *Anodonta* are very abundant in Trumbull Lake. Crofton and Fraser (1954) discussed the possibility that cercariae of *Bucephalopsis gracilescens* may use the lateral line canals to penetrate a fish which serves as the second intermediate host. Cercariae of *Bucephalus* sp. were observed by Woodhead (1927, 1929 and 1930) actively penetrating the fins of a fish, and cysts were later recovered. Development is completed when the cysts are ingested by a predaceous fish. However, the exact method by which the cercariae or metacercariae of *Bucephalopsis pusillum* reach the definitive host is not clear.

The taxonomy of gasterostome trematodes has been sadly confused. Much of this confusion has resulted from earlier works containing descriptions which were based upon a single type of cercaria and an "assumed related adult." Few of these described relationships were ever proven experimentally. As a result, elucidation of the life cycle frequently indicates that the cercaria and adult which previously had been considered as being related to one another, may actually be of two separate genera.

The subgenus *Bucephalopsis* was erected by Diesing in 1855 and was given generic standing by Nicoll in 1914 to include those gasterostomes which lacked processes, papillae, or fimbrae on the anterior sucker. *Bucephalopsis pusillum* was originally described as *Gasterostomum pusillum* by Stafford in 1904. Woodhead redescribed the species as *Bucephalus pusillus* in 1930. However, he apparently failed to observe the absence of processes on the oral sucker, a characteristic differentiating *Bucephalopsis* from *Bucephalus*. Kniskern (1952a), in a systematic review of the family Bucephalidae, again gives *Bucephalopsis* generic standing. In 1937, Nagaty proposed that *Bucephalopsis pusillum* and *Bucephalopsis arcuatus*, a marine form, were identical. Kniskern (1952a) has rejected this proposal on the basis of the opposite environments. The validity of the generic name *Bucephalopsis* has been questioned, too, by Hopkins (1954) because the original subgeneric name *(Bucephalopsis)* was given to a cercaria whose life cycle has never been established. Hopkins contends, therefore, that the name *Bucephalopsis* should be retained for the adult of this cercaria, should its life cycle ever become known. On this basis, he believes that Nicoll should never have raised the name to generic rank and Hopkins has therefore proposed the name *Bucephaloides* for those gasterostomes whose anterior sucker is free of any adornments. However, until detailed life cycles are available and the taxonomy of the group has been clarified, all specimens collected from Trumbull Lake are here considered to be *Bucephalopsis pusillum.*

FAMILY DIPLOSTOMATIDAE

Metacercariae of diplostomatid flukes were especially abundant in the flesh of the bullheads, suckers, and fathead minnows. The livers of many orangespotted sunfish were completely filled with cysts. The flesh of some bullheads was often so heavily infected that myotomes were no longer evident. In other bullheads, the cysts were so numerous that tumor-like growths appeared over much of the body. Fathead minnows carried a heavy infection of a metacercaria forming large cysts located just beneath the skin and surrounded by a sooty-black pigment. This same form encysted within the flesh of the common white suckers. In suckers, the cysts were often so numerous that the meat appeared "peppered." Only the carp was found free from encysted metacercariae. Among these encysted forms, at least five different types were distinguishable on the basis of body form alone (see Figs. 9-21). It was not possible to separate these forms according to hosts or according to areas of encystment because all showed little host specificity. It was also impossible to separate the groups on the basis of host reactions since worms which were similar in morphological details caused "blackspot" in some fish and not in others. In the past, it has been a common practice to list all "blackspot"-causing forms as neascus and to list all parasites encysting in the liver as *Posthodiplostomum minimum*. In the infected fish from Trumbull Lake,



Pimephales promelas (fathead minnow) showing "blackspot" in *situ*.

metacercariae of the diplostomulum and neascus types were found. The black cyst produced in fathead minnows and common white suckers by diplostomulum-type metacercariae was lacking when the parasites were found encysted in golden shiners or yellow perch. Similarly, when neascus-type metacercariae, similar to the forms found in colorless cysts on the liver, encysted elsewhere in the fish, the cyst would be surrounded by the heavy pigment. These concentrations of pigment in the outer cyst walls were thus clearly shown to be of host origin and also shown to be due to a reaction peculiar to various species of fish. To further complicate the host-parasite relations, pleurocercoid stages of tapeworms were often found encysted in the liver. Cysts of this latter type are easily overlooked and confused with those of neascus-type metacercariae unless both have been cleared in some reagent. Comparison of some of my specimens collected from Trumbull Lake with material from Schwink's collection and described by him (1950) indicated that perhaps 25 percent of the cysts in his material from the bluegill contained cestodes. Because of this random distribution of types of helminths, each type of metacercariae will be discussed separately.

DIPLOSTOMULUM *type Brandes*, 1892 (Figs. 12, 14, 16-21)

Synonyms: *Hemistomum* Diesing, 1850; *Tylodelphys* Diesing, 1850; *Proalaria* La Rue, 1926.

Hosts: *Pimephales promelas, Ictalurus melas, Catostomus c. commersoni, Lepomis humilis.*

Sites of infection: flesh, coelom, heart, brain, mouth, head, eyes, and fins.

As in the family Bucephalidae, flukes of this group were first know as larval forms. Since these larvae were described separately, a great deal of confusion arose concerning the taxonomy of this group of metacercariae. It should be noted that *Diplostomum* is a generic name reserved for adult flukes whose life cycles have been established, whereas the name "diplostomulum" is a name applied to a type of metacercaria. Descriptions of this group often include the following: ". . . found encysted in the eyes of fishes." This is no longer a valid criterion for identification as was shown by Hughes (1929), Haderlie (1953), and by data included in this report. "Diplostomulum" is here used to denote those metacercariae which have the following characteristics as noted by Hughes (1929):

. . . 1) fore-body foliaceous, concave ventrally;
2) hind-body present as a small conical prominence on the postero-dorsal part of the fore-body;
3) reserve bladder comprised of a system of more or less definitely arranged tubules with calcareous corpuscles, round or ellipsoidal, disposed in vesicles at the termini of small branches;
4) usually a pair of lateral organs (the so-called lateral suckers) on the antero-lateral edges beside the oral sucker;
5) no true cyst of parasite origin.

The specimens in this collection, with the exception of those metacercariae found in the eyes of an orangespotted sunfish, are generally elongate worms with an indistinctly separated hind-body. Lateral suckers occur adjacent to the oral sucker. The acetabulum is small and is situated just anterior to a large holdfast organ. This general description agrees with that given by Van Cleave and Mueller (1934) for this type of larva. The metacercariae recovered from the eyes of a sunfish are typical of those described for the group and were found free in the vitreous humor of the eye. However, with the exception of those found in the eyes, all metacercariae possessed a cyst of parasite origin. In this respect, some of my specimens differ in the criteria established by Hughes for this group.

One form of diplostomulum which occurred in the myotomes of black bullheads also occurred indiscriminately in the bodies of fathead minnows and common white suckers. In the bullhead, the host cyst was a transparent hyaline sheath covering a similarly transparent, but tougher, parasite cyst. The host cyst laid down by the minnows and suckers was also thin but was always heavily pigmented. With careful dissection, it was possible to remove the entire structure with both walls intact. The outer cyst wall was easily removed with a pair of needles, but pressure from a forceps was required to help break the parasite cyst. The contained metacercaria filled 60-75 percent of the cyst volume and was very active when released into a normal saline solution.

Bullheads were usually heavily infected with several other types of metacercariae, most of which were less abundant than the diplostomulum type. Common white suckers were heavily parasitized. The forms found encysted in the flesh of this host were so similar to those in the bullhead that it was impossible to separate them on the basis of structural details. In spite of this pronounced morphological similarity, the worms found in the suckers were enclosed in a heavily pigmented cyst as compared to the transparent cyst of the bullhead. Pigment granules were noticeable in much of the flesh adjacent to the cyst proper. All ages of suckers were heavily infected, but the degree of parasitism did not increase in the older fish.

Fathead minnows were often so heavily infected that the fish became unsightly due to the black tumor-like cysts. Because this parasitic infection was most prevalent in the minnows, and because of its obvious nature, a more extensive study of this group was made. The cyst walls and included metacercariae are similar in every respect to those described from the common white suckers. In the fathead minnow, however, the pigment was almost exclusively restricted to the host cyst as compared to the more diffuse arrangement in the flesh of the suckers. Hoffman (1954) reports that in his studies the fathead minnow showed a similar pigmentation to that described here but that the same species of parasite produced no such effect when the involved host was a killifish. The cysts found in all three hosts (bullheads, suckers, and fathead minnows) were similar in size, measuring 1.10-1.25 mm. x 0.7-1.02 mm.

The wide variation in the degree of infection of minnows over a period of two years was of considerable interest (see Table 1). In the summer of 1954, more than 90 percent of the minnows taken throughout the summer were infected. As the summer progressed, numbers of fathead minnows showed a precipitous drop in the weekly collections. This may have been due to several factors. It is known that certain minnows have a life span of only a few years. Hoffman (1956) mentions having used age group IV minnows of this species in his studies. A considerable mortality must occur between age groups I and II in Trumbull Lake, however, since only one fish of age group II was found in the entire collection over the two year period. Another factor which must be considered is the effect of the heavy parasite infection. Hoffman (1954) reported that in his experiments with cercariae of *Crassiphialia bulboglossa,* heavily infected fish died in 17-19 days. However, Hoffman also states that he feels natural infections probably do not reach sufficient concentrations to be fatal. Hunter and Hunter (1938) reported that infections with metacercariae caused a significant drop in weight. Krull (1934) found that fish exhibited a pronounced nervous reaction to penetrating cercariae and that heavily infected ones died

Table 1

Summary of Blackspot Infection in Fathead Minnows 1954-1955

	July			August		
	No. examined	No. infected	% infected	No. examined	No. infected	% infected
1954						
Age group 0	219	11	5.02	17	7	41.17
Age group I	414	384	92.90	43	40	93.00
Age group II	1	1	100.00	0	0	0.00
1955						
Age group 0	149	10	6.70	0	0	0.00
Age group I	528	112	21.20	101	81	80.20
Age group II	0	0	0.00	0	0	0.00

in 2-4 days. In experiments concerning the effect of parasitic infections, Hubbs (1927) found that when very young fish became heavily infected, they failed to show normal development. Moreover, infected fish tended to retain larval characters, showed a pronounced increase in scale numbers, and failed to increase the number of vertebrae as they developed. Attempts by Rabideau and Self (1953) to use the K factor (coefficient of condition) in the determination of the effect of parasites on fish, showed that that condition is affected more by related factors such as crowding and food supply. They felt that a fish could support a high parasitic infection if all other conditions were optimal, and likewise, that a low parasitic infection could have a very obvious effect should food be insufficient. Van Haitsma (1930) believed that the penetration of diplostomulum-type cercariae caused the death of many fish in lakes where parasitism was high.

Even though minnows became scarce in the late summer of 1954, the degree of infection did not change. In early July of 1955, minnows were again abundant, but this time the degree of infection was at a low ebb. This fact, coupled with the shortage of age group II fish, led me to believe that few of the infected fish had survived from the preceding year. At the start of the summer (early July) of 1955, the degree of parasitism was below 15 percent. As the summer progressed, the degree of infection climbed rapidly until in late August it had reached the 90 percent plus level of the preceding year. This situation was repeated in every area sampled.

An interesting item of note was a sex differentiation in the infected fish collected in 1955. In 1954 both sexes of fish were uniformly infected (92.0 percent in males; 94.9 percent in females). By mid-July of 1955, 57.5 percent of the females were infected as compared to 28.8 percent of the males. During the week of August 2 to 8 (1955), the degree of infection climbed sharply to the 90 percent level at which time both sexes became equally infected. At the same time the numbers of minnows in the weekly collections showed an abrupt drop similar to that noticed in 1954. These two events seem too closely correlated to be of mere chance. This, plus the evidence given above concerning the pathology of parasitic infections leads me to conclude that the rise in parasitism definitely hastened the disappearance of this group of fish.

DIPLOSTOMULUM HURONENSE *(LaRue) Hughes and Hall, 1929* (Fig. 16)

Host: *Lepomis humilis.*

Site of infection: vitreous humor of the eye.

One orangespotted sunfish showed a clouded condition in a portion of the lens of each eye. Upon dissection of the eye, 12 tiny diplostomulum type flukes were found in the left eye and only one was found in the right eye. The flukes are similar in structural details to those described for *Diplostomum huronense* (Hughes and Hall, 1929). The specimens in this collection measure 0.25-0.30 mm. x 0.20-0.27 mm. However, since no feeding experiments were conducted on this form, it is reported as a metacercaria of a diplostomatid fluke, possibly *Diplostomum huronense.*

DIPLOSTOMULUM CORTI *Hughes, 1929* (Figs. 18-21)

Host: *Ictalurus melas.*

Site of infection: encysted in flesh.

In one specimen of a black bullhead, the entire caudal peduncle was disfigured by tumor-like growths. Upon removal of the skin, the flesh was found to be so filled with trematode cysts that the original myotomes were no longer apparent. Several types of parasites were encysted, including *Clinostomum, Neascus,* and a small diplostomula type metacercaria. The latter fluke was enclosed in a translucent white cyst of host origin. The cyst wall was a loosely defined structure which could not be dissected out. Further indication that the cyst was of host origin was shown when some of the tissues were sectioned and mounted. No cyst of parasite origin could be found.

Hughes (1929) reported that he, too, had found similar conditions of extreme parasitism in bullheads taken from the Illinois River. The specimens collected from Trumbull Lake are pearshaped worms measuring 0.60-0.73 mm. x 0.43-0.48 mm. in an unflattened condition. The hindbody extends as an extension of the postero-dorsal part of the forebody and contains the reproductive fundaments. The forebody is developed as a large concave disc inside of which is located a large holdfast organ, closely associated with an extensive holdfast gland. A small acetabulum is situated at the immediate anterior edge of the holdfast organ. A small oral sucker occurs at the tip of a "cephalic" prominence and the lateral cotylae are apparent at the base of this structure. The excretory system consists of a series of parallel collecting canals which merge and open at the posterior tip of the worm. The average size of the flukes found in Trumbull Lake is less than that described by Hughes (1929) but corresponds closely with measurements given by Haderlie (1953).

When first removed from their cysts, the worms were very active and moved about vigorously, often extending the hindbody into a long tail-like process.

NEASCUS *type metacercariae Hughes, 1927* (Figs. 9, 10, 11, 13 and 15)

Hosts: *Perca flavescens, Lepomis humilis, Lepomis cyanllus, Notemogonus chrysoleucas, Pimephales promelas, Catostomus c. commersoni, Ictalurus melas.*

Sites of infection: liver, intestinal mesenteries, myotomes.

In the past it has been a common practice to include as "neascus" all those flukes causing "blackspot" reactions in the hosts in which they encyst. As used in this report, the term neascus is applied only to those encysted metacercariae having distinct fore and hind bodies set apart by a definite constriction, not possessing lateral suckers, and having an anastomosing system of reserve excretory canals.

Neascus type metacercariae were common in the flesh of black bullheads, in the intestinal mesenteries of yellow perch and golden shiners, and in the livers of green- and orangespotted sunfish. The transparent cysts found in the livers of most of the centrarchid fish in Trumbull Lake contained a neascus type fluke similar to the metacercaria described as *Neascus van cleavei*. This species of fluke has been shown to be the larval form of the adult *Posthodiplostomum minimum*. Van Cleave and Mueller (1934) found what they considered to be representatives of this fluke in 12 species of fish. Hoffman (1956) listed 11 species of fish while Hunter and Hunter (1940) included 23 which they found could serve as second intermediate hosts for other neascus type metacercariae. Ferguson (1943) mentions that morphologically similar forms of *P. minimum* infect both the blackhead (fathead) minnow and the bluegill sunfish. However, after feeding out the metacercariae and later using cercariae produced experimentally he was unable to infect the bluegill with the minnow strain of fluke. Klak (1940) reported that a neascus type metacercaria which caused mortality in fathead minnows did not infect golden shiners, smallmouth bass, or largemouth bass. Hoffman (1950) found that of the 14 species of fish he exposed to *P. minimum* cercariae, only sunfish and bluegills became infected. In the collection from Trumbull Lake, flukes of what appear to be *P. minimum* were taken from a variety of hosts and were found in various regions of the body. In spite of the diversity of hosts and sites of encystment, the enclosed metacercariae appeared to be similar. Hunter and Hamilton (1941) discuss host cysts in the following manner:

> . . . In the case of many representatives of the larval group, *Neascus,* this host cyst is associated with cells containing black pigment, resembling melanophores. Some of these parasites encyst on, between, or just beneath the scales while others migrate into the deeper layers of dense fibrous tissue or even between the muscle bundles themselves. Other tissue penetrating strigeids and *Clinostomum,* however, may enter the same host and come to essentially the same location and yet stimulate the production of an unpigmented connective tissue host cyst. . . .

In my collection the cysts found in the flesh of the black bullheads were thin and transparent, similar to those found in the livers of the sunfish. The intergradations of body forms of those worms found in the livers were such that the specimens found in the myotomes and mesenteries of other species of fish might easily be included as similar forms.

The data listed in the paragraphs above are seemingly inconsistent. Clearly, two situations are presented. Either physiological factors are very important in the determination of host specificity or critical descriptions of the various types of metacercariae are lacking. Whichever be the case, it should be evident that much additional study is required before the taxonomy of this larval group is completely clarified.

TREMATODA: MONOGENEA

Four species of monogenetic trematodes were encountered on the fish taken from Trumbull Lake. It is very likely that many of the flukes of this type were overlooked due to their small size. All of these trematodes were located on the gills of the hosts and often the parasites were smaller than the gill filaments to which they were attached. Because of their small size, they were difficult to prepare as suitable mounts for study. At best, the following identifications were based upon imperfect specimens. The keys used in identifying these trematodes are found in Dawes (1946) and Mizelle (1936).

Family Gyrodactylidae

Gyrodactylus *sp. Von Nordmann, 1832.*

Host: *Perca flavescens.*

Site of infection: gills.

The entire collection of this species consisted of several worms taken from the gills of a yellow perch. It was difficult to make a complete identification because of the poor quality of the preparations. Three species of *Gyrodactylus* have been recorded from North American fish. Van Cleave (1921) described G. *fairporti* from bullheads and carp of Iowa. The other two species, *G. elegans* and *G. medius,* are common European forms. However, neither is consistently reported from American hosts. Haderlie (1953) listed *G. elegans* from the skin and gills of a rainbow trout collected in California.

Family Dactylogyridae

Dactylogyrus *sp. Diesing, 1850*

Host: *Pimephales promelas.*

Site of infection: gills.

Eleven fathead minnows carried specimens of this genus. In all cases, infections were light and no fish harbored more than eight of the flukes. Many of the specimens were broken in attempts to remove them from the gill filaments to which they were attached. Mizelle and Donahue (1944) reported six species of *Dactylogyrus* from the fish of Algonquin Park, Ontario, Canada.

Tetraonchus *sp. Diesing, 1850*

Host: *Notemigonus chrysoleucas.*

Site of infection: gills.

Flukes of the genus *Tetraonchus* were recovered from the gills of two golden shiners. This was the only host to carry the genus in Trumbull Lake. Mizelle and Webb (1953) include four species from North America, most of which had been collected in Alaska.

Ancyrocephalus *sp. Creplin, 1839*

Hosts: *Perca flavescens, Pimephales promelas.*

Site of infection: gills.

The most abundant monogenetic trematodes found in Trumbull Lake were those of the genus *Ancyrocephalus.* These were the only species of flukes which infected more than one species of host and also the only group to occur in any significant number. Holl (1932) listed three species of centrarchid fish which served as possible hosts for this genus. Perch, sunfish, largemouth and smallmouth black bass were included by Hess (1930) as hosts for this group of flukes. In my collection eleven yellow perch and 32 fathead minnows carried this parasite.

Unidentified Tetraonchinae

Hosts: *Perca flavescens, Lepomis cyanellus, Esox lucius, Catostomus c. commersoni, Ictalurus melas.*

Site of infection: gills.

A variety of flukes of the subfamily Tetraonchinae were unidentifiable to genus. Most of these specimens were fragmentary or so badly distorted that further identification was impossible. It is certain that several genera are included in this material but better mounts will be required before a comprehensive report can be made.

CESTODA

Family Proteocephalidae

Proteocephalus pinguis *LaRue, 1911* (Figs. 22-25)

Hosts: *Perca flavescens, Notemigonus chrysoleucas auratus, Lepomis cyanellus, Lepomis humilis, Ictalurus melas* and *Esox lucius.*

Sites of infection: intestine, liver.

Of the 13 species of fish examined, six carried immature tapeworms of the family Proteocephalidae. Pleurocercoids were found in the liver of orangespotted sunfish. Heavy infections of worms possessing well-developed scolices but not showing any indication of segmentation occurred in the intestines of yellow perch, golden shiners, orangespotted sunfish, green sunfish, black bullheads, and northern pike. Adult worms were encountered only in the northern pike. The scolices were hookless, spineless, without any lappets or folds of tissue, and carried four well-developed lateral suckers as well as a smaller apical sucker. All of these suckers were functional. These features were sufficient to place the specimens into the genus *Proteocephalus* (LaRue, 1911). Since none of the species of fish except the northern pike harbored segmenting forms, all of the immature cestodes were tabulated as *Proteocephalus* sp. There was little difference between the structure of the scolices of the immature forms and those of the adult worms so there is reason to believe that all of these worms are of the same species. The extreme host specificity exhibited by this species of cestode suggested it might be *P. pinguis* which has often been reported from the northern pike (LaRue, 1911, 1914; Hunter, 1929; Van Cleave and Mueller, 1934; Hunter and Rankin, 1940; Bangham, 1944; Bangham and Adams, 1954). In each of these reports, *P. pinguis* was the only common species of *Proteocephalus* reported from the northern pike or from northern pike-muskellunge hybrids. In the specimens studied in this collection, the cirrus pouch has an average length of 0.215 mm. and extends approximately one-fifth to one-fourth of the distance across the proglottid. This ratio is based upon the average of measurements taken at various intervals along the same strobilus. In all cases, the vagina is found anterior to the cirrus pouch and passes posteriad across the innermost regions of the cirrus pouch. The uteri contain five to 14 lobes on each side with most proglottids having between seven and 11 lobes. Counts of the testes show a variation of 40 to 89 with the majority between 50 and 74. In some respects, these specimens closely resemble *P. fluviatilis,* a parasite of the black bass in Ohio (Bangham, 1925) which normally has a cirrus pouch measuring between 0.160 mm. and 0.212 mm. and has a ratio of the cirrus pouch to the width of the proglottid varying from 2:7 to 2:9. In *P. fluviatilis,* the testes number 73 to 98 and there are 3-7 lateral uterine outpocketings. The data collected from the specimens in Trumbull Lake indicate characteristics which are common to two groups of the genus *Proteocephalus* according to Wardle and McLeod (1952). However, on the basis of scolex features, number of tests, and number of uterine pouches, these specimens have been assigned to the group *P. pinguis* LaRue (1911). The cestodes in this collection exhibit a considerable degree of variation from proglottid to proglottid. Nevertheless, none of the specimens consistently exceed the limits prescribed for this species except in the dimension of the cirrus pouch.

CORALLOBOTHRIUM FIMBRIATUM *Essex, 1927* (Fig. 27)

Host: *Ictalurus melas.*

Site of infection: intestine.

In each of three black bullheads examined in this study, a single poorly developed cestode consisting of a scolex and several immature proglottids was found. These scolices had many irregular flaps of tissue surrounding the suckers and hence the worms were placed into the genus *Corallobothrium* Essex, 1927. Two species of *Corallobothrium* have been reported from fresh water fish in North America, namely *C. fimbriatum* and *C. giganteum.* The definitive hosts for these species are fish of the family Ictaluridae. There are conflicting data concerning the host specificity of these two forms. Haderlie (1953) found that *C. fimbriatum* infected only *I. nebulosus* and that *C. giganteum* was found only in *I. catus.* Bangham and Hunter (1939), Bangham (1941), and Bangham and Venard (1942) all reported that *C. giganteum* was restricted to *I. catus* but that *C. fimbriatum* was not restricted to this species. Van Cleave and Mueller (1934) too found that *C. fimbriatum* is not restricted to any one species. They reported that worms from all speices of Ictaluridae were small and carried only short strobila as compared to those described by Haderlie (1953). Those specimens of *C. fimbriatum* reported by Van Cleave and Mueller from *I. punctatus* were small and unsegmented, similar to those found in my collection from Trumbull Lake. In view of the descriptions of the scolices given for the two species, *C. fimbriatum* and *C. giganteum,* as described by Essex (1927), the specimens in this collection have been placed in the group *C. fimbriatum.*

Family Caryophyllaeidae

Hunter (1930) recorded 13 species of Caryophyllaeidae of North America from four species of catastomid fish. Haderlie (1953) recorded a new species from another catastomid fish, the Nevada sucker *(Catostomus tahoensis).* Of the 14 known species, four of them, representing two genera, were found to occur in Trumbull Lake. All of these parasites were found in adult common white suckers *(Catostomus c. commersoni)* and in all cases infections were light. When removed from the fish, the worms were an opaque white color and very sluggish. Gravid adults of each species were recovered, but immature forms were restricted to *Glaridacris catostomus.* It is unusual that no other immature stages of any species were found and also that never more than one adult of a single species was taken from a fish, even though several species occurred within that host.

Glaridacris catostomi *Cooper, 1920* (Figs. 26, 31)

Host: *Catostomus c. commersoni.*

Site of infection: intestine.

The genus *Glaridacris* was established by Cooper (1920) to include a single species of non-segmented tapeworm of the family Caryophyllaeidae which he had found in the stomach and intestine of a common white sucker taken from the Illinois River. Of the 18 suckers examined in this survey, three were found to harbor this parasite. In living worms, six shallow suckers were evident on the scolex, but these were not apparent in mounted specimens. After clearing, mounts of immature forms showed very little differentiation of tissues. The scolex appeared devoid of musculature and no indication of genitalia was evident. This condition was also reported in the specimens mounted by Haderlie (1953). Adults of this species, too, show a similar change following clearing but to a less marked degree.

GLARIDACRIS CONFUSUS *Hunter, 1929* (Figs. 28, 33)

Host: *Catostomus c. commersoni.*
Site of infection: intestine.

This species was originally described by Hunter (1929) from the intestine of the smallmouth buffalo fish, *Ictiobus bulbalus,* and from the gizzard shad, *Dorosoma cepedianum,* from the Mississippi River drainages in Iowa, Illinois, and Mississippi. Two of the 18 suckers taken in Trumbull Lake each carried a single specimen of this species. *G. confusus* was first reported from the common white sucker by Van Cleave and Mueller (1934). It is unusual that Hunter did not find the parasite in this fish since it commonly inhabits the same waters as the hosts he reported and is taken frequently from them.

GLARIDACRIS OLIGORCHIS *Haderlie, 1953* (Fig. 32)

Host: *Catostomus c. commersoni.*
Site of infection: intestine.

Seven Nevada suckers *(Catostomus tahoensis)* examined by Haderlie (1953) harbored a caryophyllaeid-type cestode which closely resembled *G. confusus* but which was unique in the small number of testes it contained. *G. confusus* has 25-35 testes but this new form possessed less than 10 and hence Haderlie named it *Glaridacris oligorchis.* Although the specimens described by Haderlie lacked a distinct terminal disc on the anterior end of the scolex, this structure is evident in my collections from Trumbull Lake. Single specimens occurred in only two of the 18 suckers examined. This host, *Catostomus c. commersoni,* represents a new host record for this species.

BIACETABULUM INFREQUENS *Hunter, 1927* (Figs. 29, 30, 34)

Host: *Catostomus c. commersoni.*
Site of infection: intestine.

The four specimens of *Biacetabulum infrequens* encountered in this study were found in four separate fish. The distinctive pair of acetabular suckers was very evident on the scolex of both living and mounted specimens. The original description of this species was based upon specimens recovered from the silver redhorse, *Moxostoma anisurum,* and was first described from the common white sucker by Van Cleave and Mueller (1934).

NEMATODA

Nematode parasites were conspicuously absent in many of the fish examined from Trumbull Lake. Only three species of nematode parasites are represented in the collection and a single specimen constitutes the entire collection of one of those species. Most of the forms were immature and of the few adult forms which did occur, often insufficient specimens were available to identify the worms beyond the genus to which they belonged.

Family Camallanidae

Camallanus (?) ancylodirus *Ward and Magath*, 1917

Host: *Cyprinus carpio.*

Site of infection: intestine.

A single specimen of the genus *Camallanus* was found in the carp taken from Trumbull Lake. The specimen was a small worm and the prepared mount did not show all structures clearly. As a result, this worm cannot be positively identified beyond the genus. However, Ward and Magath (1917) described only two species of this genus from the fish of North America, namely, *Camallanus ancylodirus* and *C. oxycephalus*. *C. ancylodirus* was reported as a parasite of carp found in the Mississippi River whereas *C. oxycephalus* is reported to be a parasite of white bass and crappies. On the basis of hosts alone, this specimen has tentatively been identified as *Camallanus ancylodirus.*

Family Heterocheilidae

Contracaecum spiculigerum *Rudolphi, 1809*

Synonyms: *Ascaris spiculigera* Rudolphi, 1809.

Hosts: *Perca flavescens, Catostomus c. commersoni, Lepomis humilis, Lepomis cyanellus, Esox lucius, Ictalurus melas.*

Site of infection: encysted in intestinal mesenteries.

Large robust nematodes were found encysted in the intestinal mesenteries. The worms were tightly coiled inside the cysts which were distributed in the general vicinity of the duodenum. Upon their removal from the cysts the worms were extremely sluggish. None of the infected fish harbored more than six of the parasites with most of the fish having only two or three. All of the worms were immature forms but were easily identified as *Contracaecum spiculigerum*, a parasite which commonly matures in fish eating birds such as pelicans, cormorants, and water turkeys.

Unidentified nematodes

Hosts: *Perca flavescens, Notemigonus chrysoleucas.*

Site of infection: intestine.

Two golden shiners and a yellow perch each harbored an immature nematode. While all of these worms appeared to be of the same species it was impossible to make a complete identification. Those characteristics which were visible suggested that the worms might belong to the family Hedruridae.

ACANTHOCEPHALA

Famly Rhadinorhynchidae

Leptorhynchoides thecatus *Linton, 1891* (Fig. 1)

Hosts: *Lepomis humilis, Ictalurus melas.*

Sites of infection: intestine, adipose tissues.

A single male acanthocephalan of the genus *Leptorhynchoides* was located in the posterior intestine of an orangespotted sunfish. Though certain features of its proboscis, including the number of hooks present, do not agree precisely with the original description of the genus, the counts nonetheless fall within the prescribed limits as set forth by Lincicome and Van Cleave (1949) in their discussion of the degrees of variation within this genus. After careful examination of the proboscis, the specimen was identified as *Leptorhynchoides thecatus.* Later in the season, on August 8, 1954, several cystacanths (encysted juveniles) were recovered from the adipose tissue of a black bullhead. The term "cystacanth" was proposed by Chandler (1955) to denote those juvenile acanthocephalans which reencyst in a host other than the first intermediate host *(vide infra).* The cystacanths recovered from the adipose tissues of the bullhead were sufficiently developed so that it was possible to count the number of hooks on the proboscis. The specimens were readily assigned to the species *thecatus.*

The life cycle of *L. thecatus* as described by De Giusti (1949) involves an amphipod (*Hyalella* sp.) as the first intermediate host. After the eggs are ingested by the amphipod, the newly hatched acanthor penetrates the intestinal wall and continues to develop in a bladder-like cyst. About 14 days after ingestion of the egg by the amphipod, the acanthor breaks from its cyst and becomes known as an acanthella which lies free in the haemocoel. After development in the amphipod host for 26 days or more, the acanthella becomes infective and becomes sexually mature when eaten by the proper fish. Thus, the normal definitive host for *L. thecatus* is a species of fish. However, should the acanthella be ingested prior to 26 days of development, it will burrow through the intestinal wall of the fish and reencyst (as a cystacanth) even though the fish might be of the species normally utilized as the definitive host (Van Cleave and Mueller, 1934; De Giusti, 1949). This same phenomenon was reported by Van Cleave (1920) in those instances where the species of fish involved was not the normal host utilized. Since adult Acanthocephala have not been reported from the Ictaluridae, the cystacanth stages included in this report were probably involved in a situation similar to that reported by Van Cleave (1920).

NON-HELMINTH PARASITES

Various parasites other than helminths were noted from time to time. Most obvious, perhaps, were small leeches of the genera *Piscicola* and *Placobdella* which occasionally attached to the base of the caudal fin of bullheads and green sunfish. An exceptional case was one leech (*Piscicola* sp.) which was found attached in the oral cavity of an orangespotted sunfish.

Glochidia were found encysted between the fin rays of most of the species of fish and were found encysted in the gill filaments of fathead minnows. Conspicuous white cysts which first appeared to be of helminth origin occurred on the gill filaments of the fathead minnows. Careful dissection, however, failed to reveal any metacercariae. When the contents of the cysts were examined under higher magnification, they were found to be filled with myxosporidia of the genus *Myxosoma*. These were especially common during the late summer of 1955 but had been observed only rarely prior to that time.

DISCUSSION

An examination of the physical features of Trumbull Lake and of its fauna and flora gives an insight into the sources of helminth infections carried by fish of the lake. Trumbull Lake is quite shallow and has many sand or mud bars which extend great distances into it. Due to the siltation from the surrounding farms, the lake has a high fertility which promotes the growth of rooted aquatic plants. The trees and aquatic plants in the area provide cover and food for birds and mollusks. The fauna of the lake includes both predaceous and forage fish as well as a high population of several kinds of mollusks. The shallow waters warm easily and algal blooms flourish. These, in turn, support a high crustacean population including many of those species utilized for food by the fish.

If one examines the trematode infections, two groups of flukes become evident, those which mature in fish and those employing fish as an intermediate host but developing to maturity in some other vertebrate such as a bird or mammal. Of those flukes maturing in fish, it is evident that all of the necessary factors required for the completion of the life cycle are present in abundance. Once the parasite has become introduced, the snails, clams, or arthropods required for first intermediate hosts are available. Should a second intermediate host such as a forage fish, mollusk, or insect be required, these, too, may be found. This type of life cycle involving two intermediate hosts is exemplified by *Allocreadium ictaluri*.

The life cycle of *Clinostomum marginatum* is an excellent example of a fluke requiring a host other than a fish to complete the life cycle. *Clinostomum marginatum* is a parasite of the great blue heron. This bird does not nest in Trumbull Lake but is attracted to it because the shallow bars afford excellent feeding grounds. The droppings of the bird fall into the water where the snails serving as the first intermediate hosts are present. Upon the emergence of the cercariae, suitable fish hosts are also available. When the bird feeds upon the infected fish, infective metacercariae are ingested. Many of the birds which are the definitive hosts for trematodes found in the fish of the lake commonly nest in the area. Some of them nest in the extensive beds of rushes, others nest in trees which overhang the lake. In either case, the droppings from infected birds which contain eggs of the parasites are commonly deposited in the water.

The cestode parasites (tapeworms) of the fish in this lake, insofar as is known, require an arthropod for a first intermediate host and a forage fish to serve as the second intermediate host. A predaceous fish, the northern pike, is present to serve as the definitive host. Since Trumbull Lake provides optimal conditions for the development of parasitic infections, it is not surprising to find such a high percentage of the fish carrying helminth burdens.

Since many of the fish, as a result of helminth infections, are so disfigured that they are unattractive to anglers, it might be well to consider the possible preventive measures. The lake is too small to warrant an extensive dredging program which would deepen the lake and remove many of the shallow areas which attract the aquatic birds. Because of the expense involved in such an undertaking, it would not be practical. Most of the birds in the area are of protected species so it would be impossible to destroy these definitive hosts. Even if such a program were to be initiated it would be necessary to continue it constantly since one infected bird could maintain the infections. Destruction of crustacean and insect hosts is also not practical. If one destroyed these organisms, the food chain of the fish would be broken and fishing would be poor. Another alternative measure would be the removal of the mollusks, in order to interrupt all life cycles of flukes which utilize them as intermediate hosts. Proper use of copper sulphate and other chemicals can be effective in the removal of snails and clams. Removal of these hosts would remove those worms which are responsible for the unsightly cysts in the fish.

Another feature of the lake that would make impractical any major corrective measure is the possibility of winter kill. Lakes of this type, which are so very shallow and high in organic fertilizers, are subject to severe winter kills which can drastically decimate the fish population in one season. Since this survey was completed, the lake has suffered two nearly complete winter kills which have removed all of the larger species of fish.

Since few corrective measures can be undertaken which would permanently correct the problem, it may be of value to consider the situation, *per se*. The most desirable approach to the problem is one which would avoid disturbing the environment or "balance of nature" as might result from any of the above measures. None of the helminths found in the fish from Trumbull Lake parasitize human beings. Hence, even though a person might eat infected fish, worms would not develop to maturity because of their marked host specificity. As a routine precaution, however, fish should be well cooked at all times, regardless of where they are caught. An approach which would not disturb the environment of the area would be to educate the anglers to fish for sport and recreation and not for food. If they did not care to eat the fish, recreational and sport fishing would still be available. None of the fish in Trumbull Lake are so heavily parasitized that they will no longer "bite" on hook and line. It should also be noted that although many of the fish listed in this report are parasitized, many are so lightly infected that the helminths would be obvious only to an experienced worker.

Summary and Conclusions

1. A total of 1,841 fish of varying ages taken from Trumbull Lake, Clay County, Iowa, were examined for helminth parasites.
2. Sixteen species of trematodes representing nine families were found in the 13 species of fish collected.
3. Six species of cestodes were collected which represented two families.
4. Two species of nematodes and one species of Acanthocephala were recovered.
5. Of the 1,433 adult fish examined, 845 fish carried helminths. This represented an overall infection of 58.6 percent.
6. Twenty-three of the 398 young of the year fish carried trematode metacercariae, representing an infection of 5.79 percent. No adult trematodes were ever recovered from this group.
7. An exceedingly high degree of "blackspot" infection (92 percent) in fathead minnows was found to be caused by diplostomulum and neascus types of metacercariae. The effects of these infections upon the weight, development, and mortality are discussed. The hypothesis is advanced that parasitic infections of this type may greatly increase mortality.
8. Possible methods for reducing the degree of parasitism in the lake are discussed.

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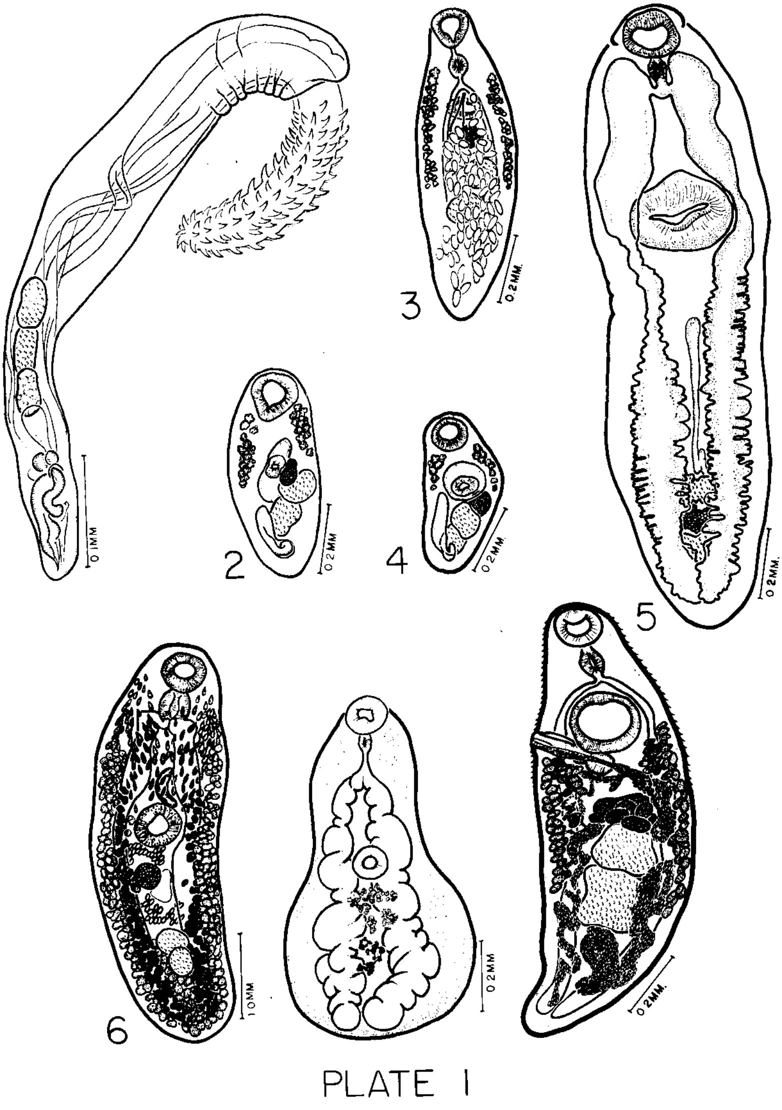

PLATE I

(Plates I, II, and III drawn with the aid of a camera lucida.)

1. ***Leptorhynchoides thecatus*** from ***Lepomis humilis.***
2. ***Bucephalopsis pusillum*** from intestine of *Perca flavescens.*
3. ***Alloglossidium corti*** from ***Ictalurus melas.***
4. ***Bucephalopsis pusillum*** from intestine of ***Pimephales promelas.***
5. ***Clinostomum marginatum*** from fins of ***Ictalurus melas.***
6. ***Allocreadium ictaluri*** from intestine of ***Ictalurus melas.***
7. ***Phyllodistomum*** sp. metacercaria from hepatic ducts of ***Catostomus c. commersoni.***
8. ***Triganodistomum attenuatum*** from intestine of ***Catostomus c. commersoni.***

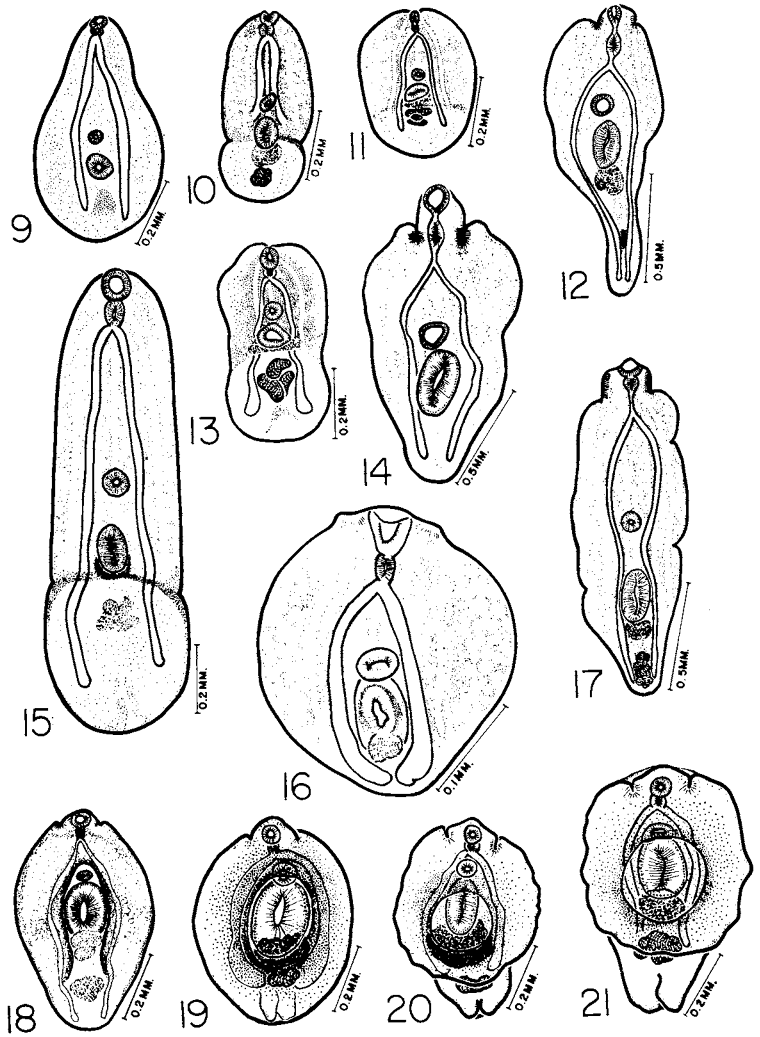

PLATE II

(All specimens in this plate unflattened unless indicated otherwise.)

9. Neascus type metacercaria after heavy flattening.
10 and 11. Normal neascus type metacercariae from liver of *Lepomis humilis.*
12. Diplostomulum type metacercaria from "blackspot" cysts in *Pimephales promelas.*
13. Neascus type metacercaria from cysts in the flesh of *Ictalurus melas.*
14. Diplostomulum type metacercaria from *Pimephales promelas.*
15. Neascus type metacercaria from liver of *Lepomis humilis.*
16. *Diplostomulum huronense* from eye of *Lepomis humilis.*
17. Diplostomulum type metacercaria from flesh of *Catostomus c. commersoni.*
18 - 21. *Diplostomulum corti* from flesh of *Ictalurus melas.*
(18, flattened specimen; others unflattened.)

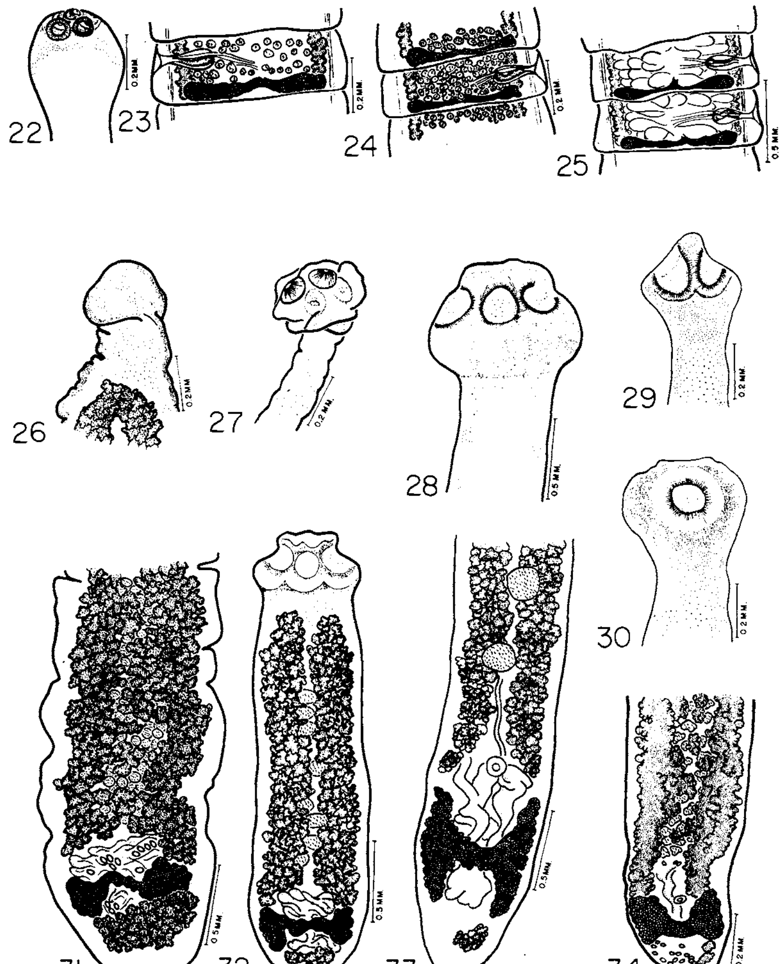

PLATE III

22. Scolex of *Proteocephalus pinguis* from *Esox lucius.*
23. Immature proglottid of *P. pinguis.*
24. Mature proglottid of *P. pinguis.*
25. Gravid proglottid of *P. pinguis.*
26. Scolex of *Glaridacris catostomi* from intestine of *Catostomus c. commersoni.*
27. Scolex of *Corallobothrium fimbriatum* from *Ictalurus melas.*
28. Scolex of *Glaridacris confusus* from *Catostomus c. commersoni.*
29. Scolex of *Biacetabulum infrequens,* lateral view.
30. Dorsal view of same.
31. Posterior portion of *Glaridacris catostomi.*
32. *G. oligorchis* from intestine of *Catostomus c. commersoni.*
33. Posterior portion of *G. confusus.*
34. Posterior portion of *B. infrequens* from *Catostomus c. commersoni.*

Table 2

Host Records

Species	Common name	Adult fish[a]		Young of year fish	
		No. ex.	No. inf.	No. ex.	No. inf.
1. *Catostomus c. commersoni* (Lacepede)	Common white sucker	18	18	6	6
2. *Lepomis cyanellus* (Rafinesque)	Green sunfish	6	6	–	–
3. *Lepomis humilis* (Girard)	Orangespotted sunfish	35	35	38	0
4. *Cyprinus carpio* (Linnaeus)	Carp	1	1	–	–
5. *Pimephales promelas* (Rafinesque)	Fathead minnow	1145	623	236	17
6. *Notropis lutrensis* (Baird & Girard)	Plains red shiner	1	1	–	–
7. *Notropis deliciosus* (Girard)	Sand shiner	62	34	9	0
8. *Notemigonus chrysoleucas* (Rafinesque)	Western golden shiner	62	34	109	0
9. *Fundulus diaphanus menona* (Jordan & Copeland)	Western banded killifish	8	2	–	–
10. *Esox lucius* (Linnaeus)	Northern pike	9	9	–	–
11. *Eucalia inconstans* (Kirtland)	Brook stickleback	1	1	–	–
12. *Ictalurus melas* (Rafinesque)	Northern black bullhead	26	26	–	–
13. *Perca flavescens* (Mitchill)	Yellow perch	69	55	–	–

[a]All fish included are at least one year old, i.e., in their second season of growth.

Table 3

Parasite Records (Figures Indicate Number of Fish Parasitized)

	Comm. white sucker	Green sunfish	Or. spotted sunfish	Carp	Fathead minnow	Plains red shiner	Sand shiner	W. golden shiner	W. bdd. killifish	Northern pike	Br. stickleback	N. black bullhead	Yellow perch
Trematoda													
Allocradium ictaluri	–	–	–	–	–	–	–	–	–	–	–	3	–
Alloglossidium corti	–	–	–	–	–	–	–	–	–	–	–	1	–
Bucephalopsis pusillum	–	1	2	–	5	–	–	–	–	2	–	2	14
Clinostomum marginatum	–	–	2	–	–	–	–	–	–	–	–	23	–
Diplostomulum corti	1	–	–	–	–	–	–	1	–	–	–	26	–
Diplostomulum huronense	–	–	1	–	–	–	–	–	–	–	–	–	–
Diplostomulum sp. metacercariae	13	4	1	–	623	–	32	8	2	2	1	17	18
Neacus sp. metacercariae	–	5	20	–	109	1	–	29	–	–	–	16	1
Phyllodistomum sp.	1	–	–	–	–	–	–	–	–	–	–	–	–
Posthodiplostomum minimum	–	5	32	–	–	–	–	2	–	–	–	–	–
Triganodistomum attenuatum	3	–	–	–	–	–	–	–	–	–	–	–	–
Ancyrocephalus sp.	–	–	–	–	32	–	–	–	–	–	–	–	11
Dactylogyrus sp.	–	–	–	–	11	–	–	–	–	–	–	–	–
Tetraonchus sp.	–	–	–	–	–	–	–	2	–	–	–	–	–
Unidentified Tetraonchinae	1	1	–	–	–	–	–	–	–	2	–	1	3
Gyrodactylus sp.	–	–	–	–	–	–	–	–	–	–	–	–	1
Cestoda													
Biacetabulum infrequens	4	–	–	–	–	–	–	–	–	–	–	–	–
Corallobothrium fimbriatum	–	–	–	–	–	–	–	–	–	–	–	3	–
Glaridacris catastomi	3	–	–	–	–	–	–	–	–	–	–	–	–
Glaridacris confusus	2	–	–	–	–	–	–	–	–	–	–	–	–
Glaridacris oligorchis	2	–	–	–	–	–	–	–	–	–	–	–	–
Proteocephalus sp.	–	4	11	–	–	–	–	2	–	9	–	2	41
Proteocephalus pinguis	–	–	–	–	–	–	–	–	–	9	–	–	–
Nematoda													
Camallanus sp.	–	–	–	1	–	–	–	–	–	–	–	–	–
Contracaecum spiculigerum	–	4	1	–	2	–	–	–	–	3	–	1	2
Unidentified Nematoda	–	–	–	–	–	–	–	2	–	–	–	–	1
Acanthocephala													
Leptorhychoides thecatus	–	–	1	–	–	–	–	–	–	–	–	1	–

Table 4

Parasites of Trumbull Lake Fish, Listed by Hosts

Host & number examined	Parasite	Number infected	Percent infected
1. Common white sucker (18)			
	Phyllodistomum sp.	1	5.6
	Triganodistomum attenuatum	3	16.7
	Diplostomulum sp. met.	13	72.3
	Diplostomulum corti	1	5.6
	Unidentified Tetraonchinae	1	5.6
	Biacetabulum infrequens	4	22.2
	Glaridacris catostomi	3	16.7
	Glaridacris confusus	2	11.2
	Glaridacris oligorchis	2	11.2
2. Green sunfish (6)			
	Bucephalopsis pusillum	1	16.7
	Diplostomulum sp. met.	4	66.7
	Neascus sp. met.	5	83.3
	Posthodiplostomum minimum	5	83.3
	Unidentifed Tetraonchinae	1	16.7
	Proteocephalus sp.	4	66.7
	Contracaecum spiculigerum	4	66.7
3. Orangespotted sunfish (35)			
	Clinostomum marginatum	2	5.8
	Bucephalopsis pusillum	2	5.8
	Diplostomulum sp. met.	1	2.9
	Diplostomulum huronense	1	2.9
	Neascus sp. met.	20	57.1
	Posthodiplostomum minimum	32	91.5
	Proteocephalus sp.	11	31.2
	Contracaecum spiculigerum	1	2.9
	Leptorhynchoides thecatus	1	2.9
4. Carp (1)			
	Camallanus sp.	1	100.0
5. Fathead minnow (1,381)			
	Bucephalopsis pusillum	5	0.4
	Diplostomulum sp. met.	623	45.1
	Neascus sp. met.	109	7.9
	Ancyrocephalus sp.	32	2.3
	Dactylogyrus sp.	11	0.8
	Contracaecum spiculigerum	2	0.1
6. Plains red shiner (1)			
	Neascus sp. met.	1	100.0
7. Sand shiner (62)			
	Diplostomulum sp. met.	34	55.0
8. Western golden shiner (62)			
	Diplostomulum sp. met.	8	12.9
	Diplostomulum corti	1	1.61
	Neascus sp. met.	29	46.8
	Posthodiplostomum minimum	2	3.23
	Tetraonchus sp.	2	3.23
	Proteocephalus sp.	2	3.23
	Unidentified nematodes	2	3.23

(Continued on Next Page)

Table 4 (Continued)

Host & number examined	Parasite	Number infected	Percent infected
9. Western banded killifish (1)			
	Diplostomulum sp. met.	1	100.0
10. Northern pike (9)			
	Bucephalopsis pusillum	2	22.2
	Diplostomulum sp. met.	2	22.2
	Unidentified Tetraonchinae	2	22.2
	Proteocephalus pinguis	9	100.0
	Proteocephalus sp.	9	100.0
	Contracaecum spiculigerum	3	33.3
11. Brook stickleback (1)			
	Diplostomulum sp. met.	1	100.0
12. Northern black bullhead (26)			
	Clinostomum marginatum	23	88.5
	Alloglossidium corti	1	3.8
	Allocreadium ictaluri	3	11.0
	Bucephalopsis pusillum	5	19.2
	Diplostomulum sp. met.	17	65.5
	Diplostomulum corti	26	100.0
	Neascus sp. met.	16	61.5
	Unidentified Tetraonchinae	1	3.8
	Proteocephalus sp.	2	7.5
	Corallobothrium sp.	3	11.5
	Contracaecum spiculigerum	1	3.8
	Leptorhynchoides thecatus	1	3.8
13. Yellow perch (69)			
	Bucephalopsis pusillum	14	20.3
	Diplostomulum sp. met.	18	26.1
	Neascus sp. met.	1	1.45
	Ancyrocephalus sp.	11	16.0
	Unidentified Tetraonchinae	3	4.4
	Gyrodactylus sp.	1	1.45
	Proteocephalus sp.	41	59.5
	Contracaecum spiculigerum	2	2.9
	Unidentified nematodes	1	1.45

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