THE YELLOW PERCH FISHERIES OF DEER CREEK RESERVOIR, UTAH, WITH NOTES ON PARASITISM BY *LIGULA INTESTINALIS*

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Deer Creek Reservoir is a major sport fisheries area in north central Utah. A deep, cold, and moderately productive reservoir, Deer Creek should provide a fine environment for fisheries development. However, fish management problems are complicated by an abundance of small, mature yellow perch (*Perca flavescens*). This study provides an analysis on the utilization and condition of Deer Creek perch.

The dam, located along the Provo River 16 km southwest of Heber, Utah, supplies culinary and irrigation water for 18 municipalities and communities of north central Utah. With a maximum surface of 2680 acres, the reservoir has a capacity of 152,564 acre feet of water.

As is typical of many temperate zone reservoirs, Deer Creek experiences spring and fall overturn and is chemically and thermally stratified during summer months. Dissolved oxygen content remains high (8-11 mg/l) in the epilimnion, and total hardness ranges from 170-222 mg/l.

At present the reservoir sustains a community of 10 species of fish (see Table 1). All but the rainbow trout and kokanee have natural reproduction in the reservoir habitat. Only the mountain whitefish, Utah sucker, and Utah chub were original inhabitants of this region of the Great Basin.

Methods

Data on perch utilization were gained through use of a creel census from 13 May to 15 September 1968. Interviews were taken three days a week, alternating days in order to effectively cover each day of the week. Boat and shore fishermen from all sections of the reservoir were included in the census.

Specimens were collected using four techniques: those supplied by creel census information, experimental gill net, shocking, and seine. This combination was used in order to reduce bias of any one method and to insure capture of smaller fish.

Standard and total length measurements were determined to the nearest millimeter for each specimen. Weight in grams was taken from a spring scale, adapted for field use. All fish scale samples were removed from the anterior right side, both above and below the lateral line. Cellulose acetate impressions were made from the scales and analyzed according to year class.

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TABLE 1. Common and scientific names for all species of fish collected from Deer Creek Reservoir, Utah, 1968.

Perca flavescens Mitchill (yellow perch)
Micropterus salmoides Lacepede (largemouth bass)
Onchorhynchus nerka Walbaum (kokanee salmon)
Cyprinus carpio Linnaeus (carp)
Lepomis cyanellus Rafinesque (green sunfish)
Gila atraris Girard (Utah chub)
Salmo trutta Linnaeus (brown trout)
Prososopium williamsoni Girard (mountain whitefish)
Catostimus ardens Jordan and Gilbert (Utah sucker)
Salmo gaindnerii Richardson (rainbow trout)

Perch stomachs were placed in individual cotton bags and stored in 10% formalin solution. A volumetric displacement analysis for food types was utilized and organismal recognition made under a dissecting microscope. The number of parasitic tapeworm larvae was recorded from the coelom of each fish.

RESULTS

Utilization by Fishermen

Since there is no bag or possession limit on yellow perch in Utah, the fisherman can, without penalty, catch and discard as many perch as he wishes. Procedures for discarding fish are well outlined by the reservoir managers; however, violation of the rules is common and has resulted in a considerable shore pollution problem.

Of the 5288 fishermen interviewed during the standard creel census, 13 May through 15 September, 699 (13.2%) utilized the perch for sport and food. The average hourly catch was 2.0 perch per fisherman. Although this would indicate good fishing, the smallness of the adult perch, averaging 173 mm (6.8 inches) in length, reflects a poor-quality fishery. Of all fish taken home by anglers during the summer of 1968, the yellow perch accounted for 39.4% of the total catch. This high percentage of the catch is due to a minority of the fishermen's (13.2%) taking full advantage of no limitations on bag or possession limits. It was estimated that 35,249 perch were caught and utilized by Deer Creek fishermen during the initial 18-week period.

A weekend creel census taken weekly from 16 September through 24 November shows that perch accounted for 55.9% of the total catch. This adds an additional harvest of 8240 yellow perch.

Weekly fluctuations in catch per hour and percentage of total catch were plotted for the standardized creel census of May through September. The poorest fishing existed in the latter part of May and the first half of July. The decrease in May can be explained by observations of spawning activity among the perch, and to an increase in trout landings owing to heavy plantings of rainbow trout by the Utah State Department of Fish and Game. The July slump in perch fishing has not been explained.

Stomach Analysis

The percentage analysis of food types by mass in Table 2 is based on the contents found in 193 perch stomachs. Organisms in the stomach contents of 0- and 1-year-class fish were difficult to recognize. Most were empty; however, of the 0 class fish all recognizable material was zooplankton. A heavy dominance of zooplankton mixed with some algae was found in 1-year-class fish. Pycha, Lloyd, and Smith (1954) indicate that perch up to 40 mm in length feed almost exclusively on macroplankton if it is available. The most recent planktonic study on Deer Creek Reservoir (Merkley, 1966) shows that the macro zooplankters *Daphnia* and *Cyclopa* are abundant throughout the reservoir. McDonald (1962) examined the stomach contents of 37 perch from Deer Creek and found *Daphnia* as the dominant food item.

Much of the zooplankton recovered from all age groups of perch during the present study period were either *Daphnia* or *Cyclopa*. It appears that all perch utilize the heavy concentrations of zooplankton present in the reservoir. In addition, the older fish feed on a wider variety of food types and less on zooplankton. Of the mature 3- and 4-year-class fish, a substantial percentage of the diet by volume (16.1%) is fish and large invertebrate material. Few of the fish were recognizable to species; those that could be identified were all perch. This type of cannibalism is often a sign of overpopulation and stunting (Eschmeyer, 1936).

Age and Size

Age, total length, standard length, weight, and condition factors were recorded for 535 yellow perch during the summer of 1968. Table 3 gives the number of fish caught per year class for each collecting technique. Collections were made from all areas of the reservoir, and no attempt was made to compare one section of the reservoir with another. Perch tend to migrate considerable distances in a large reservoir (Hasler and Burdach, 1949), and it was felt that

TABLE 2. A volume percentage analysis of food types by mass for each year class of yellow perch collected during 1968, Deer Creek Reservoir, Utah.

Year Class	Zoo-Plankton	Algae	Fish	Insects	Molluscs	Unrecog-nizable
0	99.0	..	..	..	..	1.0
1	80.0	9.0	..	..	..	11.0
2	83.3	8.3	8.3	..	..	..
3	58.2	0.9	40.0	0.9	..	..
4	60.2	4.8	24.1	1.2	9.6	..

TABLE 3. The number and age of yellow perch caught by four collecting techniques, 1968.

Year Class	0	1	2	3	4	5	Unknown
Seine	29	1	3	7	5	1	0
Gill nets	0	0	17	198	88	2	7
Shocking	20	57	22	15	5	0	10
Hook and line	0	0	4	33	2	0	9
All methods	49	58	46	253	100	3	26

overlapping during the three months' collection period would make correlations meaningless. Seine and shocking techniques were necessary for collecting 0- and 1-year-class fish. Gill net and hook and line information were selected for the older and larger fish.

Although perch can live up to 10 years or more (Sigler and Miller, 1963), fish collected in this study did not exceed 5 years in age. But observations of large perch near the dam on 9 June and 11 June might indicate that older fish do exist in the reservoir. Several gill nets were set in this area but none of the larger fish were caught.

The mean for each parameter measured on the 535 individual perch is given by year class in Table 4.

The coefficient of condition, designated as K (Lagler, 1956) is based on the formula: $K = \frac{W\,10^5}{L^3}$ where W = weight in grams and L = standard length in millimeters. Condition is a measure of the relative plumpness of a fish to its body form. The weights of 0-class fish were not taken and the condition factors were not computed. The two-year-old fish had a K factor of 2.20 and represented the year class in best condition. The 1-year-class fish were growing rapidly in length and the K-factor was generally low (1.76). Standard length, total length, and weight increased rapidly from year class 0 through 2. Increases within mature fish classes 2 through 5 were less significant.

TABLE 4. Means obtained for each year class as to length, weight, and coefficient of condition on 535 yellow perch, 1968.

Age	Mean St. Length	Mean Total Length	Mean Weight	Mean K Factor
0	49.4 mm	60.6 mm	..	..
1	85.6 mm	102.4 mm	11.7 g	1.76
2	134.2 mm	158.7 mm	54.8 g	2.20
3	173.0 mm	204.9 mm	109.6 g	2.11
4	181.4 mm	214.4 mm	117.9 g	1.97
5	185.6 mm	219.0 mm	121.7 g	1.92

Wide variations in size occurred within each year class of the perch population. This is true for all parameters, including standard length and weight. Eschmeyer (1936) suggests that this is another characteristic of a stunted population. There is some evidence suggesting that a segment of the perch population may be spawning late in the fall. If true, this could account for some of the wide variations, particularly K-factors for the 1-year-class fish. Pitt (1955) found several Deer Creek perch in spawning condition in late September 1955. This same phenomena have been recorded for other species of fish found in western reservoirs. Johnson (1968) reported second spawnings by the threadfin shad in several Arizona reservoirs. On 11 September 1968, 24 yellow perch were dissected; each had well-developed gonads. This correlates closely with Pitt's observations in late September of 1955. Two additional trips were made later to look for egg deposits, but none were observed.

We believe that the heavy population of perch, some dual spawning, and the largeness of the reservoir habitat all contribute to the extreme variations in length, weight, and condition of the perch.

The size and age information taken during this study is particularly important when compared to a study by Pitt (1955) on Deer Creek Reservoir perch. Pitt took standard length, weight, and figured K-factors for 854 yellow perch. Although he did not collect fish of 0-year-class nor record weights for 1-year-class fish, correlations can be made on the other parameters for age classes 1 through 4 years. So few 5-year-class fish were collected during either study that valid conclusions cannot be made. It might be noted that Pitt found a limited number of 6-year-class fish during his study.

Comparing the combined age classes in 1955 with those of 1968, there has been a 14.6% increase in weight for those fish in the 1968 study. This increase was greatest in the 3- and 4-year-class fish. The larger size of the older fish might be due to increased predation on the perch by largemouth bass, whose population has increased substantially in the past 10 years (Lewellen, 1969). Bardoch (1949) reported that a similar situation in Lake Mendota, Wisconsin, was partially responsible for the improved fishing and increased size of the older yellow perch. Le Cren (1958) carried out a similar study on Lake Windermere, England, for 22 years. His conclusions were that heavy fish density has little or no effect upon growth of young, immature perch but that it is a major factor in contributing to stunting of size in the mature yellow perch. Since young fish are not affected by fish density, it is not surprising to note that the 1-year-class fish from 1955 are larger than those collected in 1968. A contributing factor for this difference is partially explained on the basis of parasitism changes on the perch population in the past 13 years (see Table 5).

Parasitism by *Ligula intestinalis*

To determine the effect of the pleuroceroid larva of the tapeworm *Ligula intestinalis* in yellow perch was the purpose of Pitt's

Table 5. Percentage of fish parasitized per year class, Deer Creek Reservoir, 1955 and 1968.

Age	1	2	3	4
1955[1]	1.3	7.2	19.0	25.6
1968[2]	37.7	13.6	2.8	3.2

[1]Pitt (1955).
[2]Present study.

Deer Creek study in 1955. A comparison of perch checked during the present study might be helpful in determining any changes in quality or quantity of parasitism since 1955.

Ligula intestinalis is distributed throughout the world and its life history is well known (Wardle and McLead, 1952). The adult tapeworms have been found in at least 40 species of birds and mammals (Dogiel and Petrushevsk, 1958).

Pitt (1955) found that the California gull, the most abundant waterfowl on Deer Creek Reservoir, was the major definitive host. The tapeworm eggs, found within the feces of gulls, are deposited in Deer Creek waters and there ingested by the invertebrate fauna. Copepods, such as *Cyclops strenuus*, ingest the eggs and are capable of providing the environment for development of the procercoid larvae (Dogiel and Petrushevsk, 1958). Not only are copepods abundant in Deer Creek Reservoir (Merkley, 1966), but they constitute a large percentage of the zooplankton found within the stomachs checked in the present study. When the fish feeds upon the copepod, the pleurocercoid larva is able to develop. The yellow perch has been shown to be an effective host by many studies, including Pitt (1955) and Wardle and McLead (1952). The cycle is continued when the gull feeds upon infected perch and the pleurocercoid larvae can develop into egg-laying adults.

A total of 248 perch of all age classes were inspected for occurrence of tapeworm larvae. A total of 14.5% of the fish examined were infected. Pitt's study showed an overall occurrence of 15.0%, nearly the same as the present study. However, changes in parasitism per year class may exist when comparing 1955 and 1968 data.

To compare studies it is necessary to eliminate year classes 0 and 5 for lack of information. It might be noted that parasitism, even though limited, did occur in the 0- and 5-year classes in the present study. Table 5 shows the percentage of parasitism per age class in the 1955 and 1968 perch. During the 1968 study the young fish, 1- and 2-year classes, were parasitized at a rate of 25.6%. The mature, 3- and 4-year-class fish were parasitized on an average of 3.0%. This difference could be due to variations in intermediate (copepod) host densities during the past few years. In reference to intermediate host densities, it has been shown by Dogiel and Petrushevsk (1958) that only about 2% of all procercoid larvae ingested by fish will develop into the pleurocercoid stage. Pitt's 1955 data show that 4.2% of the 1- and 2-year classes are parasitized, while 22.3% of the 3- and 4-year classes are infected. He observed that the young fish in 1955 were feeding heavily on the abundant algae in the reservoir. It was during this period that algal growth was producing objectionable taste and odor in the water used for culinary purposes from Deer Creek Reservoir (Greenwood, per. comm.). Today the algal growth has been controlled and, as seen in the stomach analysis, all perch, particularly the young, were feeding primarily on copepods that were probable hosts of the larval tapeworms.

Many factors influence growth of fish, and parasitism, or the lack of it, is of primary concern. Pitt's study shows a possible reversal of parasitism (22.3%) on adult perch as compared to the present study (3.0%). The total effects on growth cannot be measured, but a comparison of 3-year-class fish for each study is helpful. The 3-year class is chosen because of the large number of fish examined for this age class. Unfortunately, the 3-year-class fish in the 1968 study only contained a few parasitized individuals. Comparisons are made in an attempt to show a trend and not to claim a high level of statistical significance. Pitt found that 19% of his 338 3-year-class perch were parasitized and that the year class as an average weighed 70.9 g and had a standard length of 147.5 mm. The author's 1968 studies show that 2.8% of the 253 perch were parasitized and the year class had an average weight of 109.7 g and standard length of 173.1 mm. Certainly reduced parasitism was a contributing factor to the increased size of the year class. This statement is further supported by comparing the mean size of mature fish parasitized to those of the same year class not parasitized. Considering the 3-year-class fish in the 1968 study, there was a 15.2% increase in standard length and a 39.5% increase in weight shown by the unparasitized fish.

Parasitized fish were collected from all areas of the reservoir. Pitt found the same pattern in 1955, basing his findings on the assumption that perch migrate in large bodies of water and that the intermediate (copepod) hosts were found everywhere. One area of the reservoir not investigated by Pitt was Wallsburg Bay. This is an area of small sheltered bays, and the perch collected there during 1968 were heavily infested with the pleurocercoid larvae of *L. intestinalis*. In all, 31.6% of the infected perch collected during 1968 came from this area.

Discussion

Evidence to suggest overcrowding and stunting was collected, but in comparing data from Pitt's study it is apparent that mature perch in 1968 were both larger and less frequently parasitized than those collected in 1955. Contributing factors, as to size differences, include a heavier predation on perch by the largemouth bass and to lack of tapeworm parasitism in adult perch.

Largemouth bass predation, having increased substantially since 1955, allows for less competition among surviving perch, thus resulting in increased individual growth. Unfortunately, the largemouth