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Abstract. The northern common shiner, *Notropis cornutus frontalis,* was omnivorous in its feeding, but the type of food utilized was greatly influenced by water levels. Reproduction was later in Squaw Creek than in the Des Moines River. Males had consistently higher condition factors than females. Fish grew faster in Squaw Creek than in the Des Moines River but failed to reach the length of the Des Moines River fish in their first year because of a later spawning period. Myxosporidians, nematodes, tapeworms, and copepods parasitized this species.

Introduction

The northern common shiner, *Notropis cornutus frontalis,* is one of the more commonly encountered minnows in Iowa (Harlan and Speaker, 1956). This subspecies is generally found to the north of the other subspecies, in clearer, smaller streams (Eddy and Surber, 1960). Life history data on this minnow were obtaind from Squaw Creek and the Des Moines River in Boone County, Iowa, during spring and summer of 1964.

The Des Moines River is a typical midwestern stream with a bottom composed of sand-silt and occasionally rock rubble in the study area. For a more complete description of the river in the study area, see Starrett (1950 a,b). Water levels were very low throughout the study period except during a moderate spring flood and another period of high water in early August. The water was generally quite turbid due to algal growths (Drum, 1964).

Squaw Creek is a small intermittent stream which drains the northeastern corner of Boone County. It is tributary to the Skunk River. Collections were made from 5 points along the stream on July 20 and from 4 points on August 10. This stream supported a proportionally higher population of common shiners than the Des Moines River. The bottom was sand and rock rubble; the water was cooler and less turbid than the Des Moines River in the areas sampled.

A comparative study of the growth of the common shiner in

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these two habitats was considered of value since they are geographically isolated and present two different ecological environments in which this species is found.

Materials and Methods

During the study, 1,585 common shiners were taken in 66 collections on the Des Moines River. The stomachs of 360 fish were examined for food contents, and scales were taken from 358 fish. Scales were taken from 111 fish seined from Squaw Creek. All collections were made with a common sense minnow seine (20 x 4 ft. with ¼-inch mesh). Most specimens were captured in pool areas with rock bottoms in the presence of a moderate current. After capture, the fish were anesthetized with quinaldine (Muench, 1958), measured, and returned to the water. Some fish from each collection were placed in a 10% formalin solution for further examination in the laboratory. Regurgitation of food by the minows after being placed in the formalin solution was observed on several occasions. It was not thought that one type of food would be regurgitated more readily than another. A better method would have been to suffocate the fish prior to preservation.

In a standardized laboratory procedure, the following data were recorded: (1) standard and total lengths to the nearest millimeter, (2) weight to the nearest hundredth of a gram, (3) stomach contents and per cent fullness, (4) presence of absence of parasites, (5) sex and maturity, and (6) place and date of capture. Scale samples were taken at this time also.

To determine how the measurements of preserved fish differed from the measurements of live fish, samples of 20 live fish were brought into the laboratory on three dates. These fish were anesthetized, weighed, measured, and killed by the same procedure followed in the field. Preserved length was 0.97 live length, and preserved weight was 1.08 live weight.

All measurements used in this study were standard lengths. The length conversion factor for standard length to total length was computed for 60 fish grouped into 10-millimeter classes. The factor remained constant for all sizes of fish, and the total length was 1.27 standard length.

Three scales were taken from each side of the fish from the first scale row above the lateral line directly below the origin of the dorsal fin. These scales were placed between two glass slides which were then taped together. Scales were read at 85X on a scale projector similar to the one described by Van Oosten, et al. (1934). The scales did not require cleaning. Scales were analyzed by following the procedure described by Carlander (1961).

Food habit determinations were made on that portion of the digestive tract from the esophagus to the first loop of the intestine. The stomach was split lengthwise, and percentage fullness was estimated. The contents were then scraped into a petri dish and examined with a 30X dissecting scope. A compound microscope was used if needed for identification of materials in the stomach. All organisms were identified to species when possible; however, the action of the strongly hooked pharyngeal teeth made this difficult for the macroscopic food items. After noting the food items present and the percentage of the total volume of each, the entire digestive tract and its contents were placed in a jar with the digestive tracts of the other fish from the same collection. This material was cleaned with 30% hydrogen peroxide and potasium dichromate and mounted in Hyrax for diatom determination. Proportional counts of the diatom entities were made by following the procedures described by Williams and Scott (1962).

An attempt was made to study the movements of the common shiner with wire minnow traps. This species, however, occurred in only 10% of 90 collections and was usually represented by only a single specimen.

Results

Food Habits. The common shiner was omnivorous in its feeding habits with nearly equal representation of plant and animal matter (Table 1). Hubbs and Cooper (1936) and Dobie et al. (1956) reported similar findings. Feeding was greatly influenced by water levels. During the flood period, the percentage occurrence of Bryozoa, Plecoptera nymphs, Ephemeroptera nymphs, Trichoptera larvae, and all Diptera larvae dropped, and that of *Cladophora* sp., *Spirogyra* sp., and higher plant matter rose. Corixid nymphs, which had not been utilized before this time, were found in 13% of the fish. Starrett (1950) stated that increased turbidity and volume of water probably limit the availability of insect larvae during high water periods and induce a greater utilization of plant matter.

It was found, as reported by Breder and Crawford (1922), that all sizes of fish ate the same types of food. Among the diatoms, 114 entities representing 26 genera, were identified from the digestive tracts. The most abundant species were those which Drum (1964) found dominant in the Des Moines River.

Parasites. When the study began in late April, the population of common shiners was heavily parasitized by a myxosporidian which caused large, white, rounded welts, most commonly

Table 1. Stomach contents of northern common shiners, Des Moines River, 1964.

Food item	4/25/64 to 5/13/64	6/1/64 to 6/30/64	7/1/64 to 7/31/64	8/3/64 to 8/5/64	8/8/64 to 8/27/64	Totals and means
Plant matter						
Algae						
Bottom ooze (diatoms)	45(67)	8(51)	37(63)	24(38)	9(40)	25(52)
Cladophora sp.	7(49)	12(55)	24(67)	29(38)	20(21)	18(46)
Spirogyra sp.	23(26)	6(29)	3(4)	9(10)		10(17)
Other	8(28)	8(65)	8(17)	4(29)		7(35)
Higher plant matter	38(49)	64(57)	18(38)	44(74)	46(42)	42(52)
Animal matter						
Bryozoa						
Plumatella repens			25(49)	2(10)	11(61)	13(40)
Annelida						
Lumbricus sp.	8(91)	1(100)				5(96)
Insecta						
Plecoptera nymphs						
Perlidae		4(23)	3(42)		3(50)	3(38)
Ephemeroptera nymphs	2(75)	29(45)	37(43)	2(15)	34(41)	21(44)
Hemiptera nymphs						
Corixidae				13(85)	6(65)	10(75)
Trichoptera larae		3(22)	6(48)		3(30)	4(33)
Diptera larvae						
Chironomidae	3(53)	9(19)	17(16)	2(40)	23(24)	11(30)
Other	4(13)	11(11)	2(6)		6(65)	6(24)
Adult Coleoptera	1(20)	2(35)	1(80)	2(100)	11(63)	3(80)
Other adult insects	11(37)	14(26)	9(12)	8(63)	11(35)	11(35)
Other larval insects	5(37)	7(16)	1(15)	4(35)	11(49)	6(30)
Miscellaneous and unidentified	6(21)	19(21)	8(37)	4(63)	9(49)	9(38)
Number of fish examined	60	99	121	45	35	360
Number of fish empty	9	9	19	7	5	49
Average per cent fulness	25.33	25.20	20.90	17.71	16.53	21.13

The first figure is percentage of occurrence in the stomachs examined.
The second figure is the average percentage of volume in the stomachs containing the item.
The river was at flood stage in the August 3-5 period.

found behind the operculum, under the head and at the base of the fins. More than 7% of the first 828 fish examined in the early summer had this parasite. The common shiner was the only species in the river found infected with this parasite. The parasite occurred much less frequently in late summer.

Tapeworms were found in two fish, and black grubs occurred infrequently throughout the period on this species. A nematode parasite, *Rhabdochona cascadille* Wegdor, was found in the digestive tracts of 10 fish. This species occurred only in fish at least 2 years old. Dinsmore (1962) found nematodes of the same genus in seven creek chubs, *Semotilus atromaculatus*, from the Des Moines River in Boone County in the summer of 1961.

After a high water period in early August, a copepod parasite, *Lernaea* sp., became abundant on most species of fish occurring in the Des Moines River, including the common shiner (Fee and Drum, 1965).

Reproduction. Starrett (1948) found the common shiner spawning from late June through July in the Des Moines River in 1946-47. He stated that the appearance of young in late July was evidence of this spawning period. In 1964, young were first collected on July 17 and were already 33 millimeters long (Fig. 1). Only two gravid females were collected from the Des Moines River in 1964, on June 8 and 24. One ripe male with well-developed breeding tubercles was captured on June 8. Two

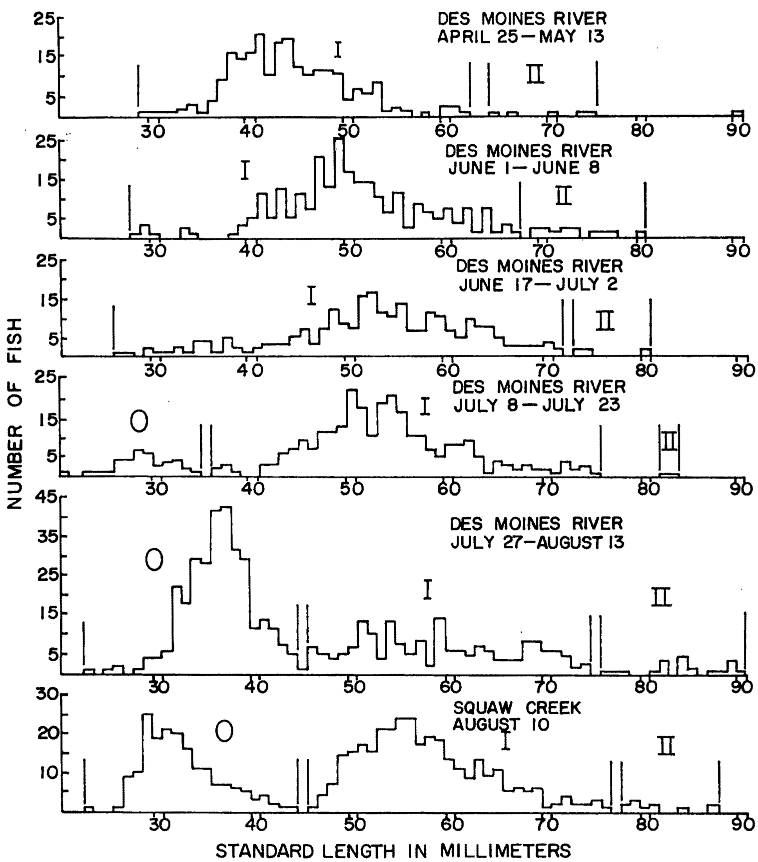

Fig. 1. Length-frequency histograms of northern common shiners, Boone County, Iowa, 1964.

females collected on July 17 had almost completely resorbed their eggs. These data indicate a spawning period earlier than that reported by Starrett.

Paloumpis (1958) stated that middle April to late May was the spawning period in Squaw Creek in 1954-55. In 1964, six gravid females and one extremely ripe male were taken from Squaw Creek on July 20. Gravid females were seined from Montgomery Creek and Onion Creek, two small tributaries to Squaw Creek, on July 20 and July 23, respectively. Paloumpis did not find common shiners in these small tributaries. It is thought that these fish moved into these smaller streams to spawn since Raney (1940) indicated that there is an upstream migration during spawning periods.

From these data, it was concluded that the northern common

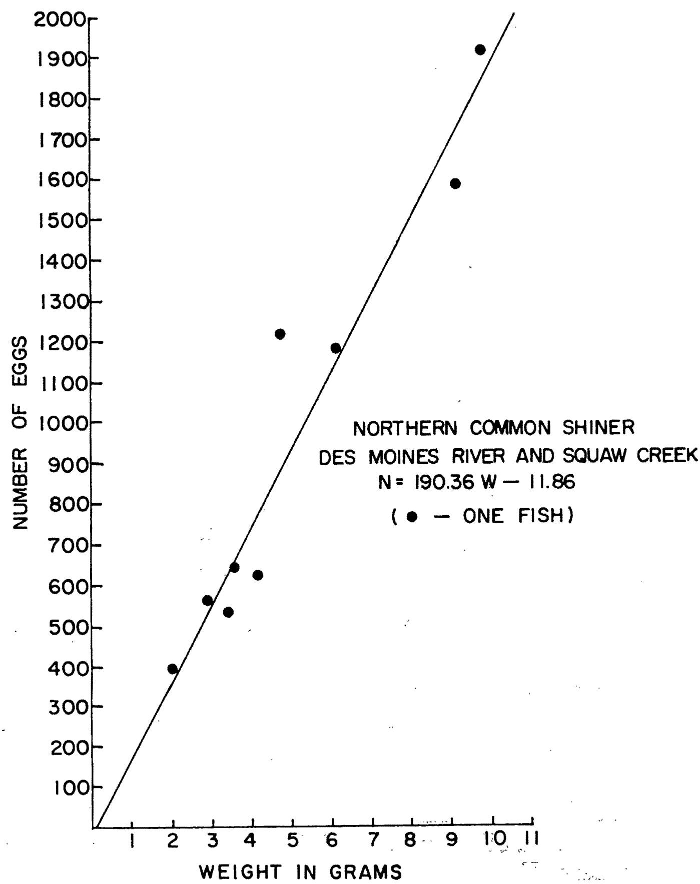

Fig. 2. Number of eggs per female common shiner at various weights

shiner spawned earlier in the Des Moines River than in Squaw Creek in 1964. The length-frequency histograms (Fig. 1) from Squaw Creek and the Des Moines River in early August substantiate this hypothesis.

Egg counts were made for nine individuals (Fig. 2) and:

$$N = 190.36\ W - 11.86$$

where N = total number of eggs
and W = weight of fish in grams.

Condition and Length-Weight Relationship. Condition factors, a measure of the relative plumpness of a fish (Lagler, 1956), were computed by using the formula $K(SL) = W\ 10^5/L^3$, where W is the weight in grams and L is the length in millimeters.

	Mean K
Des Moines River	
April 25 - May 13	
15 males	1.79
26 females	1.76
June 1 - June 30	
82 males	1.73
16 females	1.63
July 1 - July 31	
101 males	1.74
20 females	1.68
August 1 - August 15	
79 males	1.70
12 females	1.56
Squaw Creek	
July 20 - August 10	
66 males	1.72
42 females	1.68

These data show little seasonal variation during the study. It is also evident that the K(SL) factors of the fish from Squaw Creek did not differ widely from those of the Des Moines River fish captured during the same period.

Since the average K (SL) factors were consistently higher for the males than the females, the length-weight relationship was calculated separately for the sexes. Ten groups were established at 4-millimeter intervals and five fish were randomly selected for each class, where possible. The length-weight regressions for the Des Moines River fish were calculated as:

Males: 50 fish, 35-75 mm. $\text{Log } W = -4.202 + 3.247 \text{ Log } L$
Females: 46 fish, 35-75 mm. $\text{Log } W = -3.91 + 3.078 \text{ Log } L$
where W = weight in grams
and L = standard length in millimeters.

Age and Growth. The first annulus was usually characterized by distinct crossing over in the lateral fields and crowding of the circuli in the anterior field. The subsequent annuli were much harder to identify, the only characteristic found reliable was the crowding of the circuli in the anterior field. The scales of the fish from Squaw Creek were more easily read than those of the fish from the Des Moines River (possibly an indication of faster growth).

No fish collected on April 25 had formed annuli. Fish forming annuli were captured on May 7, May 13, and June 1. All fish collected on June 8 had formed annuli. May and early June were concluded to be the period of annulus formation in the Des Moines River.

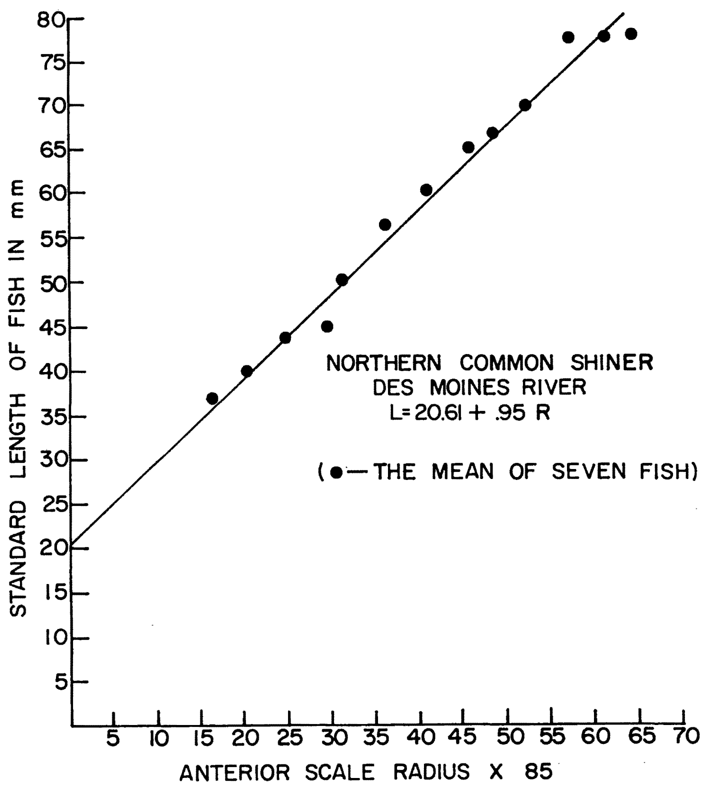

Fig. 3. Body-scale relationship of northern common shinners from the Des Moines River, 1964.

To determine the relationship between the length of the fish and the length of the anterior radius of the scale, the radii of scales from 290 fish were measured. Using scale lengths, 4 millimeter size groups were set up, and fish were selected at random until the groups, 13 in all, each had seven pairs of data. The mean scale and body lengths were then calculated for each size group (Fig. 3). The body-scale relationship is:

$$L = 20.61 + 0.95\ R$$

where L = standard length in millimeters
and R = anterior scale radius in millimeters (X85).

The lengths of the fish at the various annuli were calculated on a nomograph (Carlander and Smith, 1944) by using 20.6 mm as the focal intercept. Only eight fish were beyond age II (Tables 2 and 3), and an age V male was the only fish beyond age III. Males grew faster than females, as also was reported by Hubbs and Cooper (1936).

During the first year of life, the Squaw Creek common shiners averaged smaller than those from the Des Moines River, but the reverse was true in the second and third years. This was thought to be a result of the later spawning period but better growth rate in Squaw Creek than in the Des Moines River.

Table 2. Growth of the northern common shiner, Des Moines River, Iowa, 1964.

Year class	Age	Sex	No. of fish	Mean calculated standard length at annulus 1	2	3	4	5
1963	I	M	248	45.25				
		F	81	42.65				
1962	II	M	20	46.10	69.35			
		F	5	41.65	61.20			
1961	III	M	2	43.00	67.50	78.50		
		F	0					
1959	V	M	1	51.00	64.00	78.00	97.00	116.00
		F	0					
Totals		M	272	46.34	66.95	78.25	97.00	116.00
		F	86	42.12	61.20			

Table 3. Growth of the northern common shiner, Squaw Creek, Iowa, 1964.

Year class	Age	Sex	Number of fish	Mean calculated standard length at annulus 1	2	3
1963	I	M	61	38.95		
		F	26	35.46		
1962	II	M	4	44.75	71.25	
		F	15	42.13	64.73	
1961	III	M	2	48.00	79.00	95.00
		F	3	49.33	64.66	79.67
Totals		M	67	43.90	75.12	95.00
		F	44	42.30	64.70	79.67

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