longed retention of the wastes lowered their toxicities. A sample of an industrial waste effluent receiving stream was taken at a point where it entered the Ouachita River. Samples were transported to the field laboratory in full tightly stoppered bottles. Inasmuch as the most toxic factors apparent in this particular effluent were sulfides, dilutions were prepared based on the per cent of waste but the amount of sulfides in each solution was recorded. Dilution water was oxygenated for some 24 hours previous to setting up the tests. The test showed a very definite drop off in toxicity between 1.5 milligrams per liter of sulfide and one milligram per liter of sulfide. After allowing the sample of the effluent to stand for 24 hours and then conducting another analysis, the sulfide concentration was found to have increased from 9.7 milligrams per liter to 20.53 milligrams per liter of sulfide through anerobic decomposition of the organic matter. Tests were again set up based on sulfide content alone with the same result as previously noted—a definite break in toxicity between 1.5 milligrams per liter and 1.0 milligrams per liter of sulfides. In the preliminary test conducted on this particular waste, the fish placed in a 100% sample of the waste were dead in 10 minutes; however, the 100% sample of the same water after oxygenation of five hours previous to placing of fish in the effluent was not toxic to the fish at the end of a 72-hour period.

These toxicity studies were the first conducted by the Commission and although some analytical and engineering work must be done in addition to these studies, it is believed that they will prove extremely valuable in presenting the pollution picture in the Lower Ouachita River Basin.

PRELIMINARY STUDIES ON TILAPIA MOSSAMBICA PETERS RELATIVE TO EXPERIMENTAL POND CULTURE [1]

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ABSTRACT

Preliminary studies were conducted on the exotic cichlid, *Tilapia mossambica* Peters to determine the possibilities of incorporating this fish into the farm ponds and lakes in the Southeast.

In an 18-week experiment in concrete ponds, *T. mossambica* proved to be a more efficient fish than the bluegill, *Lepomis macrochirus* Raf. In feeding experiments *T. mossambica* gave 2.97 times greater growth than did the bluegill, in fertilization 1.69 times, and in manuring experiments 1.97 times greater growth than the bluegill.

Food habit studies conducted revealed that planktonic forms of plants and animals made up the bulk of the diet under natural conditions.

The minimum temperatures tolerated by *T. mossambica* were determined in a thermostatically controlled cold room. This fish ceased feeding at approximately 60° F., and deaths began at 52 to 58° F. with 100 per cent mortality occurring at 47 to 49° F.

The conclusion reached was that this fish cannot survive the winter conditions in most of the Southeast.

INTRODUCTION

The exotic cichlid, *Tilapia mossambica Peters,* has been the subject of much speculation in certain tropical countries of the Orient in recent years. The quest of the fisheries workers of these various countries for a fish of fast growth rate, large reproductive capabilities, and a palatableness suitable for wide human consumption has apparently been satisfied to a great extent by this particular fish.

[1] A portion of a thesis submitted to the Graduate Faculty of the Alabama Polytechnic Institute in partial fulfillment of the requirements for the degree of Master of Science in Fisheries Management, June, 1955.

Tilapia mossambica Peters is a native of east Africa (Atz, 1954) and a member of the family Cichlidae. The cichlids are a very large family composed of over 600 species and are found mainly in tropical regions.

T. mossambica (commonly called tilapia) has been introduced into Thailand (Vaas and Hofestede, 1952), the Philippines (Blanco, Acosta, and Lopez, 1953), Haiti (Lin, 1951), and Formosa (Chen, 1953). Atz (1954) lists in addition to these countries the introduction of tilapia into Sumatra, Malaya, British West Indies, Trinidad, North Borneo, West Borneo, East Borneo, Martinique, Pakistan, Ceylon, India, and the United States.

The habitat of tilapia varies extremely. This fish is found in both fresh and brackish waters. Vaas and Hofstede (1952) report that tilapia can be transferred from fresh water to brackish water of high salinity—even a salinity "exceeding that of normal sea water". Vaas and Hofsted (1952) further state that this transfer can be made reversely.

The spawning habits of tilapia are very interesting. This fish is a true mouth breeder. According to Vaas and Hofstede (1952), spawning begins at the early age of two or three months. The male selects the site of spawning in a portion of the bottom of a pond or stream that is soft. With his mouth the male moves the debris until he has cleared a depression some 12 inches in width. When this is completed, the female is induced to enter the depression and deposit the eggs. Once the eggs are deposited, the male passes over them secreting the milt. After fertilization is accomplished, the female carries the eggs and the small fish in the mouth for a period of 10 to 14 days. The eggs will incubate in 60 hours at temperatures of 80 to 83° F. Vaas and Hofstede (1952) also state that mature females lay eggs at intervals of 30 to 40 days with one male capable of fertilizing the spawns of several females. Environmental conditions govern the number of spawning times in a year (Chen, 1953).

The number of eggs or young a female may carry depends on the age of the fish (Chen, 1953). A spawner of 8 centimeters in length carried 100 to 150 eggs at each spawning as compared to 200 to 250 eggs carried by a fish of about 11 centimeters in length (Chen, 1953). Villadolid and Acosta (undated) state that a pair of mature fish in a period of one year may produce 10,000 young.

Vaas and Hofstede (1952) report tilapia to be primarily a vegetable feeder. Chen (1953) reports tilapia feeding on plankton, algae, decomposed vegetable matter, rice bran, soybean meal, chopped meat, and fish, but it had been observed to reject live food. Vaas and Hofstede (1952) stated that the young fish feed almost entirely on diatoms, unicellular algae, and small Crustaceae with larger fish consuming decaying plants, "thread algae," and unicellular algae.

The introduction of tilapia into countries having cool or cold weather conditions revealed that tilapia died at temperatures below 46° F. (Hey, 1953) and 57° F. (Chen, 1953). An examination of water temperatures recorded at Auburn during cold weather for a period of 31 weeks in 1951-1952 [2] revealed that the lowest temperature occurring during that period was 44° F. This temperature extended to a depth of seven feet in a one-acre pond.

In general, it has been said of tilapia that they grow fast, reproduce rapidly, are easy to feed, are easy to stock, are of good food quality, help in controlling injurious insects (mosquito larvae), and assist in "manuring" pond waters (Villadolid and Acosta, undated). Hey (1947) reports that tilapia attain a weight of five pounds in South Africa with the average weight being 2.5 pounds. Hey further states that for fishing tilapia provide good sport. The most common bait is the earthworm and the tackle is a small hook and gut leader. Schuster (1950) and Hofstede and Botke (1950) report the use of tilapia for clearing certain forms of filamentous algae and vegetation from small bodies of water.

The statements made regarding tilapia in general created a desire to determine if this species of *Tilapia* could be utilized in the farm ponds and lakes in the southeastern United States. Therefore, this study was undertaken with the following preliminary objectives:

1. To determine in aquaria the minimum temperatures at which tilapia feed and survive.

[2] A. P. I. Farm Ponds. 1951. Annual Report, A. P. I. Agr. Expt. Sta. (Unpublished).
———————. 1952. Annual Report, A. P. I. Agri. Expt. Sta. (Unpublished).

2. To determine by comparison with the bluegill, *Lepomis macrochirus* Raf., the growth of this fish using feeding, fertilization, and manuring.
3. To determine some of the food habits of tilapia.

MATERIALS AND METHODS

A. Feeding, Fertilization, and Manuring Experiments

Eighteen circular concrete ponds on the A. P. I. Agricultural Experimental Station were selected for these experiments. Each pond had a surface area of 0.0025 acre and a depth of two feet. The water supply for these ponds was an unfertilized impoundment. The water was piped to the ponds through a two-inch galvanized iron pipe with separate valves provided for each pond.

Each pond utilized a standpipe as the draining device. The standpipes were fitted with screen-wire funnels to prevent the escape of any small fish. A further precaution taken against the escape of small fish into the stream below was the placing of coarse cloth bags containing a water-soluble form of toxaphene at the discharge outlets of the ponds. Although the section of the stream into which the ponds drained was an area of active decomposition polluted with raw sewage and storm water from the city of Auburn, it was felt that the aforementioned precautions should be taken.

Each pond was stocked at the equivalent of 2,000 fish per acre. Bluegills for these experiments were obtained by seining from experimental ponds. The tilapia brood stock were shipped via air from the Steinhart Aquarium in San Francisco, California.

1. *Feeding.* The feeding rate of six per cent of body weight every other day was used. The food was a standard trout food with the following composition:

Material	*Pounds in Mixture*	
	1	*2*
Brewer's Yeast	10	10
Dried Skim Milk	11	11
Dried Distiller's Solubles	0	11
Peanut Meal	24	24
Wheat Middlings	24	24
Fish Meal	16	16
Salt (NaCl)	4	4

Mixture 1 was used during period June 26 to August 20 and mixture 2 during the period August 21 to October 30, 1954. No evaluation of food material was attempted; the comparison was between the efficiency of food utilization by tilapia and bluegills.

To facilitate the handling of the food material, the constituents were thoroughly mixed in their proper ratios. The required amounts of this food were placed in four-inch Petri dishes; water was added until a moist paste was formed; then the mixture was placed in a thermostatically controlled oven and allowed to dry, thus forming a cake. Drying was done at a temperature of 100 to 120° F. When the food was dried at this temperature until the cake receded from the sides of the dish, there was no gain in weight of the food material due to the water added. To obtain some indication of the utilization of the food, it was placed in a glass bowl having a diameter of five inches and a depth of two inches. The food was broken into small pieces, placed in the bowl full of water, and allowed to settle to the bottom of the bowl before lowering into the pond.

2. *Fertilization.* The inorganic fertilizers used in these experiments were a commercial 6-8-4 mixture and ammonium nitrate. These fertilizers were applied at the rate of 100 pounds of 6-8-4 plus 10 pounds of ammonium nitrate per acre per application at intervals of two weeks.

3. *Manuring.* Stable grade cow manure was used at the rate of 4,000 pounds per acre per application. The frequency of applications was governed by water color. When the water began to clear excessively, the ponds were manured at the aforesaid rate. Too frequent applications of manure could result in death of fish due to removal of oxygen as the manure decayed.

A maximum-minimum thermometer was placed in one of the ponds and allowed to remain there until cessation of the experiments. Surface temperatures were recorded at each feeding.

The fish were removed at approximately bi-weekly intervals for the periodic measurements. A minnow seine with a wire chain attached to the lead line was found to be more effective for this operation than a seine without the chain. The total weights and the total lengths of individual fish were recorded each time. Calculation of growth was made for the two-week period preceding. Where female tilapia were found to be carrying eggs, hatchlings, or fry in the mouth, these were removed to prevent overcrowding of the ponds. Any bluegill reproduction taken in the seine was also removed for the same reason.

The removal of the fish for the periodic measurements was found to be the most difficult and trying operation of this phase of the problem. In addition to the sloping configuration of the ponds, the tilapia were quite adept in avoiding the seine. These problems and the lack of experience in seining this type of pond resulted in the escape of some fish during the early stages of the study. Large amounts of time were consumed on many occasions in attempts to capture one fish thought to be remaining in the pond. Where this difficulty was encountered in the feeding experiments, the rate of feeding during the subsequent period was calculated on the presumption that the total number of fish was present and their total weight estimated from the average weight of the fish captured. Exceptions were made, of course, in the event dead fish were found. Such instances resulted in the necessary adjustments being made.

B. Determination of Minimum Temperatures Tolerated by Tilapia

For this part of the study, a thermostatically controlled cold room was employed. The refrigeration unit was mounted near the center of the ceiling of the room and was equipped with a small fan for circulation of the air.

All fish involved in this part of the study were held either in aquaria or feeding troughs at least 24 hours before the required number of fish were removed and placed in the aquaria in the cold room. One maximum-minimum thermometer was placed in an aquarium and another thermometer agreeding with the maximum-minimum in check readings was placed outside in the room. Both thermometers paralleled in readings throughout the experiments. Each aquarium contained 40 liters of water and was aerated continually throughout the experiments. A cover was provided for each aquarium to minimize evaporation.

1. *Trial No. 1.* This experiment dealt only with tilapia. Three replications were set up involving three aquairia containing one large adult in each, three aquaria containing five intermediates each, and three aquaria containing 10 small fish in each. The experiments were started at 70° F. and lowered approximately seven degrees a week until 100 per cent mortality occurred.

All fish involved in the cold room studies were fed at the rate of three per cent of body weight at each feeding. There was no definite feeding schedule. The food material was the same as that used in the feeding experiments. Food was placed in the aquaria in Petri dishes as it was utilized. When the food began to mold it was removed, the dish cleaned and the food replaced.

2. *Trial No. 2.* After the results had been obtained from the first trial, it was decided to include bluegills in this trial as checks against the cold room conditions.

Again three replications were used for each of the three general size groups of both the tilapia and the bluegills.

The temperature drops in this trial were approximately six degrees a week for the first two weeks. At the end of this period, the drop was decreased to two degrees a week. This procedure permitted a study of the effects of a prolonged exposure to temperatures 10 degrees or so above those found to be lethal in the first trial.

Feeding procedures were the same as in the first trial.

Due to the difficulty of handling bluegills in hot weather, those aquaria containing these fish were treated with one p.p.m. of acriflavin, a bactericide, to suppress or check the possible outbreaks of any diseases resulting from handling.

Spare aquaria containing water were placed in the cold room for the maintenance of water levels where needed.

C. Food Habit Studies

A dirt pond having a surface area of 0.05 acre was utilized for this study. The source of water for this pond was the same as that for the concrete ponds. Precautionary measures taken against the escape of small fish were the same as those used in the concrete ponds.

This pond was manured at the same rate and with the same schedule as the concrete ponds.

RESULTS AND DISCUSSIONS

B. Comparison of the Efficiency and Rates of Growth of Tilapia and Bluegills

1. *Feeding.* The feeding experiments were conducted for a period of 18 weeks between June 26 and October 30, 1954. The initial average total length of the bluegills was 75 millimeters and the average weight was 7.2 grams. The initial average total length of the tilapia was 77 millimeters and the average weight was 7.6 grams. At the conclusion of the study the bluegills had an average total length of 120 millimeters and an average weight of 30.8 grams. The tilapia had an average total length of 169 millimeters and an average weight of 91.6 grams. These figures reveal tilapia to be a much more efficient fish than the bluegill in response to feeding.

Observations made of the feeding bowls during the experiment indicated that tilapia utilized all of the food, while there were periodic accumulations of food in the bowls of the bluegills. This accumulated food was not removed.

Growth rates based on averages of the replications of these fish are shown for tilapia and bluegills in Table I.

2. *Fertilization.* The fertilization experiments were conducted for a period of 18 weeks between June 26 and October 30, 1954. The initial average total length of the bluegills was 73 millimeters and the average weight was 6.6 grams. The initial average total length of the tilapia was 73 millimeters and the average weight was 7.3 grams. At the conclusion of the study the average total length of the bluegills was 132 millimeters and the average weight was 42.8 grams. The tilapia had an average total length of 163 millimeters and an average weight of 72.5 grams. These figures revealed that under similar conditions the tilapia was a more efficient fish than the bluegill in utilizing the natural foods produced by fertilization. However, the major portion of the time involved in these experiments was the time in which the blugills do not obtain their best growth. Observations at this Station indicate that bluegills grow most rapidly in the spring and that food consumed in late spring, summer, and early fall is transformed into sexual products.

A summary of the growth of the tilapia and bluegills can be seen in Table II.

3. *Manuring.* The manuring experiments were conducted for a period of 18 weeks between June 26 and October 30, 1954. Each pond received a total of 40 pounds of manure (16,000 pounds per acre) during this period. The initial average total length of the bluegills was 76 millimeters and the average weight was 7.2 grams. The initial average total length of the tilapia was 76 millimeters and the average weight was 7.9 grams. At the conclusion of the study the average total length of the bluegills was 129 millimeters and the average weight was 37.5 grams. For the tilapia the average total length was 162 millimeters and the average weight was 74.1 grams. Again the figures reveal tilapia to be a more efficient fish and exhibiting a faster rate of growth than the bluegill under similar conditions. A summary of the growth of the tilapia and bluegills in the manuring experiments can be seen in Table III.

B. Determination of Minimum Temperatures Tolerated by Tilapia

1. *Trial No. 1.* Tilapia used in this trial measured from 26 to 178 millimeters in total length. All measurements are given in Table IV. This trial was conducted for three weeks in which the average drop per week was approximately 7° F. The first deaths occurred in the small and intermediate

TABLE I

A SUMMARY OF THE GROWTH OF TILAPIA AND BLUEGILLS IN CONCRETE PONDS WHEN FED A STANDARD DRY TROUT FOOD AT THE RATE OF 6 PER CENT OF BODY WEIGHT EVERY OTHER DAY DURING AN 18-WEEK PERIOD

	Tilapia				*Bluegills*			
Date of Measurements	*No. of Days Feeding*	*Average Weight of Fish*	*Average Growth of Fish*	*Avg. Weight of Food Fish Per Fish*	*No. of Days Feeding*	*Average Weight of Fish*	*Average Growth of Fish*	*Avg. Weight of Food Fish Per Fish*
		Grams	*Grams*	*Grams*		*Grams*	*Grams*	*Grams*
6/26/54	–	7.6	...	...	–	7.2	..	..
7/10/54	7	21.1	13.5	3.5	7	11.4	4.2	3.5
7/24/54	7	31.7	10.6	8.9	7	13.1	1.7	5.1
8/ 7/54	7	42.2	10.5	13.3	7	16.9	3.8	5.5
8/20/54	7	52.0	9.8	17.7	7	18.5	1.6	7.1
9/ 8/54	9	62.7	10.7	28.1	9	22.1	3.6	10.0
9/19/54	5	69.2	6.5	21.2	5	23.4	1.3	7.9
10/ 4/54	7	77.2	8.0	31.9	7	27.5	4.1	11.5
10/16/54	6	86.0	8.8	25.7	6	29.6	2.1	9.2
10/30/54	7	91.6	5.6	36.1	7	30.8	1.2	13.5

TABLE II

A SUMMARY OF THE GROWTH OF TILAPIA AND BLUEGILLS IN CONCRETE PONDS WHEN FERTILIZED AT THE RATE OF 100 POUNDS OF 6-8-4 PLUS 10 POUNDS OF AMMONIUM NITRATE PER ACRE PER APPLICATION AT APPROXIMATELY BI-WEEKLY INTERVALS DURING AN 18-WEEK PERIOD

Date of Measurements	*Tilapia* Average Weight of Fish Grams	*Tilapia* Average Growth of Fish Grams	*Bluegills* Average Weight of Fish Grams	*Bluegills* Average Growth of Fish Grams
6/26/54	7.3	...	6.6	..
7/10/54	20.7	13.4	12.0	5.4
7/24/54	35.4	14.7	15.4	3.4
8/ 7/54	50.0	14.6	21.9	6.5
8/20/54	56.9	6.9	25.6	3.7
9/ 8/54	62.2	5.3	33.4	7.8
9/19/54	65.3	3.1	36.0	2.6
10/ 4/54	68.9	3.7	39.4	3.4
10/16/54	69.7	0.8	41.6	2.2
10/30/54	72.5	2.8	42.8	1.2

TABLE III

A SUMMARY OF THE GROWTH OF TILAPIA AND BLUEGILLS IN CONCRETE PONDS WHEN FERTILIZED AT THE RATE OF 4,000 POUNDS OF FRESH COW MANURE PER ACRE PER APPLICATION AT APPROXIMATELY 4-WEEK INTERVALS DURING AN 18-WEEK PERIOD

Date of Measurements	*Tilapia* Average Weight of Fish Grams	*Tilapia* Average Growth of Fish Grams	*Bluegills* Average Weight of Fish Grams	*Bluegills* Average Growth of Fish Grams
6/26/54	7.9	...	7.2*	..
7/10/54	23.5	15.6	14.2*	7.0
7/24/54	33.7	10.2	18.0	3.8
8/ 7/54	38.5	4.8	21.9	3.9
8/20/54	49.8	11.3	24.3	1.4
9/ 8/54	57.4	7.6	28.6	4.3
9/19/54	59.9	2.5	31.7	3.1
10/ 4/54	64.9	5.0	34.3	2.6
10/16/54	67.7	2.8	35.3	1.0
10/30/54	74.1	6.5	37.5	2.1

* Based on two ponds; one pond started two weeks late.

TABLE IV

MEASUREMENTS OF TILAPIA USED IN TEMPERATURE TOLERANCE IN TRIAL NO. 1

Aquaria No.	*No. of Fish*	*Avg. Total Length Millimeters*	*Average Weight in Grams* Beginning	End
1	1	178	97.4	96.8
2	1	179	97.7	96.7
3	1	126	34.6	32.9
4	5	72	7.1	6.7
5	5	73	7.1	6.7
6	5	69	6.7	6.2
7	10	26	0.5	0.4
8	10	26	0.5	0.4
9	10	26	0.5	0.4

groups of tilapia at 52.5° F. (Table V) with deaths occurring from this point until 100 per cent mortality was reached at 47° F.

TABLE V

DEATHS OF TILAPIA IN TEMPERATURE TOLERANCE IN TRIAL No. 1

Temp. ° F.	*Duration of Exposure in Days*	*Aquaria Numbers*								
		1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
70.0	1	--	--	--	--	--	--	--	--	--
68.5	3	--	--	--	--	--	--	--	--	--
67.0	1	--	--	--	--	--	--	--	--	--
65.5	1	--	--	--	--	--	--	--	--	--
63.5	2	--	--	--	--	--	--	--	--	--
62.0	1	--	--	--	--	--	--	--	--	--
60.5	4	--	--	--	--	--	--	--	--	--
59.5	1	--	--	--	--	--	--	--	--	--
57.5	1	--	--	--	--	--	--	--	--	--
55.5	1	--	--	--	--	--	--	--	--	--
53.5	1	--	--	--	--	--	--	--	--	--
52.5	1	--	--	--	--	--	--	--	2	1
50.5	1	--	--	--	2	--	--	7	5	1
47.5	2	--	1	1	2	5	5	3	1	6
47.0	1	1	--	--	1	--	--	--	2	2

The effects of temperature became extremely noticeable at 52.5° F. with one of the large fish exhibiting much distress and with the death of three of the small fish. The fish exhibiting distress first began to lose their sense of equilibrium. The fish would roll from side to side, at length coming to rest on the dorsal fin. Movement of the pectoral fins and laborious breathing were typical movements. In the early stages of this distress, the fish could return to the normal position after some effort. Eventually the fish would remain inverted with death following in 24 to 48 hours. This type of distress was not seen at all in the small fish.

The response to food placed in the aquaria was very poor. It was difficult to determine at what point the large and intermediate fish stopped feeding, but it appeared to be at temperatures slightly in excess of 60° F. The small fish fed rather consistently until temperatures of 60° or slightly less were reached.

Some fish of all size groups began to show less movement at 57° F. If the fish were disturbed, they would move a short distance, coming to rest on their ventral surfaces. This decrease in movement in all fish became more pronounced as temperatures were decreased.

2. *Trial No. 2.* This treatment was conducted for a period of approximately seven weeks. The temperature drop averaged 5.5° F. per week for the first two weeks. During this time there were some deaths in the bluegill aquaria. These were to be expected because of the handling involved. The death of one tilapia also occurred during this period and cannot be explained. From this point the temperature was lowered approximately 2° F. a week until 100 per cent mortality of the tilapia occurred. Measurements of the tilapia used in this trial can be seen in Table VI and the measurements of the bluegills in Table VII. A summary of the deaths of both tilapia and bluegills can be seen in Table VIII.

The distress witnessed in the first trial was not observed to occur among the tilapia in this trial.

The temperatures at which 100 per cent mortality of tilapia occurred in the laboratory were corroborated by observations made in the field. When water temperatures dropped to 46° F., 100 per cent mortality occurred among tilapia in concrete and earthen ponds.

C. FOOD HABIT STUDIES

The digestive system of tilapia is typically that of a plankton feeder. The intestine is extremely long and much coiled. There is no true stomach. The structure existing in the place of the stomach is a bulb-like structure and apparently serves as a place for storage of food. Examination of materials from this structure and from the anterior part of the intestine revealed little, if any, change in appearances of food ingested.

For the qualitative examination of contents, a one-inch section of the gut immediately posterior to this bulb was removed and subjected to macroscopic and microscopic examination. The selection of this particular part of the gut was made because observation revealed this section of the gut usually contained more food material than did the bulb. This of course, was determined by the amount of food available and the degree of feeding.

TABLE VI

MEASUREMENTS OF TILAPIA USED IN TEMPERATURE TOLERANCE IN TRIAL No. 2

Aquaria No.	*No. of Fish*	*Avg. Total Length Millimeters*	*Average Weight in Grams*	
			Beginning	*End*
1	1	204	141.8	137.9
2	5	105	23.4	24.3
3	10	34	1.8	0.9
7	1	207	147.6	127.3
8	10	36	1.0	0.8
9	10	35	0.9	0.8
10	5	109	23.9	19.9
12	1	207	167.6	162.4
17	5	118	27.9	29.6

TABLE VII

MEASUREMENTS OF BLUEGILLS USED IN TEMPERATURE TOLERANCE IN TRIAL No. 2

Aquaria No.	*No. of Fish*	*Avg. Total Length Millimeters*	*Average Weight in Grams*	
			Beginning	*End*
4	1	170	73.3	66.6
5	1	195	120.9	111.1
6	10	37	0.6	0.6
11	5	83	6.8	4.5
13	1	158	61.0	61.0
14	10	39	0.8	0.7
15	10	37	0.6	0.8
16	5	83	6.5	6.1
18	5	82	6.4	5.6

Examination of food material present in the gut of tilapia revealed it to be primarily a plankton feeder. The remains of animal life were found but were decidedly in the minority. The most dominant forms present were those of plankton algae. Fragments of filamentous algae were found. The variety of food organisms present and the amount of debris present indicates feeding activities to take place in all parts of the fish's environment. The debris and certain of the animal fragments suggest bottom feeding. Plankton algae suggests a utilization of those forms suspended in the water.

Observations on tilapia in aquaria revealed that they picked up food material from the bottom, fed up and down the sides of the aquaria or up and down any vegetation present, cleaning whatever material they could from these surfaces. These fish have been observed suspending themselves in the water of aquaria and with pumping or sucking motions of the mouth ingesting any material floating in the water. This behavior was especially noticeable when zooplankton was introduced into the aquaria. If a dry food was placed on the surface of the water, the fish would not hesitate to rise to the top and swim along with mouth partly projecting from the surface of the water, straining the food material from the water as it passed through the mouth. This procedure was accompanied by a small sucking noise. In addition to the food materials mentioned, these fish also fed upon the larvae of *Chaoborus* and *Chironomus* and the branched alga, *Pithophora,* when introduced into aquaria containing these fish.

Table VIII

Deaths of Tilapia and Bluegills in Temperature Tolerance in Trial No. 2

Temp. ° F.	Duration of Exposure in Days	*Tilapia* Aquaria Numbers									Bluegills Aquaria Numbers								
		1	2	3	7	8	9	10	12	17	4	5	6	11	13	14	15	16	18
70.0	1	–	–	–	–	–	–	–	–	–	–	–	–	3	1	2	5	4	–
68.0	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
66.0	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
65.0	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
64.0	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
63.0	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
62.5	1	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
60.0	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
59.0	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
58.0	5	–	2	2	–	1	3	4	–	1	–	–	–	–	–	–	–	–	1
57.0	9	–	–	5	1	8	4	1	–	–	–	–	–	–	–	–	–	–	–
55.0	6	–	–	2	–	1	1	–	–	1	–	–	–	–	–	–	–	–	–
53.0	7	–	2	1	–	–	2	–	–	3	–	–	–	–	–	–	–	–	–
51.0	9	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–
49.5	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

This utilization of a wide variety of types of food apparently accounts, in part, for the rapid growth of these fish. In addition, the food chain of this fish is very short as compared to that of the bluegill.

From the 18 fish examined, the following genera or families of phytoplankton were found in varying abundances:

Ankistrodesmus	x
Cosmarium	x
Closterium	xx
Volvocaceae (?)	x
Scenedesmus	xxx
Staurastrum	xx
Micrasterias	x
Pediastrum	x
Tetradesmus (?)	x

x Rare
xx Common
xxx Abundant

In addition to the above, diatoms of many species were present in all specimens and were extremely abundant. Fragments of filamentous algae were rare. Unidentifiable phytoplankton forms were abundant in two specimens.

Animal life was represented by remnants of small crustacea, bryozoan statoblasts, one small fish, remains of insect larvae, and oligochetes. Debris to a large extent composed the visible bulk. For final determination of organisms present, the microscope was used.

Fish examined ranged in length from 113 millimeters to 169 millimeters and had an average weight of 47.7 grams.

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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.