



Parasite incidence in relation to size and condition of trout from two Montana lakes
by Alfred C Fox

A THESIS Submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree
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Abstract:

Rainbow trout (*Salmo gairdneri*) were taken from Cliff Lake and brown trout (*Salmo trutta*) and rainbow trout were collected from Meadow Lake, southwestern Montana during the summer of 1959. Parasites were predominant in the digestive tracts of rainbow trout from Cliff Lake. Meta-cercarial cysts, located in the musculature, were most common in rainbow and brown trout from Meadow Lake. Trout, from both lakes, were observed to have greater numbers of parasites accompanying increased length. The metacercaria of *Bolbophorus confusus* is reported for the first time from North America. It was found to be common in the rainbow and brown trout from Meadow Lake. Cysts were generally distributed over the body of the fish but they occurred in greater numbers anteriorly and dorsally. The fewest cysts were found in the posterior portions near the caudal fin. No important effects of parasite incidence on condition of trout was determined.

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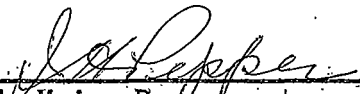
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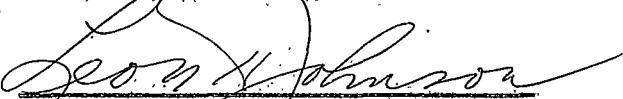
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Abstract

Rainbow trout (Salmo gairdneri) were taken from Cliff Lake and brown trout (Salmo trutta) and rainbow trout were collected from Meadow Lake, southwestern Montana during the summer of 1959. Parasites were predominant in the digestive tracts of rainbow trout from Cliff Lake. Metacercarial cysts, located in the musculature, were most common in rainbow and brown trout from Meadow Lake. Trout, from both lakes, were observed to have greater numbers of parasites accompanying increased length. The metacercaria of Bolbophorus confusus is reported for the first time from North America. It was found to be common in the rainbow and brown trout from Meadow Lake. Cysts were generally distributed over the body of the fish, but they occurred in greater numbers anteriorly and dorsally. The fewest cysts were found in the posterior portions near the caudal fin. No important effects of parasite incidence on condition of trout was determined.

Introduction

Although numerous investigations have been made on parasite infestations in fish, very few concern the effects of parasites on the growth rate and condition of cold water fish. A comprehensive study by Woodbury (1940) revealed no apparent deleterious effects of parasites on the condition of yellow perch (Perca flavescens) in Walsh Lake, Michigan. Conversely, Hubbs (1927), Cross (1934, 1935), Richardson (1936), Langlois (1937), Hunter and Hunter (1938), and Hoffman (1956) found harmful effects of parasites on the condition of fish hosts.

The present investigation concerns the effects of parasites on the growth rate and condition of rainbow trout (Salmo gairdneri) and brown trout (Salmo trutta). The objectives of the study were twofold: to obtain information on distribution of parasites within the body of the fish, and to determine parasite incidence in relation to growth rate and condition.

Fish were collected from Cliff Lake and Meadow Lake in southwestern Montana. These areas were selected because of known parasite infestation of trout. Cliff Lake is located about 40 miles southeast of Ennis, Montana. It lies at an elevation of 6313 feet (mean sea level) and is surrounded by high cliffs. It has an area of 620 acres and a shoreline of about 13 miles. The maximum depth is 125 feet and most of the lake has a depth in excess of 40 feet. Meadow Lake, an impoundment on the Madison River, is located about five miles north of Ennis, Montana. The lake has a maximum surface area of 1945 acres and lies at an elevation of 4840 feet. The maximum depth is 38 feet, but most of the lake is less than 15 feet in

depth.

Rainbow trout were collected in Cliff Lake from early June through September 1959. Both rainbow and brown trout were secured in Meadow Lake from early August through September. Fish collections were made by 125-foot experimental gill nets (mesh 0.75 - 1.5 inches). Total lengths to the nearest 0.1 inch and weights to the nearest 0.01 pound were obtained for all fish taken. Specimens were iced and transported to the laboratory where they were frozen for future examination.

Host Examination

The fish were thawed only to the point where the viscera could easily be removed. All fins were then removed flush with the body and the head was cut off as shown in figure 1. This method of decapitation severed the

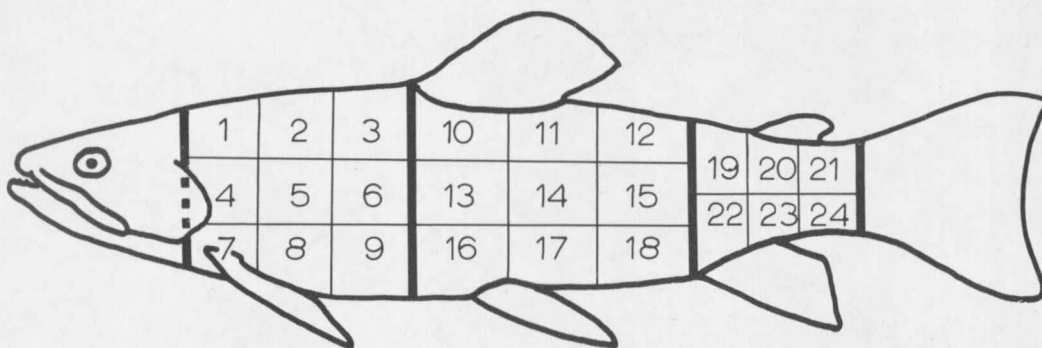


Fig. 1. Diagram of fish showing "portions" (heavy vertical lines) and "sections" (numbered areas) used in mapping distribution of parasites.

esophagus at a point immediately anterior to the base of the pectoral fins.

A mid-ventral incision permitted removal of the viscera. The body cavity and visceral organs were examined for parasites. The digestive tract was opened and its content thoroughly flushed into a container. The content of the tract was carefully decanted until most extraneous material had been removed. That remaining was microscopically examined and all parasites were removed and preserved. An examination of the digestive tract was then made to locate any encysted parasites.

The partially thawed body of the fish was cut into two parts along the median saggital line. Each part was then cut into three portions (Fig. 1). These portions were weighed to the nearest 0.01 gm. and then subdivided into sections (Fig. 1). The flesh in each section was teased apart, under a microscope, to locate encysted parasites. When a parasite was found its approximate position, in the section, was recorded (Fig. 2).

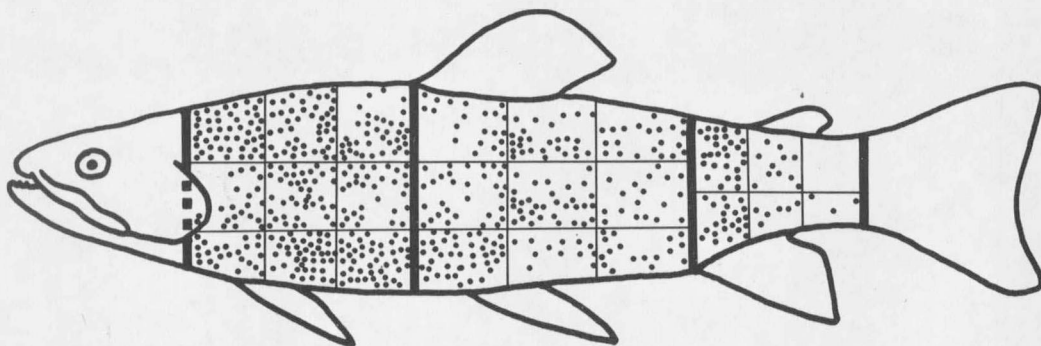


Fig. 2. Distribution of metacercariae on left side of brown trout from Meadow Lake. Each dot represents one metacercarial cyst.

Parasite Incidence and Condition of Trout

Cliff Lake Rainbow Trout. The rainbow trout population of Cliff Lake is believed to consist largely of hatchery fish. Stocking records show that 35,000 rainbow trout (4 - 10 in. total length) were planted during the eight month period immediately preceding this study. Fin deformities characteristic of recently introduced hatchery fish were noted for 18 of 69 fish collected. Abundance of hatchery fish was further indicated by the scale samples taken. Difficulty was encountered in locating true annulus marks on most scale samples and it was not possible to age these fish. All parasitized trout taken from Cliff Lake were arranged by length groups and the average number of parasites was obtained for each group (Table 1). Condition of trout was determined by the following:

$$C = \frac{w \cdot 100,000}{l^3}$$

where w = weight and l = length.

Parasites were found in 54 of 69 trout examined. These were confined to the digestive tracts except in two fish which had nematodes (Eustrongylides sp.) encysted in the musculature. The parasites found in the digestive tracts included: nematodes (unidentified), cestodes (Dibothriocephalus sp.), acanthocephalans (Neoechinorhynchus sp.), and trematodes (Crepidostomum farionus). Nematodes occurred in 47 trout and were usually located in the pyloric caecae and intestines. The average number per fish for each collection period was as follows: 7.0 in June; 27.5 in August; 19.3 in September. The greatest number found in any one fish was 238. Cestodes occurred in 44 trout and were found in the same areas as nema-

Table 1. Length and condition of rainbow trout from Cliff Lake, showing the kinds and numbers of parasites.

Total length in inches	Number of fish	Average number of parasites				Average number of parasites per length group	Average C- factor per length group
		Nema- todes	Cestodes	Acantho- cephalans	Trema- todes		
7.0 - 7.9	1	3.0	-	-	1.0	4.0	43.8
8.0 - 8.9	2	6.0	4.5	-	1.5	12.0	39.2
9.0 - 9.9	4	1.7	2.0	1.7	0.7	6.2	38.1
10.0 - 10.9	13	3.3	5.1	5.2	4.1	17.7	32.9
11.0 - 11.9	12	5.7	6.4	6.1	2.9	21.2	31.5
12.0 - 12.9	8	9.0	12.4	2.1	1.7	25.2	31.0
13.0 - 13.9	7	34.4	5.3	21.1	3.1	64.1	34.6
14.0 - 14.9	6	48.7	5.2	3.8	-	57.6	35.3
15.0 - 15.9	-	-	-	-	-	-	-
16.0 - 16.9	1	238.0	1.0	4.0	2.0	245.0	38.6

todes. The average number per fish for each collection period was as follows: 8.0 in June; 4.5 in August; 5.9 in September. The greatest number found in any one fish was 20. Acanthocephalans occurred in 34 trout and were usually located in the stomach and intestines. The average number per fish for each collection period was as follows: 17.1 in June; 3.2 in August; 2.1 in September. The greatest number found in any one fish was 116. Trematodes occurred in 31 trout and were found in the same areas as acanthocephalans. The average number per fish for each collection period was as follows: 3.4 in June; 2.0 in August; 2.2 in September. The greatest number found in any one fish was 19.

The average C-factor of the 15 non-parasitized trout was higher (37.7) than that of the 54 parasitized trout (33.7). The difference in C-factor is appreciable and may be due to either parasite infestation or the presence of newly planted fish. Twelve of the non-parasitized trout had fin deformities and corresponded in size to fish of recent hatchery plants. Hatchery trout were known to have a higher C-factor than wild fish.

In general the longer the trout the greater the number of individual parasites and kinds of parasites it contained (Table 1). This could have resulted from a longer exposure time since body length is generally determined by age. No individual parasite group (nematodes, cestodes, acanthocephalans, trematodes) or combination of groups appeared to influence length or condition more than any other group or combination. It was noted, however, that fish with no more than two kinds of parasites had

an average C-factor of 35.0 and an average total length of 10.8 inches while those with three or four kinds had an average C-factor of 32.2 and an average total length of 12.0 inches.

Meadow Lake Brown Trout. Thirty brown trout from Meadow Lake were examined and all were found to be parasitized. Metacercariae, tentatively identified as Bolbophorus confusus or some closely related species, were the most numerous parasite and occurred in all fish. A nematode (Eustrongylides sp.) was found in five trout. Another species of nematode was found in the digestive tract of one fish. This closely resembled the nematodes found in rainbow trout from Cliff Lake.

Metacercarial cysts were most common in the musculature immediately underlying the integument, but a few were deeply embedded. Cysts were also found in the integument and fins. The lemon-shaped host cysts were 850 - 1500 μ long and 550 - 1000 μ wide. They were either black or white in color. These cysts were first thought to be separate species, but later the white cysts were deemed to be more recently encysted metacercariae than the black. Metacercariae in the black cysts were similar to those in the white cysts, but were larger and had better developed gonads. The average lengths of metacercariae were 2341 μ from 100 black host cysts and 2021 μ from 100 white host cysts.

The fluke, Bolbophorus confusus, is reported as being common in Europe. However the adult of this species has been reported only once on this continent and here the host was a pelican (Pelicanus sp.). The metacercaria has not been previously reported in North America. The intermediate fish hosts of this species in Europe are members of the Cyprinidae,

Esocidae, Mugilidae, and Percidae. The cercaria and snail host are unknown, but the final host is a pelican.

The nematode, Eustrongylides sp., was found encysted in the musculature (adjacent to the body cavity), the stomach wall, liver, ovaries, and small intestine. In a few instances the cysts were sac-like and suspended from these organs. Nematodes were tightly coiled in the disc-shaped cysts which averaged about 13 mm. in diameter and about 5 mm. thick. The worms were bright red in color and averaged about 57 mm. in length when extended.

The average number of metacercarial cysts per fish was 194 with a range of 4 to 1141. The distribution and number of metacercarial cysts was determined for each body portion and section (Fig. 2) of each fish. There was no significant difference (at the 99 percent level) between the number of cysts found in either side of the fish. More cysts (48 percent) were found in the anterior than in the central (42 percent) or posterior (10 percent) portions. The number of cysts was greater in the dorsal sections of the anterior and central portions, than it was in the central or ventral sections of these portions. The section (10) under the dorsal fin, had most cysts (8.4 percent of total), while the two most posterior sections (21 and 24) contained the fewest cysts (0.61 and 0.55 percent respectively).

Brown trout taken from Meadow Lake were aged, by the scale method, and determined to be from the year classes II, III, IV, and V. The average number of metacercariae in 20 trout, of year classes IV and V, was 293

and that for 10 trout, of year classes II and III, was 67. The greater number of metacercariae in the older fish probably resulted from a longer exposure period.

The average length of trout in year classes IV and V was 16.4 inches (total length) and that of fish in year classes II and III was 14.3 inches (total length). Thus the longer fish were more heavily parasitized than the shorter fish.

The average C-factor of 30 brown trout was 34.4 and the range was 28.0 to 41.3. Despite the wide range, no relationship could be found between C-factor and numbers of metacercariae. The average C-factor of 13 fish that had over 100 metacercariae was 34.4 and that for 17 fish with less than 100 metacercariae was 34.5. No appreciable differences could be determined between trout infested with metacercariae and other parasites (nematodes and trematodes) or those infested with only metacercariae.

Meadow Lake Rainbow Trout. The rainbow trout population of this lake is believed to consist largely of hatchery fish. Stocking records show that about 70,000 rainbow trout (9 - 10 in. total length) were planted during the two year period immediately preceding this study. Fin deformities characteristic of recently introduced hatchery fish were noted in nine of 30 fish collected. Abundance of hatchery fish was further indicated by the scale samples taken. Difficulty was encountered in locating true annulus marks on most scale samples and it was not possible to age them.

Parasites were found in 25 of 30 trout examined. The metacercaria of

Bolbophorus confusus, located in the musculature, was the most numerous parasite and occurred in all 25 trout. Unidentified nematodes were found in the digestive tracts of five trout. These closely resembled those found in rainbow trout from Cliff Lake. The fluke, Crepidostomum farionus, occurred in the digestive tracts of four fish. Parasite infestation, of the digestive tracts of these trout, was considered light, since the greatest number of parasites found in any one fish was seven.

The average number of metacercarial cysts per fish was 34 with a range of 1 to 167. There was no significant difference (at the 99 percent level) between the number of cysts found in either side of the fish. More cysts were located in the central (46 percent) than in the anterior (41 percent) or posterior (13 percent) portions. The number of cysts was greater in the dorsal sections of the anterior and central portions than it was in the central or ventral sections of these portions. The greatest number of cysts (9.9 percent of total) was found in the section (10) under the dorsal fin and the fewest cysts (1.0 percent of total) were found in the posterior section (24).

The number of metacercarial cysts was generally greater in the longer fish. Fourteen trout (14.0 - 16.1 in. total length) had an average of 58 metacercariae while 11 trout (9.1 - 13.9 in. total length) averaged 15 metacercariae. Since length is generally determined by age the longer fish would be older and exposed to infestation for a longer time.

The average C-factor of parasitized trout was 35.5 and that of non-parasitized trout 33.6. Nine fish which averaged more than 34 meta-

cercariae had an average C-factor of 34.5 while 16 fish with less than 34 metacercariae averaged 36.0 and five trout without parasites had an average C-factor of 33.6. Due to the small sample size and presence of hatchery fish no significance can be attached to these minor differences in condition.

The longer trout from both Cliff and Meadow Lakes generally had greater numbers of parasites than the shorter fish. This agrees with Woodbury (1940) in his studies of Clinostomum marginatum in perch. He summarized 12 previous investigations and reported that the longer fish had greater numbers of parasites in nine of these studies. Conversely, Langlois (1936) found that the shorter bass fingerlings had the largest number of Proteocephalus ambloplitis larvae. Hubbs (1927) showed that the effect of Proteocephalus ambloplitis larvae on Hybopsis gracilis was similar to that found by Langlois (1936).

My study on trout from Cliff and Meadow Lakes showed little relationship between the parasite incidence and condition of trout. It is possible that blood tests, stamina tests, and analysis of fecundity will show that parasite incidence does effect the condition of trout.

Acknowledgements

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James E. McCauley identified Crepidostomum farionus, Dibothriocephalus sp. and Neoechinorhynchus sp. The writer is also indebted to James P. Fry and Kenneth Muller who provided assistance in the field. Appreciation is also extended to the owners of Nealley's Resort and Meadow Lake Lodge for the many kindnesses and assistance they provided. The Montana Agricultural Experiment Station furnished some financial assistance and the Montana Fish and Game Department supplied certain equipment.

Summary

1. Rainbow trout were taken from Cliff Lake, and brown trout and rainbow trout were collected from Meadow Lake, southwestern Montana.

2. A total of 69 rainbow trout from Cliff Lake; 30 rainbow trout and 30 brown trout from Meadow Lake collected from early June through September 1959 was examined for parasites.

3. Rainbow trout from Cliff Lake were infested with parasites in the digestive tract including: nematodes (unidentified), cestodes (Dibothriocephalus sp.), acanthocephalans (Neoechinorhynchus sp.), and trematodes (Crepidostomum farionus).

4. The rainbow and brown trout from Meadow Lake were severely infested with a metacercaria, tentatively identified as Bolbophorus confusus. These parasites were largely located in the musculature immediately underlying the integument.

5. The metacercaria of Bolbophorus confusus has not been previously reported for North America.

6. Metacercarial cysts were most numerous along the dorsal surface

of the fish and in the anterior body region. The greatest concentration of cysts was in the musculature ventral to the dorsal fin.

7. The longer trout from both lakes were found to contain more parasites than the shorter ones.

8. No appreciable deleterious effects of parasites on condition of the fish hosts were found.

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