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Age and Growth of River Carpsucker in Des Moines River, Iowa[1]

By Marvin Buchholz

Introduction

Although the northern river carpsucker, *Carpiodes carpio carpio* (Rafinesque), is one of the more abundant species of fish in the Des Moines River, it is not a well known fish. Few laymen are acquainted with it. Precise information on its life history is limited, and its ecological role has not been determined. The river carpsucker is rarely utilized by commercial or sport fishermen and for this reason is usually classified as a rough fish. A few carpsuckers enter the commercial fishery of the Mississippi River (Barnickol and Starrett, 1951). Some are taken by sport fishermen using extra small hooks and bits of doughball or bread for bait (Harlan and Speaker, 1956). This life history study is a step in determining the relationships of the carpsucker to the other fishes in the Des Moines River, which is essential to the best management of that fishery.

The area from which the specimens were taken for this study is a stretch of the Des Moines River approximately four miles long immediately below the Frazer dam in Boone County, Iowa. The townships concerned are R22W, T84 and 85N; and R26W, T84 and 85N. Except during high water conditions, this section of the river is shallow enough in most places to be fished by men in waders. There are, however, several pools over six feet deep of considerable size, as well as shallower pools of smaller size, created by the current under many flood-deposited trees and snags in the channel. Sand is the predominant bottom type in this area, but bedrock and boulders are apparent at several points. There are muck bottoms in those areas sheltered from the current. For a more complete description of the Des Moines River study area see Starrett (1950).

Although no specific investigations were made to determine a habitat preference by the river carpsucker, it was learned from experience which habitats would produce the most carpsuckers. The adults were taken in the greatest numbers from the deeper more quiet sections of the river. Some were taken under brushpiles and others in the narrow channel sometimes found near the bank. Few were taken in shallow or in fast moving water. Young-of-the-year were captured almost exclusively in the shallow waters.

[1]From Project 38. Iowa Cooperative Fisheries Research Unit, sponsored by the Iowa State Conservation Commission and the Industrial Science Research Institute of Iowa State College, with the cooperation of the Fish and Wildlife Service, U.S.D.I.

Materials and Methods

The period of collection extended from March 26 through November 17, 1956. A total of 1,441 river carpsuckers was taken. In addition, 103 highfin carpsuckers, *Carpiodes velifer* (Rafinesque), 15 quillback carpsuckers, *C. cyprinus* (LeSueur), and 15 plains carpsuckers, *C. forbesi* Hubbs, were taken during this period. The majority were taken with an electric shocker powered by a 110 volt AC generator, rated at 0.75 Kva. The shocker was operated from a boat in water to deep to wade, and by wading in shallower water. The use of the electric shocker was limited somewhat by the fact that the turbidity prevented recovery of fish at depths below three feet. Other fish were caught with experimental gill net, hoop net, bag seine, common sense minnow seine, and trammel net-electric shocker combination. These gear proved to be inefficient for capturing carpsuckers and were not used extensively.

All measurements were made to the nearest tenth of an inch. Weights were recorded in grams for those fish under 500 grams and in ounces for those fish over 500 grams. The total length as used in this study is that distance from the tip of the snout to the tip of the caudal fin when compressed. The fork length is that distance from the tip of the snout to the fork of the caudal fin. The standard length is that distance from the tip of the snout to the posterior edge of the hypural plate, marked externally by a crease when the caudal fin is bent to either side. The results of this study are in total lengths unless specified otherwise. Length conversion factors, based on 53 fish from 3.4 to 13.7 inches in length, are:

$$\begin{aligned} \text{Standard length} &= .754 \text{ total length} \\ \text{Fork length} &= .890 \text{ total length} \\ \text{Standard length} &= .848 \text{ fork length} \end{aligned}$$

Impressions were made of the scales on clear plastic strips by means of a roller press of the type described by Smith (1954). The impressions were distinct and easily interpreted when examined by means of a standard scole projector at 49 magnifications.

Length-Weight Relationship

The fish were grouped into one-half inch classes and the mean lengths and weights determined for each interval (Table 1). The length-weight relationship for these 209 carpsuckers can be described by the equation:

$$\begin{gathered} \text{Log W} = -2.966 + 2.809 \text{ (log L)} \\ \text{where W} = \text{weight in hundredths of pounds} \\ \text{and L} = \text{total length in inches} \end{gathered}$$

A test, made according to the procedures outlined by Snedecor (1946, p. 119), showed that the regression coefficient, 2.809, was significantly different from 3.0 at the 1 percent probability level. The weight apparently does not increase as the cube of the length. The length-weight relationships of 17 males and 20 females captured during July were compared by an analysis of covariance and found not to differ at the 5 percent level of probability, either in slope of the regression lines or in adjusted mean weights.

The coefficient of condition, C, was computed for 209 carpsuckers using the formula $C = W(10^5/L^3)$, where W is the weight in pounds and L is the total length in inches (Table1). The average condition factors ranged from 84 for the 1.5-1.9 inch fish to 41 for the 17.5-17.9 inch fish. The fish became relatively less plump as their length increased. The average condition factor for 11 spent females was 42 while the average for 35 females carrying eggs was 47. A test, conducted according to the procedures outlined by Snedecor (1946, p. 81), showed that the difference between the means was significant

Table 1
Mean Weights and Condition Factors, at Half-Inch Size Groups, of River Carpsucker, Des Moines River, 1956

Total Length in Inches	Number of Fish	Weight in Pounds		Mean Length	Calculated Weight[1]	Average C[2]
		Mean	Range			
1.5- 1.9	10	.005	-	1.8	.004	84
2.0- 2.4	10	.008	.005- .01	2.3	.007	60
2.5- 2.9	10	.01	.005- .02	2.6	.01	56
3.0- 3.4	10	.02	.01 - .02	3.2	.02	65
3.5- 3.9	7	.02	.01 - .03	3.6	.03	51
4.0- 4.4	10	.03	.01 - .05	4.2	.04	47
4.5- 4.9	10	.06	.05 - .06	4.7	.05	52
5.0- 5.4	10	.07	.03 - .09	5.2	.07	53
5.5- 5.9	10	.09	.08 - .10	5.6	.09	51
6.0- 6.4	3	.12	.11 - .12	6.2	.12	48
6.5- 6.9	3	.14	.12 - .14	6.5	.13	48
7.0- 7.4	3	.15	.13 - .19	7.3	.18	38
7.5- 7.9	1	.23	-	7.8	.22	49
8.0- 8.4	10	.29	.25 - .33	8.3	.26	50
8.5- 8.9	6	.30	.28 - .32	8.5	.28	49
9.0- 9.4	4	.37	-	9.4	.38	46
9.5- 9.9	5	.40	.37 - .44	9.7	.41	44
10.0-10.4	5	.46	.41 - .48	10.2	.48	43
10.5-10.9	5	.55	.50 - .62	10.6	.53	47
11.0-11.4	4	.64	.62 - .69	11.1	.60	46
11.5-11.9	10	.68	.50 - .80	11.7	.70	41
12.0-12.4	8	.84	.75 - .94	12.2	.78	46
12.5-12.9	10	.92	.75 -1.06	12.7	.88	44
13.0-13.4	10	1.05	.81 -1.19	13.2	.98	46
13.5-13.9	10	1.11	1.00 -1.31	13.7	1.09	44
14.0-14.4	10	1.32	1.19 -1.44	14.2	1.20	46
14.5-14.9	9	1.33	1.13 -1.50	14.7	1.32	42
15.0-15.4	4	1.48	1.13 -1.62	15.2	1.46	42
15.5-15.9	1	1.62	-	15.7	1.59	42
17.5-17.9	1	2.22	-	17.5	2.16	41

[1]Log W = —2.966 + 2.809 (Log L).
[2]The identity of the fish is not necessarily the same for the observed weights and the C factors.

at the 1 percent probability level. No seasonal differences in condition factors were noted from April through August.

Age and Growth

Two major difficulties were encountered in interpreting the age of a carpsucker from its scale. The first was in learning to identify an annulus. A number of characteristics were used, for no one character would identify all annuli. The first annulus characterized by a crossing-over along the complete length of the lateral portion, was the most easily identified. The second annulus was often identified in the same manner. Thereafter, the crossing-over was apparent only at the antero- and postero-lateral positions of the scale. The distance between circuli was helpful, in that the annulus was preceded by a band of closely formed circuli and followed by a band not so closely formed. In the posterior section of the scale the annulus was usually evidenced by an increased space between circuli. In the anterior portion all circuli appear like broken lines while those at the annulus are more finely broken. The circuli themselves often thicken just prior to the annulus.

The other major difficulty was in distinguishing between true annuli and false ones. The false annuli, capable of having any of the above characteristics, were recognized by not having a combination of the required characteristics, by their proximity to true annuli, and by the fact the thickening of the circuli is less than in a true annulus.

An understanding of the relationship between the length of the fish and the radius of the scale was necessary to determine the growth by scale analysis. The radii of approximately 150 scales were measured at a postero-lateral position, which was the same position used to take measurements for the growth analysis. The scale measurements, rather than body lengths (Whitney and Carlander, 1956), were then grouped into five millimeter intervals and from each interval ten pairs of data were selected at random. The means when plotted showed the body-scale relationship to be linear and a linear regression was calculated: $L = 0.57 - 0.393(S)$, where L is the total length in inches and S is the postero-lateral scale radius multiplied by 49 millimeters.

The growth of the carpsucker was determined on the assumption that the distance between annuli was proportional to the growth during the same period. Since the body-scale relationship was shown to be linear, a nomograph was constructed (Carlander and Smith, 1944) and used with 0.57 inches as the focal intercept.

Spoor (1938) found that the radius varied less in length in the lateral portions than in the anterior portion for the common sucker, *Catostomus commersonnii* (Lacépède). Brezner (1956) found this to be true for the river carpsucker. In addition, the annuli are more easily recognized there. All measurements for growth analysis were made at a postero-lateral position.

The annulus is completed when the fish starts its faster growth after the slow winter growth. One fish captured May 11 had just formed its annulus while five other fish captured the same day had not laid down an annulus. One fish taken on May 22 had not formed its new annulus. No fish were collected from this date to June 13. All fish taken June 13 and later had formed new annuli. The month of May is apparently the period of annulus formation.

The amount of growth completed from the time of annulus formation to the time of capture was determined from the scale measurements. By using the average increments for each year of life (Table 2) as the expected growth, it was shown that age group I fish completed 34 percent of their expected growth by June 16 and added another 25 percent in the next month, but only an additional 7 percent by August 8. The percentage of expected growth completed up to July 16-23 for the individual age classes I through VII ranged from 59 to 80 percent, indicating that the greatest portion of growth took place early in the summer in 1956.

The calculated lengths representing the growth of river carpsucker in the Des Moines River are given in Table 2. The average annual increments rise through the second year and continually decrease thereafter, with the exception of the last year which is represented by only one fish. Growth appears to be quite uniform throughout the year classes, with the exception of the 1947 class, which is represented by only one fish. Year classes 1952 and 1954 show better than average growth, while the 1953 year class exhibits a lower than average growth.

Sufficient data were not available to determine if there was a difference in growth rates between sexes. Brezner (1956) reported that the females grew faster and larger than the males. The largest and oldest specimen taken in the present study was a 17.5 inch male.

It should be noted that the older fish tend to have lesser calculated lengths than do the younger fish at the same annuli. This trend is frequently noted in growth data computed from scales and is known as Lee's phenomenon of apparent change of growth rate. Van Oosten (1928) reviewed the possible explanations of this phenomenon and Hile (1936) proposed that a higher rate of mortality in the faster growing fish would produce this effect. A differential mortality of this type is the most acceptable explanation for the apparent change in growth rates found in this study. A higher natural mortality among the faster growing individuals would allow the slower growing fish to become older. Therefore, the scales of the older fish, the slower growing individuals, would not be representative of the entire year class at earlier annuli.

Table 2

Average Calculated Lengths, Weights and Increments of Growth of the River Carpsucker of the Des Moines River, Boone County

Year Class	Age Class	Number of Fish	Average Length at Capture, Summer, 1956	Average Calculated Total Length at Annulus								
				1	2	3	4	5	6	7	8	9
1955	I	109	5.0	3.0								
1954	II	26	8.7	3.0	7.0							
1953	III	13	9.3	2.9	5.4	7.8						
1952	IV	14	11.6	3.3	6.0	8.5	10.5					
1951	V	24	12.8	2.7	5.8	8.3	10.6	11.9				
1950	VI	39	13.3	2.7	5.9	8.0	9.8	11.3	12.6			
1949	VII	24	13.7	2.7	5.6	7.7	9.3	11.0	12.3	13.2		
1948	VIII	11	14.0	2.4	5.5	7.2	8.9	10.2	11.5	12.6	13.4	
1947	IX	1	17.5	4.1	5.6	7.6	9.1	10.5	12.4	13.9	15.1	16.4
Grand average length in inches				2.9	6.0	8.0	10.0	11.2	12.3	13.1	13.6	16.4
Number of fish				261	152	126	113	99	75	36	12	1
Average increment in inches				2.9	3.2	2.2	2.1	1.5	1.3	1.0	0.8	1.3
Summed increments of length				2.9	6.1	8.3	10.4	11.9	13.2	14.2	15.0	16.3
Grand average weight in pounds				.01	.11	.24	.45	.62	.81	.96	1.07	1.80
Average increment in pounds				.01	.10	.14	.22	.21	.22	.20	.17	.37

Another discrepancy in this table may partially be explained in the same manner. This discrepancy is that the average lengths at capture for the age classes II, V, VI, and VIII exceed the calculated lengths at the next annulus, as obtained from the next older age group. For example, the average length at capture for age group II (8.7 inches) is greater than the average calculated length at the third annulus (7.8 inches) for age group III. In addition to the already proposed differential mortality, three other factors may be involved: (1) A year class may be faster growing than the preceding year class. Age classes II, IV, and V appear to be above average in growth. Age class III appears to be a slower growing group. It is very reasonable on this basis that the average length at capture for age group II fish be greater than the average length at the third annulus for those of age group III. (2) Growth in 1956 may have been above average. Muncy (1957) showed that the growth for the channel catfish in the same area for 1956 was above average. Then the fish, even though taken in midseason, may be larger than the next older year class at the end of the previous year. (3) The methods used in obtaining the fish may have been selective for the larger ones. The main gear used to capture the fish was the electric shocker and all sizes were taken by this gear. However, there may have been times when the gear was selective for the larger sizes. Larger fish are affected at a lesser voltage than the smaller fish (Fisher, 1950). The effective electric field may, therefore, be smaller for small than large fish. Selectivity would have occurred at any time the voltage was not great enough to stun the smaller fish and yet was sufficient to stun the larger ones. The current varies with the distance between electrodes, the conductivity of the water and the conductivity of the bottom. All of these conditions can vary, so that it is difficult to determine if or when selection takes place. It is possible that in operating the electric shocker there was a tendency to select the larger fish from those stunned, particularly at those times when a large group was stunned.

The grand average lengths were used in the derived length-weight equation to obtain grand average weights and average annual increments in weight (Table 2). The smallest increments in weight were made by the younger fish. The greatest increments were made during the third, fourth, and fifth years of life. However, the percentage increases in weight were greatest in the younger fish.

Fecundity

Harlan and Speaker (1956) indicate that April and May is the spawning time of the carpsucker in Iowa and that the eggs are broadcast over the bottom and are left unattended. Brezner (1956) extends this spawning time from April through June for Missouri. Starrett (1948), considered this species to be an intermittent spawner upon observing several size groups of eggs in the ovary. A spawning period of May through July was suggested in 1956 by the fact that fingerlings of 1.0-1.4 inches appeared in the catch from June through August.

The ratio of spent females to the total number of females examined was 2 to 6 for May, 4 to 19 for June, and 15 of 30 for July. Spawning was definitely underway in May and it is possible that some fish spawned in April, but no data on condition of ovaries were collected at that time. The continued increase in percentage of females spent suggests that spawning continued into July. The fact that not all females were spent by the end of July gives further support to this idea. However, not all gravid females spawned. By August the eggs of some females were becoming soft and starting to lose their shape. It is believed that these eggs were being absorbed.

The diameters of 100 eggs were measured from each of two gravid females by means of the scale projector and the resulting size distributions were plotted. These fish were collected on the 16th of June and their lengths were 10.9 and 11.8 inches. Two definite modes, 2.9-3.4 and 5.4-5.9 millimeters at a magnification of 49X, were evident for both fish. Another size group, whose members were not recognizable as eggs with the unaided eye, was found upon magnification. This group appeared transparent (the larger sizes were opaque) upon magnification and were about one-third the size of the smallest opaque group. These smaller eggs were not included in the egg counts given later.

Field observations also support the idea that the carpsucker is an intermittent spawner. Two females taken during June were considered as being only partly spent, suggesting a prolonged spawning period.

The youngest mature female examined was two years old with an estimated 4,828 eggs. Only 13 fish of age class III were aged and no record was made as to their sexual maturity. Mature females were taken at ages IV-VII. No record was made as to the sexual maturity of the males, except that five of age class II were recorded as immature, as determined from the size and texture of the testis.

The estimated number of eggs per female ranged from 4,828 for a 9.6 inch two year old to 149,744 for a 14.1 inch five year old. The average number of eggs for all females was 102,766 at a mean length of 13.5 inches. A linear regression analysis was made of the length of the fish on the number of eggs (Figure 1, straight line): $N = 141{,}539 + 18.137(L)$, where N in the number of eggs and L is the total length in inches. To obtain a better fit of the regression line to the data, another linear regression was made on the logarithms of the length of the fish and the logarithms of the number of eggs (Figure 1, curved line): $\text{Log } N = -2.435 + 6.549(\text{Log } L)$. The correlation coefficient in this case was 0.83, as compared to 0.62 for the first regression.

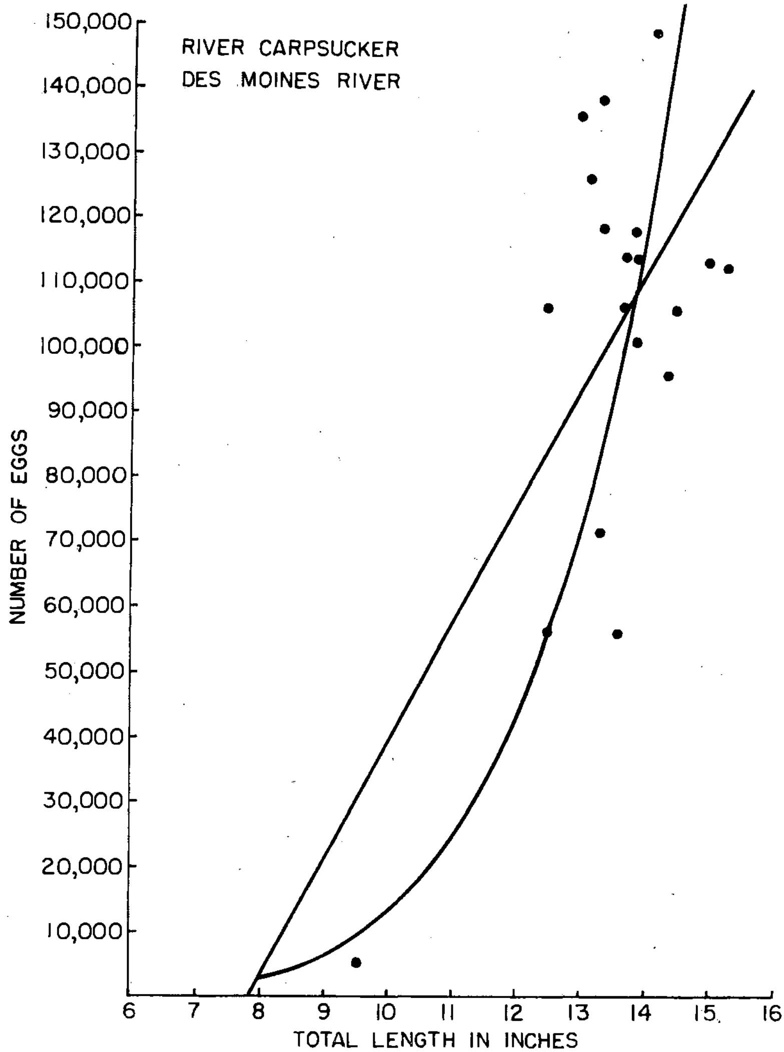

Figure 1. Number (N) of eggs per female carpsuckers at different total lengths (L). Formula for the straight line is N = 141, 539+18,137 (L). Formula for the curved line is Log N = —2.435 + 6.549 (Log L).

Food Habits

The carpsucker is considered to be a bottom feeder and its food is often described as bottom ooze. In this study the stomachs of 104 carpsuckers were examined to determine the principal food items (Table 3.) Nearly all stomachs containing food also contained fine sand grains and varying amounts of mucous, these items sometimes completely filling the stomach. Of the stomachs examined, 28 were found to be empty.

Among the major food items were: diatoms, 71 percent (percent of stomachs containing one or more); green algae, 69 percent; blue-green algae, 55 percent; desmids, 54 percent; dipterous larvae and pupae, 41 percent; *Difflugia* sp., 37 percent; Rotifera, 24 percent; and Copepoda, 22 percent.

When present in a stomach, *Difflugia* sp. and the algae were usually abundant. The numbers of Diptera, Copepoda and Rotifera varied greatly. The stomach of a 10.5 inch fish contained an estimated 50 dipterous larvae and 20 pupae, while the usual number of dipterous larvae was less than five. The stomach and a one-half inch section of the intestine of a 2.6 inch carpsucker contained over 30 Copepoda and 20 or more nauplii. The usual number of copepods was less than 10.

There appears to be little change in the type of organisms taken for food as the fish becomes older. Plant materials, pieces of stems and roots, were found only in the larger fish. One large carpsucker had eaten three snails, *Physa* sp., which were too large to be eaten by small fish. A decrease in the percent of stomachs containing Copepoda, *Difflugia* sp., Bryozoa, Nematoda, and algae may be more apparent than real, due to an increase in the number of empty stomachs in the larger fishes.

When the frequency of occurrence of the food items was plotted according to the month in which the sample was taken, no conclusions could be drawn as to seasonal variations in the food habits of the carpsucker.

Starrett (1950) reported that Diptera larvae are an important food item of the minnows in the Des Moines River and that competition may exist between minnows in the winter for these larvae. Diptera larvae are also the most important single food item of the channel catfish under 4 inches in the Des Moines River and are of lesser importance as the fish becomes older (Bailey and Harrison, 1948). It is possible that the utilization of dipterous larvae by carpsuckers may involve serious competition with minnows and catfish, but more information would be needed to determine whether there ever is a serious shortage of food for these species.

While examining the stomach contents, two cestodes were found. These were identified as the unsegmented *Glaridacris* sp. and *Biacetabulum infrequens*. Several external parasites were also observed during the course of the study. These were identified as the parasitic copepods, *Argulus* sp. and *Lernaea* sp. The latter were most frequently found attached to the fin or at the base of the fin.

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Table 3

Frequency of Occurrence of the Organisms Found in the Stomachs of the Carpsucker, Des Moines River, Boone County, Summer, 1956

	Length of Fish by 1-Inch Size Groups															
Food Item	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total	%
Insecta (immature)																
Tricoptera			1							1			1		3	.03
Diptera	1	9	6	7		1		1	2	1	1	4	4	2	43	.41
Hemiptera			1							1					2	.02
Ephemeroptera														1	1	.01
Crustacea																
Cladocera		1		1						1		3	1		7	.07
Copepoda		5	2	3				2	1	2	1	3	1	3	23	.22
Ostracoda		2	2										1		5	.05
Difflugia sp.	2	11	4	7		1		2	2		1	3	2	2	39	.37
Rotifera	2	11	2	4				1		1	1	1	1	1	27	.24
Bryozoa		7	4									1			12	.15
Nematoda		2	2	1		1									6	.06
Mollusca													1		1	.01
Algae																
Diatoms	5	20	8	13		2		2	2	3	1	5	4	4	74	.71
Desmids	5	16	7	9				2	2	2	1	4	3	1	56	.54
Green algae	5	17	7	13		2		2	2	3	1	4	6	3	71	.69
Blue-green algae	5	12	6	10				1	1	2	1	4	6	4	58	.55
Plant material								1	2	1			3	2	12	.15
Unidentified eggs			4	2					2			2	2	3	17	.16
Number examined	5	20	8	15	0	2	0	6	2	4	3	14	17	8	104	
Number empty	0	0	0	2	0	0	0	3	0	0	2	8	9	4	28	

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