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Bionomics of the Flathead Chub, *Hybopsis gracilis* (Richardson)

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Aspects of the life history of the flathead chub were investigated between 7/15/75 to 8/31/76 in Perry Creek, Iowa, a Missouri River tributary. Age and growth data from 288 fish revealed that the population consisted of 4 age groups. Total lengths based on summation of increments averaged 78, 110. 132 and 150 mm for age groups I through IV. The weight-length relationship for preserved fish was log W = −1.7615 + 2.9802 (log L). The coefficient of condition for all fish was K_{SL} = 1.7 and K_{TL} = 0.96. Sexual maturity was reached when the fish were 2 years old and a standard length > 105 mm. Spawning extended from mid-July to mid-August. Mature females averaged 4,974 eggs/ovary. Perry Creek provided a stable environment for growth and development but no old or large chubs were taken. Destruction of chub habitat in the Missouri River and its tributaries is suggested as a possible reason for the paucity of older fish.
INDEX DESCRIPTORS: Flathead chub, *Hybopsis gracilis*, age and growth, weight-length relationships, condition factors, fecundity.

The flathead chub occurs in 4 major North American drainage systems (Mackenzie, Saskatchewan, Missouri-Mississippi and Rio Grande) and ranges over the Great Plains from the Northwest Territory south to New Mexico and east to the Mississippi River (Olund and Cross, 1961; McPhail and Lindsey, 1970; Scott and Crossman, 1974). It is restricted to the Missouri River drainage system in the western half of Iowa (Harrison and Speaker, 1954; Cleary, 1956). In South Dakota the chub is widely distributed because the state is drained principally by the Missouri River. Previous investigators considered it a "characteristic" species (Evermann and Cox, 1896), abundant (Churchill and Over, 1933) and a dominant minnow in the Missouri River and its tributaries, particularly in western South Dakota (Bailey and Allum, 1962).

This species is associated with large turbid rivers and their tributaries, especially alkaline streams exhibiting large water level fluctuations and shifting sandy-loam substrates (Olund and Cross, 1961; Baxter and Simon, 1970). Since completion of 6 mainstem impoundments on the middle Missouri River, the river water is less turbid and water level fluctuations less extreme than in times prior to dam construction. Environmental changes brought about by the dams and other man-made structures may have affected flathead chub distribution and survival. Schmulbach *et al.* (1975) and Kallemeyn and Novotony (1977) took few chubs in extensive sampling of Missouri River fish populations below Gavins Point Dam.

Even though the flathead chub is widely distributed and large, reaching > 300 mm TL, basic information on its life history is unavailable. Therefore, we undertook this study to add to man's knowledge and appreciation of the chub's significance in lotic ecosystems.

STUDY AREA

The fish used in this study were collected from 15 July to August 31, 1975 in Perry Creek, a tributary of the Missouri River in northwestern Iowa. The creek contains the only known substantial population of flathead chubs within a 75 km radius of Vermillion, S.D. The creek originates in Plymouth County and flows southwesterly approximately 60 km to its confluence with the Missouri River at Sioux City in Woodbury County. Perry Creek drains 188 km^2 of predominantly loess soils, has a stream gradient which varies from 2.65 to 1.89 m/km, and streamflows from 0 to 272 m^3/sec (9,600 cfs). The upstream portion of the watershed experiences sheet and gully erosion and the entire stream has substantial bank erosion resulting in an average annual sediment load of 185,000m^3. The most downstream 915 m of Perry Creek travels through a cement conduit (U.S. Army Corps of Eng., 1970). Movement of fish between Perry Creek and the Missouri River is possible during the open water season.

METHODS AND MATERIALS

Flathead chubs were never abundant, but 314 were taken with a straight minnow seine, a portable DC electro-fishing apparatus (Dirigo Electrofisher model 500) and double-funneled minnow traps. The seine measured 6.1 x 1.2 m with a mesh size of 0.48 cm. All specimen were preserved in 10% formalin in the field and returned to the laboratory for processing.

Each fish was measured for standard, fork and total length. Wet weights of preserved fish were recorded to the nearest 0.01 g after allowing the fish to dry on paper toweling for 2 min. Scale samples were taken above the lateral line at a point ventral to the most anterior ray of the dorsal fin. At least 5 scales from each fish were imprinted on plastic slides using a roller press. Subsequently, the slides were viewed on a microprojector at 41X.

The first annulus in flathead chub scale impressions was frequently difficult to identify. We used scales from young-of-the-year fish (<82 mm TL) from the Moreau River (S.D.) to assist us in assessing the position of the first annulus since no young-of-the-year were taken in Perry Creek. Scale impressions of each fish were aged at least 3 times. Nomograph strips were marked, and growth in length during previous years was determined from an appropriate nomograph by direct proportion without an intercept correction.

Weight-length relationships were computed using the logarithmic expression of the regression of weight on length: log W = log a + n log L; where, log W = weight in g and log L = standard length in mm, and a and n were constants determined from the empirical data.

The coefficient of condition or relative well being of the population (K values), was computed using the cube relationship of weight and length: $K = W/L^3 \times 100{,}000$; where, W = weight in g and L = standard length in mm. K values were also computed for total length measurements.

After length and weight measurements were recorded, the body cavity was opened, the fish sexed and the gonads removed. Gonads were dried for 2 min. on paper toweling, weighed to the nearest 0.01 g, and expressed as a percentage of the total body weight. Female fecundity estimates were made gravimetrically. Sexual maturity and degree of gonadal development were estimated for each fish by visual inspection.

RESULTS

Age and Growth

The precise time when flathead chubs form annuli was not established in this study. However, we examined the scales from 11 fish taken between May 14 and June 8, 1976. These fish were not used in the age and growth portion of the study, but two taken in early June had developed an annulus on the scale margin. Therefore, we assume that annulus formation takes place between late May and mid-June.

The Perry Creek flathead chub population consisted of 4 age groups, I through IV (Table 1). The 288 chubs used in this portion of the study averaged 78, 110, 132, and 150 mm TL based on the summation of increments at the end of their 1st, 2nd, 3rd, and 4th year of life, respectively. The mean annual length increment decreased as the fish grew older, 78, 32, 22, and 18 mm, respectively. Lee's phenomenon was not evident.

Table 1. *Mean calculated total length (mm) per age group at each annulus of* Hybopsis gracilis *from Perry Creek, Ia.*

Age Group	No. of Indiv.	Mean Total Length at Capture	Range in Total Length	Total Length at Each Annulus 1	2	3	4
I	16	101.5	82-124	67.7			
II	79	131.4	118-146	81.6	113.8		
III	181	143.9	130-160	77.3	107.8	130.0	
IV	12	162.2	147.172	73.8	108.0	130.2	148.0
Total 288			Total fish used	288	272	193	12
Mean				77.8	109.6	130.0	148.0
Standard Deviation				10.3	8.2	6.4	8.0
Mean Annual Increment				77.8	32.3	22.2	17.8
Growth Based on Sum of Increments				77.8	110.1	132.3	150.1

Table 2. *Annual growth (mm) during calendar years for each age group of* Hybopsis gracilis *from Perry Creek, Ia.*

Year of Life	Increment of growth in calendar year 1971	1972	1973	1974
4				17.8
3			22.2	22.2
2		34.2	30.5	32.2
1	73.8	77.3	81.6	67.7

Growth rates were varied during the first year of life for each year class, being larger than average in 1973 and smaller in 1974 (Table 2). An analysis of variance performed on growth during the first year of life revealed that these differences were highly significant ($F_{3,284}$ = 10.35). After the first year of life growth was quite uniform suggesting that Perry Creek provided a stable environment for older flathead chubs between 1971 and 1974. At least two thirds of the annual growth in length occurred between annulus formation (late May to mid-June) and time of capture during the last 2 weeks of July.

Weight-Length Relationships

Separate weight-length relationships were calculated for preserved fish of both sexes and for all fish. (Table 3) Weight-length relationships for both sexes were similar and the relationship for all fish was described by the formula log W = −1.7615 + 2.9802 (log L).

Table 3. *Weight-length relationships for* H. gracilis *from Perry Creek, Ia. W = weight in g and L = standard length in mm. All fish were preserved in 10% formalin.*

	No. of Specimens	
Females	152	Log W = −1.7005 + 2.9373 (Log L)
Males	135	Log W = −1.4020 + 2.6210 (Log L)
Total Sample	288[1]	Log W = −1.7615 + 2.9802 (Log L)

[1]Includes one unsexed immature fish.

Table 5. *Mean number of eggs per female for various length classes in* H. gracilis *from Perry Creek, Ia.*

Standard Length Classes (mm)	Number of Specimens	Mean Number of Eggs Per fish	Range in Egg estimates	Mean number of Eggs Per 10 g of Body Weight
0-105	3	2,094	826-2,991	1,331
106-115	33	4,035	2,205-7,288	1,643
116-125	48	5,516	2,335-13,073	1,769
126-135	12	5,810	2,850-12,325	1,567
136-up	5	5,678	2,541-8,803	1,176
Total		101		
Mean no. of eggs/female		4,973.5		
Standard deviation		2,200		

Conversion Factors

Length conversions were computed from the measurements of 288 preserved specimens and are expressed by the following relationships: SL = 0.827 TL; SL = 0.913 FL; FL = 0.906 TL; FL = 1.096 SL; TL = 1.103 FL and TL = 1.2095 SL.

In 1976, we also determined what effect preservation had on length and weight measurements. Unfortunately, we were able to secure only 6 fish for this portion of the study because the summer drought decimated the flathead chub population in Perry Creek. These 6 fish gained an average of 9.4% of their live weight and lost an average of 3.2%, 2.8% and 2.7% of their live standard, fork, and total lengths, respectively, after preservation in 10% formalin for 4 weeks.

Table 4. *Coefficient of condition values, "K," for* H. gracilis *from Perry Creek, Iowa. All fish were preserved in 10% formalin.*

	Female No.	K(SL)	K(TL)	Male No.	K(SL)	K(TL)	Both Sexes No.	K(SL)	K(TL)
Immature	11	1.72	0.94	21	1.69	0.92	32	1.70	0.93
Developing and Ripe	101	1.78	1.00	54	1.59	0.90	155	1.70	0.97
Spent	21	1.66	0.94	14	1.59	0.88	35	1.63	0.92
Total Sample	152	1.73	0.99	135	1.64	0.91	288	1.70	0.96

SL = Standard Length
TL = Total Length

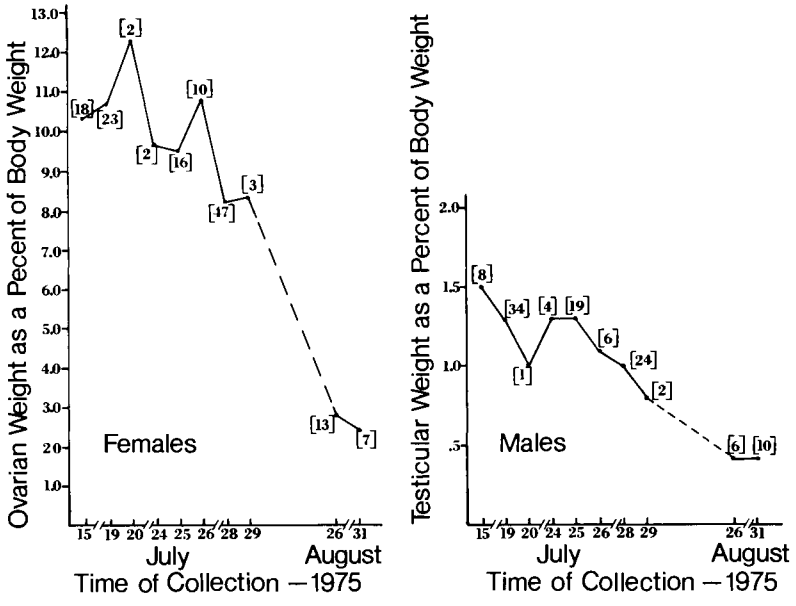

Figure 1. Average gonadal weight expressed as a percentage of body weight for sexually mature H.gracilis. Number of specimens in [ ].

Coefficient of Condition

The relative well being of preserved chubs was determined using both standard and total lengths. Since gonadal development can influence K values, separate determinations were made for immature, developing (including ripe), spent, and all fish for each sex.

Differences in K values within a sex were small amounting to < 0.1 K units (Table 4). Developing and ripe females had the highest values and spent males the lowest. The condition factors for all specimens were $K_{SL} = 1.70$ and $K_{TL} = 0.96$.

Sexual Maturity and Spawning

In Perry Creek, sexual maturity was reached by most fish when 2 years old and their length exceeded 105 mm SL (127 mm TL). Only 33 of 288 fish (11.4%) were immature including 12 immature yearlings (Tables 1 and 4). Five yearlings, 3 females and 2 males, were mature. Among age group II fish, 21 of 79 (26.6%) were immature. All fish in age groups III and IV were sexually mature and both sexes appeared to reach sexual maturity at about the same age and length.

Actual spawning was not observed, but by using the gonadal weight to body weight percentage as a dependent variable, we determined that spawning extended from mid-July to mid-August (Fig. 1). All sexually mature fish were spent by August 26, 1975. Fish were only taken in the "pools" of the creek which may suggest that spawning occurred in pools. During the peak of spawning (July 15-26), the ovaries averaged 10.3% and the testes 1.3% of the body weight. Unfortunately, no fish were taken from July 29 to August 26, so the exact time when spawning terminated was not determined. Irregular water temperature observations during spawning averaged 18.5 C in the morning and approximately 25 C in the afternoon.

Based on estimates from 101 developing and ripe ovaries, the mean number of eggs per female was 4,974 (Table 5). The mean number of eggs per female increased with increased body length up to 130 mm SL, and thereafter a slight decline was observed. The most efficient egg production (1,769 eggs/10 g body weight) was observed in the 116-125 mm SL class which consisted almost entirely of age III fish.

Parasitic Burden

Although no work was done on parasitism, it was observed that many Perry Creek flathead chubs were heavily parasitized. The parasites consisted mainly of neascus type metacercaria of a digenetic trematode in the family Diplostomatidae, commonly known as the "black grub."

DISCUSSION

The life history of the flathead chub was investigated for 2 years in Perry Creek (Ia.), a small Missouri River tributary with a modest chub population. Flathead chubs are common farther south in the channelized Missouri River and its tributaries (Fisher, 1962) and in turbid Missouri River tributaries of western South Dakota (Bailey and Allum, 1962), but uncommon or absent from the Big Sioux River which forms the Iowa-South Dakota boundary (Cleary, 1956; Nickum and Sinning, 1971) and from the unchannelized Missouri River below Gavins Point Dam, the most downstream dam (Schmulbach *et al.*, 1975). The ecological requirements of the chub are poorly understood.

Olund and Cross (1961) studied geographical variation in flathead chub morphology and described two subspecies, *Hybopsis gracilis gracilis* and *H.g. gulonella*. Bailey and Allum (1962), however, attributed the morphological variation they observed in South Dakota flathead chubs to environmental factors. Our study produced no evidence for either hypothesis so we did not ascribe a subspecies to the Perry Creek population, although Dr. Frank Cross examined a few specimens and tentatively suggested that the population represented intergrades between the two subspecies.

Using coefficient of condition factors, K_{SL} and K_{TL}, as indicators, Perry Creek flathead chubs appeared to be in good condition despite being heavily parasitized by trematode metacercaria. The relative well being of all fish was $K_{SL} = 1.70$ and $K_{TL} = 0.96$. Both values exceeded the general well being of 10 fish taken from Oahe Reservoir during 1960-62 where $K_{TL} = 0.71$ (Carlander, 1969). In general, females tended to be slightly heavier than males of the same length.

Sexual maturity was usually reached when the fish were 2 years old and exceeded 105 mm SL (127 mm TL). All fish 3 and 4 years old were sexually mature and 73.4% of the 2 year olds were mature. Bishop (1975) stated that flathead chubs from the Peace River (*H. gracilis gracilis*) reached sexual maturity by age IV. Olund and Cross (1961) believed that *H.g. gracilis* reached sexual maturity at 85 mm SL and *H.g. gulonella* after attaining 65 mm SL. Evidently the Perry Creek chubs were fast growing while immature, but their growth slowed markedly after attaining sexual maturity.

Spawning took place from mid-July through mid-August in 1975. Our observations substantiated those of other authors who placed spawning somewhere between late June and early September (Churchill and Over, 1933; Olund and Cross, 1961; McPhail and Lindsey, 1970; Bishop, 1975).

There is only one published aging study on flathead chubs, that of Bishop (1975), from the Peace River, Alberta. When immature fish from both populations were compared, their mean fork lengths at time of capture were similar. Age I and II Peace River chubs averaged 91 mm and 112 mm FL while Perry Creek chubs had comparable lengths of 92 mm and 119 mm. However, age III and IV Peace River fish with mean fork lengths of 168 mm and 182 mm were much larger than Perry Creek chubs of the same age who averaged only 130 mm and 148 mm FL.

The Peace River is a large ecosystem which may have more food and diverse habitats than Perry Creek, thus accounting for the faster growth observed in the Peace River population after the first 2 years. Peace River chubs also do not become sexually mature until 4 years old, while Perry Creek chubs mature when 2 years old. Also, the subspecies recognized by Olund and Cross (1961) as *H. g. gulonella* is smaller than *H. g. gracilis* to which the Peace River fish presumably belong. If the Perry Creek population represents subspecific intergrades, its chubs may be smaller for a given age simply because of their genetic complement.

Only 4 age groups were represented in Perry Creek samples and most fish were 2 and 3 years old. We took no young-of-the-year, relatively few yearlings and more 3 than 2 year old fish (Table 1). Considering that growth in length from 1971 through 1974 was similar for older fish (Table 2), it is also reasonable to assume uniform recruitment and mortality during those years. If sampling was nonselective and all age groups uniformly distributed, we should have taken more yearlings than 2 year olds and more 2 year olds than 3 year olds. This did not occur. Essentially, our samples consisted of sexually mature fish (88.6%) which were collected from the deeper pools in the creek. Most immature fish must have been distributed elsewhere in the ecosystem. We were unsuccessful in locating them by sampling in riffles and other habitats. Young-of-the-year were probably too small to be retained in the seine until fall because flathead chubs spawn relatively late in the year (mid-July through mid-August). We did no sampling after September 27th in either 1975 or 1976.

Failure to collect older and larger flathead chubs is more difficult to explain. In North America, older and larger specimens often occur in the northern part of a species range if the ecosystem is undisturbed and the population unexploited. In the Peace River, Bishop (1975) found many fish over 4 years old with some up to 10 years old and total lengths exceeding 300 mm. We do not believe that we failed to collect older and larger chubs in Perry Creek because of sampling or distribution bias. In our opinion, the larger fish simply were not present and probably are uncommon in the Missouri River proper (Schmulbach *et al.*, 1975). Large flathead chubs were formerly taken from the unchannelized Missouri River below Gavins Point Dam, and several are in the permanent fish collection at the University of South Dakota. However, none have been taken within the last 10 years by personnel at the University of South Dakota.

A combination of factors is probably responsible for the paucity of older and larger specimens in this part of the chub's range. It is possible in a river as large as the Missouri that the older chubs simply were not sampled by the collection methods used. We believe, however, that a reduction in suitable habitat for larger fish is important. Only 84 km of the Missouri River below Gavins Point Dam is natural and free-flowing. Moreover, the watershed and all tributary streams have been affected by changes in vegetative cover, and some have experienced in-channel changes as well. From our observations, it would appear that habitat alteration has increased natural mortality so that few older and larger flathead chubs exist in this part of its geographic range.

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