VARIATION IN THE GROWTH RATE OF KNOWN-AGE LARGEMOUTH BASS (*Micropterus salmoides Lacepede*) UNDER EXPERIMENTAL CONDITIONS

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ABSTRACT

Experiments were conducted in three ponds and nine plastic swimming pools to determine the variation in growth rate of largemouth bass (*Micropterus salmoides*) during their first year of life.

Known-age fish were obtained from artificially stripped and fertilized eggs and from the nest of one pair of largemouth bass. The fry were stocked into pools or ponds.

Fathead minnows (*Pimephales promelas*) were stocked into three ponds and four large plastic pools as brood fish to provide offspring as forage for the bass which were added later. Golden shiners (*Notemigonus crysoleucas*) were stocked into the ponds after the bass were added. Fathead minnows, mosquito-fish (*Gambusia affinis*) and golden shiners were added at intervals in the small pools after the bass were approximately one inch long, and in the large pools to supplement the original stocking of fathead minnows.

Samples of approximately 10 bass were taken periodically. The weight and total length of each fish was measured and the fish was returned. When the experiments were terminated, weight and total length were again taken and sex was determined when this could be done without sacrificing the fish.

Seventy-one to 243 bass were stocked as fry or one-inch fingerlings into each pond or pool. Survival to approximately one year of age varied from 1.0 to 34.5 percent.

Variation in growth rate within individual pools or ponds ranged from 1.9X (largest individual weighed 1.9 times as much as smallest individual in the population) to 20.3X. Coefficient of variability ranged from 14.2 to 94.0. Variation between individuals of a population was, in general, closely correlated with both population density and rate of growth. Variation was greatest in those populations having the greater densities and the slower growing individuals.

Differences in growth rate between the sexes could only be determined in the pond experiments as most bass in the pools did not reach sexual maturity during the study period. In all three pond populations, the males were larger than the females when the experiments were terminated. In Liles', Gay's and Knott's ponds the males averaged 188.0, 163.0 and 363.6 grams, respectively, while the females averaged 162.1, 149.4 and 328.9 grams, respectively.

Males attained sexual maturity at a smaller size than the females.

INTRODUCTION

Rate of growth in a fish species is a difficult item to measure because of the large number of extrinsic and intrinsic factors which operate on each species. These factors have been discussed by Brown (1957) and by Lagler, *et al.* (1962).

As a result of the action of many factors, rate of growth within a species varies, not only between different bodies of water, but between individuals within the same body of water. A comparison of the works of Clugston (1964), Cooper, *et al.* (1963), Swingle (1949), and Viosca (1928, 1942) illustrates the variation in growth rate of largemouth bass

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(*Micropterus salmoides*) that exists between different bodies of water. Variation in growth rate of largemouth bass within a single body of water was measured by Cooper (1936), Lambou (1958), Kramer and Smith (1960), Regier (1963), and Viosca (1929, 1952).

In recent years, more and more emphasis has been placed on the genetic basis for growth in a species of fish. A necessary prerequisite for studies of this type is a determination of the amount of variation which exists between individuals within a population.

The objective of the present study was to determine the amount of variation in the growth rate of largemouth bass. The fish in each pond or pool were of uniform age and initial size, and were exposed to the same environmental conditions.

MATERIALS AND METHODS

This study was carried out from March 1964 through April 1965. Twelve populations of largemouth bass were studied in three ponds, four large plastic pools, and five small plastic pools.

Pond Experiments

The three ponds were located near the town of Wendell, North Carolina, about twenty miles east of Raleigh and were leased for the study period from the pond owners.

Noxfish, a fish toxicant containing 5% rotenone, was used to remove the existing fish populations before experimentation began. Fathead minnows (*Pimephales promelas*) and golden shiners (*Notemigonus crysoleucas*) were selected as the forage species for the three ponds. On April 16, 17, and 24, 1964, 500 adult male and 500 adult female fathead minnows were stocked in each pond. The adult minnows were stocked as brood fish about one month before any other fish were added in order that they might reproduce and have young on which the largemouth bass could feed.

Two hundred adult golden shiners of undetermined sex, 7.6 to 12.7 centimeters in total length, were added to each pond on June 5, 1964, as brood fish. These were added after the young bass were too large to be eaten by the shiners.

A fertilization schedule was established for the period from April through October of 1964 for each pond. Each application of fertilizer consisted of 50 pounds of nitrate of soda, 40 pounds of superphosphate, and 3.3 pounds of muriate of potash. This gave the equivalent of 8-8-2 ratio at the rate of 100 pounds per acre, as recommended by Swingle (1947). Fertilizer was added when transparency of the water exceeded 18 inches. Applications were discontinued after September 1964. Liles' Pond received eight applications, Gay's Pond received six applications, and Knott's Pond received eight applications during the entire study period.

Samples of all the populations of bass were taken periodically and all weights were recorded in grams using a triple beam balance. The total length of each fish was recorded in millimeters. Sex of the bass could not be determined during the sampling period.

Each time a population was sampled, individual lengths and weights were recorded, and variation between the smallest and largest individuals was determined. A variation factor was calculated which measured the magnitude of difference between the individuals of extreme sizes in a population. This variation factor is an expression of the numerical factor by which the size of the smallest fish must be multiplied to equal the size of the largest fish.

When the final measurements were recorded, every bass was anesthetized with a 1:3000 solution of MS-222 Sandoz (ethyl M-amenobenzoate) as recommended by Bove (1962). Each was then dried carefully and weighed to the nearest tenth of a gram. Total lengths were recorded for each fish to the nearest millimeter. Attempts were made to determine the sex of each fish without dissection since it was desirable

to keep the bass alive for further experiments. The number and total weight of all forage fish in the ponds were also recorded.

This weighing procedure was also used in obtaining final measurements of bass in both large and small plastic pools.

Liles' Pond

This pond had a total surface area of 1.00 acre and an average depth of approximately three feet. On May 18, 1964, 200 largemouth bass fingerlings one inch long and 32 days of age were stocked into Liles' Pond. The number of bass stocked into each pond was determined by the number available for stocking on a particular date, but all bass in a single pond were of uniform age and of the same initial size.

During the period from April 23 to April 27, 1965, all the largemouth bass and forage fishes were removed from this pond by the use of seines and Noxfish.

Gay's Pond

This pond had a total surface area of 0.84 acre and an average depth of approximately four feet. On May 27, 1964, 136 largemouth bass fingerlings 37 days of age were stocked into Gay's Pond. During the period from April 21 to April 24, 1965, all the largemouth bass and forage fish were removed from this pond by the use of seines and Noxfish.

Knott's Pond

This pond had a total surface area of 0.95 acre and an average depth of approximately five feet. On May 13, 1964, 300 largemouth bass fry seven days of age were stocked into Knott's Pond. On April 14 and 15, 1965, all the largemouth bass and forage fish were removed from this pond by the use of seines and Noxfish.

Large Circular Plastic Pool Experiments

The large pools, numbered 2, 3, 5, and 6 in a series of 9, were located at the Genetics Nursery on the North Carolina State University campus. Each large pool was 24 feet in diameter and four feet deep. The water depth was maintained at approximately 3.5 feet.

On April 24, 1964, 15 pairs of adult fathead minnows were stocked into each large pool as brood fish. A fertilization program was also instigated at this time and was continued to June. After June an adequate plankton density was maintained without the use of additional fertilizer. Each application of fertilizer consisted of the equivalent of an 8-8-2 ratio at the rate of 100 pounds per acre.

In May 1964, 100, 243, 100 and 200 largemouth bass were stocked into large pools numbered 2, 3, 5, and 6, respectively. Final measurements were made on all bass in the large pools on April 29, 1965. Length and weight were determined for each fish and sex was determined when possible.

During the period from July 1, 1964 through April 2, 1965 mosquitofish (*Gambusia affinis*), fathead minnows, and golden shiners were added to each large pool as food for the bass. This was to supplement the original stocking of fathead minnows. The frequency of feeding, size of fish fed, and number of fish fed, varied with abundance of forage fish, the number and size of largemouth bass in each large pool, and the number of forage fish present from the previous feeding.

Small Circular Plastic Pool Experiments

The small pools, numbered 21 through 26 in a series of 88, were also located on the Genetics Nursery area. Each small pool was 10 feet in diameter and two and one-half feet deep.

Each small pool was fertilized at approximately monthly intervals from April through June of 1964. After June all small pools maintained an adequate plankton density without the use of additional fertilizer.

Each application of fertilizer contained the equivalent of 100 pounds per acre of an 8-8-2 fertilizer.

In April and May 1964, largemouth bass were stocked into small pools numbered 21 through 26 at a rate of 71, 182, 200, 200, 100, and 251 per pool, respectively.

During the period from June 1964 through April 1965, forage minnows were added at intervals.

Final measurements were made on the bass in the small pools on April 29, 1965.

ARTIFICIAL STRIPPING AND FERTILIZATION OF LARGEMOUTH BASS EGGS

Several methods were used to obtain adult female largemouth bass in order to begin the experiments. Collecting sexually mature adult males was not a problem.

On March 13, 1964, eight pairs of adult bass were obtained from the National Fish Hatchery at Cheraw, South Carolina. One pair of bass was placed in each of several concrete or plastic pools. One pair was observed to spawn on April 16, and the resulting fry were used in experiments since their age was known to within a three-hour period.

On May 18, 200 of these 32-day-old fingerlings were stocked into Liles' Pond and 100 were stocked into Large Pool Number 5.

A second method used to obtain gravid female largemouth bass was by seining. A fifty-six foot, one-half inch mesh, nylon seine was used and several farm ponds in the Raleigh area were seined almost daily.

On April 20, 1964, a gravid female bass of approximately 1,300 grams was brought into the laboratory. The eggs were stripped into syracuse watch glasses and fertilized using the technique described by Smitherman and Hester (1962). The water in the watch glasses was changed twice daily. The water temperature was maintained between 67.5°F. and 69.0°F. and the fry began hatching in 48.5 hours. The hatching percentage was low, probably due to inadequate experience by the investigator with these techniques. Of a total of 2,348 eggs, only 552 fry hatched to give a hatching percentage of 23.5.

As soon as the eggs hatched, the fry were placed in finger bowls where they remained until the yolk sac was almost absorbed. Water from the pools into which the fry were to be stocked was brought into the laboratory and gradually added to the finger bowls to condition the fry to water in the pools.

When the fry were 11 days old, they were stocked into the small pools at the Genetics Nursery. Two hundred fry were stocked into each of the two small pools, number 23 and number 24, and 100 fry were stocked into Small Pool Number 25.

In addition to the 500 fry described above, 404 fry were obtained from eggs of this same female crossed with a different male from Seaforth Lake. On April 29, 1964, 71 fry were stocked into Small Pool Number 21 and 182 fry were stocked into Small Pool Number 26. All of these last 404 fry were not held at the same temperature and therefore they developed at different rates. This variation in rate of development between groups necessitated stocking the fry on different days.

On May 6, 1964, two gravid female bass of about 500 grams each were seined from Dairy Pond Number One on the North Carolina State University campus. The fish were brought into the laboratory where their eggs were artificially stripped and fertilized. A total of 1,569 eggs were stripped from one female. Groups of these eggs were fertilized with milt from seven different males. Hatching occurred in approximately 50 hours at 75°F. A total of 806 eggs hatched to give a hatching percentage of 51.3. When the fry were seven days old, 300 were stocked into Knott's Pond, 179 were stocked into Large Pool Number 3, 200 were stocked into Large Pool Number 6, and 100 were stocked into Large Pool Number 2.

The second female was crossed with two males. Of the 200 eggs used, 66 eggs hatched for a hatching percentage of 33. Seven days later the fry were stocked into Large Pool Number 3 along with the 179 fry from the previous female.

One other female largemouth bass was brought into the laboratory on May 19, 1964; crosses were attempted, but no eggs hatched.

RESULTS

Pond Experiments

The fish population in each pond was sampled monthly from June to September 1964. In April 1965 the experiments were terminated and final measurements were made.

Liles' Pond

During the period April 23-27, 1965, all fish were removed from this pond and the experiment was terminated. Twenty percent of the fish survived to 376 days. The bass in this pond had an abundance of food and all were sexually mature when the experiment was terminated.

On May 26, 1964, during a routine inspection, green sunfish, *Lepomis cyanellus*, mosquitofish, and redfin pickerel, *Esox americanus americanus*, were found in the pond. Contamination by these fish species had probably occurred from swampy areas along the feeder stream.

When final measurements were made on the bass in this pond, 1,300 green sunfish, 12 to 18 centimeters long weighing a total of 16,426 grams (36 pounds); six redfin pickerel, 18 to 23 centimeters long, weighing a total of 600 grams; and several small schools of mosquitofish were removed in addition to 106 golden shiners, 12 to 18 centimeters long weighing 6,519 grams. No fathead minnows were recovered from the pond.

Gay's Pond

All fish were removed from this pond between April 21 and 24, 1965, and the experiment was terminated. Survival to 369 days in this pond was 34.5 percent. Every male in the population was sexually mature at the end of one year, but several of the smaller females possessed very immature eggs.

Only a few forage fish of a size suitable for the bass to eat were removed from the pond at the termination of the experiment. This population also had the smallest individuals of the three pond populations. Apparently food supply was the major factor limiting growth of these fish.

Only four fathead minnows were recovered from the pond during the final measurements, but 47 golden shiners, 13 to 18 centimeters long and weighing 2,820 grams were removed. According to Lawrence (1957) these shiners were too large for bass of this size to eat.

Knott's Pond

All fish were removed from Knott's Pond on April 14 and 15, 1965, and the experiment was terminated. Survival to 344 days in this pond was 13.6 percent. Each individual was sexually mature when the experiment was terminated.

Growth of the bass in this pond was the most rapid of all the populations studied. Small fathead minnows were present throughout the experiment.

Less than 100 small fathead minnows were recovered from the pond, but 50 golden shiners, 13 to 18 centimeters long and weighing approximately 3,000 grams were recovered.

Plastic Pool Experiments

Four large and six small pools were stocked on April 29 to May 18, 1964, with largemouth bass seven to 32 days old (Table 1). Fish kills were observed in Large Pool Number 6 on September 25, 1964, when all five bass present were killed, and in Small Pool Number 23

TABLE 1. MEASUREMENTS OF LARGEMOUTH BASS STOCKED INTO FOUR LARGE AND FIVE SMALL CIRCULAR PLASTIC POOLS.

Pool Number	Stocking			Termination			
	Date (1964)	No. Bass	Age of Bass (days)	Date (1965)	No. Bass	Percent Survival	Age of Bass (days)
LP 2	May 13	100	7	April 14	1	1.0	343
LP 3	May 13	243	7	April 29	15	6.2	357
LP 5	May 18	100	32	April 29	20	20.0	378
LP 6	May 13	200	7	September 25	5	2.5	142
SP 21	April 29	71	9	April 29	1	1.4	374
SP 22	April 29	182	9	April 29	41	22.5	374
SP 23	May 1	200	11	April 12	29	14.5	357
SP 24	May 1	200	11	April 29	17	8.5	374
SP 25	May 1	100	11	April 29	29	29.0	374

TABLE 2. SUMMARY OF ALL PONDS AND POOLS WITH RESPECT TO VARIATION, WEIGHT, LENGTH, DENSITY OF LARGEMOUTH BASS, AND SURVIVAL.

Pond or Pool Number	Variation factor (weight)	Average weight (grams)	Average total length (centimeters)	Age of fish (days)	Density of stocking per acre	Density at termination per acre	Rate of Survival (per cent)
SP 25	20.30	14.65	10.7	374	55,550	16,095	29.0
SP 24	15.81	26.4	11.9	374	111,000	9,435	8.5
LP 5	14.98	89.7	18.0	378	9,630	1,926	20.0
SP 22	13.95	18.0	10.9	374	101,010	22,755	22.5
SP 23	5.54	29.43	13.0	357	111,000	16,095	14.5
Liles' Pond	4.39	174.4	23.2	376	200	40	20.0
Gay's Pond	2.95	159.2	22.9	369	136	56	34.5
LP 3	2.25	83.55	19.1	357	23,400	1,445	6.2
LP 6	2.15	89.9	18.5	142	19,260	482	2.5
Knott's Pond	1.90	350.1	27.9	344	300	43	13.6
LP 2	—	234.9	23.9	343	9,630	96	1.0
SP 21	—	73.4	18.0	374	39,405	555	1.4

on April 12, 1965, when all 29 bass died. A partial kill occurred when 33 of the 41 bass in Small Pool Number 22 died on April 29, 1965. Water analyses indicated these deaths resulted from oxygen deficiencies. The experiments in these three pools were terminated when the fish died.

In all nine pool experiments, survival varied from one to 29 percent. In Large Pool Number 3, seven males and one female reached sexual maturity, and in Small Pool Number 25, three males reached sexual maturity. Small Pool Number 22 contained two males and one female and Small Pool Number 24 had one male sexually mature at termination.

In Small Pool Number 21, many young bass died during their first day in the pool. On May 27, 1964, only two survivors were found by seining. One bass died on July 6, 1964. When the experiment terminated after 374 days, only one bass was present, representing 1.4 percent of those stocked.

DISCUSSION

Variation seemed to be closely correlated with density. Differences in population size at termination of experiments were relatively small (five to 47 individuals) yet the containers in which these populations were held varied from 0.0018 acre to 1.004 acres. Thus Small Pool Number 21 with only one individual had a density of 555 fish per acre while in ponds the density was not greater than approximately 56 fish per acre. In general, the greater the population density, the greater the variation (Table 2) and coefficient of variability (Figure 1). In the four small pools containing more than one fish each, the population density was great and ranged from 9,435 to 22,755 fish per acre. The variation factors for these dense populations were high and ranged from 5.54 to 20.30. With the exception of one pool (Large Pool Number 5 which had a variation factor of 14.98) all the populations in large pools or in ponds had variation factors of less than 5. The average combined variation factors for the small pools, large pools, and ponds were 13.90, 6.46, and 3.08, respectively.

The coefficient of variability was calculated for each population. This coefficient of variability and its relationship to density of the fish in the population is presented in Figure 1. There appeared to be no correlation in those populations with more than 300 cubic feet of water per fish. In populations with 120 cubic feet or less of water per fish there appeared to be a definite correlation between density and coefficient of variability. A regression calculated for the seven most dense populations gave an equation of $Y = 81.43 - 0.3502X$. The regression of the coefficient of variability on density in cubic feet of water per fish as seen in Figure 1 was found to be significant in its fit only at the 85% level of confidence with an F value of 2.300 with 1 and 4 degrees of freedom.

Variation seemed to be correlated with rate of growth as well as density. Variation in general was greatest in those populations with the slower growth rates and the greater densities. Thus in Small Pool Number 25 where the fish averaged 14.7 grams, the variation factor was 20.30 whereas in Knott's Pond the bass averaged 350.1 grams and had a variation factor of only 1.90.

It appears that variation was closely associated with growth rate, density of stocking and survival density of each population. This agrees with the statement made by Krumholz (1949: 198).

> "Other things being equal, the rate of growth of fishes in newly stocked waters is dependent on two factors: (1) the intensity of stocking, and (2) the rate of survival of original planting."

Those populations with the greater variation in general had the higher densities. Density (both stocking and survival) was in general greater in the small pools than in the large pools, and greater in the large pools than in the ponds (Table 2).

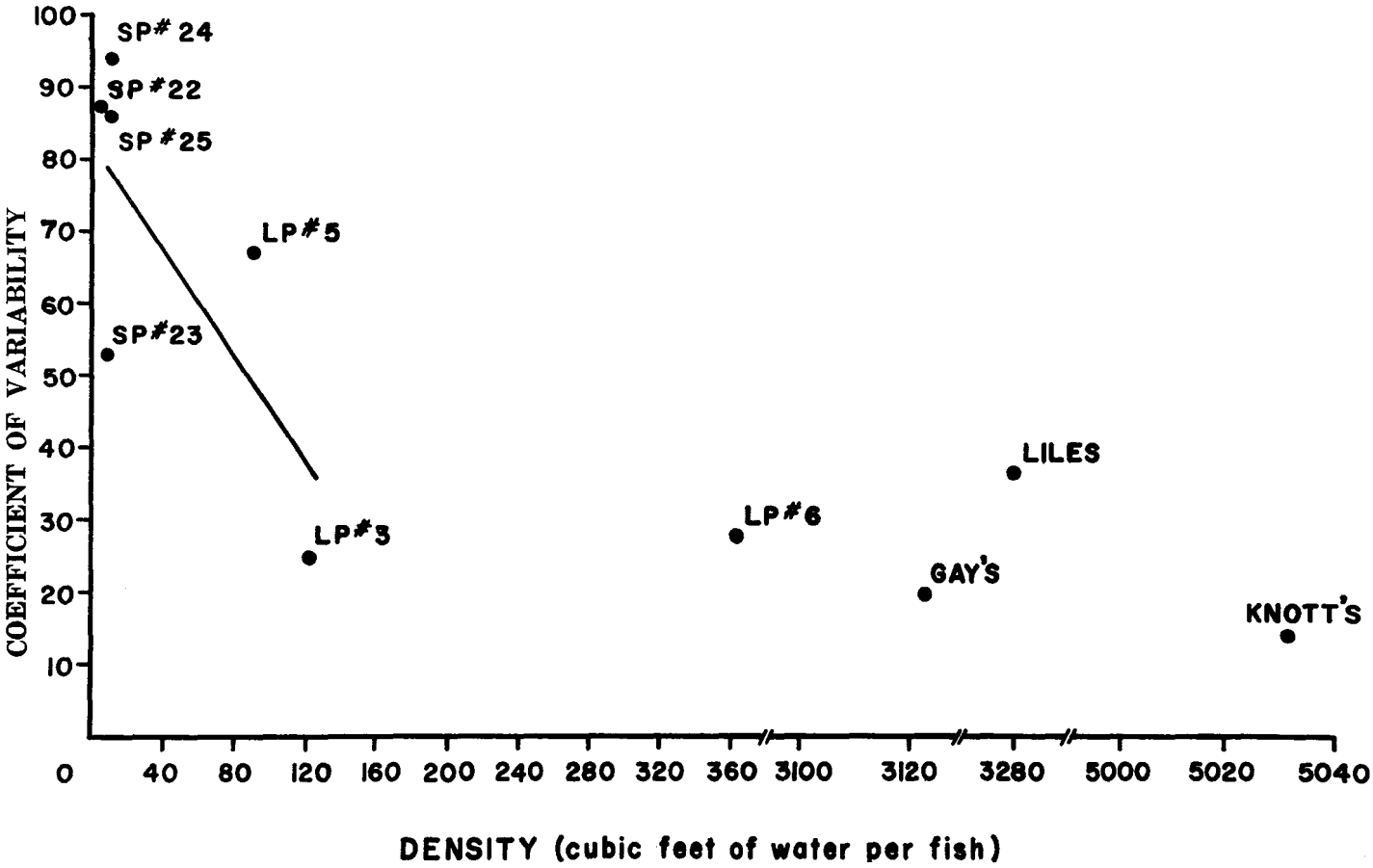

Figure 1. Coefficient of variability as related to density of largemouth bass in three ponds, three large pools (LP) and four small pools (SP).

Survival to termination was low regardless of whether the fish were originally stocked as fry or as fingerlings. Survival rates ranged from 1.0 to 34.5 percent and were far less than those of W. H. Brown (1952a, 1952b). He obtained survival rates for largemouth bass fry stocked for 15 months that varied from 64.4 percent to 85.3 percent with a mean of 71.3 percent. When he stocked largemouth bass fingerlings, survival after 18 months ranged from 47.1 to 83.3 percent, with a mean of 65 percent. Swingle (1951) also found that in experimental bass-bluegill ponds, survival of fingerling bass at the end of six months after stocking ranged from 18.9 to 100 percent and averaged 66.5 percent.

Differences in growth rate between the sexes could only be determined in the pond experiments as most of the bass in the pool populations did not reach sexual maturity during the study period. The sex ratio in Liles' Pond consisted of 19 males to 21 females with the three largest individuals being males and the four smallest individuals being females. In this pond, the males reached an average weight of 188.0 grams whereas the females only reached an average weight of 162.1 grams.

The sex ratio in Gay's Pond consisted of 34 males to 13 females with the largest individual being a female and the two smallest individuals being males. The males reached an average weight of 163.0 grams and the females reached an average weight of 149.4 grams.

In Knott's Pond the sex ratio was 25 males to 16 females. The largest individual was a male and the four smallest individuals were females. The males reached an average weight of 363.6 grams and the females 328.9 grams.

In all three pond experiments of the present study the average weight of the males at the end of their first year of life was slightly greater than that of the females. Padfield (1951), however, found the average weight of females to be greater than males for each age group.

Percentages of fish reaching sexual maturity in both large and small pools were low. This could have been due to density of the populations as well as lack of sufficient food. It was noted in these populations that the males reached sexual maturity at a lower weight and smaller size than did the females.

The bass in the large pools were smaller in average size than the bass in the pond experiments and only ten individuals in all the large pools were sexually mature at the termination of the experiment. The greater density of stocking (Table 2) and a limited food supply could account for the slower growth in the large pools as compared with the pond experiments.

The bass in small pools grew more slowly than those in large pools or in ponds. Only seven bass reached sexual maturity in the small pools. Intensity of stocking and lack of sufficient food was probably the reason for this.

In general, more variation existed in the small pools at termination than in either the large pools or ponds (Table 2). Density of the bass in these small pools could account for this because some of the individuals were cannibalistic and thus grew much faster than others in the population. In addition the bass in these small pools grew more slowly than those in the large pools and ponds.

Growth rates of the bass in the small pools did not vary greatly between pools (Table 2) even though in Small Pool Number 21 only one individual survived until termination of the experiment.

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