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ESTIMATION OF THE FECUNDITY OF SMALLMOUTH BASS, *MICROPTERUS DOLOMIEUI* LACEPEDE, FOUND IN THE WILSON DAM TAILWATERS, ALABAMA

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ABSTRACT

Fecundity of smallmouth bass was estimated from 33 specimens (257 to 544 mm total length) collected in the Wilson Dam tailwater (Alabama) prior to spawning. Estimated fecundity ranged from 2,600 to 27,200 mature ova per female. Ova diameters ranged from 0.31 to 3.13 mm, but only ova exceeding 1.56 mm appeared to be mature. Fecundity can be predicted about equally well from knowledge of total length or weight measurements and to a lesser extent from knowledge of age.

INTRODUCTION

The Tennessee River drainage forms the southeastern periphery of the natural range of smallmouth bass, *Micropterus dolomieui* Lacepede, in northern Alabama. Within the Tennessee River Valley, the waters below Wilson Reservoir Dam are known for consistent production of large size smallmouth bass. The fecundity study described here is a part of the general life history investigation of smallmouth bass in the tailwaters of Wilson Dam.

Fecundity as employed in this paper was defined by Kelley (1962) as the total number of mature ova in both ovaries during any one season. Historically, black bass researchers have estimated the total fecundity, that is, the number of ova, not just mature ova, in ovaries prior to spawning. Total fecundity is an extreme exaggeration of the actual deposition complement of potentially fertile ova. A more accurate estimate of the spawning potential is achieved by separating potentially mature ova from immature ova in the ovaries just prior to spawning.

Little published information exists concerning smallmouth bass fecundity. Total fecundity estimates of 2,000 to 10,000 ova per female were given by Bower (1897), while Culler (1938) estimated 20,825 ova for a 432 mm female. Watson (1955) summarized total fecundity of smallmouth bass as 8,000 ova per pound. These authors do not describe their methods; it is assumed they were reporting estimates of all ova within the ovary. Other estimates have been reported by Carlander (1953), Bennett (1971), and Emig (1966).

MATERIAL AND METHODS

Thirty-six pairs of smallmouth bass ovaries were collected in April of 1972, 1973, and 1974. The total length and weight of each fish were recorded at the time of collection, and ages were determined by standard scale reading techniques. Ovaries were removed and preserved in 10 percent formalin at the time of collection.

Unless total ova counts are made, unbiased estimation of numbers of ova may be dependent upon the subsample site selected within an ovary (Reynolds, 1965). Therefore, the right ovary from a mature female (457 mm total length) was used to determine the number and size of ova within various sectors of the ovary. Three cross sections, each representing approximately 10 percent of the ovary weight, were taken from the anterior, middle, and posterior regions of the ovary. Each cross section was then further subdivided into three lateral samples representing the medial, central, and distal portions of the particular ovary region (Otsu and Uchida, 1959). From each subsample, all ova greater than 0.31 mm in diameter were counted and measured to the nearest 0.06 mm.

Ova diameter frequencies obtained from the nine subsamples within the single ovary were compared by the nonparametric Kolmogorov-Smirnov two-sample test. These results showed a significant (0.05 level) difference between the ova distributions of the three medial samples (anterior, middle, and posterior) pooled and the three pooled distal samples. The central samples were not significantly different from the other pooled groups. In addition, there were significant differences in ovum diameter frequencies between the medial and central and between the central and distal portions of the anterior sample. Based on these analyses, it was concluded that representative samples of the entire ovary could be obtained from a complete cross section taken from the midregion of an ovary.

To determine if ovum diameter frequencies differed between left and right ovaries, a pair of mature ovaries was compared. A cross-sectional disc was removed from the midregion of each; all ova were measured. Frequencies were compared again using the Kolmogorov-Smirnov two-sample test. The distributions were not significantly different at the 0.05 level; thus no differences in the size frequency of ova from the left and right ovaries were assumed.

Based on these preliminary studies, the diameters of 200 randomly selected ova from the midregion cross section of the right ovary were measured on each of 36 smallmouth bass. Since it was expected that immature ova would also be present in the ovary, distributions of ova diameters were plotted on normal probability paper (Harding, 1949) to reveal bimodality. Mature ova were defined as all ova falling in the larger diameter group of the ova diameter frequency distribution for each specimen. These determinations were verified by examination of development stages (see James, 1946).

To estimate fecundity for each speciment, the total number of ova (both mature and immature) in the midregion sample was counted and expanded by the ratio of total ovary weight (both ovaries) to sample weight. This total ova count was then corrected by the percentage of mature ova in the midregion sample.

RESULTS

Examination of the ova diameter distributions revealed a bimodal distribution in 33 of the 36 specimens. Of the 33 samples with bimodal distributions, the points of inflection between modal groups ranged from 1.31 to 1.62 mm (Table 1). Twenty-four of the ova samples had a point of inflection at 1.56 mm. The point of inflection tended to be related to fish size, with six small specimens (257-361 mm) having values less

than 1.56 mm and three large specimens (457-544 mm) having values greater than 1.56 mm. Ova in the larger modal group contained numerous yolk granules and minute oil droplets. Ova in the smaller modal group lacked appreciable amounts of yolk. James' (loc. cit.) study of the histology of ovaries from largemouth bass, *Micropterus salmoides* (Lacepede), and bluegill, *Lepomis macrochirus* Rafinesque, contained a description of mature ova corresponding to the ova found in the larger modal group of smallmouth bass. Only ova in the larger modal group which contained reasonable deposition of yolk were considered mature.

The three remaining fish did not contain large eggs, were small (241-305 mm), and three years of age. Four other three-year-old specimens exhibited a bimodal ova diameter frequency distribution.

The estimated fecundity of 33 smallmouth bass ranged from 2,600 to 27,200 mature ova per female (Table 1). Regression analyses were performed to describe the relations between fecundity and (1) total length (L), (2) weight (W), and (3) age (A). The linear equations independently calculated for each variable were:

(1) $F = -23{,}300 + 87.5\,L \qquad (r^2 = 0.818)$
(2) $F = -956 + 10.6\,W \qquad (r^2 = 0.882)$
(3) $F = -12{,}400 + 4{,}909\,A \qquad (r^2 = 0.691)$

where F = fecundity as the number of ova in the larger modal group.

The mean ova diameters of the 33 larger modal groups ranged from 1.75 to 2.82 mm, but were only partially correlated to length, weight, or age of the specimen. The percentages of ova in the larger modal group category ranged from 29.0-65.0 percent. Whether the variation is normal or a result of sampling or experimental error is not yet determined. No statistical relation of this percentage to total length, weight, or age was found.

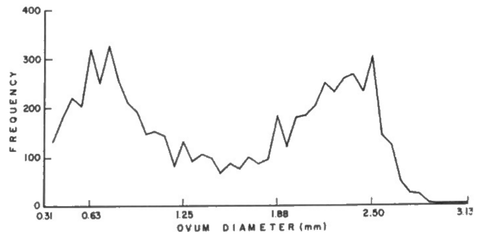

FIG. 1: *Composite ovum diameter frequencies of 6,600 ova, 200 randomly selected from each of 33 mature smallmouth bass females.*

TABLE 1: *Ovum diameter distributions and fecundity of 33 smallmouth bass from the Wilson Dam tailwater.*

Specimen Number	Date Collected	Total Length (mm)	Total Weight (g)	Age (yr)	Point of Inflection Between Modal Groups (mm)	Percent of Sample in Second Modal Group	Mean of Larger Modal Group (mm)	Estimated Fecundity
1	4-5-72	495	1760	—	1.5625	52.5	2.3437	25,104
2	4-5-72	427	1215	—	1.5625	42.5	2.0937	8,748
3	4-5-72	452	1480	—	1.5625	47.0	2.3437	14,601
4	4-14-73	516	1905	VII	1.5625	52.5	2.2187	26,504
5	4-14-73	373	726	V	1.5625	51.5	2.2187	5,230
6	4-21-73	457	1315	V	1.6250	51.0	2.4062	13,480
7	4-23-73	351	998	III	1.5625	48.0	2.1250	3,599
8	4-28-73	554	2268	—	1.6250	31.0	2.4062	24,223
9	4-28-73	305	408	—	1.5625	51.5	2.8212	2,943
10	4-9-74	408	1250	IV	1.5625	65.0	2.2187	15,503
11	4-9-74	381	1134	IV	1.5625	59.0	2.2500	14,027
12	4-10-74	305	454	IV	1.5000	54.5	1.9687	5,629
13	4-13-74	521	2268	VII	1.5625	39.0	2.1562	18,424
14	4-13-74	538	2722	VI	1.6250	52.5	2.3125	27,243
15	4-13-74	305	454	IV	1.4375	47.0	1.8125	2,601
16	4-13-74	348	726	IV	1.5625	51.0	2.0000	4,818
17	4-13-74	257	272	III	1.3750	53.5	1.8437	2,689
18	4-13-74	511	1996	VII	1.5625	40.5	2.1250	19,928
19	4-13-74	429	1270	—	1.5625	49.5	2.1870	8,463
20	4-13-74	328	726	IV	1.5625	59.0	2.2187	5,462
21	4-13-74	259	272	III	1.5000	62.5	2.0312	2,685
22	4-13-74	328	590	IV	1.5625	56.0	2.2187	6,348
23	4-13-74	478	1905	VI	1.5625	60.5	2.3437	21,369
24	4-13-74	521	2359	VII	1.5625	29.0	2.2187	21,716
25	4-13-74	356	726	IV	1.5625	62.5	2.2500	10,836
26	4-13-74	315	544	III	1.3125	48.0	1.7500	3,680
27	4-13-74	361	816	IV	1.4375	39.5	1.9375	5,301
28	4-13-74	356	680	IV	1.5625	49.5	2.2812	5,961
29	4-13-74	432	907	—	1.5625	45.5	2.1875	10,150
30	4-13-74	356	680	IV	1.5625	54.0	2.2500	6.154
31	4-13-74	408	1225	VI	1.5625	53.0	2.2187	9,945
32	4-13-74	330	544	IV	1.5625	52.0	2.0312	4,024
33	4-13-74	358	635	V	1.5625	51.0	2.2187	6,550

Ova diameter frequencies of occurrence are presented in figure 1. Ova diameters ranged from 0.31 to 3.13 mm. The composite larger modal group sample had a mean ovum size of 2.19 ± 0.29 mm and contained 54 percent of all ova sampled.

DISCUSSION

Ova diameter frequency distributions have been utilized to define sexual maturity in a variety of species (e.g., Clark, 1934; Hickling and Rutenburg, 1936; Newton and Kilambi, 1969; Otsu and Uchida, 1959; Vogele, 1975). The same approach appears appropriate for smallmouth bass. Twelve Age IV bass were examined in this study, all of which contained mature ova. Seven Age III specimens were examined. Three fish in this group contained no ova greater than 1.31 mm in diameter and were judged to be sexually immature. The shortest female containing mature ova was 257 mm (10.0 inches) and three years of age.

Emig (1966) reports data showing that smallmouth bass females in Iowa and New Mexico are reproductively mature at Ages II and III. In addition, both studies by Koster (1957) and Harlan and Speaker (1956) showed that the size of females at sexual maturity is smaller than that found in the Wilson tailwater. These are not surprising results, since maturity of Wilson Dam tailwater smallmouth is defined as the presence of mature ova in the ovary, not simply the presence of ova as traditionally defined.

Mature ova ranged in size from 1.31 to 3.31 mm in diameter. Only three fish contained ova greater than 2.81 mm in diameter. These ova were translucent and characteristically contained a single large oil droplet. According to James (1946), these particular fish were fully ripe and were probably ready to spawn at the time of collection. The composite ova diameter distribution of the 33 specimens containing mature ova indicates that, in general, slightly more than half (54 percent) of all ova in sexually mature smallmouth bass is of sufficient size and morphology to be considered potentially fertile.

Of the 36 fish examined, six contained over 20,000 mature ova. These values are extremely high relative to previously published figures and apparently reflect the large size specimens in the Wilson tailwater sample. When total ova counts (Carlander, 1953; and Emig, 1966) of similar size specimens were compared, the estimated number of all ova in Wilson tailwater smallmouth was found to be similar to the values determined in other studies. The highest estimated number of mature ova (27,243) was obtained from a 538 mm (21.2 inch) fish weighing 2,722 g (6.0 pounds). As larger smallmouth bass are obtained from the Wilson tailwater, it is expected that higher mature ova counts will be obtained.

The regression analyses indicate that total length and weight are better predictors of fecundity than age. The lack of a better regression with age is at least partially due to the small number of individuals in each age class except IV. Even if more samples were taken in each age class, it appears that length or weight would be a better predictor of fecundity than would age.

In comparing the regression equations of length and weight, the length equation predicts that mature ova production begins at 266 mm (10.5 inches), which is quite close to the actual data. By contrast, the weight equation predicts that fish weighing 100 g produce mature ova. This extrapolation does not correspond with observed data. Length-weight relations for female smallmouth bass from the Wilson tailwater show that fish weighing 100 g are approximately 200 mm in length. It should also be noted that the weight equation predicts that 4,800 mature ova will be added with each additional 454 g (1.0 pound) of female weight. This value is somewhat lower than those reported by Emig (1966) or Watson (1955), but again only mature ova have been included in the present fecundity estimates whereas the above authors were reporting values derived from total ova estimates.

LITERATURE CITED

Bennett, G. W. 1971. Management of lakes and ponds, second edition. Van Nostrand Reinhold Company, New York. 375 pp.

Bower, Seymour. 1897. The propagation of smallmouth black bass. Transactions of the American Fisheries Society, 25:127-136.

Carlander, K. D. 1953. Handbook of freshwater fisheries biology. William C. Brown Company, Dubuque, Iowa. 281 pp.

Clark, F. N. 1934. Maturity of the California sardine (*Sardina caerulea*) determined by ova diameter measurements. California Division of Fish and Game, Fisheries Bulletin Number 42. 49 pp.

Culler, C. R. 1938. Notes on warmwater fish culture. Progressive Fish-Culturist, 36:19-24.

Emig, J. W. 1966. Smallmouth bass, pp. 354-365. *In* Alex Calhoun (ed), Island Fisheries Management. Department of Fish and Game, State of California. 546 pp.

Harding, J. P. 1949. The use of probability paper for the graphical analyses of polymodal frequency distributions. Journal of the Marine Biology Association, United Kingdom. 28:141-153.

Harlan, J. R., and E. B. Speaker. 1956. Iowa fish and fishing. third edition. Iowa State Conservation Commission, Des Moines, Iowa. 377 pp.

Hickling, J. F., and E. Rutenburg. 1936. The ovary as an indicator of spawning period of fishes. Journal of the Marine Biology Association, United Kingdom, 21:311-317.

James, J. F. 1946. Histology of gonadal changes in the bluegill *Lepomis macrochirus*, Rafinesque, and the largemouth bass, *Huro salmoides* (Lacepede). Journal of Morphology, 79(1):63-86.

Kelley, J. W. 1962. Sexual maturity and fecundity of the largemouth bass, *Micropterus salmoides* (Lacepede), in Maine. Transactions of the American Fisheries Society. 91(1):23-28.

Koster, W. J. 1957. Guide to the fishes of New Mexico. University of New Mexico Press, Albuquerque, New Mexico. 116 pp.

Newton, S. H., and R. V. Kilambi. 1969. Determination of sexual maturity of white bass from ovum diameters. The Southwestern Naturalist, 14(2):213-220.

Otsu, Tamio, and R. N. Uchida. 1959. Sexual maturity and spawning of albacore in the Pacific Ocean. United States Fish Wildlife Service Fisheries Bulletin, 59:287-305.

Reynolds, J. B. 1965. Life history of smallmouth bass, *Micropterus dolomieui* Lacepede, in the Des Moines River, Iowa. Iowa State Journal of Science, 39(4):417-436.

Vogele, L. E. 1975. Reproduction of spotted bass, *Micropterus punctulatus*, in Bull Shoals Reservoir, Arkansas. United States Fish Wildlife Service Technical Paper 84. 21 pp.

Watson, J. W. 1955. The Maine smallmouth. Maine Department of Inland Fisheries and Game, Fish Research Bulletin Number 3. 31 pp.