Biology Of The Flathead Chub In The Lower Yellowstone River, Montana

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Abstract

The flathead chub (Platygobio gracilis) (Cyprinidae), *which has declined in much of the Missouri River drainage, was investigated in 1997 by sampling with stationary nets at a mainstem irrigation diversion dam on the lower Yellowstone River, Montana. Total lengths of 1,327 chubs sampled ranged from 32 mm to 304 mm. Mean length of 71 known females (181 mm TL) was significantly greater than mean length of 145 known males (138 mm TL, P<0.05). Ages of 281 fish of both sexes ranged from one to seven years. Maximum ages of males and females were 5 and 7 years, respectively. Mean number of eggs per female (mean length, 186 mm TL; mean weight, 68.5 g) was 6,981; eggs were typically of two or more sizes per fish, indicating non-synchronous development. One large female had 36,150 eggs, of which 28,200 were fully developed. The presence of numerous chubs of diverse sizes and ages at the free-flowing, turbid lower Yellowstone River contrasts with declines in abundance at other more altered locations in the Missouri River basin.*

Key Words: Missouri River, fishes, *Cyprinidae*, fish ecology.

Introduction

The flathead chub *(Platygobio gracilis) (Cyprinidae)* is a small minnow inhabiting the interior plains region of the United States and Canada (Olund and Cross 1961). It is widespread in the United States throughout the Missouri and Lower Mississippi rivers and also is found in parts of the South Canadian River in Oklahoma and the Rio Grande in New Mexico. Its range in Canada extends from southern Saskatchewan and Alberta northward to the Mackenzie River drainage (Kucas 1978). The latitudinal distribution of the flathead chub is one of the most extensive of any North American freshwater fish.

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Flathead chubs are found typically in turbid, alkaline waters with moderate to strong currents and naturally-fluctuating hydrographs (Olund and Cross 1961). Impoundments and channel alterations along much of the Missouri River have altered the hydrograph and decreased turbidity. These changes have reduced the amount of suitable habitat for the flathead chub and many other native fishes (Pflieger and Grace 1987, Hesse 1994). The species remains abundant, however, in the lower Yellowstone River and portions of the upper Missouri River (Hesse 1994) where suitable habitat remains.

We collected flathead chubs as part of a fish entrainment study at a major irrigation diversion canal on the Lower Yellowstone River that permitted investigation of aspects of this species' age, growth, fecundity, and food habits. Such information has been fragmentary and inadequate. Most reports on flathead chubs have focused on distribution and general habitat requirements (Cross and Moss 1987, Bramblett and Fausch 1991); only a few studies have addressed its biology (Martyn and Schmulbach 1978, Gould 1985, Hesse 1994). Our objective was to characterize the life history of this species in the Lower Yellowstone River.

Study Site

The study was conducted at the Intake Diversion Dam and Canal, 25 km downriver from Glendive, Montana, on the lower Yellowstone River. The Intake Diversion Project was authorized in 1904 and under the Reclamation Act of 1902 to provide irrigation water for agriculture in the lower Yellowstone valley in eastern Montana and western North Dakota. It was constructed over the period 1905-1909. The project irrigates 22,312 ha of cropland that produces alfalfa, other hay crops, silage, and sugar beets (U.S. Bureau of Reclamation 1983).

Water is briefly retained at the Intake site by a low head dam across the main channel, and impounded water flows by gravity through 11 orifices into the canal. The canal is operated from May through September (U. S. Bureau of Reclamation 1983).

Methods

Fish sampling

Three of the eleven canal orifices were sampled in 1997. Stationary nets of multifilament nylon (1.27-cm bar mesh) with bags narrowing to a cod end (0.64-cm bar mesh) were suspended over the orifices (on the canal side) and captured fish as they entered the canal. Nets were fished intermittently, day and night; chubs were sampled from 22 May through 29 August. The nets were typically set for one hour and checked immediately thereafter for fish. Numerous species in addition to flathead chubs were captured. We assumed that chubs sampled in the nets as they entered the canal were representative of the population in the river.

A total of 1,327 chubs was caught and measured for total length (TL) during the entire sampling season; 424 of these fish were also weighed. Age was determined for 281 fish, which included 27 males, 48 females, and 206 individuals of unknown sex. Sex was determined by visual examination of gonads for 145 males and 71 females, stomachs sampled for food items from 178 fish, and fecundity estimated for 53 female fish. Male fish were classified as mature based on the presence of large developed testes, usually with flowing milt; females were classed as mature based on the presence of large eggs loosely attached to the skein.

Age and growth

Scales for age determination were taken from immediately above the lateral line and posterior to the dorsal fin. Impressions of the scales were made on plastic slides (Clutter and Whitesel 1956). Scales were interpreted for age by counting annuli with the aid of a Biosonics Optical Pattern Recognition System (OPRS). We were not able to independently validate annuli because no other information on age of individual fish was available.

Fecundity

We separated egg samples from ovarian tissue and obtained an aggregate egg weight for each fish. Total weights of large, mature eggs and small, undeveloped eggs were recorded separately. Numbers of eggs of each size were estimated based on total weights of large and small eggs and the weights of random subsamples of 100 eggs of each size. The diameters of 25 eggs of each size from each female were measured with an ocular micrometer. We attempted to assess maturation stage of different sizes of eggs from stained histological cross-sections of six samples of large and small eggs.

Food habits

Stomach contents were removed, examined under a dissecting microscope, and individual organisms identified when practicable. Contents were then filtered, patted dry, and weighed with an analytical balance. Mean weight of contents was expressed as a percent of body weight.

Statistical analyses

Linear regression methods were used to characterize length-weight relationships, and t-tests were used to compare slopes of regression lines and lengths of fish by sex (Steele and Torrie 1980). $P<0.05$ was required for statistical significance.

Results

Fish lengths and weights

The 1,327 flathead chubs sampled ranged from 32 mm to 304 mm TL (mean, 147 mm TL). Lengths of fish were unimodally distributed with most fish 110-190 mm TL (Fig. 1). For fish of known sex (145 males, 71 females) from which length and weight were measured, mean length of females (181 mm TL) was significantly greater than of males (138 mm TL, t-test; $P<0.05$). No significant difference was found in the slopes of length-weight relations for males and females (t-test, $P>0.05$), so known males and females were combined with 208 fish of unknown sex to create one combined length-weight relation (Fig. 2).

Age and growth

Ages of 281 fish, which had total lengths of 86-266 mm, ranged from one to seven years. The youngest mature males were age-1, and the youngest mature females were age-2. The overall proportion of fish of each age that was mature was not accurately determined because of small sample sizes of fish of known sex and age. None of 27 males were older than age-5, although seven females out of the 48 fish of known sex were ages 6 or 7.

Mean lengths of fish at the time of sampling were 108 mm TL at age-1+ (i.e., with one annulus plus any post-

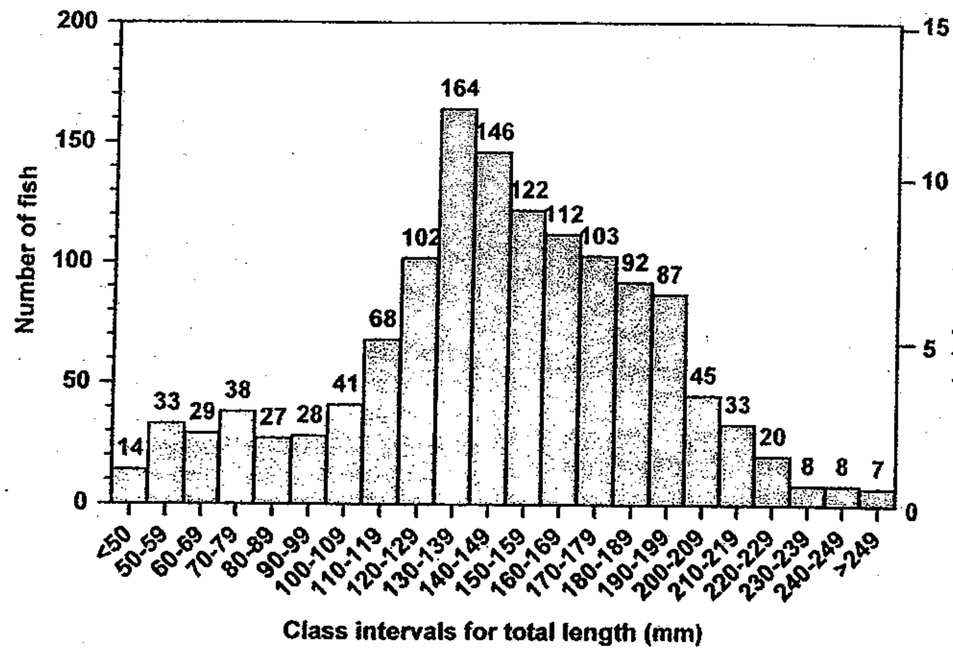

Figure 1. *Length-frequency distribution of flathead chubs (n = 1,327) sampled 22 May - 29 August, 1997, at the Intake Diversion Canal.*

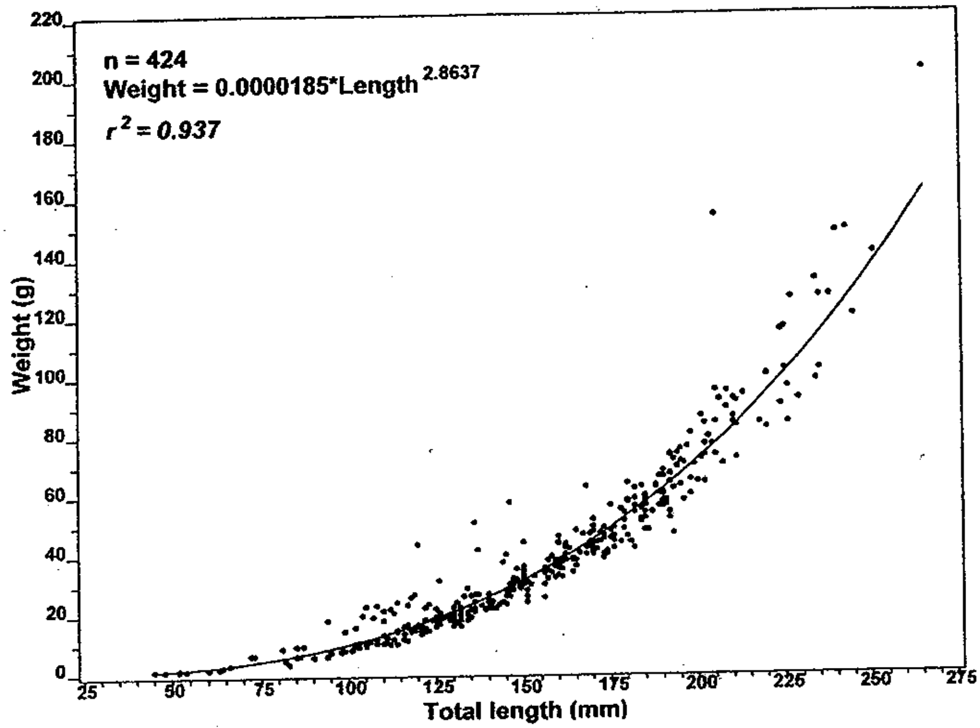

Figure 2. *Combined male and female length-weight relation for flathead chubs, Intake Diversion Canal.*

annulus growth), 129 mm at age-2+, 147 mm at age-3+, 164 mm at age-4+, 196 mm at age-5+, 221 mm at-age 6+, and 246 mm at age-7+. Considerable overlap existed in length for a given age. Length increments did not decrease with age (Fig. 3).

Fecundity

We observed no countable developed eggs in 11 of 53 (21%) female fish dissected to determine fecundity. Two of these 11 females were small (107 and 127 mm TL), and the other nine females ranged from 146 to 218 mm TL. Because these nine females were caught late in the sampling season (29 July-21 August), absence of developed eggs indicated that each had already spawned.

We observed that eggs in many specimens occurred in two distinct size classes (large and small) based on diameter; some specimens seemingly had a range of egg sizes. Thirty-four of 42 (81%) females with developed eggs contained two different sizes of eggs falling into two size categories that slightly overlapped in diameter. Twenty-nine samples with both large and small eggs contained predominantly (>50%) large eggs. Lengths of these fish ranged from 133 to 251 mm TL (mean, 187 mm). Five samples (14%) contained predominantly (>50% by number) small eggs. Lengths of these fish ranged from 122 mm to 211 mm TL (mean, 179 mm). Eight of 42 fish contained only one size class of eggs; seven had only small eggs and one had only large eggs.

The total number of eggs per fish peaked in late June. Mean weight of all eggs combined was 5.4 grams, or 7.8 percent of mean body weight. The largest number of eggs in an individual fish was 36,150 of which 28,200 were

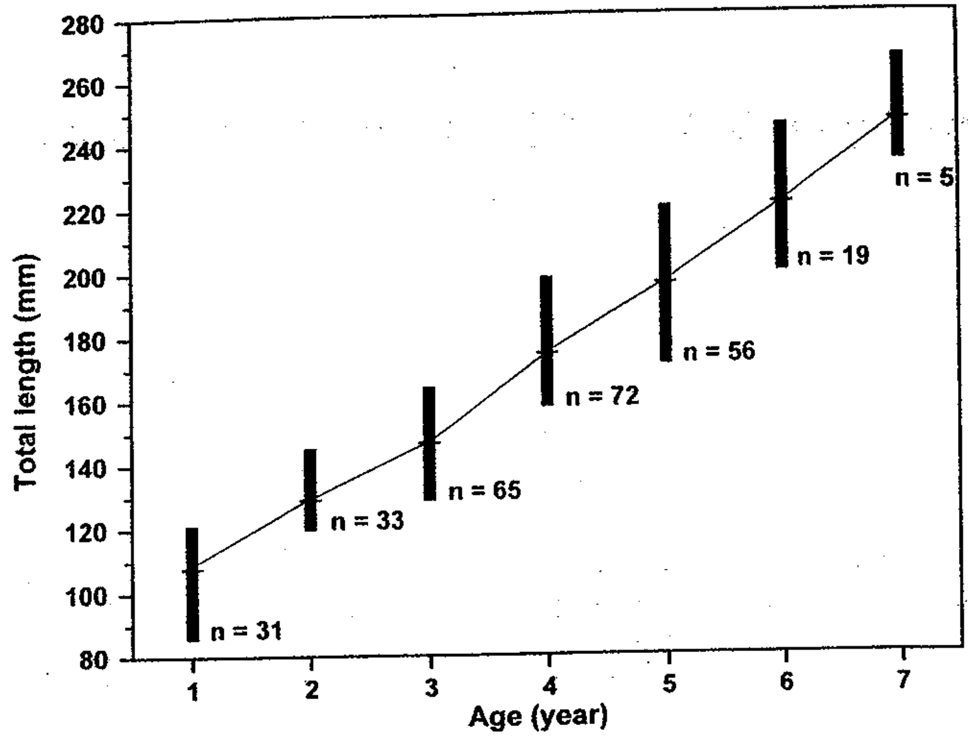

Figure 3. *Mean lengths and range of lengths by age, flathead chubs, Intake Diversion Canal.*

large eggs. Egg numbers were highest in a few fish aged 4 and 5. Mean total number of eggs per specimen (mean length 186 mm TL, mean weight 68.5 g) was 6,981, of which about 58 percent were large eggs. Large eggs were typically greater than 1 mm in diameter (mean, 1.11 mm) and small eggs typically less than 0.8 mm in diameter (mean, 0.41 mm). Large and small eggs occurred over a large range of fish lengths and ages. The relation between fish weight and estimated fecundity was positive but not close (Fig. 4); it was obscured by the apparent spawning activity during the sampling period.

Histological analysis of cross sections indicated that the different sizes of eggs (both large and small) were at intergrading stages of development. There was no evidence that the eggs were in the process of being reabsorbed.

Food habits

Only three of 178 stomachs examined contained identifiable organisms. Sixty-seven stomachs were empty. Identifiable organisms were insects in the orders Coleoptera, Hymenoptera, Orthoptera, and Trichoptera. Contents of all other stomachs were masticated beyond recognition, a mixture of organic debris and invertebrate parts. Stomach contents constituted an average of 0.26 percent of the total fish weight. Larger fish of both sexes tended to have greater weight of stomach contents. There was no evidence of a consistent seasonal pattern to stomach fullness.

Discussion

The ages at first maturity of fish in our study (age-1 for males, age-2 for females) were similar to those reported from a small Missouri River tributary in Iowa (Martyn and Schmulbach 1978) where maturation occurred mostly at age-2. Lengths of mature fish in their

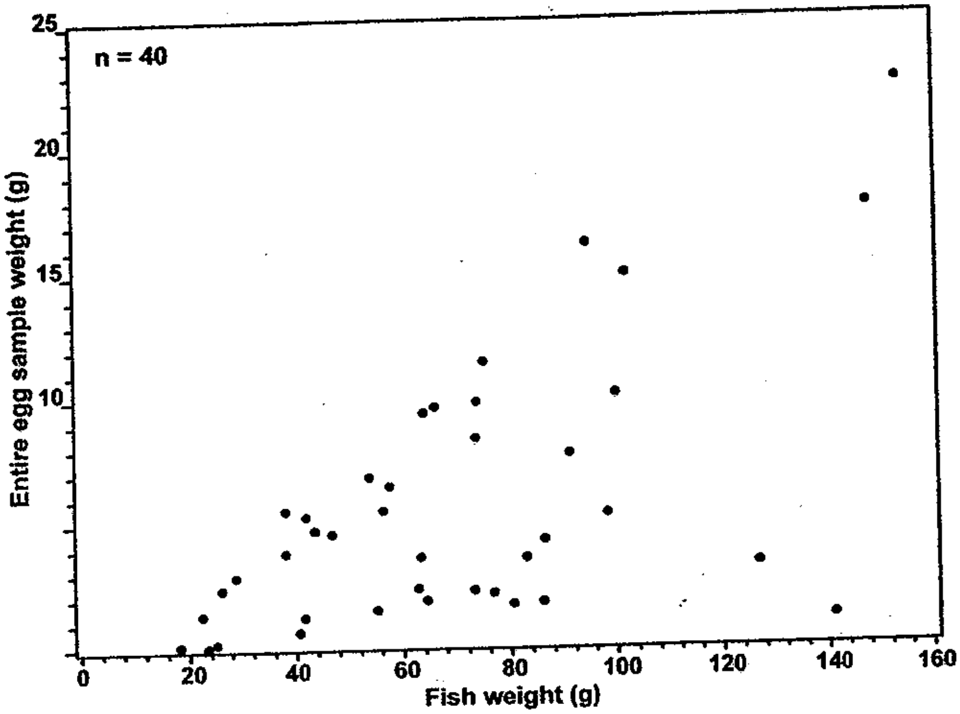

Figure 4. *Relation between flathead chub weight and weight of eggs, Intake Diversion Canal.*

study exceeded 127 mm TL, whereas in our study, the smallest mature female was 107 mm TL. Gould (1985) reported that flathead chubs from the Musselshell River, Montana, fell into three size groups although he was unsuccessful in determining the age of specimens using scales, opercula, or vertebrae. He concluded that maturation occurred at age-3 based on sizes of mature fish.

Sexual size dimorphism was evident in flathead chubs. Females lived longer, grew larger, and matured at an older age than males. Most freshwater fishes show a larger-female dimorphism to some extent, thereby permitting higher fecundity in large females (Bell 1980). The rarer larger-male pattern is more characteristic of clearer waters where courtship pairing has strong visual cues, and would be expected to be absent in fishes inhabiting more turbid waters. However, no information is available on the spawning behavior of flathead chubs (Gould 1985).

Our ability to age flathead chubs with scales contrasted with Gould (1985), whose efforts were unsuccessful. We experienced difficulty in using scales to age flathead chub in this study but detected annuli only within a small anterior portion of the scale. Scales from two other areas of the body (above the lateral line posterior to the head, and immediately posterior to pectoral fins) were also evaluated for use in age determination. These scales proved typically smaller and the circuli even more closely packed than those from our preferred location (above the lateral line and posterior to the dorsal fin).

Fecundities of fish in this study (mean, 6,981 eggs) were much higher than reported by Gould (1985, <1,000 mature eggs/fish) and Martyn and Schmulbach (1978, mean = 4,974 eggs). Much of this difference is attributable to larger fish in our samples. The largest fish reported by Martyn and Schmulbach (1978) was 172 mm TL and the largest by Gould (1985) was 160 mm

TL. Mean length of our fish for which fecundity was estimated was 186 mm TL, and 15 fish were between 200 and 255 mm TL. Fecundity differences were not necessarily attributable to higher egg weight as a percentage of total body weight. Gould's (1985) fish had gonad weights that ranged from 2.3 to 5.9 percent of body weight, our 40 fish averaged 7.8 percent, and Martyn and Schmulbach's (1978) fish averaged 10.3 percent at peak spawning.

The presence of two or more sizes of eggs in individual flathead chubs was not reported by other authors. Chubs from the Musselshell River, Montana, contained a range of egg sizes at all seasons (Gould 1985), but the presence of both small and large eggs in an individual chub was not mentioned. Multiple egg sizes are often associated with fractional and multiple spawning, which is common in many freshwater fishes. It may increase fitness through repeated use of the available body cavity for holding eggs. (Matthews 1998).

The reasons for the non-synchronous egg development in flathead chubs are not clear. The chub is developing eggs of several stages at the same time, of which two or more sizes probably will be spawned in a single season. Although spawning of this species is poorly known, the non-synchronous egg development in the flathead chub may be adaptive in river habitats where peak discharge and optimal spawning condition vary yearly by a month or more. We have observed other species in the Yellowstone River, including paddlefish (*Polyodon spathula*) and shovelnose sturgeon (*Scaphirhynchus platorynchus*) to spawn over periods exceeding a month, depending on river discharge. The collection of spawned-out females from 29 July to 21 August is consistent with previous studies (Olund and Cross 1961, Martyn and Schmulbach 1978) indicating spawning between late June and early September, depending on location. For definitive conclusions and reliable data on maturation schedules, individual chubs should be monitored over time. It is unclear if a relation exists between timing of spawning and Yellowstone River discharge although this identifies a need for future investigation.

The difficulty of identifying specific organisms in the diet of flathead chubs has not been reported by investigators elsewhere. Davis and Miller (1967) characterized them as a "fortuitous feeder" and a generalist based on anatomical and physiological comparisons with other minnows, but did not investigate food habits. Flathead chubs in the Peace River, Alberta, fed mainly on drifting terrestrial insects such as Hymenoptera, Hemiptera, and Trichoptera (Bishop 1975). Olund and Cross (1961) reported that the flathead chub was chiefly carnivorous, feeding mostly on terrestrial insects and occasionally vegetation. Their sample sizes were <10 fish per location at seven sites throughout the Great Plains (Canada to New Mexico), however, and many stomachs contained no food (their Table 1). Inasmuch as other non-minnow species sampled at the Intake Canal contained identifiable organisms, the advanced state of digestion of the stomach contents in our study was probably aided by the hooked pharyngeal teeth of the chubs (Olund and Cross 1961). Other methods such as visual observation must be used to adequately determine food habits of these fish.

The presence of chubs of all sizes and ages in the turbid, unimpounded Yellowstone River contrasts sharply with declines or disappearance of this species at other Missouri River locations (Pflieger and Grace 1987, Hesse 1994). Pflieger and Grace (1987) reported that flathead chubs have suffered a large decline in the lower Missouri River since the 1940s coincident with declines in turbidity, a result of upriver impoundment. They suggested that declines in chub abundance may have resulted from increased predation from sight-feeding predators and increased competition from other minnows favored by clearer waters. The turbid, unimpounded discharge of the lower Yellowstone River may be a significant factor in the high chub abundance and year-class diversity observed in our study. As plausible as such speculation may be, the actual cause(s) of declines elsewhere may be difficult to determine in the large-river habitats of flathead chubs. In view of the disappearance of these fish from other altered and impounded locations in the Missouri River drainage, maintenance of a natural hydrograph and turbidity should be considered vital to the conservation of this species.

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