Swingle, H. S. 1957. Revised procedures for commercial production of bigmouth buffalo fish in ponds in the southeast. Southeastern Assoc. Game and Fish Comm., Proc. 10: 162-165.
Tarzwell, C. M. 1944. The possibilities of a commercial fishery in the TVA impoundments and its value in solving the sport and rough fish problem. Amer. Fish. Soc., Trans. 73: 137-157.
Tennessee Valley Authority. 1967. Division of Forestry Development, Annual Report, 39 pp.
Van Oosten, J., H. J. Deason, and F. W. Jobes. 1934. A microprojection machine designed for the study of fish scales. Jour. du. Conseil 9(2): 241-248.
Walburg, C. H., and W. R. Nelson. 1966. Carp, river carpsucker, smallmouth buffalo and bigmouth buffalo in Lewis and Clark Lake Missouri River. Bur. Sport Fish. and Wildl. Research Report 69.
Weiss, G. 1950. For Fishermen only. Missouri Conservation Comm., Jefferson City, Mo. 48 pp.
Wirth, T. L. 1958. Lake Winnebago fresh-water drum. Wisconsin Conserv. Bull. 23(5): 30-32.

TILAPIA AUREA (STEINDACHNER), A RAPIDLY SPREADING EXOTIC IN SOUTH CENTRAL FLORIDA

By Jon Buntz and Charles S. Manooch, III
Florida Game and Fresh Water Fish Commission
Lakeland, Florida

ABSTRACT

Tilapia aurea were introduced into Florida by the Florida Game and Fresh Water Fish Commission in 1961. Original stocking was in managed pits at Pleasant Grove Research Station. From this beginning they have spread to numerous private ponds, four creeks, two rivers and several public lakes. Enriched bodies of water are preferred habitats and native species present have not retarded establishment of *T. aurea*.

Most of the present study was conducted on Lake Parker, a 2291 acre eutrophic lake in Polk County. Surveys of the fish population on Parker revealed seasonal congregations of *T. aurea*. This gregarious behavior was correlated with temperature and habitat preference. During January and February, the species was heavily congregated at an electro-power plant. Water temperatures at the plant ranged as high as 9 degrees Fahrenheit above background lake temperatures. Concentrations were also evident in areas where the lake bottom was primarily muck. As water temperature increased, tilapia competed with centrarchids for sand-bottom spawning areas.

Length-weight studies revealed above average empirical weights, when compared to Alabama pond-raised tilapia. A 14 day creel, randomly selected over a 2 month period, was conducted on the lake to determine catachability.

INTRODUCTION

The Florida Game and Fresh Water Fish Commission obtained 3,000 *Tilapia aurea* from Auburn University in August, 1961, (Crittenden, 1962). These individuals were placed in experimental phosphate pits at the Pleasant Grove Research Station. Several media publicized *T. aurea* as a highly desirable species. With this encouragement friends were given fish for stocking, fishermen caught them and stocked private ponds, and some fishermen who felt the Commission was proceeding too slowly, stocked them in public lakes.

After the Florida Game and Fresh Water Fish Commission completed the experiments, it was decided that *T. aurea* would be undesirable to the Florida

fisheries. The reasons for this decision were; low catchability, and the fact that tilapia are extremely resistant to chemical control (D. Holcomb, personal communication).

From this introduction tilapia have spread rapidly to several counties of south central Florida.

MATERIAL AND METHODS

Information from four fish sampling methods is utilized in this report. They include electro-shocking, trammel nets, minnow seines, and creel survey.

The electro-shocking device consists of a portable generator (capable of producing 230 volts) connected to two copper cable electrodes suspended on booms in front of the boat. The boat was powered slowly along the shoreline for one hour and one-half hour periods and the fish were collected with dip nets. This was an effective means of sampling in areas where tilapia were concentrated.

Trammel nets, with inner stretch mesh of 3 inches and outer stretch mesh of 12 inches, each 125 yards long, were set in the evening and recovered the following morning. Some of the nets were set adjacent and perpendicular to the shore and others were placed in open water. Nets proved very effective for obtaining adult specimens.

The seine was 20 feet by 4 feet with a quarter inch stretch mesh. This was usefull in sampling for tilapia reproduction and to verify their presence.

Statistics were recorded in tenths of pounds and the nearest inch group.

A creel was taken on Lake Parker to establish: catch per unit effort, per cent of fishermen fishing primarily for *T. aurea*, per cent of total harvest, and public comment on tilapia as a food fish. The creel consisted of 14 days randomly selected over a 2 month period. It included 10 week days, 2 Saturdays and 2 Sundays. The survey was conducted between 4:00 and 6:00 in the afternoon, regardless of weather. This particular time was selected because there were more fishermen on the lake, enabling the creel to encompass as many individuals as possible.

Length-weight studies were conducted to compare average empirical weights of Florida specimens with those of Alabama pond-raised *Tilapia aurea*. Individuals used to obtain data were measured to determine total lengths, then categorized in specific inch groups. The inch groups were weighed in aggregate (Swingle, 1965) and empirical weights calculated to the nearest hundredth of a pound.

Bottom samples were taken by inserting a 6 foot, clear plastic tube into the substratum as far as possible. A cork was placed in the proximal end of the tube to prevent sampled material from seeping out as the instrument was extracted. The tube was calibrated to the nearest quarter inch. This data was used to correlate bottom types with *T. aurea* and centrarchid concentrations.

When fishermen reported observing tilapia in a body of water, sampling was done to verify their presence. Streams tributary to lakes containing the species, and bodies of water adjoining them, were sampled. If *T. aurea* did not appear in samples it was concluded that they were not present in significant numbers. We were unable to conclude that fish were not present where access was available through connecting waterways.

Parker, a 2291 acre eutrophic lake, was exploited frequently because of its dense population of *T. aurea*. Several other bodies of water were sampled but only to determine if the species was present.

DISCUSSION

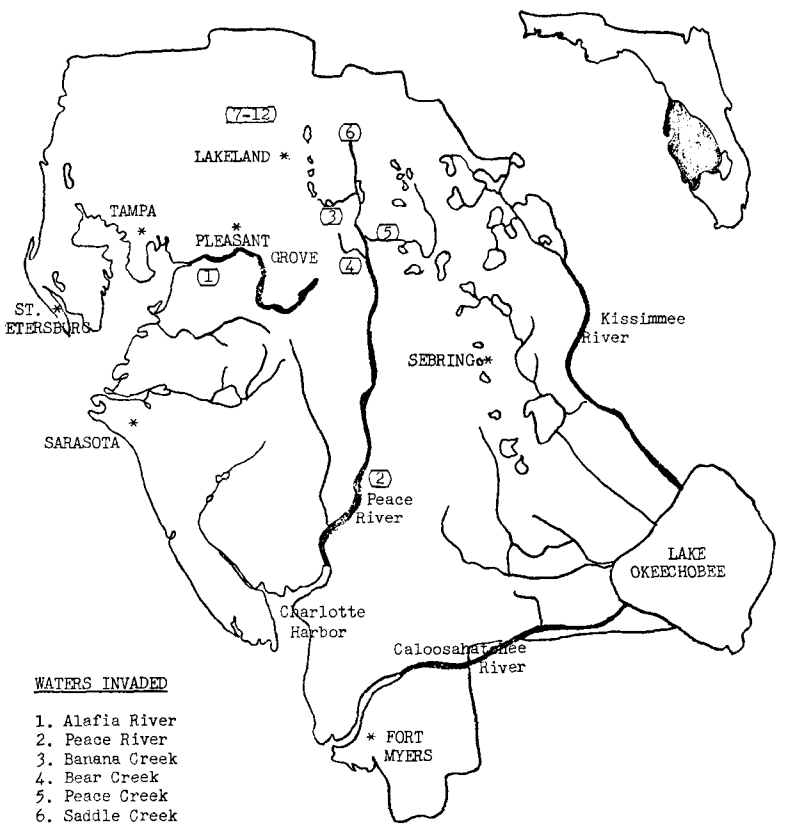
From its introduction at the Pleasant Grove Research Station, the *T. aurea* has spread to:

Rivers	*Creeks*	*Lakes*	*Private Ponds*
1) Alafia	1) Banana	1) Banana	10+
2) Peace	2) Bear	2) Hancock	
	3) Peace	3) Hollingsworth	
	4) Saddle	4) Mirror	
		5) Morton	
		6) Parker	

Known distribution includes several counties (Figure 1), however, as private ponds are involved total dispersal is unknown at present. Additional bodies of water may be invaded after this year since the region had unusually heavy rains in May, June, and July. Numerous lakes connected by boat canals indicate time will be the major factor limiting spread from central Florida south.

All waters from which *T. aurea* were collected, except Lake Morton, were eutrophic. Morton is located in the City of Lakeland and has numerous ducks, swans and other waterfowl fed 10 pounds of cracked corn daily. The tilapia probably utilized this feed and might explain their success. The lake was totally renovated in October, 1966. One hundred forty-six pounds of tilapia were collected, comprising 20 per cent by weight of an acre block net sample (Ware, 1966). Since this renovation, no *T. aurea* have been collected but reinvasion is certain, since adjoining lakes have this species in their population. Earlier work (Crittenden, 1962) suggested that bass predation might prevent tilapia from becoming a nuisance fish. The Lake Morton experience indicates this is not so.

Figure 1. Areas of Invasion of *Tilapia aurea* in South Central Florida.



Tilapia aurea appear to prefer enriched waters and muck bottom areas. The preference to muck seems to be seasonal. January and February samples in Lake Parker revealed concentrations of *T. aurea* in areas of muck deposits, and in the outflow of the electro-power plant (Table 1). Water temperatures were 4° - 9° F. higher at this location and were considered the congregating factor (Table 1, Stations I and II). Snatch hooking during winter months was popular at the plant where the outflow kept the concrete canal scoured clean. At the extreme opposite end of the lake, large aggregates of tilapia were found over deposits of muck 4 inches to greater than 6 feet in depth (Table 1, Stations III and IV). Other groups were found throughout Lake Parker, always correlated with muck deposits, this was verified with the electro-shocker. Sandy substrata were only sparsely populated with tilapia during this period (Table 2).

TABLE 1.
Winter Concentrations Correlated with Muck Substrata

Station	*Location*	*Date*	*Percent of Total Weight Tilapia*	*Percent of Total Weight Centrarchids**	*Bottom Type*
I	Electro-plant	1/23/68	19.88	15.71	20" muck
II	Electro-plant	1/23/68	63.19	2.09	12" muck
III	Opposite end	1/31/68	50.41	26.22	4"-6' muck
IV	Opposite end	2/22/68	51.91	8.08	6' + muck

*Centrarchids included largemouth bass, bluegill, redear, black crappie, and warmouth.

TABLE 2.
Winter Concentrations Correlated with Sand Substrata

Station	*Date*	*Percent of Total Weight Tilapia*	*Percent of Total Weight Centrarchids**	*Bottom Type*
V	2/16/68	2.96	83.25	5" sand
VI	2/21/68	3.46	75.01	8" sand
VII	2/21/68	6.60	89.81	10" sand
VIII	2/22/68	14.00	20.04	2" (50 yds. from muck
IX	2/28/68	0.00	18.32	10" sand
X	3/6/68	0.46	48.10	4.5" sand
XI	3/6/68	0.37	20.53	4" sand

*Centrarchids included largemouth bass, bluegill, redear, black crappie, and warmouth.

Evidence has been presented that tilapia are in the Peace River. Samples recently conducted in the southern portions yielded none (Ware, personal communication). The extreme northern portion was sampled and a few *T. aurea* were collected. This portion is more enriched than the lower. Further surveys revealed that tilapia congregate around areas utilized by cattle as watering sites. The substrata in these locations had deposits of organic debris from cattle feces. Bottom samples taken in Lake Parker and the Peace River verified that *T. aurea* congregate around decaying organic detritus.

When water temperatures reach a critical point, males separate from the schools and establish territories. Females disperse throughout open waters of the lake and return to the shoreline to spawn (McBay, 1961). When spawning activities began in

Lake Parker, large numbers of fish were no longer collected at previous locations (Table 3). Shocker samples along the shoreline recovered tilapia where they had not been collected before. In one and a half hours 185 tilapia were obtained and 180 of these were males. Tilapia, bluegill and redear were collected from the same spawning area, indicating competition for spawning ground takes place between these species.

A 20 foot minnow seine was used to check various lakes to verify the presence of *T. aurea*. Small specimens were collected easily in this manner and enabled the investigation to encompass the major part of the region. The seine was also used to pick up young-of-the-year in Lake Parker, where periodic checks were made on growth and dispersal of the species.

The creel conducted on Lake Parker (Table 4) should be discussed before an analysis of the data is attempted. Those fishermen designated as "tilapia fishermen" are individuals fishing primarily for *T. aurea* by means of snatch hooks or cast nets. "Other fishermen" are those fishing for any other species. Tilapia harvested by "tilapia fishermen" are calculated under "tilapia/hour". Any other species is figured under "others/hour". *T. aurea* caught by "other fishermen" are included in "per cent of total fish, tilapia". The tilapia taken by "other fishermen" were generally less than 5 inches and only appeared at the end of the survey period. These fish were young-of-the-year. This agrees with McBay's (1961) findings on the food habits of

TABLE 3.
Tilapia Dispersal from Muck Areas in Latter Part of May

Station	*Date*	*Percent of Total Weight Tilapia*	*Percent of Total Weight Centrarchids**	*Bottom Type*
I	5/7/68	28.15	28.53	20" muck
	5/24/68	9.00	53.43	
III	5/1/68	78.24	11.45	4"-6' muck
	5/29/68	9.40	46.67	

*Centrarchids included largemouth bass, bluegill, redear, black crappie, and warmouth.

TABLE 4.
14 Day Creel From Lake Parker 1968

Date	*Total Fishermen*	*Tilapia Fishermen*	*Other Fishermen*	*Tilapia hour*	*Other hour*	*% Tilapia Fishermen*	*% Tilapia in Total Catch*
5/19	59	20	39	4.76	1.18	33.89	51.00
5/22	48	6	42	2.25	1.32	12.50	7.08
5/27	162	1	161	0.00	3.83	0.62	0.60
5/29	174	5	169	0.00	1.98	2.87	0.41
6/27	36	0	36	0.00	1.74	0.00	1.96
7/5	45	0	45	0.00	2.92	0.00	35.10
7/7	70	2	68	0.00	2.95	2.85	28.00
7/9	77	2	75	0.00	3.08	2.60	6.50
7/11	141	0	141	0.00	2.65	0.00	16.25
7/13	43	2	41	3.33	4.10	4.60	15.71
7/15	23	0	23	0.00	2.08	0.00	32.00
7/19	24	0	24	0.00	2.12	0.00	4.87
7/20	60	0	60	0.00	2.33	0.00	23.07
7/25	29	0	29	0.00	2.57	0.00	14.70
Daily Average	70.78	2.71	68.07	0.74	2.49	4.28	16.95

the species. He found that 3 to 5 inch groups utilized insects and 6 to 9 inch groups consumed algae. The fact that only occasional reports of large specimens being taken by sports fishermen further substantiates their overall herbaceous diet as adults.

Fishermen were randomly selected to give opinions of this new species as a food fish. Out of 366 persons interviewed, 159 (43%) had tasted the fish. Approximately 64 per cent thought that tilapia were a desirable food fish. Most of the dissatisfied complained that the flesh was too soft. Anglers were not questioned on their opinion of *T. aurea* as sport fish. However, during the cooler months fishermen came from surrounding areas to Lake Parker to snatch hook larger individuals.

The creel data also revealed per cent of fishermen fishing exclusively for *T. aurea*. The first 2 days of the survey indicated high percentages of "tilapia fishermen". Congregation during the cooler months provided successful snatch hooking around the power plant. As water temperature increased, the fish dispersed throughout the lake, and fisherman success dropped. Samples revealed that tilapia moved out from concentration points, and anglers returned to conventional methods of fishing. As the "tilapia harvest/hour" decreased the "others/hour" increased.

Specimens from Lake Parker were compared with corresponding inch groups from Alabama (Swingle, 1965) to establish a comparable length-weight relationship. The average empirical weights of the Florida tilapia were generally higher, indicating *T. aurea* have done quite well in Florida's natural environment. A sharp reduction in body weight was noted for the 12 and 13 inch groups (Table 5). Specimens for these groups were not collected until May 19, while other groups were obtained in March, so differences in weight may be correlated with spawning activities. In Florida waters tilapia obtain greater lengths than Alabama specimens. This occurs in Florida natural waters as compared to Alabama pond-raised individuals. The largest individual harvested has been a 7 pounder at 19 inches. The large size of Florida specimens may be attributed to available habitat, climate and geographic location. Eutrophic lakes easily satisfy herbaceous food requirements for the species and climate is such that winter kills due to low temperatures are unlikely.

TABLE 5.
Length-Weight Comparisons of Lake Parker and Alabama Pond-Raised *Tilapia aurea*

Length (inch)	*Average Empirical Weight South Central Florida (pound)*	*Average Empirical Weight Alabama (pound)*
4	0.07	0.04
5	0.10	0.08
6	0.18	0.15
7	0.28	0.27
8	0.37	0.40
9	0.58	0.58
10	0.83	0.79
11	1.03	1.05
12	1.17	1.48
13	1.65	1.74
14	2.27	1.90
15	2.53	0.00
16	2.90	0.00

CONCLUSIONS

From its introduction to Florida 7 years ago, the *Tilapia aurea* has become the fastest spreading exotic in the state. Tilapia utilize eutrophic lakes that are becoming undesirable for sports fisheries and more suitable for rough fish. This does not ease the problem since their catchability is low. Some selected areas make the harvest of

T. aurea easier, but they appear to be competing for space and spawning areas with centrarchids. This was made evident when 266 pounds of the species were collected in a 125 yard trammel net, comprising 84 per cent by number and weight of the sample. The juveniles of this species are in competition with young centrarchids for available food. Invertebrates are utilized extensively by the smaller representatives of both groups (McBay, 1961). The length-weight relationship is indicative of the large sizes obtained by Florida tilapia. Their short food chain, plus a favorable climate, enables *T. aurea* to contriubte tremendously to the biomass of the aquatic environment.

Commercial exploitation is possible but even native fisheries, under present Florida law, are not fully utilized.

It is evident from what has happened in South Central Florida that control of both experimental species and news media is needed. If tilapia present problems similar to the introduced carp (Hubbs, 1968) it is already too late to stop the problem with known methods of control. Tilapia will continue to spread throughout Florida and may invade other southeastern states. What effects they may have on native sport fisheries is unknown. Hopefully, the problems experienced with *T. aurea* will stimulate more caution and better control of non-native species.

ACKNOWLEDGMENTS

The authors wish to acknowledge the assistance of Robert Betz and Mrs. Wilma Selph in collecting specimens and preparing this paper. Editing by Dennis Holcomb is also sincerely appreciated.

LITERATURE CITED

Crittenden, Edward, 1962. Status of *Tilapia nilotica* Linneaus in Florida. Proc. Ann. Conf. S.E. Game and Fish Comm., 17 (1962): 257-262.

Hubbs, Clark, 1968. An Opinion of the Effects of Cichlid Releases in North America. Trans. Amer. Fish. Soc. 97: 197-198.

McBay, Luther G., 1961. The Biology of *Tilapia nilotica* Linneaus. Proc. Ann. Conf. S.E. Game and Fish Comm., 15: 208-218.

Swingle, Wayne E., 1965. Length-Weight Relationships of Alabama Fishes. Agr. Exp. Sta. Fisheries 3: 87.

Ware, F. J., 1966. Lake Morton Tilapia Eradication Project. Florida Game and Fresh Water Fish Comm. 2. (Unpublished).

COMPARATIVE STRENGTH OF THE 1966 YEAR CLASS OF STRIPED BASS, *ROCCUS SAXATILIS* (WALBAUM), IN THREE VIRGINIA RIVERS[1]

By George C. Grant and Edwin B. Joseph
Virginia Institute of Marine Science
Gloucester Point, Virginia 23062

ABSTRACT

The age composition, as determined from scale impressions, of striped bass stocks in the James, York, and Rappahannock Rivers during the period June 1967 – March 1968 indicates a relative deficiency of the 1966 year class in the James River. Similar results are shown in samples from non-selective gear (pound nets, fyke nets), selective gear (gill nets, haul seines, hook-and-line), and routine surveys using a 30-foot semi-balloon trawl.

[1] Virginia Institute of Marine Science Contribution No. 290 . To be presented at the meeting of the Southern Division of the American Fisheries Society, Baltimore, Md., October 21-23, 1968.

[2] This project was funded in part with Anadromous Fish Act (P. L. 89-304) funds.