EXPERIMENTS ON THE COMMERCIAL PRODUCTION OF GOLDEN SHINERS

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The golden shiner (*Notemigonus crysoleucas*) has been one of the most popular bait minnows for many years. Most fishermen in the Southeast prefer golden shiners over all other species of minnows for both bass and crappie fishing. As a result, commercial minnow producers have shown increased interest in raising these fish.

Prather *et al.*, (1953) summarized briefly some of the experiments conducted on golden shiners at the Agricultural Experiment Station of the Alabama Polytechnic Institute up to that time. More detailed information from these experiments together with results obtained in later investigations are presented in this paper.

Numerous workers have studied the foods consumed by the golden shiner. The principal items eaten are algae and microcrustacea. However, insects, aquatic plants, snails, and even small fish are used to some extent (Ewers, 1933, Ewers and Boesel, 1935, Hubbs and Cooper, 1936, and Swingle, 1946). Swingle and Smith (1938) found in extensive tests in ponds at Auburn, Alabama, that production of plankton and other fish feeds was increased by the use of commercial fertilizers. Pond fertilization is the most economical method of increasing the food supply for fish, especially for those that feed largely upon algae and microcrustacea.

PRODUCTION IN FERTILIZED PONDS

The experiments were conducted in ponds varying from 0.25 to 3.5 acres in size. Maximum depths ranged from 6 to 12 feet, and no aquatic weeds were present except at the shoreline. Fertilization was started during February, with 3 to 5 applications being made at intervals of 2 weeks until the pond water became highly colored with algae and microscopic animals. Fertilization was then continued once each month until October. The rate used was equivalent to 200 pounds of 8-8-4 per acre per application. An occasional application of peanut meal or similar organic material was made whenever the response to inorganic fertilization appeared abnormally slow. The production per acre of shiners in fertilized ponds at several rates and times of stocking is given in Table I.

The production of shiners in ponds stocked and fertilized similarly varied considerably in both weight and numbers; however, the variation in numbers was much greater than in weight. The lowest weight per acre (381.7 pounds) was produced in a pond stocked with 300 medium-sized (3-4 inch) brood shiners on March 3, whereas the highest weight (575 pounds) was produced in a pond stocked April 30 with 2,400 large (4-6 inch) brood fish. The lowest number per acre (34,170) was produced where 300 brood fish was stocked March 3, whereas the highest number (393,913) was produced where 500 brood fish was stocked January 28.

Large brood fish stocked at the rate of 500 per acre the last of January produced such large numbers of young fish that very few grew to a marketable size. When medium-sized brood fish were used at the same rate and time of stocking, reproduction was still heavy enough to produce overcrowded populations in one of two ponds. Where 300 medium-sized brood fish were stocked on March 3, a desirable population was produced and practically all fish reached marketable size by end of year. When ponds were stocked as late as April 30, there was little or no difference between the 600 and 1,200 rates of stocking; desirable populations of marketable fish were produced in all ponds.

TABLE I

SUMMARY OF PRODUCTION PER ACRE OF SHINERS IN FERTILIZED PONDS AT VARIOUS DATES AND RATES OF STOCKING

Date Stocked	*Brood Fish Per A.* *No.*	*Total Lgth. (Inches)*	*Applica. of Fertilizer‡*	*Date Drained*	*Production Per A.* *Lbs.*	*No.*
Mar. 3, 1955	300	(3-4)	11 inorganic	Jan. 30, 1956	381.7	34,170
Jan. 28, 1955	500	(4-6)	10 inorg.+ 1 org.	Feb. 28, 1956	452.0	393,913*
Jan. 28, 1955	500	(3-4)	12 inorg.+ 1 org.	Jan. 31, 1956	386.0	152,444
Jan. 28, 1955	500	(3-4)	12 inorg.+ 1 org.	Jan. 17, 1956	449.0	36,059
Apr. 30, 1951	600	(4-6)	9 inorganic	Feb. 7, 1952	513.4	43,246†
Apr. 30, 1951	1,200	(4-6)	9 inorganic	Feb. 7, 1952	410.8	49,202†
Apr. 30, 1951	2,400	(4-6)	9 inorganic	Feb. 7, 1952	575.0	234,780

* Of this number, 106,000 small shiners (72 pounds) went out spillway following heavy rains in June and July, and were caught in catch basin below pond.

† Average of 2 ponds; all other are individual ponds.

‡ Inorganic—200 pounds per acre 8-8-4 (or equivalent); organic—100 pounds per acre peanut meal.

The size of shiners generally determines their value, and therefore the size distribution of the minnows produced is of as great importance as either total number or total weight. The following example illustrates the importance of size (Table II).

TABLE II

THE PRODUCTION PER ACRE, SIZE, AND RELATIVE VALUE OF GOLDEN SHINERS

Production Per Acre *Pounds*	*Number*	*No. Larger Than 2.5 Inches*	*Average Lbs. Per 1,000 Fish*	*Value to Producer*
386	152,444	16,292	7.4	at $15 per 1,000—$244.38
449	36,000	35,645	12.4	at $25 per 1,000—$891.13

Obviously the pond that produced the smaller number of shiners was more profitable, since practically all were of marketable size. On the other hand, the pond that produced the larger number of minnows was much less profitable, because only about 11 percent were large enough for sale when the pond was drained. No value was placed on the small shiners, since there was no demand for them. However, they can be restocked and grown to a larger size. Rearing small shiners to a usable size is discussed later in this paper.

It did not appear from the results of these and other experiments that the number of minnows produced per acre could be regulated reliably, either by the time of stocking or by the number of brood fish used. In these and other experiments, however, the greatest number of minnows resulted from stocking brood fish in January, February, or early March. Low numbers per acre usually resulted from stocking brood fish in late March or during April or May.

PRODUCTION IN FERTILIZED PONDS WITH SUPPLEMENTAL FEEDING

All feeding tests were conducted in 0.25-acre ponds having an average depth of 4 feet and a maximum depth of 6 feet. Sufficient water was added as needed to keep the ponds full, but flushing was not practiced. Feed was added to fertilized ponds during various seasons to determine the effect on production and survival of golden shiners. Two ponds were stocked November 6 at the rate of 400 brood fish per acre, and each pond was fertilized the following year as stated in the previous section. Poultry laying mash was fed as follows:

5 pounds per acre per day—April 1–May 31
20 pounds per acre per day—June 1–September 26
20 pounds per acre per day—December 1–December 31
40 pounds per acre per day—January 1–January 15

Seining during the spring indicated heavy reproduction, and large numbers of young shiners were produced during each of two different hatching periods. By August 19 the young shiners were 3 to 5 inches in length and in good condition. However, on September 14 shiners were observed dying in both ponds. Water analyses made during the next several days showed the oxygen content of the water to be as low as 0.3 p.p.m. at a depth of 4 feet at 1 p. m.

Although feeding was stopped from September 26 to December 1, the shiners continued dying at intervals during September, October and January. The ponds were drained on March 22, and an average per acre of only 6,338 shiners weighing 184.9 pounds was recovered. These results indicated that supplemental feeding of poultry laying mash at rates as high as 20 to 40 pounds per acre per day may cause mortalities of shiners during fall and winter.

PRODUCTION IN FERTILIZED PONDS WITH WINTER FEEDING ONLY

Further tests with winter feeding were conducted in three ponds, each of which was stocked February 25 at the rate of 1,200 brood shiners per acre. Each pond received 12 applications of fertilizer. In addition, soybean cake was fed daily as shown in Table III.

TABLE III

FEEDING SCHEDULE AND COST OF FEED AND FERTILIZER

	Pounds Soybean Cake Fed Daily Per Acre	*Dates Fed*	*Total Pounds Fed Per Acre*	*Cost of Feed and Fertilizer Per Acre*
1st pond	10	11/ 3— 2/ 4	940	$ 85.60
2nd pond	10	11/ 3—11/25	...	.....
	20	11/26— 2/ 4	1,640	113.60
3rd pond	10	11/ 3—11/25	1,160	94.40
	20	11/26— 1/ 1	...	.....

The ponds were drained the next February and the results obtained per acre are given in Table IV.

TABLE IV

TOTAL PRODUCTION, NUMBER OF MARKETABLE SHINERS, AND VALUE TO PRODUCER

	Production		*Number 3-Inch or Larger*	*Value to Producer at $20 Per 1,000*
	Number	*Pounds*		
1st pond	261,527	858.5	26,152	$523.04
2nd pond	220,308	879.9	41,418	828.36
3rd pond	201,815	379.3	2,422	48.44

In each pond there were few shiners large enough for sale despite feeding during November, December and January. It appeared likely that feeding would have been more beneficial had it been started during October while the water temperatures were warmer. The production in numbers was above average in each pond, and no deaths were observed at any time. However, the poundage in the third pond was low, possibly because of late spawning, insufficient food during summer, or parasites and diseases.

These results also indicated that shiners could be fed soybean cake at rates up to 20 pounds per acre per day during November, December and January without deaths resulting from low oxygen concentrations.

Using average values for feed, fertilizer, and minnows, the returns to the producer above expenses were $437.44 in pond 1 and $714.76 in pond 2. There was a loss of $45.96 in pond 3 because of the very small number of marketable size fish when the pond was drained. Here again the size of the fish produced was more important than the total number.

WINTER FEEDING OF SMALL SHINERS

As previously stated, one of the principal problems in golden shiner culture is overproduction of small fish, which results in a majority of the minnows being too small for sale when the ponds are drained. These small shiners must be restocked during the winter and raised to a size of 3 inches or larger before spawning occurs in the spring.

Three ponds were stocked February 11 at the rate of 40,000 small shiners per acre, weighing 3 pounds per thousand. The fish in one pond were fed soybean cake daily from February 11 through March 31 at the rate of 8.2 percent of the original weight of shiners stocked. Shiners in the second pond were fed fish meal at the same rate as the first pond, while the shiners in the third

pond were fed twice as much fish meal as those in the second pond. All ponds were drained on April 10, and the results obtained are shown in Table V.

TABLE V

PRODUCTION, COST OF FEED, AND VALUE OF SHINERS FOLLOWING WINTER FEEDING

Feed	*Number Recovered*	*% Survival*	*Pounds Per A*	*Cost of Feed*	*Value Above Feed Costs*
Soybean cake...	38,000	95	228	$29.50	at $15 per 1,000—$540.50
Fish meal.....	23,288	58	233	44.10	at $20 per 1,000—$421.66
Fish meal.....	29,440	74	259	88.20	at $20 per 1,000—$500.60

In general, all of the fish grew from 2 inches in length to a marketable size of 3 inches or larger, depending mainly upon percentage of survival. In the first pond the surviving shiners doubled in weight while in the other two ponds their weight almost tripled.

Another pond was stocked December 5 at the rate of 150,000 small shiners per acre weighing 3 pounds per thousand. Soybean cake was fed January 1-March 31 at the rate of 2.7 percent of original shiner weight per day. The pond was drained April 10. Eighty percent of the shiners stocked survived and their average weight was 6.9 pounds per thousand. Even with the high rate of stocking this lower feeding rate appeared very satisfactory, since the surviving minnows doubled their weight and increased from 2 to 3 inches in length. Thus, with an expenditure of $43.20 for feed, these small unmarketable shiners were raised to salable size, having a value of $1,800.00.

In another test two ponds were each stocked February 1 with 520,000 small shiners per acre weighing 1,248 pounds. They were fed Auburn No. 1 fish feed (35 percent soybean oil meal, 35 percent peanut oil meal, 15 percent fish meal and 15 percent distillers dried solubles) daily at the rate of 60 pounds per acre during February. The rate was decreased to 40 pounds per acre during March and to 20 pounds during April because of the danger of a fish kill during the warmer weather. Oxygen remained adequate and no kills occurred. The ponds were drained April 24. Average survival was 85 percent and the shiners had increased in weight from an average of 2.4 to 4.9 pounds per thousand.

FEEDING LARGE SHINERS IN HOLDING PONDS

It is very important that minnows be fed adequately while being held crowded in holding ponds awaiting sale. Heavy losses frequently occur among shiners that are in poor condition due to prolonged starvation.

As many as 80,000 large shiners weighing 1,000 pounds were held per acre in ponds during winter and early spring. They were fed Auburn No. 1 fish feed at the rate of 1 percent of their body weight per day. These shiners stayed in excellent condition and actually gained 1 pound per thousand in a period of 2 months. Losses amounted to less than 2 percent.

TRANSFER OF YOUNG SHINERS FROM BROOD TO REARING PONDS

As indicated previously in this paper, regardless of time of stocking, rate of stocking, rate of fertilization, and rate of feeding, golden shiners frequently reproduced so heavily that unprofitable populations of small shiners were produced. It appeared, therefore, that instead of trying to raise shiners to a marketable size in brood ponds it would be more desirable to transfer the young fish from the brood pond and grow them to a marketable size in rearing ponds.

Five ponds were stocked at the rate per acre of 40,000 small shiners having a weight of 0.5 pounds per thousand on June 4. All ponds received 5 applications of fertilizer during the summer. Each pond was fed Auburn No. 1 fish feed at the rate of 10 pounds per acre per day. Three of the ponds were drained October 5 to November 11, while two were left over winter without additional feeding and were drained March 1.

Another pond was stocked on July 28 at the rate per acre of 36,000 shiners weighing 36 pounds. Fertilizer was applied three times. No feed was given

the shiners, and the pond was drained November 11. The results per acre are shown in Table VI.

TABLE VI

PRODUCTION OF SHINERS IN REARING PONDS FOLLOWING TRANSFER FROM BROOD PONDS

No. Stocked	*Treatment*	*Fertilizer and Feed Cost*	*Drained*	*Shiners Recovered*	
				Number	*Pounds*
40,000	Fert.+ Feed	$51.48	Oct.-Nov.	34,705	550*
40,000	Fert.+ Feed	51.48	March	40,800	590†
36,000	Fert. Only	12.00	November	24,182	261

* Average of 3 ponds.
† Average of 2 ponds.

There were no deaths due to low oxygen concentrations in any of the ponds. Seining during early fall showed that very light spawning had occurred in all ponds. Rapidly growing golden shiners spawned here at 7 to 8 months of age. Most recently hatched shiners were killed during harvesting operations in those ponds drained in October-November, but probably account for the higher number recovered in the ponds drained the next March.

Although this method of management produced a relatively small number of shiners per acre, almost all were 3 to 5 inches in total length and therefore of marketable size. Very little of the weight was made up of tiny shiners too small for sale (Table VII).

TABLE VII

NUMBER, SIZE DISTRIBUTION, AND VALUE OF SHINERS PER ACRE

Treatment	*Drained*	*Number in Each Inch Group and Average Weight Per 1,000 Fish*						*Value**
		3-Inch		*4-Inch*		*5-Inch*		
		No.	*Lbs.*	*No.*	*Lbs.*	*No.*	*Lbs.*	
Fert.+ Feed	Oct.-Nov.	11,878	9.0	21,255	18.4	1,568	33.6	$822.15
Fert.+ Feed	March	13,130	8.4	25,935	16.0	1,735	31.6	963.03
Fert. Only	November	14,810	7.4	8,906	15.0	466	27.7	458.78

* Fish Weighing 6 to 8 pounds per 1,000—$15.
8 to 12 pounds per 1,000—$20.
12 to 16 pounds per 1,000—$25.
16 to 35 pounds per 1,000—$30.

A majority of the fish that received supplemental feeding were larger than 15 pounds per thousand. Therefore, more than 40,000 per acre should be stocked where the demand is mainly for shiners smaller than 15 pounds per thousand. Additional research is needed to determine the rate of stocking necessary to prevent spawning by these young fish before cold weather.

TREATMENTS FOR PARASITES AND DISEASES

It was found that best results were obtained when all brood fish were treated to control parasites and diseases before they were stocked in ponds. The following treatments were used separately.

1. Potassium permanganate—10 p.p.m. for 1 hour.
2. Formalin—15 p.p.m. for 6 hours.
3. Acriflavine—1 p.p.m. for 12 hours.

The potassium permanganate was generally effective in controlling fungus. It also controlled some of the gill flukes and external protozoans.

The formalin eradicated most of the gill flukes and external protozoan parasites, while the acriflavine reduced losses resulting from bacterial diseases. All these treatments were made in concrete tanks. However, pond treatments with 2 p.p.m. potassium permanganate have proved beneficial in the control of fungus, gill flukes, and external protozoans. Daily applications for 2 or 3 days were more effective than single treatments.

SUMMARY AND CONCLUSIONS

The production of golden shiners in ponds stocked and fertilized in a similar manner for a period of approximately one year varied considerably. The varia-

tion in numbers was greater than in weight. The lowest weight per acre (382 pounds) was produced by stocking with 300 medium sized brood fish on March 3. The highest weight (575 pounds) was produced by stocking with 2,400 large brood fish on April 30. The lowest number per acre (34,170) was produced where 500 brood fish were stocked January 28. The ponds received 9 to 12 applications of 200 pounds 8-8-4 commercial fertilizer or the equivalent per acre.

One of the principal problems in golden shiner culture is the overproduction of small fish, which results in a majority of the minnows being too small for sale when the ponds are drained. Even where supplemental feeding was used, golden shiners frequently reproduced so heavily that few of the young were large enough for sale at the end of the year.

The use of Auburn No. 1 fish feed (which contains 35 percent soybean oil meal, 35 percent peanut meal, 15 percent fish meal and 15 percent distillers dried solubles) at the rate of 10 pounds per acre per day during the summer and fall caused no mortality. Where heavier rates of supplemental feeding were used during the summer in addition to fertilization, frequently there were fish kills because of low oxygen concentrations in the pond water.

Small shiners averaging 2 pounds per thousand doubled their weight in 2 to 3 months (February to April) when fed daily on Auburn No. 1 fish feed at the rate of 3 to 5 percent of their body weight.

The only method of management that consistently produced nearly 100 percent marketable shiners in each pond involved the transfer of young shiners from the brood pond to rearing ponds during June and July. The rate of stocking used was 40,000 per acre. In addition to fertilization, Auburn No. 1 fish feed was fed at the rate of 10 pounds per acre per day. There were no deaths due to low oxygen concentrations during summer or fall. This method produced a relatively small number of shiners per acre, but practically all were 3 to 5 inches in length. The only small fish present resulted from very light spawning in each pond. The gross income less expenses for fertilizer and feed varied from $770.00 to $912.00 per acre.

It is very important that minnows be fed adequately while being held crowded in holding ponds awaiting sale. Heavy losses frequently occur among shiners that are in poor condition because of prolonged starvation.

As many as 80,000 large shiners, weighing 1,000 pounds, were held per acre in ponds during winter and early spring. They were fed Auburn No. 1 fish feed at the rate of 1 percent of their body weight per day. These shiners stayed in excellent condition and actually gained one pound per thousand in a period of 2 months. Losses amounted to less than 2 percent.

It was found that best results were obtained when all brood fish were treated for parasites and diseases before they were stocked in ponds. Treatment in tanks for one hour only with 10 p.p.m. potassium permanganate was effective in controlling fungus, gill flukes, and external protozoan parasites. One treatment with 15 p.p.m. formalin for 6 hours also effectively eliminated gill flukes and external protozoan parasites. Treatment with 1 p.p.m. acriflavine for 12 hours reduced losses resulting from bacterial diseases.

Daily treatments in ponds with 2 p.p.m. potassium permanganate for 3 days also controlled fungus, gill flukes, and external protozoan parasites.

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