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THE GROWTH OF CAGED Tilapia aurea (Steindachner) IN FERTILE FARM PONDS

By WILLIAM ARMBRESTER, JR.
Agricultural Experiment Station
Auburn University, Auburn, Alabama

Caged *Tilapia aurea* were cultured for a 10-week period in four experimental ponds (between 10 and 26 acres) to determine how efficiently these fish are able to use plankton as a source of food and to determine the value of Purina Trout Chow and Auburn No. 2 as supplemental rations for caged *T. aurea* in two common types of fertile farm ponds.

Fingerling *T. aurea* were stocked at the rate of 150 fish per 0.25-cubic meter cage (0.956 pounds per cage). There were four cages per pond.

Blooms of plankton were produced by inorganic fertilizer in two ponds which contained established bluegill-bass populations, and blooms of plankton were produced by a combination of supplemental feeding of catfish and inorganic fertilizer in the other two ponds which contained catfish under intensive culture.

One cage of *T. aurea* per pond received no supplemental ration. Three cages of *T. aurea* received supplemental rations six days per week. The three rations consisted of Purina Trout Chow at 3.0 per cent of the weight of fish per day, Auburn No. 2 at 3.0 per cent, and Auburn No. 2 at 1.5 per cent.

T. aurea consumed plankton efficiently enough for considerable growth. The mean production of *T. aurea* which received no supplemental feed was 8.90 pounds of fish per cage in the bluegill-bass ponds and 24.39 pounds of fish per cage in catfish ponds.

C feed conversion values (Swingle, 1958) indicated that Auburn No. 2 as a supplemental ration in all cases was unsatisfactory. C values for *T. aurea* which received the Purina Trout Chow ration in the bluegill-bass ponds were 1.0 and 1.5. C values for *T. aurea* which received the Purina Trout Chow ration in the catfish ponds were 3.3 and 6.3.

There was less variation in weight among harvested *T. aurea* than among the fingerlings which were stocked. There was less variation in weight among *T. aurea* in catfish ponds than among *T. aurea* in bluegill-bass ponds.

INTRODUCTION

The blue tilapia, *Tilapia aurea* (Steindachner), has been evaluated as a pondfish (Swingle, 1960; McBay, 1961; Shell, 1966; Kilgen, 1969; Pagan, 1970) and as a new exotic in several lakes of South Central Florida (Buntz and Manooch, 1969). Buntz and Manooch (1969) demonstrated that *T. aurea* did not provide an additional sport fishery in Florida but that these fish did provide a source of additional food when the public harvested them by special methods, such as snagging or cast netting. Swingle (1960) demonstrated that *T. aurea* (then identified as *Tilapia nilotica*), when fed, was an efficient pondfish, yielding a maximum of 4,003.7 pounds per acre in 208 days from 100 brood. However, there was a high percentage of fish of unharvestable size. Swingle (1960) noted that ponds stocked with *T. aurea* withstood high feeding rates, up to 100 pounds of feed per acre per day, without any depletion of dissolved oxygen or heavy phytoplankton scums. McBay (1961) demonstrated that temperatures below 55°F for extended periods were lethal to *T. aurea* (then identified as *T. nilotica*) at sizes of 11 inches and below. McBay also demonstrated that *T. aurea* (then identified as *T.*

nilotica) are primarily consumers of phytoplankton. Shell (1966) demonstrated that with *T. aurea* (then identified as *T. nilotica*) the optimum conversion rate was at a feeding rate lower than that which would provide the maximum growth rate. Kilgen (1969) demonstrated that larger crops of catfish could be produced in ponds by the stocking of *T. aurea* with the catfish. He concluded that *T. aurea* fed on wastes of the catfish and phytoplankton. Pagan (1970) demonstrated that *T. aurea* could be cultured in cages and that they would not reproduce in cages.

These evaluations did not indicate that *T. aurea* would be a desirable exotic for the waters of Florida. Indeed, this fish may possibly prove to be an undesirable introduction. Therefore new information regarding the biology of *T. aurea* is important.

Evaluations did, however, indicate that *T. aurea* has several desirable characteristics as a pondfish. Of course the most important characteristic of *T. aurea* is its lower lethal temperature, which prevents its spread in temperate waters. Certainly the possibility of a permanent introduction should be considered before culturing *T. aurea.*

The purpose of this experiment was to evaluate plankton as a source of natural food for *T. aurea* and to evaluate Auburn No. 2 as a type of supplemental feed. Since these fish were to be cultured in cages, plankton would be their only source of natural food. Objectives of the experiment were as follows:

1. To determine how efficiently *T. aurea* are able to use plankton as a food source.
2. To determine whether or not Auburn No. 2 (a nutritionally incomplete feed) would be a satisfactory supplement with plankton as the only source of natural food.
3. To compare the plankton blooms of two common types of farm ponds, catfish culture ponds and bluegill-bass ponds, as sources of food for *T. aurea.*
4. To determine if these fish could be produced in cages without the trouble of feeding.

MATERIALS AND METHODS

Experimental Design

The design consisted of four farm ponds, 16 cages, and 2400 *T. aurea.* Two ponds were bluegill-bass ponds, and two ponds were catfish culture ponds. Each pond contained four cages. Each cage contained 150 *T. aurea.* The growth of *T. aurea* within each cage was influenced by two factors: (1) one of two pond treatments and (2) one of four feeding treatments (Table 1). A pond treatment was the result of the density of the plankton

TABLE 1. Generalized treatment program for 16 cages of *T. aurea.* There were four feeding treatments of equal replication within pond treatments and two pond treatments of equal replication within feeding treatments. Feeding treatments were Purina Trout Chow at 3.0 per cent of fish weight per day (Treatment A), Auburn No. 2 at 3.0 per cent (Treatment B), Auburn No. 2 at 1.5 per cent (Treatment C), and no supplemental feed (Treatment D). Catfish ponds produced dense blooms of plankton, bluegill-bass ponds produced moderate blooms.

Ponds	Feeding Treatments A	B	C	D
	Cage No.			
S-8 (Catfish culture)	14	5	6	16
S-14 (Catfish culture)	3	2	1	4
S-6 (Bluegill-bass)	11	9	8	7
S-3 (Bluegill-bass)	10	12	13	15

bloom within a pond. This was because the two catfish ponds received extensive fertilization in the form of catfish feed (which was fed to the catfish, not to the caged *T. aurea*) and inorganic fertilizer and the two bluegill-bass ponds received inorganic fertilizer only. A feeding treatment was the result of a type of a supplemental feed at a particular feeding rate or the result of a lack of any supplemental feed. The small amount of feed which was fed to the caged *T. aurea* had a negligible effect upon the plankton blooms of the various ponds, i.e. a maximum 5.8 pounds of feed per acre in a fertile farm pond over a 10-week period would have an insignificant effect on the plankton bloom in that pond.

The difference between the two pond treatments was evaluated on the basis of the Student's *t*-distribution where cage production values (harvested weight within cages minus the stocking weight) would be considered as dependent variables (Steel, R. G. D. and J. H. Torrie, 1960). Three feeding treatments (B, C, and D) were compared separately to the fourth feeding treatment (A), the control, also on the basis of the Student's *t*-distribution where cage production values were again considered as dependent variables.

Cages

The cages were cylindrical in shape and 0.25-cubic meters in volume. Each cage had a diameter of 0.626 meters and a height of 0.814 meters. Twelve of the cages had feeding rings of ⅛-inch mesh hardware cloth. The rings were 0.27 meters in diameter and 0.3 meters in height. Plastic dish pans (0.13 meters deep, 0.27 meters wide, and 0.31 meters long) were attached below 8 of the feeding rings. The dish pans and feeding rings were placed in a manner which would retain sinking feed (Auburn No. 2), but would allow the fish to swim in and consume the feed.

Ponds

The four ponds used in this experiment, S-3, S-6, S-8, and S-14 (Table 1), were part of the Agricultural Experiment Station, Auburn University, Auburn, Alabama. They were chosen for this experiment because they represented two common types of farm ponds of the Southeastern United States. Pond S-8 (10.7 acres) and pond S-14 (12.4 acres) contained catfish, 4,000 per acre, under intensive culture. Pond S-3 (10 acres) and pond S-6 (25.5 acres) were bluegill-bass ponds. The feeding of catfish plus 17.4 pounds per acre of triple superphosphate fertilizer in ponds S-8 and S-14 (Table 2) produced dense blooms of plankton, and applications of inorganic fertilizer in ponds S-3 and S-6 (Table 3) produced moderate blooms of plankton. Average visibility readings (taken weekly for 9 weeks with the Secchi disk) were 2.29, 1.93, 1.18, and 1.22 feet for ponds S-3, S-6, S-8, and S-14 respectively.

TABLE 2. Amount of feed, pounds of Auburn No. 2 per acre per day, fed to the catfish in ponds S-8 and S-14 during 1970. *T. aurea* were stocked on July 9.

Pond	Period	Amount
S-8	March 17-April 11	5.0
S-8	April 15-May 20	8.0
S-8	May 21-June 10	15.0
S-8	June 11-August 8	25.0
S-8	August 10-September 30	25.0
S-14	March 20-April 11	5.0
S-14	April 15-May 20	8.0
S-14	May 21-June 10	15.0
S-14	June 11-August 8	25.0
S-14	August 10-September 30	25.0

TABLE 3. Applications of 17.4 pounds per acre of triple superphosphate in ponds S-3 and S-6.

Date	Pond
February 27	S-3
March 13	S-3
March 27	S-3
May 25	S-3
July 17	S-3
August 17	S-3
September 9	S-3
February 27	S-6
March 13	S-6
March 27	S-6
May 25	S-6
July 17	S-6
September 9	S-6

Stocking

These fish, which were young-of-the-year, were reared to fingerling size (between 20 millimeters and 91 millimeters) in 14 separate plastic pools (approximately three meters in diameter). On July 9, 1970, they were taken from the plastic pools and combined in a single holding tank. While in the holding tank, they were given a prophylactic treatment for external parasites (100 ppm formalin for 1.0 hours). Next, the fish were taken from the tank and separated into two different size groups, greater than 1.5 inches and less than 1.5 inches. Those under 1.5 inches were discarded. Based on a random sample of 226 fish, the coefficient of variation in weight of the larger fish was 114. Finally, the larger fingerlings were stocked randomly into the cages until there were 150 fish per cage. The mean stocking weight was 0.956 pounds per cage.

Feeding

Each pond contained one cage of fish which received Purina Trout Chow (nutritionally complete, closed formula) at 3.0 per cent of the total fish weight within the cage per day (Treatment A), one cage which received Auburn No. 2 (nutritionally incomplete, composed of 35 per cent peanut meal, 35 per cent soybean meal, 15 per cent fish meal, and 15 per cent distiller's dry solubles) at 3 per cent (Treatment B), one cage which received Auburn No. 2 at 1.5 per cent (Treatment C), and one cage which received no artificial feed (Treatment D). See Table 1. All fish in all cages were weighed biweekly to maintain these feeding rates.

RESULTS AND DISCUSSION

Results of the four feeding treatments (A, B, C, and D) indicated that plankton without any supplemental feeding would produce considerable crops of *T. aurea,* and that Purina Trout Chow as a supplement would produce larger crops. Results also indicated that, within a given pond, Auburn No. 2 as a supplement would not produce crops of *T. aurea* nearly as large as those which could be produced by Purina Trout Chow (a nutritionally complete feed) as a supplement (Table 4). Mean production values within treatments were 25.92, 16.62, 15.57, and 16.20 pounds of fish per cage for treatments A, B, C, and D respectively. B, C, and D were significantly different from A, the control, at the 0.05 level.

One would expect Auburn No. 2 to be of some value to caged *T. aurea,* as indicated by cages 7, 8, 9, 12, 13, and 15 (Table 4). However, one additional factor, which was not considered at the beginning, was the

TABLE 4. Production of *T. aurea*, pounds per cage, from 16 cages. Refer to Table 1 for individual cage numbers.

Ponds	Feeding Treatments A	B	C	D
	Production Values			
S-8 (Catfish culture)	34.28	23.12	21.39	24.70
S-14 (Catfish culture)	26.06	21.23	20.23	22.28
S-6 (Bluegill-bass	20.28	11.08	11.04	9.08
S-3 (Bluegill-bass)	23.07	11.04	9.61	8.73

effect of the dish pans used in treatments B and C. These devices occupied valuable space in the cages near the surface of the water.

Due to this additional factor, Auburn No. 2 as a supplement must also be evaluated on the basis of differences between treatments B and C, where the dish pans were part of both treatments. Within ponds, the higher feeding rate of 3.0 per cent (Treatment B) consistently produced larger crops of *T. aurea* than the lower feeding rate of 1.5 per cent (Treatment C). However, the average increase in this case was small, slightly more than one pound per cage (Table 4). Thus, it would seem that slightly larger crops of *T. aurea* could be produced in fertile ponds by feeding Auburn No. 2 at feeding rates of from 1.5 to 3.0 per cent than those crops which could be produced without feeding.

C conversion values (Swingle, 1958) indicated that the efficiency of Auburn No. 2 as a supplemental feed was unsatisfactory in all cases (Table 5). C values, 1.51 and 1.05 from cages 11 and 10 respectively, indicated that Purina Trout Chow was a satisfactory supplement in bluegill-bass ponds where a high rate of growth was not possible without feeding (Table 5). However, C values from catfish culture ponds, 6.27 and 3.29 from cages 3 and 14 respectively, indicated that Purina Trout Chow did not provide satisfactory increases in crops of fish over those crops which were produced without feeding.

TABLE 5. C conversion values from 16 cages where:

$$C = \frac{\text{Pounds of feed added}}{\text{Total amount of fish produced minus that which was produced without feeding in the same pond.}}$$

Refer to Table 1 for individual cage numbers.

Ponds	Feeding Treatments A	B	C	D
	C Conversion Values			
S-8 (Catfish culture)	3.29	..*	..*	...
S-14 (Catfish culture)	6.27	..*	..*	...
S-6 (Bluegill-bass)	1.51	5.17*	2.45*	...
S-3 (Bluegill-bass)	1.05	4.47*	4.68*	...

* Cages which were influenced by feeding rings, devices used to retain sinking feed.

Results of the ponds treatments indicated that the plankton blooms of catfish ponds produced larger crops of *T. aurea* than the plankton blooms of the bluegill-bass ponds (Table 4). The mean production among cages of the catfish ponds was 24.11 pounds per cage, and the mean production among cages of the bluegill-bass ponds was 12.99 pounds per cage. The difference between these two means was significant at the 0.05 level.

Another difference between the two types of ponds (which was noticed after the experiment had been completed) was that there was less variation in weight, within cages, among the *T. aurea* from the catfish ponds than that among the *T. aurea* of the bluegill-bass ponds (Table 6). However, all the fish, within cages, were of a fairly uniform size after the 10-week period.

TABLE 6. Coefficients of variation from 16 cages of *T. aurea*. Refer to Table 1 for individual cage numbers.

Ponds	Feeding Treatments A	B	C	D
	Coefficients of variation			
S-8 (Catfish culture)	16	20	19	17
S-14 (Catfish culture)	13	19	17	15
S-6 (Bluegill-bass)	33	33	29	35
S-3 (Bluegill-bass)	..	17	30	25

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