AGE AND GROWTH DIFFERENTIATION BETWEEN THE SEXES OF THE LARGEMOUTH BLACK BASS, *MICROPTERUS SALMOIDES* (LACEPEDE)[1]

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I. INTRODUCTION

It is generally accepted among fishery workers that practically all large, old largemouth black bass, *Micropterus salmoides* (Lacepede), are females. The purpose of this problem was to collect information in order to determine whether or not there was a basis for this general opinion. This work should also serve to increase the knowledge concerning the life history of the largemouth black bass. The objectives aimed at in this research are outlined as follows: (1) A more practical method than those now in use for preparing temporary scale mounts. (2) The differences, if any, between the sexes with regards to: (a) Growth in length, (b) Growth in weight, (c) Periods of fastest growth, (d) Longevity.

The growth rates of many fish of different species have been worked out and these works are recorded extensively throughout the literature. However, little work has been done on the differences in growth rates between sexes of the various fish studied. Differential mortality between the sexes has been shown for only a limited number of species, and little published information on this subject was found for the species under consideration in this problem.

Bennett (1937) in his study of the growth of Wisconsin largemouth bass inferred that a differential rate of growth might exist between the sexes. No definite statement was made, however, due to lack of sufficient information. Stroud (1948) reported that in Norris Reservoir male and female bass grew at approximately the same rate throughout the one, two, and three year age groups. He stated that the oldest bass (seven years old) was a female and concludes that the lack of males in this age group was due to their more rapid growth and, consequently, earlier mortality. Eschmeyer (1939) wrote, "a comparison of the relative growth of males and females, for the several age groups well enough represented to justify the making of this comparison (I-III), shows only slightly faster growth of the male largemouth . . ." He also reported that any differences in the relative growth of the sexes in Norris Lake bass are probably small.

These opinions are in accordance with the findings of various authors on several fishes of the family *Centrarchidae,* under which the largemouth bass is classified. Some of the works of these authors

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are reviewed below. Hubbs and Hubbs (1935), in their work on the centrachid genera *Apomotis* and *Helioperca,* indicated that the male grows more rapidly than the female. They indicated also that more males were present than females for each age group in their total collection. According to Hubbs and Cooper (1935), male centrachid fishes grow faster than the female. Their work was done on fishes of the genera *Xenotis* and *Apomotis* for which existed, in both cases, differential mortality. In the former genus the male had the longer life span while in the latter the opposite was true.

That a sexual difference in mortality exists in the largemouth bass is shown by Gentry (1949). He collected 167 specimens of largemouth bass ranging in size from three to twelve pounds. Fifteen per cent of those between three and five pounds were males, five per cent between five and seven pounds were males, and no males at all were found above seven pounds.

Sexual differentiation with regard to growth and mortality has been shown for fish belonging to other families. Van Oosten (1937) showed that the female longjaw, *Leucichthys zenithicus* (Jordan and Evermann), is heavier than the male at corresponding lengths and ages. He stated that there was a changing sex ratio with age, the males becoming relatively fewer than the females in each older age group. Spoor (1938), in his work on the sucker, *Catostomus commersonnii* (Lacepede), reported that male and female grow at the same rate until the fifth year. Above that age, the female grows the faster. He also stated that above the eighth year females are more abundant than males. As shown by Raney and Lachner (1946), the sexes of the hog sucker, *Hypentelium nigricans* (Le Sueur), grew at about the same rate for the first five years. Thereafter the growth rate decreased, more rapidly in males than in females. The oldest specimen in the study proved to be a female. Males, it was found, matured earlier in life than females. Applegate (1943) reported sexual dimorphism with respect to age in specimens of mudminnows, *Umbra limi* (Kirtland). He stated that with increasing size and age their relative abundance decreased and in the larger and older fish the females showed a distinct numerical dominance. He believed that this was due to the fact that the female of the species possesses a greater inherent ability to survive.

To Stroud (1947), the growth pattern of the yellow bass, *Morone interrupta* Gill, showed the correlation of slow growth with a long life span. He added that in the case of the white bass, *Lepibema chrysops* (Rafinesque), a faster growth rate was associated with early mortality. Hile (1936) observed a changing sexual ratio with age in the cisco, *Leucichthys artedi* (Le Sueur). He also believed that slow growth in a population tended to eliminate the less viable males from the higher age groups. This, he stated, was in agreement with the conclusions of Geiser (1923) who believed that females were inherently better fitted than males to survive adverse environmental conditions. That slow growth was correlated with a long life span was shown by Schneberger (1935) who found that this was true in his studies on yellow perch, *Perca flavescens* (Mitchell). McCay (1933) in experiments with brook trout, *Salvelinus fontinalis fontinalis* (Mitchell), found that those trout which for some reason failed to grow lived much longer than those that grew normally on a similar diet. He concluded that ". . . it is possible that longevity and rapid growth are incompatible and that the best chance for an abnormally long life span belongs to the animal that has grown slowly and attained late maturity."

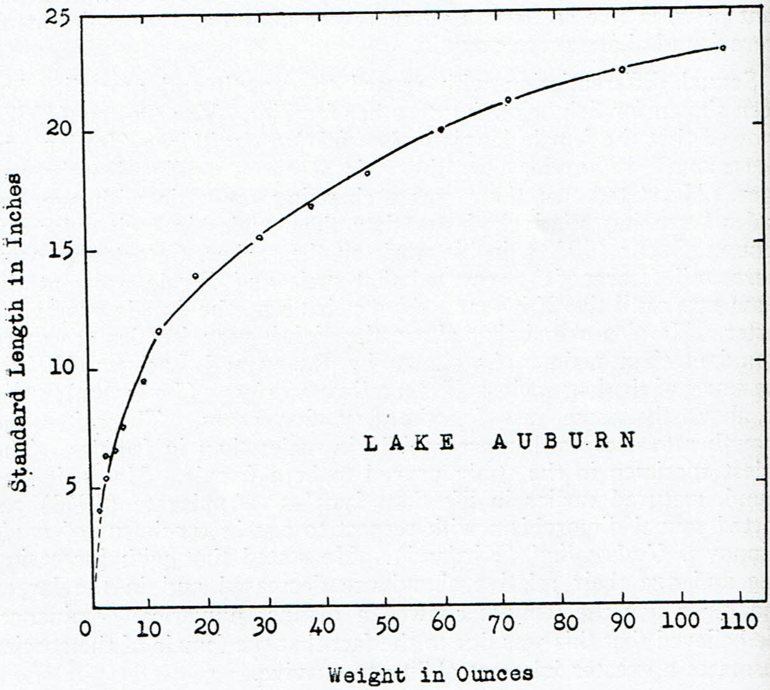

Fig. 1. The length-weight relationship for the bass from Lake Auburn, Alabama.

II. Materials and Methods

This study is based upon the examination of scales from 287 specimens of largemouth black bass. Of the total number, 186 were collected from Lake Auburn on draining the lake September 27, 1949. The 101 remaining specimens were recovered from Silver Lake after a total poisoning of the lake population on October 15, 1949.

Lake Auburn is a private club-owned lake situated approximately four miles south of Auburn, Alabama, near the Chewacla State Park Area. This lake is an artificial impoundment which had been stocked under the supervision of the Farm Ponds Department, Alabama Polytechnic Institute, Auburn, Alabama. The 12-acre lake constructed in 1931 had been an experiment in lake management since its stocking in 1932 (Swingle and Smith, 1943). After loss of the population of the lake due to a washout of the dam in 1938, the lake filled after repairs had been made and was restocked that fall. Since that time the lake was fertilized and managed according to the policies of the Farm Ponds Department. In the spring of 1949, it was decided to drain Lake Auburn and start it over again to improve fishing.

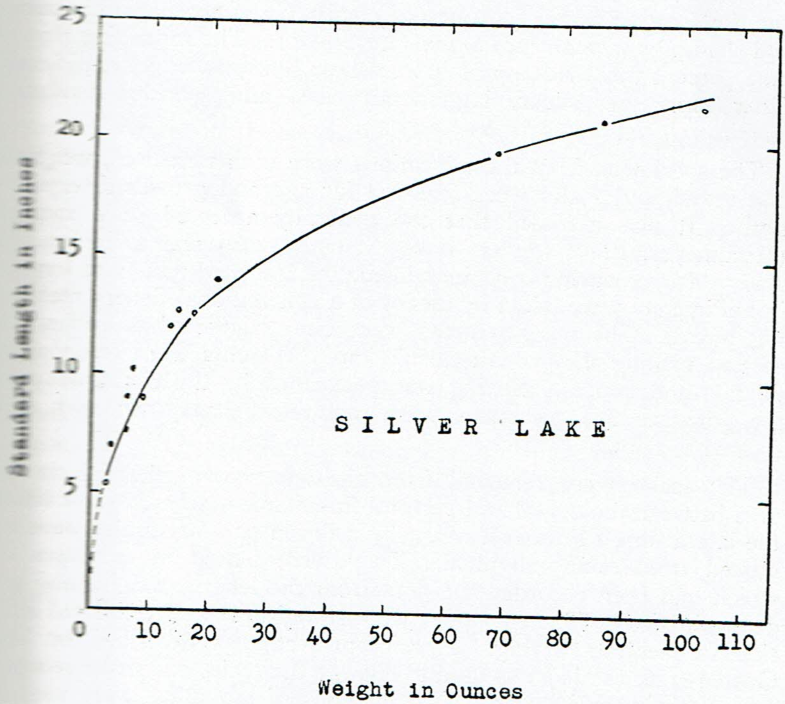

Fig. 2. The length-weight relationship for the bass from Silver Lake, Alabama.

During that year the lake was not fertilized. In the fall of the year the lake was drained. The fish population was segregated according to species, counted, and weighed. After these operations had been completed, it was found that the lake was supporting 199.8 pounds of fish per acre. The population consisted of largemouth bass, bluegills, *Lepomis macrochirus macrochirus* Rafinesque, white crappie, *Pomoxis annularis* Rafinesque, yellow bullhead, *Ameiurus natalis* Le Sueur, and red-eared sunfish, *Lepomis microlophus* (Gunther).

Silver Lake is a natural body of water which had never been managed for fish production prior to the date of poisoning. This fifty-acre lake, owned by the International Paper Company and located on the Southlands Plantation near Bainbridge, Georgia, was formed by the overflow of the Flint River. This occurred approximately twenty years ago. The lake, consequently, was stocked with a population of fish similar to the river population in that area. In 1949, because fishing had been poor, it was decided to poison out the fish population of the lake and restock. A total kill was obtained by the use of rotenone. It was estimated that the lake was supporting sixty-one pounds of fish per acre, of which sixty-one per cent consisted of non-sport fishes: buffalo, *Ictiobus bubalus* (Rafinesque), gar, *Lepisosteus osseus* (Rafinesque), carp, *Cyprinus carpio* Linnaeus, and shad, *Dorosoma cepedianum* (Le Sueur). The remaining thirty-nine percent was made up of sport fishes: bluegills, crappie, pickerel, *Esox niger* Le Sueur, largemouth bass, and speckled bullhead, *Ameiurus nebulosus* (Le Sueur).

The specimens from these locations were each measured, weighed, and sexed, and scales were removed for age and growth determinations. It was assumed that the generally accepted scale method (Eschmeyer, 1939; Lagler, 1949; Stroud, 1948) was valid for this study. In measuring each individual, the standard and total lengths in millimeters were taken by means of a conventional fishery measuring board. The measurements were later converted to inches for ease in making the growth calculations. Weights were recorded in pounds and ounces. Sexing was performed by the examination of the gonads. All specimens were mature, the majority with well formed testes and ovaries.

The scales were removed from the left side of the fish in the area between the dorsal and pectoral fins, immediately above or below the lateral line (Prather). Usually a dozen or more scales were removed from each individual. They were placed in envelopes on which had been recorded the data from the length, weight, and sex determinations. The envelopes were stored in a well ventilated location to facilitate drying. A microprojector as described by Van Oosten *et al.* (1934) was used to enlarge the scales and make recognition of the annuli easier. Two methods of mounting were used in the preparation of scales for projection. The first method employed was to moisten selected scales from each envelope with water and compress them between two glass slides. The slides, when in position, were held together by rubber bands at the ends. This is described by Lewis and Carlander (1948) and other authors (Applegate, 1943; Lagler, 1949). This method proved not applicable for the study of larger scales. Annuli and foci were indistinct when magnified images of scales from large bass were reflected on the screen of the microprojector. A second method was employed involving the use of Syracuse watch glasses and a waterglass-glycerine solution. Fifteen watch glasses were marked by means of paper strips, each bearing the standard length, weight, and individual number of a specimen. From the envelope containing scales from a specimen, four to six clear, uninjured scales were chosen. These were placed flat against the bottom of the appropriate watch glass and covered with the waterglass-glycerine solution. This mixture has been described by various writers (Lagler, 1949; Prather) for use in the preparation of permanent scale mounts. The scales were kept immersed in the solution from one to three hours. The more opaque scales required a longer period of time to clear sufficiently for use in the microprojector. After becoming fairly translucent, the scales were positioned in the projector. Their reflected images on the screen were then carefully studied for annual growth marks. It was noted that in positioning the watch glass, the scales frequently shifted about, thus making a resetting necessary. This was eliminated by increasing the viscosity of the solution by doubling the amount of glycerine called for in the formula (Prather). This latter method proved the better of the two and was used exclusively for the remaining scale studies.

Two methods were employed in calculating the standard lengths at each annulus to determine which was the more practical. A mechanical device developed by Joeris was experimented with but could not be used on the projector employed in the study. Actual measurement of distance between annuli appeared sufficient (Van Oosten, 1929). This was performed by marking the scale focus, annuli, and anterior margin on the strip of paper used earlier to identify the scales contained in the watch glasses. The strip was placed along the primary radius of the scale image. The distances as marked on the strip were measured with a rule graduated in millimeters. The figures from the measurements were then substituted in the formula shown below.

$$L_n = R_n \frac{L_t}{R_t}$$

where

L_t = standard length of fish at time of capture,
R_t = magnified total anterior scale radius,
L_n = standard length of fish at end of n^{th} year,
R_n = magnified anterior scale radius within n^{th} annulus.

Stroud (1947) stated that this formula is based ". . . on the assumption that the relation of growth of the anterior scalar field to that of the body is roughly constant, and that the presence of an annulus establishes the limit of a year's growth." Through the use of this formula, the standard lengths at the times of annulus formation were calculated for each specimen used in the study.

III. Discussion of Results

Scale Mounts. The method employed of immersing scales in a waterglass-glycerine solution to render them suitable for study when used in a microprojector was found to be satisfactory. The water-glass-glycerine solution used for that purpose was prepared by dissolving 60 grams of sodium silicate in 100 cubic centimeters of water that had been brought to the boiling point. This solution was filtered through coarse filter paper. Twenty cubic centimeters of glycerine was mixed thoroughly with 40 cubic centimeters of the above water-glass solution and kept in a stoppered bottle. In preparing mounts, select scales were kept in the solution from one to three hours, the length of time depending on the opaqueness of the scales. When cleared sufficiently for study, the scales were positioned in the microprojector and their reflected images on the screen studied for annual growth marks.

TABLE 1. *Calculated standard lengths attained by various age groups of Silver Lake male bass at the end of each year of life, and the number of individuals comprising each age group*

Age Group	Average Standard Length in Inches	No.	Average Calculated Length in Inches at End of Each Year of Life						
			1	2	3	4	5	6	7
VII	....	....	....	....	....	....	....	....	....
VI	16.6	1	4.6	10.4	11.8	13.2	14.3	15.7	....
V	11.0	2	2.7	5.4	7.4	9.3	10.0	....	....
IV	10.9	5	2.8	5.5	7.7	9.6	....	....	....
III	10.0	13	2.8	7.0	8.5	....	....	....	....
II	9.0	31	3.1	7.3	....	....	....	....	....
I	....	....	....	....	....	....	....	....	....
Average length			3.2	7.1	8.8	10.7	12.1	15.7	....
Average increment			3.2	3.9	1.7	1.9	1.5	3.6	....

TABLE 2. *Calculated standard lengths attained by various age groups of Silver Lake female bass at the end of each year of life, and the number of individuals comprising each age group*

Age Group	Average Standard Length in Inches	No.	Average Calculated Length in Inches at End of Each Year of Life						
			1	2	3	4	5	6	7
VII	20.8	2	5.9	10.4	12.3	14.1	16.2	17.7	19.4
VI	19.9	2	7.1	10.8	13.0	15.2	17.0	18.5	....
V	16.5	4	5.8	10.0	12.4	13.8	15.4	....	....
IV	11.9	3	4.9	8.2	9.8	10.2	....	....	....
III	11.4	7	3.4	7.7	10.2	....	....	....	....
II	9.8	31	3.5	8.0	....	....	....	....	....
I	....	....	....	....	....	....	....	....	....
Average length			5.1	9.1	11.5	13.5	16.2	18.1	19.4
Average increment			5.1	4.0	2.4	2.0	2.7	1.9	1.3

Growth Differentation. A definite growth difference between the sexes of bass from Silver Lake was found (Tables 1 and 2). The average yearly growth increments of the males and females showed that, with the exception of the sixth year, the females increased in length at a relatively higher rate than the males. The paucity of specimens may explain the exception.

TABLE 3. *Calculated standard lengths attained by various age groups of Lake Auburn male bass at the end of each year of life, and the number of individuals comprising each age group*

Age Group	Average Standard Length in Inches	No.	Average Calculated Length in Inches at End of Each Year of Life						
			1	2	3	4	5	6	7
VII	....	....	....	....	....	....	....	....	....
VI	18.7	5	7.6	9.8	13.5	15.3	16.6	17.6	....
V	17.1	13	7.0	11.2	13.1	14.7	16.0	....	....
IV	15.8	14	6.5	10.9	13.0	14.8	....	....	....
III	15.0	20	7.0	11.3	13.4	....	....	....	....
II	11.7	16	5.0	8.4	....	....	....	....	....
I	11.0	21	6.6	....	....	....	....	....	....
Average length			6.6	10.3	13.2	14.9	16.3	17.6	....
Average increment			6.6	3.7	2.9	1.7	1.4	1.3	....

A slight growth difference between the sexes was found in the Lake Auburn population. As indicated in tables 3 and 4, the females grew slightly faster than the males for age-groups I, II, and VI. Age-groups III, IV, and V showed a relatively small difference in growth rate between the sexes. It will be noted that the length increments in table 4 of the Lake Auburn female bass differed considerably from those increments in table 2 of Silver Lake female bass. It will also be noted that the largest females from Lake Auburn averaged 19.5 inches in standard length at the end of the ninth year; whereas, for the largest female from Silver Lake to average 19.4 inches, only seven years were necessary. When the average standard lengths of the specimens from each location are compared through age-group V, it is evident that Lake Auburn females were longer than Silver Lake females for each age group. Above age-group V, the average lengths of Silver Lake females became greater. One explanation of this changing growth pattern is that apparently more food was present for the females in age groups one through five in Lake Auburn than for Silver Lake females of similar classification. This could be attributed to the management program practiced in Lake Auburn.

The length-weight relationships of the bass from Lake Auburn and Silver Lake are shown in figures 1 and 2. One growth curve is shown for each location because not enough difference was found be-

TABLE 4. *Calculated standard lengths attained by various age groups of Lake Auburn female bass at the end of each year of life, and the number of individuals comprising each age group*

Age Group	Average Standard Length in Inches	No.	Average Calculated Length in Inches at End of Each Year of Life								
			1	2	3	4	5	6	7	8	9
IX	20.5	2	8.9	11.2	13.3	15.0	16.5	17.4	18.1	19.0	19.5
VIII	20.0	2	6.9	11.3	13.7	15.0	16.2	17.3	18.1	19.0	....
VII	19.2	6	7.6	10.5	12.5	14.4	16.0	17.2	18.1	....	....
VI	18.8	8	7.0	9.8	12.6	14.6	16.3	17.7	....	....	....
V	17.6	8	6.4	9.7	12.5	15.1	16.5	....	....	....	....
IV	17.0	10	6.5	11.0	13.6	15.3	....	....	....	....	....
III	16.4	15	6.7	11.0	14.0	....	....	....	....	....	....
II	13.1	12	6.8	10.4	....	....	....	....	....	....	....
I	11.1	34	7.0	....	....	....	....	....	....	....	....
Average Length			7.0	10.6	13.1	14.9	16.3	17.4	18.1	19.0	19.5
Average Increment			7.0	3.6	2.5	1.8	1.4	1.1	0.7	0.9	0.5

tween the sexes to necessitate separate plottings. This curve indicates that the male and female in each location increased in weight at about the same rate per unit of length.

Tables 5 and 6, compiled from data in figures 1 and 2 respectively, show the estimated weights for each year of life of the specimens in the study. As shown in table 5, Lake Auburn males were present in the first six age groups and grew at approximately the same rate as the females. In table 6, Silver Lake females were heavier than the males for each age group. While the bass increased in length (Tables 3 and 4) more during the first year than the second, the reverse was true regarding increase in weight (Tables 5 and 6).

Differential Mortality. Differential mortality between the sexes was indicated by the changing sex ratio with regard to age for the bass from each location. The dominance of Lake Auburn males in age-groups II, III, IV, and V is indicated in table 7. Females were dominant in age-groups I, VI, VII, VIII, and IX. No males were present in age-groups VII, VIII, and IX. The oldest males were six years old and the oldest females were nine years old. In Silver Lake (table 7), the males dominated age-groups III and IV. The females dominated age-groups V, VI, and VII. The oldest male was six years old and the oldest females were seven years old.

TABLE 5. *Estimated weights and weight increments in ounces at the end of each year of life of Lake Auburn male and female bass (number of specimens in parenthesis)*

Sex and Increment	Age Groups								
	1	2	3	4	5	6	7	8	9
Male	3.0	10.0	18.0	26.0	33.0	42.0	....	....	....
Increment	3.0	7.0	8.0	8.0	7.0	9.0	....	....	....
	(21)	(16)	(20)	(14)	(13)	(5)	....	....	....
Female	3.3	10.7	18.9	26.0	33.5	41.3	47.0	54.0	59.0
Increment	3.3	7.4	8.2	7.1	7.5	7.8	5.7	7.0	5.0
	(34)	(12)	(15)	(10)	(8)	(8)	(6)	(2)	(2)

TABLE 6. *Estimated weights and weight increments in ounces at the end of each year of life of Silver Lake male and female bass (number of specimens in parenthesis)*

Sex and Increment	1	2	3	4	5	6	7
Male	1.0	3.5	5.0	11.0	13.0	31.5	....
Increment	1.0	2.5	1.5	6.0	2.0	18.5	....
	....	(31)	(13)	(5)	(2)	(1)	....
Female	2.0	6.0	11.3	16.5	34.5	52.8	67.5
Increment	2.0	4.0	5.3	5.2	18.0	17.8	15.2
	....	(31)	(7)	(3)	(4)	(2)	(2)

That environmental conditions affect the longevity of the species is indicated in table 8. Lake Auburn, where management practices were employed, appeared to offer better conditions for a longer life span than did Silver Lake. Age-group V included fourteen percent of the Lake Auburn males, but only four percent of the males from Silver Lake. In age-group VI also, a smaller percentage of males was present in Silver Lake than in Lake Auburn. The females in each location had longer spans of life than the males. In age-group IX, two percent of the total sample of Lake Auburn females was represented. Due apparently to poorer conditions for growth, the females did not live so long in Silver Lake. Four percent of the total sample was represented in age-group VII.

TABLE 7. *Number of male and female bass and the percent female in each age group from Lake Auburn and Silver Lake*

Lake Auburn			Age Group	Silver Lake		
Male	Female	Percent		Male	Female	Percent
....	2	100	IX	....	....	....
....	2	100	VIII	....	....	....
....	6	100	VII	....	2	100
5	8	61	VI	1	2	66
13	8	38	V	2	4	66
14	10	41	IV	5	3	37
20	15	42	III	13	7	35
16	12	42	II	31	31	50
21	34	61	I	....	....	....

TABLE 8. *Percentage in each age group of the total samples of male and female bass from Lake Auburn and Silver Lake*

Lake Auburn				Age Group	Silver Lake			
Male		Female			Male		Female	
Number	Percent	Number	Percent		Number	Percent	Number	Percent
....	....	2	2	IX	....	....	....	....
....	....	2	2	VIII	....	....	....	....
....	....	6	6	VII	....	....	2	4
5	5	8	8	VI	1	2	2	4
13	14	8	8	V	2	4	4	8
14	15	10	10	IV	5	10	3	6
20	22	15	16	III	13	25	7	14
16	18	12	13	II	31	59	31	64
21	26	34	35	I	....	....	....	....
89	....	97	....	....	52	....	49	....

IV. Summary

A study of 287 male and female largemouth bass was made to determine the relative differences between the sexes. The results of this study are summarized as follows:

1. A method for the preparation of temporary mounts of scales to be used with a microprojector is described. This method is practical and its use is recommended for the scale method in determining the ages of other fishes.

2. A differential growth rate appeared to exist between the sexes. The females tended to be relatively longer than the males for each age group. This seemed to occur, however, in environments where conditions for rapid growth were not present. Under good conditions for growth, only a slight differentiation was noted.

3. Male and female bass increased in weight at about the same rate per unit of length. Silver Lake females were heavier than the males at the end of each year of life. Lake Auburn females were only slightly heavier than the males for each year period. While the bass increased in length more during the first year than the second, the reverse was true regarding increase in weight.

4. Differential mortality between the sexes occurred in the largemouth bass. In the higher age groups, larger numbers of females than males were present. No male specimen in this study was over six years of age, while the oldest females were nine years old. This substantiates the belief that the majority of old, large bass are females.

5. The life span of bass was shorter in Silver Lake where conditions of growth were poor than in Lake Auburn where conditions for growth were favorable.

6. Females appeared to be better fitted for survival under adverse conditions than males. Under poor conditions for growth, males grew more slowly and had the higher rate of mortality. In habitats favorable for good growth, the males grew at approximately the same rate as the females, but again males had the higher rate of mortality for the upper age groups.

7. The faster growing individuals of each sex lived longer than those which grew slower.

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