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THE RATE OF GROWTH AND SURVIVAL OF BLUEGILL FRY AS SHOWN BY STOCKING HATCHERY PONDS AT DIFFERENT INTENSITIES.

by

Louis A. Krumholz

In March, 1941, it was decided that experiments should be performed which might furnish more accurate knowledge of the rates of growth and survival of bluegills from the "golden fry" stage in the hatchery ponds of the Department of Conservation. At the same time it seemed advisable to check the value of certain inorganic commercial fertilizer for increasing the growth rate of hatchery-reared fish. No feeding of any kind was planned for the experiment.

Five small ponds at the Wolf Lake Hatchery near Mattawan, Michigan, were made available for these experiments. Each of these ponds is individually fed through a bubbler system either from the feeder spring or through other ponds, and it is possible to drain each pond separately into a seining basin below. These two factors lessened the difficulties in performing the experiments.

The ponds used in the experiment vary in size from 0.85 to 1.59 acres and are located just south of the display pond. The size, the type of bottom, the plants present and the source of water of each pond is given in Table I. The maximum depth of all ponds was 7-8 feet. Pond 8

was the only one fertilized. All of the ponds were dry during the winter of 1940-41, and were filled in April, 1941.

On May 27, 1941, Mr. Willard Hall of the Wolf Lake Hatchery, Mr. W. F. Carbine of the Institute for Fisheries Research, and the writer visited Lime Lake, Van Buren County, to collect bluegill fry for stocking the above-mentioned ponds. A total of about 150,000 yolk fry were collected from 9 colonies of nests in $2\frac{1}{2}$ - $3\frac{1}{2}$ feet of water. The nests were small and varied from 9-16 inches in diameter.

Ponds 3, 4 and 5 were stocked the same afternoon by Mr. Carbine and the writer, as shown in Table II. At the suggestion of Mr. Henry Hatt, foreman at the Wolf Lake Hatchery, the figure of 1,800 fry per inch of the collecting tube (inside diameter $\frac{1}{2}$ inch) was used in estimating the numbers of fry. The volumes of fry in the tube were estimated to the nearest one-eighth inch (graduations marked on the tube were at 1/4-inch intervals), and two 1-inch and two 2-inch samples were preserved in 10 per cent formalin to check on the number of fry per inch. Actual counts of these samples were as follows:

			Per cent error
Sample 1	1-inch	1,934 fry	7.4
Sample 2	1-inch	2,285 fry	26.9
Sample 3	2-inch	3,680 fry	2.2
Sample 4	2-inch	4,557 fry	26.6

The average for the four samples was 2,076 fry per inch, an average error of 15.3 per cent. The minimum error was 2.2 and the maximum error 26.9 per cent. Inasmuch as all the counts were more than 1,800 fry per inch, it is evident that all the ponds were stocked more heavily than was called for in the experiment (Table II). The average length of these fry was 5.8 mm. (0.23 inch).

Late in the afternoon of May 27, Pond 8 was fertilized with 100 pounds of Swift and Company 10-6-4 commercial fertilizer and 50 pounds of crushed limestone. On the recommendation of Mr. Henry Hatt, the fertilizer and limestone were broadcast over the entire surface of the pond with the exception of the shallow area at the east end where the water is less than a foot in depth.

Lime Lake and Clear Lake, Van Buren County, and Dumont Lake, Allegan County, were visited May 29 by Messrs. Willard Hall and Roy Hatt of the Wolf Lake Hatchery and W. F. Carbine and the writer, but no fry were collected.

Ponds 7 and 8 were stocked on May 31 by Messrs. Willard Hall and Roy Hatt with fry taken from Lime Lake, Van Buren County. The Institute for Fisheries Research was not notified of this stocking until June 2. Inasmuch as no fry were available on May 29, Mr. Carbine and the writer returned to Ann Arbor after arranging to call Mr. Jay Marks, Superintendent of the Wolf Lake Hatchery, on June 2 to find out whether or not fry were available for stocking Ponds 7 and 8. When Mr. Marks was contacted by telephone the morning of June 2, he informed the writer that the ponds had been stocked on May 31 because the fry were available and it would save a trip from Ann Arbor to the Wolf Lake Hatchery. Upon arrival at Wolf Lake Hatchery the afternoon of June 2, it was found that Ponds 7 and 8 had been stocked, using the figure of 1,500 fry per inch of the collecting tube, rather than that of 1,800 fry per inch as was used for Ponds 3, 4 and 5. No samples had been taken at the time the ponds were stocked but the assurance was made that samples would be taken of similar fry by the same men. As a result, three 1-inch and three 2-inch samples were preserved by Messrs. Roy Hatt and Hoodemaker on June 12. The actual counts of these samples were:

			Per cent error
Sample 1	1-inch	2,496 fry	66.4
Sample 2	1-inch	2,478 fry	65.2
Sample 3	1-inch	2,257 fry	50.5
Sample 4	2-inch	4,978 fry	65.9
Sample 5	2-inch	4,592 fry	53.1
Sample 6	2-inch	5,026 fry	67.5

The average was 2,425 fry per inch, an average error of 61.7 per cent. The average length of these fry was 5.0 mm. (0.2 inch).

If the fry used in stocking Ponds 7 and 8 were of the same size as those in the samples, which is markedly smaller than those used in stocking Ponds 3, 4 and 5, the number of fry per inch should certainly have been stocked using a figure greater than 1,800 fry per inch rather than the lower figure of 1,500. As a result, Ponds 7 and 8 were stocked at a rate of over 320,000 fry per acre rather than 200,000 fry per acre originally called for in the experiment. The actual rate of stocking in the ponds is given in Table II.

This statement and others concerning the discrepancy in figures are not made in criticism of the personnel at the Wolf Lake Hatchery, as it is quite evident from the variations in the counts of the preserved samples that it would be very difficult to stock any water with a given number of fry without actually counting a measured sample from each nest. The actual counts do indicate, however, that hatchery ponds in this district have probably been stocked more heavily in the past than was realized by fish culturists. Based on the counts of ten samples, it would seem that an average of 2,300 fry per inch might be more reliable in future operations.

The ponds were visited by the writer on June 11 and all the trays were removed. An inspection was made of all the ponds but no fish were seen as they were probably one-half inch or less in length. However, there were large numbers of snails and tadpoles in each pond. Pond 8, which had been fertilized, contained "clouds" of daphnia, especially near the overflow pipe and near the shores.

On June 24, the ponds were visited again and fish were seen in each. Samples were collected and the lengths of the fish were estimated as follows:

Pond 5	five-eighths to seven-eighths inch
Pond 4	one-half to five-eighths inch
Pond 3	one-half to five-eighths inch
Pond 7	three-eighths to one-half inch
Pond 8	three-eighths to one-half inch

These fish were not actually handled on a measuring board. A ruler was placed near the fish as they lay in the net and measurements taken. The fish in each pond were very uniform in size and in most cases were grouped in schools. The fish in Pond 5 were considerably larger than those in other ponds.

Series of about 50 fish from each of the five ponds were measured on July 3 (Table III). The fish in Pond 5 averaged more than one inch (26.7 mm.) in length, whereas in all of the other ponds the average length was less than one inch. Pond 3 probably received some fertilization from the remains of the food supply of the trout in Pond 2. Although there are some "scavenger fish" (sturgeon, carp and suckers) in Pond 2, these fish probably do not pick up all the waste material. On July 3, Pond 8 was again fertilized with 100 pounds of Swift and Company 10-6-4 commercial fertilizer.

On July 15, collections of fish were made from each of the ponds, except number 5, by the writer and on July 31 by Mr. Carbine, and measurements taken (Table III). No fish were taken in Pond 5 because of the difficulty in making collections. On August 29, Mr. Carbine and Dr. W. C. Beckman made collections in all ponds and recorded the measurements (Table III). All fish taken in the collections throughout the summer were returned to the water after measurements were taken. Records were kept of the mortality due to such handling.

On October 24, Mr. Lee Anderson of the Institute staff, and the writer, with the aid of the personnel of the Wolf Lake Hatchery, drew the water down in Pond 7 and secured a complete count and weight of all the fish present. The remaining four ponds were drained on October 28 and 29 and the fish counted and weighed. A length series for a number of fish was taken for each of the ponds. The length range and the average length for the series is shown in Chart Ia. In the case of Pond 4 where there were only 419 bluegills recovered, measurements were made of all individuals. The regular procedure employed by pond culturists was used in draining each of the ponds. The water level was lowered slowly so that no fish would be trapped in the weeds. The weeds were piled, leaving runways toward the outlet to facilitate the removal of the fish. When the water was sufficiently low, the screen at the outlet was removed and the fish allowed to pass into the seining basin. The fish were then transferred to tank trucks and taken to the hatchery and placed in concrete tanks. The outside ponds were allowed to refill with water.

Ten samples of 1,000 bluegills each, from each of Ponds 3, 7 and 8 were counted and weighed. The remaining fish taken from these ponds were weighed and the numbers computed from the average weights of the ten 1,000-fish samples. Actual counts and weights were made of all fish

recovered from Ponds 4 and 5. Table IV indicates the number of bluegills recovered, the average total length in millimeters, the average weight in pounds of 1,000 fish, the percentage survival, the number of bluegills produced per acre, and the weight in pounds of bluegills per acre for each of the five ponds. The rate of survival was computed from the number of bluegill fry actually stocked and the number of bluegills recovered when the ponds were drained. After counting, measuring and weighing, the bluegills were returned to their respective ponds.

The other fish recovered when the ponds were drained were as follows:

Pond 5 - 1 brook trout, 27 muddlers, 17 Iowa darters.

Pond 4 - 3,543 Iowa darters, 1 sucker.

Pond 3 - 1,630 green sunfish, 1,275 pumpkinseeds, 172 suckers, 30 Iowa darters, 4 sand shiners, 1 smallmouth black bass.

Pond 7 - 12 Iowa darters.

Pond 8 - no other kinds.

Survival of Fry and Production of Bluegills

The survival of fry and the production of bluegills depends, among other things, on the availability of food and space. The figures on the survival and production, together with the rates of stocking for each pond, are given in Table IV. In Pond 5 the survival of fry was greater than in any of the unfertilized ponds. Pond 5 was stocked with fewer fry per acre than any of the ponds and there was more food and space available for each fish than in any other pond. The bluegills recovered from Pond 5 at the end of the summer weighed twice that of those from Pond 4, and about 10 times that of the fish from Ponds 3 and 7. Although the production per acre in Pond 5 was not as great as in Ponds 3, 7 and 8, it must be remembered that the bottom of Pond 5 was sand and there was

little vegetation. In Pond 4 when there was no vegetation and the bottom was the same as in Pond 5, the production of bluegills was only one-fourth that of Pond 5. The survival of fry in Pond 4 was very low. Inasmuch as there was no vegetation and there was one darter for every 12-13 square feet of bottom, these bottom-feeding fish had first chance at any food available on the pond floor. This might also have eliminated any possibility of the bluegills getting much of the bottom fauna as it emerged. It is possible that many of the bluegills in Pond 4 starved to death.

The percentage of survival of bluegill fry in Pond 3 was second to that of Pond 5 in the unfertilized ponds. However, as previously stated, Pond 3 probably received some fertilization from Pond 2. Inasmuch as Ponds 3, 4 and 5 were all stocked with fry from the same collection, it is unlikely that only Pond 3 would have received the fry of the green sunfish and pumpkinseeds which were present when the pond was drained. These fry, along with those of the other extraneous fish recovered from Pond 3 probably came from Pond 2 through the water supply pipe. The production of bluegills in Pond 3 was nearly five times that of Pond 5 although it was stocked 50 times as heavily. There was an abundant growth of vegetation which, along with the fertilization from Pond 2, probably contributed considerably to the food supply. The total production of fish in Pond 3 was greater than that in any of the other ponds.

In Pond 7, which was stocked at a rate most closely approximating that used in hatchery practice, the survival was only 18 per cent. The production of bluegills in Pond 7 was greater than in any other pond. The bottom in this pond was more suited to good fish production than any of the unfertilized ponds.

The survival of fry in Pond 8, which was fertilized throughout the summer, was more than double that of Pond 7 although the two ponds were stocked with like numbers of fry per acre. This high survival in Pond 8 was probably due to the large numbers of daphnia present during the earlier part of the summer. Thus the fry were assured an ample food supply at the start. The use of fertilizer in Pond 8 was probably responsible for the large plankton population. The production of bluegills in pounds per acre in Pond 8 was less than half that of Pond 7 although the number of fish per acre in Pond 8 was more than double that in Pond 7. The area of Pond 8 is 0.9 acres and the average depth about 3 feet. Thus the volume of Pond 8 is about 117,000 cubic feet of water. When this pond was drained in October, 1941, a total of 114,492 fish were recovered, an average of about one fish for every cubic foot of water in the pond. It is evident that, even though there may have been ample food for the fish in Pond 8, there might not have been enough space for the fish and they failed to grow.

Rate of Growth

The growth curves for the fish in each of the five ponds is given in Chart I. In Pond 5, where the number of fry stocked per acre was the smallest, the average rate of growth was greater than in any other pond. At the end of the first summer the bluegills in Pond 5 averaged 4.0 inches in length. The average length for bluegills in Michigan at the end of the first summer is 1.7 inches and they do not normally reach a length of four inches until sometime during the third summer (Beckman). The fish in Pond 5 ranged in size from 2 3/4 to 4 3/4 inches, but half of them were more than four inches long (Chart II). These fish will probably reach legal length (six inches) sometime during their second

summer of life. The average bluegill in Michigan doesn't reach legal length until the fourth summer.

The fish in Pond 4 averaged about 3.2 inches in length at the end of the first summer, slightly more than the average Michigan bluegill at the end of its second summer of life (3.0 inches). The size range in the fish recovered from Pond 4 (Chart I) was much greater than that of Pond 5. Some of the fish had reached a length of only one inch whereas others were more than four and one-half inches. The competition for food from the darters discussed previously may be accountable for this extreme size range. It is evident that some of the fish "got the jump" on the others and fared better during the summer.

In Pond 3 the fish ranged in size from 1.2 to 3.4 inches at the end of the summer. These fish had an average length of 2.0 inches, only 0.3 inch longer than the average bluegill in Michigan. These fish all grew at a uniform rate during the summer.

The bluegills in Pond 7 had an average length of 1.8 inches, or only 0.1 inch longer than the average bluegill of this age for the state. Some of the fish from Pond 7, however, reached a size of more than four inches during the first summer but the great majority were less than two inches long. This pond was stocked at approximately the same intensity as done in hatchery practice. There was plenty of vegetation available for cover and no competition from other species, and yet these fish grew very little faster than the average wild fish throughout the state.

The fish in Pond 8 had the greatest size range (0.8 to 5.4 inches) of any pond. Only 26 of the 114,492 fish recovered at the end of the summer were more than 1.75 inches. These 26 fish (3.0 to 5.4 inches) were probably cannibalistic and preyed upon the smaller fish. The

average size of the fish in Pond 8 was only slightly more than one inch, or only about 0.6 as large as average wild bluegills in the state. Although the survival in this pond was high, the size of the fish was very small.

Value of Fertilization

The use of commercial fertilizer in Pond 8 showed that a greater number of fry survived the extreme stocking rate (323,333 fry per acre), possibly due to the increased plankton production early in the summer. As the fish increased in size, however, the food and space for normal growth were insufficient and those fish which grew rapidly early in the summer probably preyed on the smaller fish. There were no submerged aquatic plants in Pond 8 during the summer. Experiments by other fisheries workers have shown that fertilization may retard or even prevent the growth of submerged aquatic plants. Fertilization might be of value in ponds which are more lightly stocked (5,000 to 10,000 fry per acre) and further experimentation along these lines should be done.

Summary

1. The survival of bluegill fry stocked at a rate of 2,500 per acre is greater than at much higher rates (100,000 to 325,000 fry per acre).

2. Ponds stocked at a rate of 2,500 fry per acre yield larger, more uniformly-sized fish than ponds stocked more heavily, even in sand-bottom ponds where there is little or no submerged aquatic vegetation.

3. Bluegills, stocked as "golden fry", at a rate of 2,500 individuals per acre reach as large a size in their first summer as do wild bluegills in Michigan sometime during their third summer of life.

4. Bluegill fry stocked at approximately the rate used in hatchery practice (250,000 to 350,000 fry per acre) reach a length at the end of

their first summer only slightly larger than the average wild bluegill of the same age.

5. Other fish, notably darters, seem to offer severe competition to very young bluegills.

6. The type of bottom and the amount of submerged aquatic vegetation affect to some degree the supply of food and the rate of growth of young bluegills.

7. Fertilization apparently causes increased abundance of plankton organisms available as food for bluegill fry.

8. Fertilization retards the growth of submerged aquatic plants.

This experiment should be continued, including fertilization, for at least one more year (1942) to determine the mortality of fishes during the winter months and the growth rate during the second summer of life. The third year (1943), these same ponds should be stocked with the same number of fry per acre, and the use of commercial fertilizer in Pond 8 should be continued in order to determine the carrying capacity for each of the ponds and the value of the use of commercial fertilizer in a pond which has been lightly stocked.

INSTITUTE FOR FISHERIES RESEARCH

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Report typed by: R. Bauch

Table I

Size, type of bottom, plant growth

and source of water of 5 ponds

at Wolf Lake Hatchery

Pond No.	Area in acres	Type of bottom	Plants present	Source of water
5	1.27	Sand	Chara (scarce)	Spring
4	1.00	Sand	None	Spring
3	0.85	Sand and little muck	Chara (abundant) Cattails	Pond 2
7	1.59	Muck with sand shore	Chara (abundant) Cattails	Spring
8	0.90	Muck with sand shore	Cattails	Pond 3

Table II

Theoretical and actual stocking data of

5 ponds at Wolf Lake Hatchery

Pond No.	Theoretical rate of stocking per acre	Actual rate of stocking per acre	No. of fry to be stocked	No. of fry actually stocked	Per cent error
5	2,000	2,452	2,540	3,114	15.3
4	20,000	23,874	20,000	23,874	15.3
3	100,000	118,454	85,000	100,686	15.3
7	200,000	323,333	318,000	514,100	61.7
8	200,000	323,333	180,000	291,000	61.7

Table III

Dates of collections and average sizes

from 5 ponds at Wolf Lake Hatchery

	Pond 5	Pond 4	Pond 3	Pond 7	Pond 8
7/3/41	26.7	17.3	24.9	14.0	16.7
7/15/41	...	24.8	30.1	23.5	19.3
7/31/41	...	31.0	38.1	30.2	23.0
8/29/41	79.0	68.2	45.6	41.3	30.0
10/29/41	100.3	79.8	51.7	44.7	26.2

Table IV

Pond No.	Rate of stocking per acre	Total no. of fry stocked	No. of bluegills recovered per acre	Total no. of bluegills recovered	Per cent survival	Av. wt. per 1,000	Av. total length in millimeters*	Pounds of bluegills per acre	No. of other fish recovered	Total production per acre
5	2,452	3,114	893	1,133	36.4	39# 10 oz.	100.3	34.6	45	35.6
4	23,874	23,874	419	419	1.8	21# 2 oz.	79.8	8.8	3,544	26.1
3	118,454	100,686	38,256	32,518	32.3	4# 2 oz.	51.7	158.6	3,124	210.1
7	323,333	514,100	58,064	92,321	18.0	3# 8 oz.	44.7	203.2	12	203.2
8	323,333	291,000	127,213	114,492	39.3	10 oz.	26.2	82.6	...	82.6

* 25.4 mm. = 1 inch

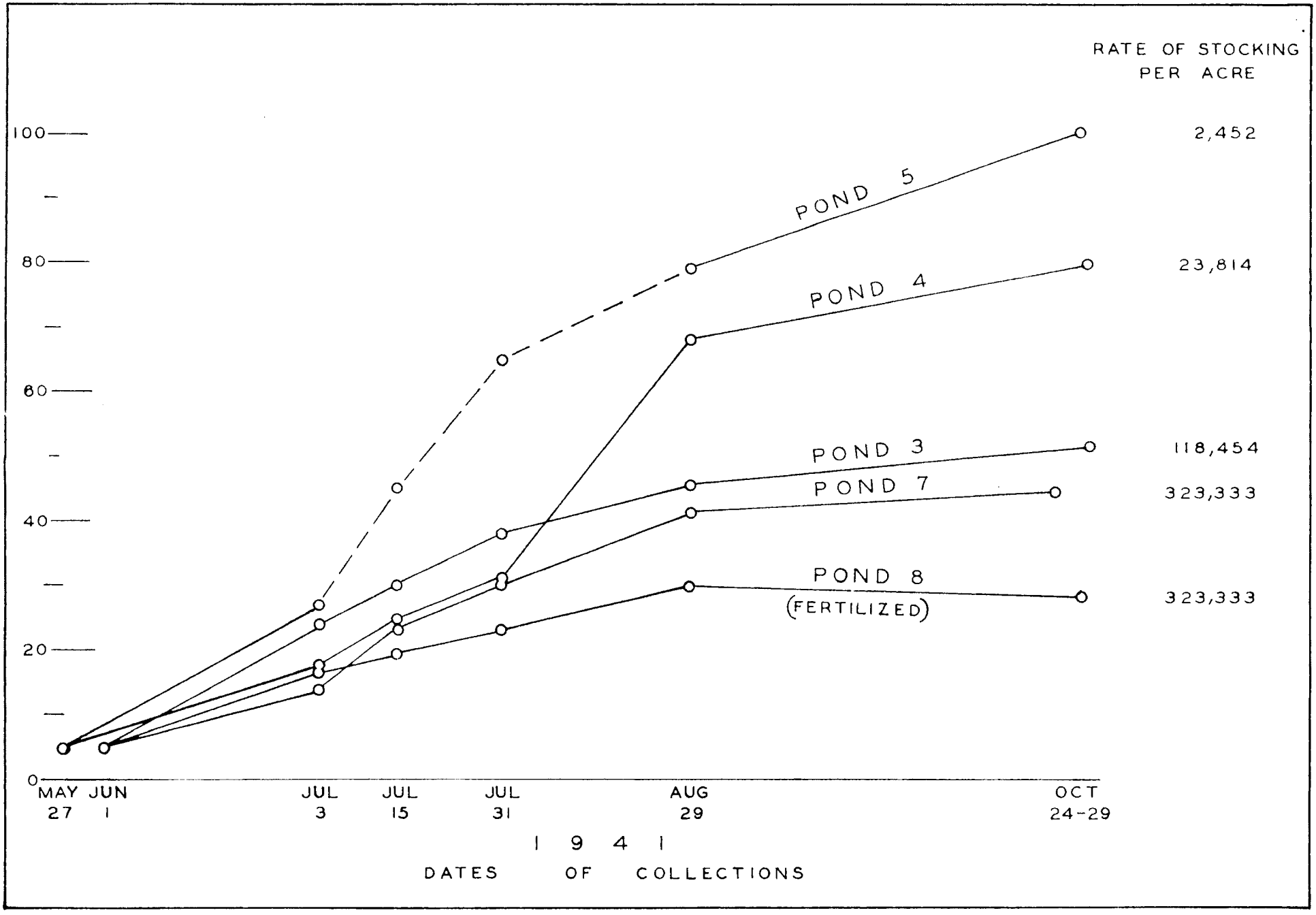

CHART I. GROWTH CURVE OF BLUEGILLS DURING FIRST SUMMER

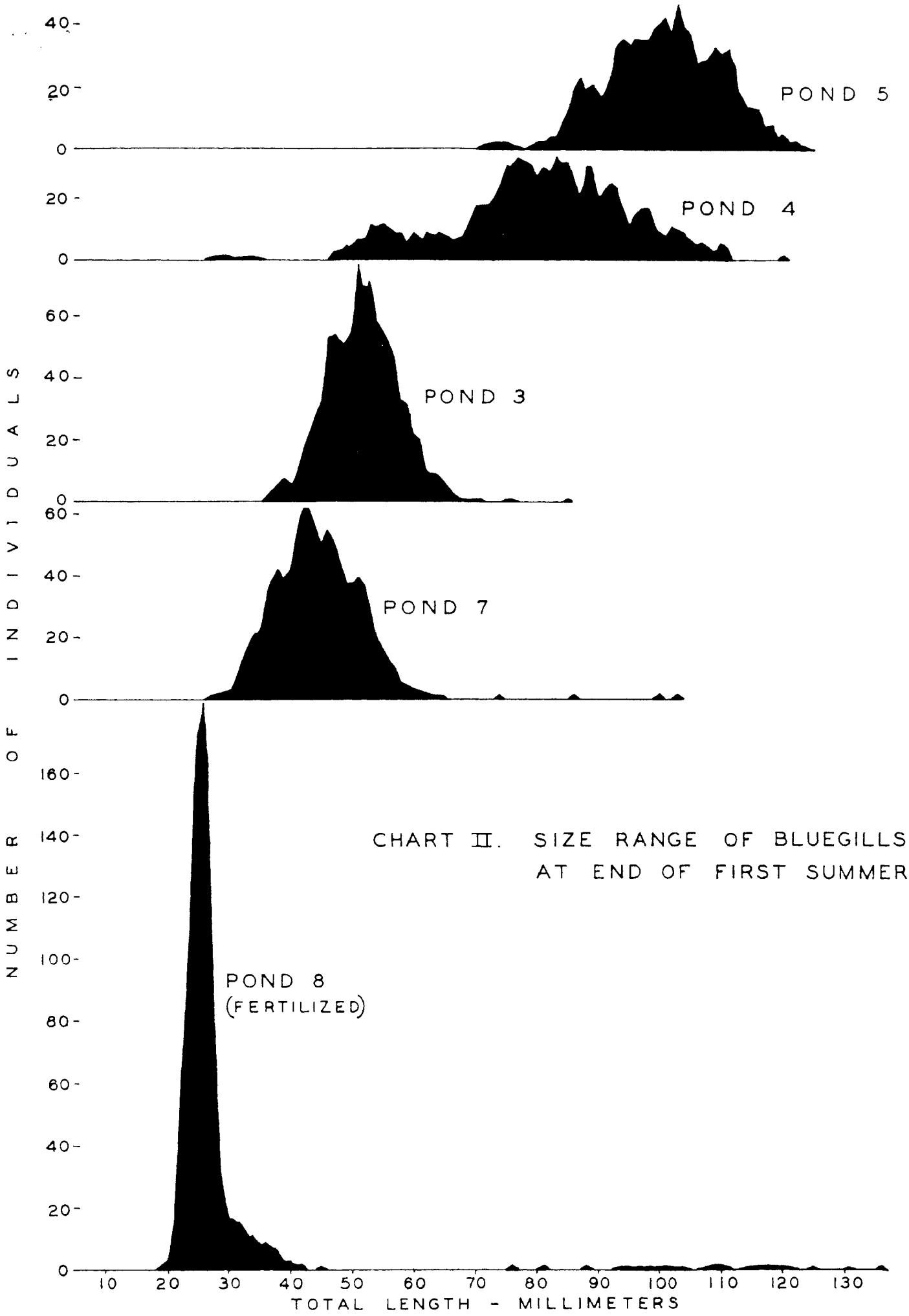

CHART II. SIZE RANGE OF BLUEGILLS AT END OF FIRST SUMMER