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Growth and Reproduction of Yearling *Tilapia Aurea* in Iowa Ponds¹

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SYNOPSIS. *Tilapia aurea* were introduced in three Iowa ponds with the knowledge that they would not overwinter. Differential growth of the sexes and aggressive behavior interfered with tests on effects of crowding tilapia in pens. Females began reproducing at 31 g in mid-July and offspring were up to 179 mm total length or 82 g in October. Stomachs were usually empty in females brooding eggs, and condition factors were lower for females

brooding fry than for other females. Males grew faster and had higher condition factors than females. Yearling tilapia 89-162 mm total length in May, added an average of 0.86 to 2.71 g per day from June 1 to early September in the 3 ponds. In Bailey's Pond, the population in late September was estimated at 1450 kg of black bullheads, 37 kg of channel catfish, and 550 kg of tilapia per hectare.

INDEX DESCRIPTORS: *Tilapia*, Cichlidae, growth of fish, fish populations.

Tilapia (Family Cichlidae) are widely used in fish culture in tropical Africa and Asia. Since these fish are an important source of protein in areas where some of our students may work, we were anxious to learn more about them and therefore tried the species in three Iowa ponds. Since these fish will not survive in water less than 13°C, there is no danger of their becoming established and competing with native fish in north central United States. Childers & Bennett (1967) reported that *Tilapia mossambica* reproduced and grew well in central Illinois ponds and could be used in biological control of aquatic vegetation if the fish were overwintered in heated waters.

The stock of *Tilapia aurea* which we used originally came from Israel and was secured through the courtesy of the Fish Farming Experiment Station, U. S. Bureau of Sport Fisheries and Wildlife, Stuttgart, Ark. They were yearling fish, 89-162 mm total length (3.5-6.4 inches) when received April 26, 1968 and May 9, 1969. The fish were held in tanks at the university for over a month until pond water temperatures were sufficiently high. Some fish were lost during this time, probably to columnaris. An attempt to overwinter the tilapia failed because of disease.

GROWTH IN PENS

As one part of the study tilapia were placed in a series of pens to compare growth at various population densities. The pens and techniques were similar to those in a parallel study of channel catfish in the same pond (Walker & Carlander, 1971). Six 3 by 3 foot (0.9 by 0.9 m) pens of 0.5 inch (13 mm) hardware cloth, in 2 feet (0.6 m) of water, were stocked with 2, 4, 8, 12, 18, and 24 tilapia respectively on May 29, 1969. Heavy mortality, probably from columnaris,

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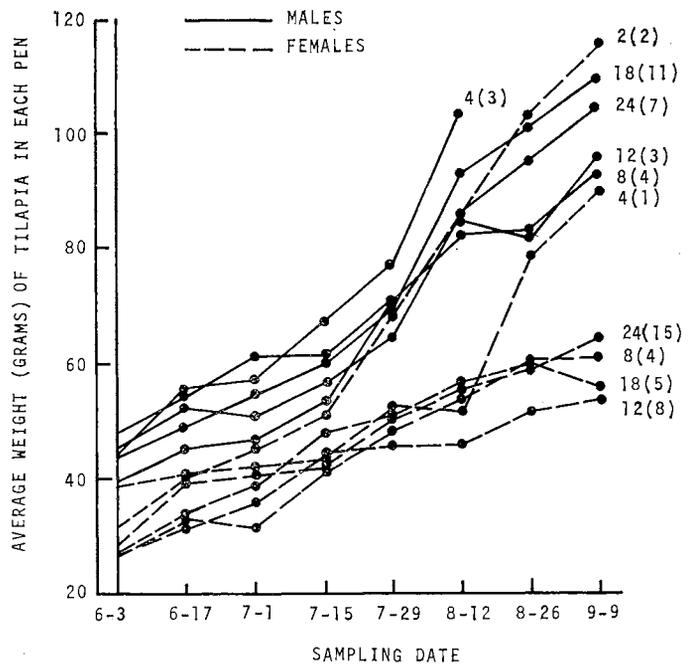


Fig. 1. Average growth of male and female tilapia in pens. The number of fish of the given sex is in parenthesis.

made it necessary to replace many of the fish. On June 3, the yearling tilapia in the pens were 95-160 mm total length and averaged 128 mm and 35 g. In 70 days the average growth was 0.78, 0.68, 0.52, 0.33, 0.63, and 0.45 g per day in the pens with 2, 4, 8, 12, 18, and 24 fish respectively. Growth was most rapid in the two pens with the fewest fish, but the relationship between population density and average growth was not as clear as it had been with channel catfish (op. cit.).

Differential growth of the sexes and differences in sex ratios in the pens complicated the experiment. Sexes were not recognized when the fish were placed in the pen, but were determined at the end of the study, Sept. 9. Sex was also recorded for most of the fish as they spawned. By fol-

lowing the measurements back it was possible to determine the growth history of the males and females in each pen (Figure 1). The females grew very little after July 15, except in pens 2 and 4. In pen 2 there were no males and the three males escaped from pen 4 between August 12 and 26 thereby permitting the remaining female to grow very rapidly the last 4 weeks. Yashouv (1958) noted that intensive breeding retarded the growth of the females.

Social behavior may also have affected growth in the pens. When two males were put in a 38-liter aquarium on July 25, 1968, there were territorial skirmishes and one was dead within 8 hours. Nearly all the scales on both sides of the body behind the fins had been pecked off. There was no evidence of scale loss due to fighting in the pens.

Population density had no detectable effect on the relative plumpness of the fish, as measured by condition factor, K, which is computed by dividing the weight in grams by the cube of the standard length in millimeters. The average condition factor was higher in August and September, 3.70 (176 fish, range 2.72-4.15), than in June and July, 3.55 (334 fish, range 3.09-4.45). There was also evidence of an increase in K with increase in length in August and September, but not earlier.

REPRODUCTION

The biweekly examination of the fish in the pens gave an opportunity to collect some data upon the reproductive season. Yashouv (1958) stated that a *Tilapia aurea* male may prepare two or three nests side by side. Visibility was too poor to permit observation of nest building in the pens, but one male, which had escaped from the pens, was observed on Aug. 28 and 29 building a nest in water about 14 cm deep a short distance from one of the pens. The nest, from rim to the base, was 12 cm deep and approximately 35 cm wide. At the approach of man, the male would leave the nest after a brief lateral display and remain in deeper water until the intruder was gone.

After the female has expelled her eggs into the nest and the male has fertilized them, the female picks up the eggs and incubates them in her mouth. Females with eggs or fry in their mouths were found in the pens from July 15 through Sept. 9 (Table 1). In pen 24 most of the females had fry at 4-week intervals and data from other pens suggested the same trend. One of the two females in pen 2 was incubating eggs on Aug. 12 and Sept. 9 even though no males were in the pen. The smallest female to incubate eggs was 97 mm long and weighed 31 g. Surface water temperatures in mid-morning were 23-29°C from July 15-Sept. 2 but had dropped to 21.9° by Sept. 9.

At the end of the pen study on Sept. 9, the fish were sacrificed to determine gonad development. Females brooding eggs had the smallest eggs in the gonads, and those no longer brooding had the largest eggs. The digestive tract was empty in 6 of 7 females brooding eggs but contained food in the 15 females brooding young. The females tending fry had the lowest mean condition factor, 3.48. The mean condition factor for those with eggs was 3.69, for those without a brood was 3.79, and for the 20 males was 3.94.

GROWTH OF YEARLINGS IN PONDS

Tilapia were also stocked in three ponds. Recapture of the fish to determine their growth throughout the season was not very successful.

TABLE 1. NUMBERS OF FEMALES WITH EGGS OR FRY IN THEIR MOUTHS.

		Pen number						
		2	4	8	12	18	24	Combined
Number of females		2	1	4	8	5	15	35
July 15	eggs	-	1	1	3	1	3	9
	fry	-	-	2	1	1	7	11
July 29	eggs	-	-	-	-	2	2	4
	fry	-	-	-	1	1	3	5
Aug. 12	eggs	1	-	1	-	1	1	4
	fry	-	-	-	3	2	9	14
Aug. 26	eggs	-	1	1	3	2	2	9
	fry	-	-	-	-	-	1	1
Sept. 9	eggs	1	1	1	2	1	1	7
	fry	-	-	2	4	3	6	15

Lost Lake, a 0.93 hectare (2.3-acre) pond in Ledges State Park, was stocked with only 15 tilapia on June 1, 1968. Since this pond is usually less than 1 m deep in fall and winter, no other fish were present. Coontail (*Ceratophyllum demersum*), duckweed (*Lemna*), and watermeal (*Wolffia*) became very abundant during the summer. Seining and electro shocking failed to take any yearling tilapia although some young fish were caught indicating successful reproduction. Treatment of the lake with rotenone Oct. 3, 1968 resulted in capture of 8 of the 15 tilapia. They were 228-264 mm in total length and averaged 249 mm and 288 g, an increase of 96 mm and 230 g over the average when stocked.

Lake LaVerne, on the Iowa State University campus, was stocked with 75 tilapia May 31 to June 4, 1968 and with 60, June 1, 1969. Lake LaVerne is an artificial lake of 1.13 ha, with a maximum depth of about 2.4 m. Goldfish and green sunfish were abundant in the lake, and several other species of fish were collected occasionally. Algae and aquatic vegetation had been a problem on the lake, but treatment with Aquathol in 1968 gave good control which lasted through 1969. An electric shocker, seines, gillnets, and wire basket traps caught only 3 yearling tilapia in Sept. 1968 and only 5 in Sept. 1969. The 3 fish taken Sept. 2-19, 1968 were 236-251 mm and averaged 242 mm and 289 g, an increase of 110 mm and 244 g. Three females taken Sept. 19-23, 1969, were 187-204 mm and averaged 196 mm and 135 g compared to the 2 males which were 223-254 mm and averaged 238 mm and 292 g. The difference in growth of the sexes was not recognized in 1968 and the fish were not dissected to determine sex since it was hoped that they could overwinter in the laboratory.

Bailey's Pond, a 0.29-ha (0.72-acre) pond, just northeast of Ames, had a maximum depth of 4 m, and received runoff from the fertile cropland surrounding it. The pond had been stocked in 1956 with largemouth bass and bluegill, but these winterkilled some years later. Black bullheads were the only fish in the pond when tilapia and channel catfish were stocked May 29 to June 8, 1969. Tilapia were stocked only in wire pens but some escaped into the pond, June 7 and in mid-August. Seven females collected Sept. 25 - Oct. 1, 1969 were 196-222 mm and averaged 203 mm and 170 g compared to 8 males which were 205-238 mm and averaged 228 mm and 273 g. These fish were all significantly larger than the tilapia in the pens when the study was ended on Sept. 9.

The average increment was 1.84 g per day in Lost Lake, 2.71 in Lake LaVerne in 1968, 1.44 in 1969, and 1.60 in Bailey's Pond. These means are based upon only a few fish and are affected by sexual differences in growth but they in-

TABLE 2. ESTIMATE OF THE FISH POPULATION IN BAILEY'S POND, SEPTEMBER, 1969.

	Number finclipped	Number removed Marked	Number removed Unmarked	Estimated Population	Approximate pounds per acre	Kilograms per hectare
Bullheads	157	86	5233	9300	1300	1450
Channel catfish	43	33	205	265	33	37
<i>Tilapia aurea</i>	782	270	4248	9250	490	550

dicating growth rates equal to or more rapid than shown by *Tilapia aurea* of similar sizes in Israel: 1.0-1.5 g/day (Yashouv, 1958) and 0.8-2.2 (Chervinski, 1966).

GROWTH OF YOUNG TILAPIA

Young tilapia were collected in each of the ponds in October indicating successful reproduction. Spawning time was known only in the pens in Bailey's Pond. Since spawning continued throughout the summer, the average sizes of the young tilapia do not tell us much. Many of the smallest fish were not caught or measured. Growth was evidently slowest in Lake LaVerne. The ten largest in Oct. 1968 averaged 69 mm and 4.9 g. In Oct. 1969 only two were over 65 mm and these were 84 and 90 mm.

In Lost Lake, 211 young tilapia averaged 103 mm (range 53-179 mm) and 22.9 g (the largest, 82 g) on Oct. 3, 1968. In Bailey's pond the ten largest, 138-149 mm, averaged 61 g on Oct. 1, 1969.

The length-weight relationship of 180 young tilapia, 42-149 mm, total length, from Bailey's Pond was computed as:

$$\text{Log } W = -5.404 + 3.339 \text{ Log } TL$$

where W = weight in grams
and TL = total length in millimeters

The slope 3.339 tested significantly above 3.0. Thus, the tilapia were becoming increasingly plump as they grew longer.

To convert standard to total length, ratios were computed for several size classes as follows:

Standard length range	Number of fish	TL/SL ratio
40-59	10	1.307
60-119	30	1.294
150-159 females	6	1.271
180-189 males	6	1.279

FISH POPULATION IN BAILEY'S POND

The fishery management class made a marking and recapture estimate of the fish population of Bailey's Pond, Sept. 16-27, 1969 and then treated the pond with rotenone on Oct. 1 and collected the dead fish on Oct. 1-4. A manuscript report giving details of the estimates is available from K. Carlander at Iowa State University. The total population was estimated at 2000 kg/ha or 1800 lb/acre, (Table 2) higher than reported for other Iowa waters (Carlander & Moorman, 1956). The black bullheads were mostly of two size groups: young fish, 70-89 mm, total length, and adults, 130-169 mm.

About 11% were young, 85% adult, and 4% intermediate. In late May, 265 yearling channel catfish, 73-150 mm, were stocked. Survival was good and they were 141-238 mm in September. The tilapia population came from the 72 yearlings stocked in the pens. The 72 yearlings weighed about 2.7 kg (6 lb) when stocked on June 3. On Oct. 1 the biomass of yearling and young tilapia was approximately 160 kg (or 550 kg/ha).

At least two factors contributed to the high production in Bailey's pond. The pond receives drainage from well fertilized cropland and the fish population consisted of species capable of feeding on producers and detritus, thus converting more of the energy to fish flesh than is possible with predatory species.

CONCLUSION

These studies indicate *Tilapia aurea* are able to grow and reproduce successfully in Iowa ponds, in the presence of other species.

No test was made of their ability to control algae or other vegetation. Childers & Bennett (1967) reported that 1,000 *Tilapia mossambica* per acre controlled algae and submerged vegetation. Over 13,000 tilapia per acre were produced in Bailey's Pond but most of these were small. Bailey's Pond did not have an algae or aquatic weed problem.

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