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Reproductive Potential of Largemouth Bass in Ponds and Food Habits of Fingerlings

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REPRODUCTIVE POTENTIAL OF LARGEMOUTH BASS IN PONDS AND FOOD HABITS OF FINGERLINGS [1]

By Percy W. Laarman and James W. Merna

Abstract

In ponds at the Saline Fisheries Research Station, the relationship between egg potential of largemouth bass and number of fingerlings produced was negative. The least squares regression for number of mature eggs (Y) on total length of females in centimeters (X) was $Y = -39,123 + 2,191 X$ with a correlation coefficient (r) of 0.85. A bimodal length-frequency distribution of young-of-year bass was evident and appeared to be food related. Bass less than 10 cm long ate primarily zooplankton, but larger fingerlings shifted to crayfish and fish. Density of fingerlings did not affect overall abundance of zooplankton in the ponds.

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[1] Contribution from Dingell-Johnson Project F-35-R, Michigan.

Introduction

In 1976, the Michigan Department of Natural Resources increased the statewide minimum size limit on largemouth bass (Micropterus salmoides) from 25.4 cm (10 inches) to 30.5 cm (12 inches). The increase was based on data available at the time on reproduction, growth, survival, and exploitation of the species. Latta (1974) referring to largemouth bass stated, "the relationship between spawning stock and size of the year class produced is unknown." A more recent compilation of biological data on largemouth bass verified Latta's conclusion (Heidinger 1976).

Information on number of spawners vs year-class strength has dealt primarily with largemouth bass in combination with other species of fish. Bennett et al. (1969) reported a negative relationship or no relationship between the number of spawners per hectare and the estimated number of bass fry produced in Ridge Lake, Illinois. Kramer and Smith (1962) reported that size of the spawning stock did not determine year-class strength in Lake George, Minnesota. In Lake Carl Blackwell, an impoundment in Oklahoma, year-class strength was independent of numbers of brood stock (Summerfelt 1975). There was little correlation between the number of adult largemouth bass and the strength of the resulting year class in four ponds (0.3 to 3.6 ha) stocked in combination with other species (Mraz and Cooper 1957). They also reported little consistency in the success of natural reproduction from one year to the next when the same combination of species was used to stock the ponds.

The objectives of this study were to determine the relationship between the potential number of largemouth bass eggs and number of fingerlings surviving the first summer in ponds void of other fish, and to determine food habits of young-of-year bass.

Methods

The experiment was conducted at the Saline Fisheries Research Station, Saline, Michigan. Nine ponds were stocked with adult largemouth bass and three ponds without fish were used as controls for the zooplankton part of the study. The nine ponds were divided into groups of three and on a random basis each pond of a group received 8, 16, or 32 adult bass. In early April 1978, all 12 ponds were drained to remove extraneous fish and refilled with water. Ponds were stocked from 17 April to 25 April, prior to the spawning season. During the summer enough water was run into the ponds to compensate for losses from evaporation and leakage. Area and mean depths of the ponds are given in Table 1.

The stocked bass were progeny of bass originally obtained from the Wolf Lake State Hatchery. Fecundity was determined from ovaries of 27 cohorts, 2 to 4 years old, ranging in total length from 21 to 38 cm. Ovaries were blotted dry and weighed after extraneous tissue was removed. Three subsamples from each ovary were weighed and number of eggs counted to determine the mean number of eggs per unit weight of ovary. Largemouth bass ovaries contain eggs of more than one size. Therefore, ova 0.75 mm and larger were considered mature as described by Kelley (1962). Only mature eggs were counted. The potential number of eggs per pond was determined from the mean length of bass when stocked and the number of adult females recovered in the fall.

Fingerlings were first collected by seine on 8 June and biweekly thereafter until 17 August. On each date about 10 fish per pond were collected for stomach analyses. Stomach analyses consisted of sorting and counting the food organisms. A sample of individuals of each genera of plankton from the stomachs was measured.

Samples of zooplankton were taken 9 and 30 June, 21 July, 2 and 17 August. On each collection date four samples were taken per pond, one from each quadrant. The quadrant was also divided into four parts and the sample was taken from the center of a part randomly selected.

A plankton net of No. 10 nylon mesh with a diameter of 31 cm, and 1 m in length was used. The net was pulled with a constant motion from bottom to surface. To assure standard measurements each sample was centrifuged at a constant rate to determine the volume of zooplankton per sample. From the four samples per pond, the volume of plankton (ml/m^3) was determined for each pond. Plankters were identified to genera and counted in subsamples. An estimate of the total number of plankters per pond sample was determined from the subsamples. Length measurements were obtained for each genera of plankton.

Ponds were drained between 25 September and 11 October. Fingerlings were counted, measured, and samples were preserved for stomach analyses. Numbers, lengths, weights, and sex were determined also for adult bass.

Results

Numbers and mean lengths of adults stocked and recovered during the fall draining are given in Table 2. Overall, 76% of the stocked adults were recovered in the fall.

The regression line calculated for number of mature eggs (Y) on total length of fish in centimeters (X) was:

$$Y = -39,123 + 2,191\ X \pm \left(t_{27df} 5745 \sqrt{0.037 + \frac{(25.8 - X)^2}{454}} \right)$$

with a correlation coefficient (r) of 0.85. Based on the equation, a bass 25 cm long contained 15,652 ± 2,319 eggs and a 30-cm bass contained 26,607 ± 3,259 eggs. Fecundity of bass varies with length, weight and age (Kelley 1962). From 2,000 to 109,314 eggs per female have been reported by Carlander (1977).

Number of fingerlings recovered and egg potential per pond ranged from 170 to 7,553 and 55,254 to 328,198, respectively (Table 3).

A negative relationship existed between number of fingerlings (A) and egg potential (B) and was best described by the polynomial equation:

$$A = 12,985 - 0.1968\,B + [(9.4)(10^{-7})]\ B^2 - [(13.6)(10^{-13})]\,B^3.$$

About 53% of the variation in number of fingerlings was due to egg potential. Pond 15 with the lowest egg potential (55,254) produced the greatest number (7,553) of fingerlings. Pond 7 with a slightly greater egg potential (92,693) produced the least number (170) of fingerlings. The greatest egg potential (328,198) was in Pond 17 and only 370 fingerlings were produced. Since the pond with the lowest egg potential produced the most fingerlings, the minimum number of spawners or lowest egg potential necessary to produce a year class of fingerlings could not be determined.

Growth rate of fingerlings was density dependent (Table 4). In the fall, the relationship between mean length and density of fingerlings per pond was $r = -0.63$. Transformation of the variables to $\log_e$ changed the value of r to -0.86. This relationship between growth rate and density of fingerlings suggested competition for food, but stomach analyses and availability of zooplankton did not substantiate the concept of food as a factor.

A bimodal length distribution of bass fingerlings was evident when the ponds were drained. Excluding Pond 9 because length measurements were not taken, all other ponds except Pond 7 had a distinct bimodal distribution of bass lengths (Table 4). All of the 170 fingerlings in Pond 7 were 10 cm or longer and bimodality was less evident. Fingerlings between 8 and 9.9 cm long were absent in seven ponds. In Pond 16 there were no fingerlings between 12 and 13.9 cm long.

Bimodal length distribution of young-of-year bass in lakes and reservoirs has been reported by Aggus and Elliott (1975), Summerfelt (1975), Shelton et al. (1979), and Timmons et al. (1980). Cooper (1937) reported the same phenomenon in state-operated rearing ponds in Michigan. The authors attributed the causes to interrupted spawning and/or availability of prey species. In the current study, interrupted spawning was not observed and other prey species were not available to bass fingerlings. Cannibalism among fingerlings first became evident on 17 August. A fingerling (8.1 cm long) collected on that date contained a small bass in its stomach. Samples collected later in the fall provided additional evidence that fingerlings were cannibalistic (Table 5). A correlation coefficient (r) of -0.39 between total number of adults stocked and number of fingerlings recovered suggested that cannibalism by adults had little impact on the number of fingerlings produced.

Food habits of fingerlings were much different in the fall than earlier in the summer. In the fall, fingerlings less than 10 cm long ate fewer cladocerans than earlier, but copepods remained as important food organisms (Table 5). Beginning 17 August, insects (mainly midge larvae and pupae) became more important as food items. Insects, crayfish and fish replaced zooplankters in the diet of fingerlings longer than 10 cm. The availability of cladocerans in the fall is not known since the last plankton samples were collected 17 August. Kramer and Smith (1960) also reported that microcrustacea were the primary food items of young-of-year bass and as the fish increased in size, their diet shifted from the smaller organisms (cladocerans, copepods and rotifers) to the larger forms (*Hyalella*, immature and adult insects, and fish).

Cladocerans and copepods were eaten in the same ratio as found in plankton samples from ponds containing fish. In both stomach and plankton samples, 79% of the total number of organisms were cladocerans and 19% copepods (Table 6). In control ponds, plankton samples consisted of 42% cladocerans, 57% copepods, and 1% other. I have no explanation for the difference in composition of plankton samples between control ponds and experimental ponds with bass.

The genera of cladocerans in both stomach and plankton samples were *Alona*, *Alonella*, *Bosmina*, *Ceriodaphnia*, *Chydorus*, *Daphnia*, *Diaphanosoma*, *Holopedium*, *Leptodora*, *Leydigia*, *Moina*, *Pleuroxus*, *Scapholeberis*, *Sida*, and *Simocephalus*. Copepods were *Cyclops* and

Diaptomus. Plankters found most consistently in stomach and plankton samples were Bosmina, Chydorus, Daphnia, Diaphanosoma, and Cyclops. Mean lengths of Bosmina, Chydorus and Cyclops were significantly longer in the stomachs than in plankton samples (Table 7). There was no significant difference in mean lengths of Daphnia and Diaphanosoma. In control ponds, Chydorus, Daphnia, Diaphanosoma, and Cyclops were the same size as in stomach samples and Bosmina were identical in length to those in plankton samples from ponds containing fish.

The standing crops of zooplankton varied considerably among ponds and collection dates (Table 8). Apparently young-of-year bass had little impact on the zooplankton population. Although zooplankton was the primary food and bass fingerlings ate the greatest numbers (Table 5) during August, the largest standing crops occurred during the same month. The correlation between fingerling density vs mean standing crop of zooplankton was $r = -0.31$. In an earlier experiment with bluegills in the same ponds, Latta and Merna (1977) reported that zooplankton virtually disappeared by mid-July from ponds with abundant fry, whereas zooplankton abundance remained high throughout the summer in ponds with few or no fry. Densities of bluegill fry that affected the zooplankton populations were much greater than densities of bass fingerlings in this study.

In summary, there was a negative relationship between egg potential and number of fingerlings produced. However, larger ponds would be required to determine the minimum number of spawners per hectare necessary to produce a year class since the pond with the lowest egg potential produced the most fingerlings. Bass less than 10 cm long ate mainly zooplankton, but larger fingerlings shifted to crayfish and cannibalism. Density of fingerlings did not seem to affect zooplankton abundance in the ponds. The bimodal length-frequency distribution of young-of-year bass appeared to be food related.

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Table 1.--Area and mean depths of experimental ponds at the Saline Fisheries Station.

Pond number	Area (hectares)	Mean depth (meters)
5	0.30	1.3
6	0.28	1.2
7	0.26	1.2
8	0.25	1.2
9	0.27	1.3
10	0.25	1.1
13	0.20	1.0
14	0.21	1.0
15	0.29	1.0
16	0.24	1.0
17	0.24	1.0
18	0.20	1.0

Table 2.--Number and mean total length of adult largemouth bass stocked and recovered from the experimental ponds.

Pond number[a]	Stocked[b]		Recovered		
	Number	Length (cm)	Number		Length (cm)
			Male	Female	
5	32	24.4	12	15	33.5
6	8	36.1	5	2	38.7
7	16	23.9	5	7	27.4
8	16	22.9	9	7	33.0
9	32	23.4	11	8	32.3
15	8	22.9	2	5	33.3
16	8	35.8	2	5	39.2
17	32	34.5	13	9	37.9
18	16	36.3	6	5	40.7

[a] Ponds 10, 13, and 14 were controls with no fish.

[b] Fish stocked in ponds 5, 7, 8, 9, 15 were two years old and ranged in length from 20.6 to 28.2 cm; fish in ponds 6, 16, 17, 18 were four years old and ranged from 30.5 to 39.6 cm in length.

Table 3.--Egg potential and number of fingerling large-mouth bass recovered in the fall from experimental ponds (± 2 standard errors).

Pond number	Number of potential eggs	Number of fingerlings recovered
5	215,061 ± 33,896	926
6	79,944 ± 11,956	791
7	92,693 ± 17,053	170
8	77,356 ± 18,952	3,432
9	97,171 ± 20,490	1,149
15	55,254 ± 13,537	7,553
16	196,574 ± 29,139	1,038
17	328,198 ± 46,674	370
18	202,052 ± 30,391	536

Table 4.--Length-frequency distribution of young-of-year largemouth bass in the fall from the experimental ponds.

Length group (cm)	Pond number[a]							
	5	6	7	8	15	16	17	18
4.0- 5.9	718	432	0	0	7524	21	160	168
6.0- 7.9	55	307	0	3394	0	617	87	234
8.0- 9.9	0	0	0	0	0	202	0	0
10.0-11.9	4	3	61	4	0	21	7	5
12.0-13.9	11	1	49	14	1	0	27	20
14.0-15.9	18	8	12	3	4	29	45	45
16.0-17.9	35	6	20	4	8	41	39	37
18.0-19.9	25	8	24	11	11	58	5	27
20.0-21.9	49	20	4	2	5	49	0	0
22.0-23.9	7	6	0	0	0	0	0	0
24.0-25.9	4	0	0	0	0	0	0	0
Total	926	791	170	3432	7553	1038	370	536
Weighted mean length (cm)	7.3	6.7	13.9	7.1	5.1	9.4	8.8	8.6

[a] Fingerlings from Pond 9 were not measured.

Table 5.--Mean number of food organisms per young-of-year largemouth bass (empty stomachs excluded).

Date of collection	Number of fish sampled	Number of fish with food	Mean length of fish (cm)	Number of organisms per fingerling				
				Cladocera	Copepoda	Insects[a]	Fish	Crayfish
8 June	64	64	2.0	32	14	0.8	0	0
22 June	59	56	3.5	76	20	2.8	0	tr
7 July	52	48	4.5	214	62	1.6	0	tr
20 July	100	98	4.8	297	59	1.7	0	0.1
2 Aug	80	78	5.5	511	129	1.3	0	0
17 Aug	75	75	6.0	682	80	7.2	tr[b]	tr
Sep-Oct[c]	52	35	7.0	28	109	14.8	0	tr
Sep-Oct[d]	75	59	15.2	tr	0.1	3.7	0.7	0.8

tr = Less than 0.1 organism per stomach.

[a] Insects were primarily midge pupae and larvae.

[b] One fingerling 8.1 cm long contained one fish.

[c] Fingerlings less than 10 cm long.

[d] Fingerlings greater than 10 cm long.

Table 6.--Percentage of cladocerans and copepods in stomach and plankton samples of the total number of organisms, in the collections made 8 June to 17 August, 1978.

Pond number	Cladoceran Stomach samples	Cladoceran Plankton samples	Copepoda Stomach samples	Copepoda Plankton samples
Experimental				
5	87	91	12	7
6	69	84	31	15
7	89	61	10	38
8	89	91	10	9
9	91	47	9	52
15	69	83	30	13
16	54	87	42	9
17	81	89	17	9
18	84	81	12	15
Mean	79	79	19	19
Control				
10		36		61
13		31		69
14		60		40
Mean		42		57

Table 7.--Mean lengths of most abundant genera of zooplankton in stomach and plankton samples collected 8 June to 17 August, 1978, from experimental ponds. Number of organisms measured in parentheses.

Genera	N [a]	Mean lengths (mm)		t values [b]
		Stomach samples	Plankton samples	
Cyclops	9	0.83 (3,452)	0.66 (5,148)	3.37*
Daphnia	9	1.23 (1,179)	1.42 (2,711)	-1.07 NS
Bosmina	9	0.37 (2,243)	0.31 (4,729)	6.38**
Chydorus	7	0.36 (1,538)	0.25 (725)	4.20**
Diaphanosoma	7	0.66 (479)	0.60 (889)	0.94 NS

[a] Number of ponds in which the organisms were found in both fish stomach and plankton samples.

[b] Asterisks denote mean lengths that were significantly different (t-test) at *P<0.05, **P<0.01, NS = not significant.

Table 8.--Standing crops of zooplankton (ml/m^3) in experimental ponds on five collection dates.

Pond number[a]	June 9	June 30	July 21	Aug 2	Aug 17	Mean per pond (ml/m^3)
5	7.0	14.1	5.7	34.3	51.5	22.5
6	19.1	8.5	21.1	50.8	131.8	46.3
7	23.7	24.7	22.4	21.8	76.9	33.9
8	9.1	15.8	39.6	26.1	25.8	23.3
9	42.5	22.4	5.2	30.0	20.8	24.2
10	7.3	19.0	15.6	50.0	188.1	56.0
13	53.8	15.6	17.3	17.4	12.8	23.4
14	2.4	13.1	13.1	24.1	21.3	14.8
15	4.4	7.1	13.6	15.5	8.3	9.8
16	0.4	2.4	7.1	12.1	12.0	6.8
17	5.2	3.2	2.1	4.1	18.0	6.5
18	10.3	1.9	18.0	30.7	32.5	18.7
Mean (ml/m^3) per collection date[b]	13.5	11.1	15.0	25.0	42.0	

[a] Control ponds without largemouth bass were numbers 10, 13, and 14.

[b] Excluding control ponds.

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