Smith, S. F. 1971. Effects of a thermal effluent on aquatic life in an East Texas reservoir. Southeast Assoc. Game and Fish Comm., Proc., 25: 374-384.
Strawn, K. 1963. Resistance of threadfin shad to low temperatures. Southeast. Assoc. of Game and Fish Comm., Proc., 17: 290-293.
Tennessee Valley Authority. Division of Forestry Relations. 1954. The shad called threadfin. Prog. Rept. n.p.
Tennessee Valley Authority. Division of Forestry Relations. 1960. The sauger story. Prog. Rept. n.p.
Tennessee Valley Authority. Division of Forestry Development. 1969. Fish and fishing around TVA steam plants. Leaflet No. F70FR1. n.p.
Tennessee Valley Authority. Fisheries and Waterfowl Resources Branch. 1972. Fish inventory data, Pickwick Reservoir. 14 p.
Tennessee Valley Authority. Division of Forestry, Fisheries, and Wildlife Development. 1973. Annual Report. n.p.
Trembley, F. J. 1960. Research project on effects of condenser discharge water on aquatic life. Progress Report, 1956-1959. The Institute of Research, Lehigh University, 154 p.
Walburg, C. H., G. L. Kaiser, and P. L. Hudson. 1971. Lewis and Clark Lake Tailwater Biota and some relations of the tailwater and reservoir fish population, p. 449-467. *In* G. E. Hall (ed.) Reservoir fisheries and limnology, Amer. Fish. Soc., Special Pub. No. 8.
Wrenn, W. B. 1974. Fisheries studies in relation to a long heated discharge channel (Colbert Steam Plant, Tennessee River). Ph.D. thesis, Virginia Polytechnic Institute and State University, 104 p.

INTERACTIONS OF BLUE TILAPIA AND LARGEMOUTH BASS IN A POWER PLANT COOLING RESERVOIR

by
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ABSTRACT

In the presence of a dense population of blue tilapia, the population of northern largemouth bass declined in three years to one-third its 1972 abundance in Trinidad Lake, Texas. A pond experiment with Florida largemouth bass indicated that bass failed to reproduce successfully at a tilapia density of 2000 lb/A, but at 1000 lb/A some bass spawning occurred. Trends in gonosomatic indices suggest that eggs were retained by bass at high tilapia densities.

INTRODUCTION

Various cichlids of the genus *Tilapia* have been brought into the United States, principally for evaluation as biological controls of vegetation (Courtenay and Robbins 1973). Among these species, the blue tilapia, *T. aurea,* has become established in numerous lakes in Florida (Crittenden 1962; Buntz and Manooch 1968; Courtenay and Robbins 1973). High standing crops in ponds (Swingle 1960) and lakes (Crittenden 1962) of the southern United States make this species of high potential for commercial production, but interference with spawning of other species, particularly centrarchids, occurs at high densities of tilapia (Buntz and Manooch 1968).

In Trinidad Lake, Henderson County, Texas, blue tilapia were inadvertently introduced in the late 1960's. Since that time, the population has increased to nearly 2000 pounds per acre (unpublished data). Since 1972, population levels of blue tilapia and other species have been monitored by netting activities. Recruitment of northern largemouth bass, *Micropterus salmoides salmoides,* has apparently ceased to occur, and annual stocking of Florida largemouth bass, *M. salmoides floridanus,* since 1972 has failed to result in successful spawns, in spite of high survival, good growth, and rapid maturity by the introduced subspecies.

The objectives of this study were to elucidate the interactions of blue tilapia and largemouth bass through analysis of lake data on population changes and reproductive state, and to test, by an experiment in ponds, the hypothesis that high populations of tilapia inhibit reproduction of bass.

This study was conducted as a part of Texas Agricultural Experiment Station Project 1896, with support through a grant from the Texas Power and Light Company. The field assistance of Leslie Hall, Timothy O'Keefe and Michael Van Den Avyle is gratefully acknowledged.

MATERIALS AND METHODS

Description of Study Area

Trinidad Lake is a 303 ha cooling reservoir for the Texas Power and Light Company Steam Electric Generating Station. The main body of the reservoir, exclusive of intake and discharge canals, consists of 237 ha and averages 3 m deep. Open lake temperatures range seasonally from approximately 10 to 35 C. Thermal stratification infrequently occurs and oxygen levels are generally maintained near saturation. The lake, which first filled in 1925, exceeds pH 9 and is highly eutrophic. Seasonal variations in limnological parameters were described by Gleastine (1974).

Principal fish species of the lake are blue tilapia, channel catfish *(Ictalurus punctatus)*, gizzard shad *(Dorosoma cepedianum)*, carp *(Cyprinus carpio)*, freshwater drum *(Aplodinotus grunniens)*, and bluegill *(Lepomis macrochirus)*, as indicated by gillnet samples. Threadfin shad *(D. petenense)* also occur abundantly in seine samples. Common predatory species, besides largemouth bass, are longnose gar *(Lepisosteus osseus)* and spotted gar *(L. oculatus)*. Blue tilapia is a subtropical fish which survives winter temperatures in Trinidad Lake by concentrating in the heated effluent of the power plant.

Population Sampling

Experimental gillnets were set once each month at 10 sites for two consecutive one-day intervals starting in January, 1973. Five nets were 150 ft. long with equal panels of 1.0, 1.5, 2.0, 2.5, 3.0 and 3.5 inch square multifilament mesh (Standard Nets), and five nets were 130 ft. long with equal panels of 2.5, 3.0, 3.5 and 4.0 inch mesh. The Standard Nets were always set at the same five sites the first set each month. Sets of the Standard Nets on the second day and sets of the larger nets on both days were at variable sites. All catches were returned to the laboratory for measurement of total length and weight. Sex and maturity were also determined.

Pond Experiment

An experiment to determine the reproductive success of bass at three densities of blue tilapia was conducted using three half-acre earthen ponds near Trinidad Lake. Each pond was filled with lake water and on 19 March, 1975, stocked with adult tilapia (mean weight 0.4 lb.) at the following rates: Pond 1 - 0; Pond 2 - 500 lb.; Pond 3 - 1000 lb. On 21 March, 10 adult Florida bass were added to each pond. Due to low availability of northern largemouth bass in Trinidad Lake, Florida bass were used. During the following week, 500 adult threadfin shad were stocked into each pond for forage. Each pond was checked for reproduction by seining on 10 May, and Ponds 2 and 3 were drained on 29 May and 5 June, respectively, to determine production of young bass and to determine sex of the adult bass. Because of the high density of young bass in Pond 1, it was not drained, but 8 of the 10 adult bass were recovered by hook-and-line and by electrofishing.

Ovary Analyses

To determine temporal changes in reproductive state of bass in the lake, ovaries from female Florida bass were collected from gillnet and electrofishing samples during the period February to July, 1975. Gonosomatic indices, modified from Kaya and Hasler (1972), were calculated for comparison with those of the bass used in the pond experiments. The following index, based on wet weights, was used: Gonosomatic Index = Ovary Weight/(Fish Weight - Ovary Weight).

RESULTS

Trends in Bass Populations

Catches of bass in Standard one-night gillnet sets and in all net sets for the period January-June of each year were used to indicate population changes, since data based on equal effort among years were available for that period. Catches of northern largemouth bass declined steadily to less than one-third their 1973 level (Table 1), while Florida bass increased in occurrence as more stocked year-classes were recruited. Absence of small fish, as indicated by length-frequency distributions, substantiated the failure of small northern largemouth to be recruited (Table 2). This change in abundance of northern largemouth, as well as the absence of northern x Florida bass crosses, indicated that reproduction in the lake was being suppressed, possibly in response to the high population of blue tilapia which had developed in the early 1970's.

Pond Experiment

The pond experiment indicated that Florida bass reproduction was inhibited by high tilapia densities. Within a month following stocking, schools of bass fry were observed in Pond 1, where no

tilapia had been stocked. No fry were observed in the ponds stocked with tilapia, but these ponds were more turbid, probably because of tilapia nesting activities. On 10 May, a single seine sample in Pond 1 contained 35 bass fingerlings which averaged 35mm long. Similar seine samples in Ponds 2 and 3 contained no bass fingerlings.

Table 1. Catch of northern and Florida largemouth bass in five Standard monthly one-night gillnet sets at fixed sites, and total catch in 20 fixed and variable monthly gillnet sets, January-June, 1973-1975.

	Standard Nets, Fixed Sites		*All Nets, Fixed and Variable Sites*	
	Northern Bass	*Florida Bass*	*Northern Bass*	*Florida Bass*
1973	22	4	60	9
1974	18	9	50	15
1975	6	34	18	61

Table 2. Length-frequency distributions of northern largemouth bass caught in gillnets, January-June, 1973-1975.

Length Interval (mm)	*1973*	*1974*	*1975*
300-350	1	1	0
350-374	0	4	0
375-399	13	7	0
400-409	7	2	0
410-419	10	1	2
420-429	12	10	2
430-439	8	11	3
440-449	3	3	4
450-459	3	9	5
460-469	2	2	0
470-479	1	0	2

When Ponds 2 and 3 were drained, Pond 2, with an intermediate tilapia density, produced 2007 bass fingerlings (mean length 51mm), whereas Pond 3, stocked at lake density of tilapia, yielded no bass fingerlings. However, reproduction by tilapia and threadfin shad had occurred in both ponds. A total of 409 and 976 lb. of adult tilapia were recovered from the respective ponds. Data on ponds at the time of draining are given in Table 3. Because high numbers of small bass were observed at the periphery of Pond 1, it was not drained and the number of young fish was not determined.

A count of tilapia nests following draining indicated that 516 nests had been built in Pond 3, whereas only 208 nests were found in Pond 2. The bottom of Pond 3 had a definite "honeycomb" appearance due to the density of nests in shallow areas. No bass nests were observed in either pond.

Table 3. Fish population parameters in experimental ponds at termination of experiment.

	Pond 1	*Pond 2*	*Pond 3*
Young Bass	Very Abundant	2007	None
Adult Bass Males	3	8	3
Adult Bass Females	5	2	7
Adult Tilapia	None	409 lb.	976 lb.
Young Tilapia	None	Abundant	Abundant
Adult Shad	Not Determined	272	172
Young Shad	Not Determined	Abundant	Abundant
Tilapia Nests	None	208	516

Ovary Analyses

Gonosomatic indices of ovaries from bass in each of the three experimental ponds showed a general increase with increase in tilapia density (Table 4). This trend indicates that bass in ponds with tilapia probably did not spawn, in the case of Pond 3, or perhaps spawned incompletely, in the case of Pond 2.

Table 4. Lengths and gonosomatic indices for Florida largemouth bass in experimental ponds and in Trinidad Lake, 1975.

			Total Length (mm)		*Gonosomatic Index*	
Location	*Month*	*Number of Fish*	*Mean*	*Range*	*Mean*	*Range*
Pond 1	May	5	379	307-442	.0153	.0098-.0230
Pond 2	May	2	413	400-426	.0222	.0165-.0280
Pond 3	May-June	7	377	302-421	.0366	.0155-.0603
Trinidad	February	12	379	277-470	.0536	.0194-.0657
Lake	March	9	329	260-456	.0650	.0235-.1059
	May	9	326	288-415	.0116	.0033-.0354
	June	7	324	290-415	.0056	.0032-.0136
	July	12	381	320-438	.0057	.0029-.0107

Gonosomatic indices from Ponds 1 and 2 were similar to those from the lake at approximately the same time (May-June), whereas those from Pond 3 were much higher than the mean lake index at that time (Table 4). If lake fish were subjected to similar conditions as pond fish, e.g. tilapia density, temperature regime, etc., and had not spawned, gonosomatic indices from Pond 3 rather than Pond 1 should have approximated the lake index. Either resorption began earlier in the lake or lake spawning did occur. No reproduction was found in the lake, indicating a corresponding failure of bass to spawn, to hatch, or to survive as fry.

DISCUSSION

Bass reproduction in Trinidad Lake ceased to occur as the population of blue tilapia reached high levels. Tilapia densities similar to those in the lake also prevented successful bass reproduction in ponds; however, at a population level about half of that in the lake, spawning did occur in the pond experiment. Unfortunately, no data are available on bass abundance in the lake during the period before present tilapia densities were reached; however, age and growth studies (C. Hall, unpublished data), indicate that the 1970 and 1971 year-classes have comprised a substantial proportion of the population of northern largemouth during the study period.

The actual mechanism of suppression of spawning was not directly evident. The high density of nests in Pond 3 may have reflected competition for nest sites between tilapia and bass. The high gonosomatic index for Pond 3 may indicate that, in the absence of suitable nesting sites, eggs were retained in the ovaries rather than being spawned. Similar competition for nesting sites has been suggested by Buntz and Manooch (1968), but unequal sex ratios in our pond experiments may also have been involved. Chew (1972) indicated that largemouth bass spawning was inhibited by a buildup of a repressive factor secreted by forage species, particularly centrarchids, at high densities. Although tilapia populations rather than centrarchid populations were high in our study, the presence of a repressive factor is also a possible explanation in Trinidad Lake.

The successful spawning of bass at intermediate densities of tilapia is encouraging for the development of a management program. Tilapia serve as an important forage for largemouth bass in Trinidad Lake, and likely are in part responsible for rapid growth rates. If tilapia populations can be controlled to allow bass reproduction, it should be possible to concurrently maintain a self-sustaining bass population with rapid growth, as well as a tilapia population with sizeable production of harvestable food fish.

LITERATURE CITED

Buntz, J. and C. S. Manooch, III. 1968. *Tilapia aurea* (Steindachner), a rapidly spreading exotic in South Central Florida. Proceedings of the Annual Conference, Southeastern Association of Game and Fish Commissioners 22: 495-501.

Chew, R. L. 1972. The failure of largemouth bass, *Micropterus salmoides floridanus* (Le Sueur), to spawn in eutrophic, over-crowded environments. Proceedings of the Annual Conference, Southeastern Association of Game and Fish Commissioners 26: 306-319.

Courtenay, W. R., Jr. and C. R. Robbins. 1973. Exotic aquatic organisms in Florida with emphasis on fishes: a review and recommendations. TAFS 102: 1-12.

Crittenden, E. 1962. Status of *Tilapia nilotica* Linnaeus in Florida. Proceedings of the Annual Conference, Southeastern Association of Game and Fish Commissioners 16: 257-262.

Gleastine, B. W. 1974. A study of the cichlid *Tilapia aurea* (Steindachner) in a thermally modified reservoir. Unpublished M. S. thesis, Texas A&M University. 258 pp.

Kaya, C. M. and A. D. Hasler. 1972. Photoperiod and temperature effects on the gonads of green sunfish, *Lepomis cyanellus* (Rafinesque), during the quiescent, winter phase of its annual sexual cycle. TAFS 101: 270-275.

Swingle, H. S. 1960. Comparative evaluation of two tilapias as pondfishes in Alabama. TAFS 89: 142-148.

THE USE OF ISOLATION COVES IN ASSESSING MUSKELLUNGE STOCKING MORTALITY

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ABSTRACT

A method to determine short term muskellunge stocking mortality by using isolation coves is discussed. The method allows for free movement and feeding of muskellunge while restricting lakeward movement. Mortality of muskellunge was readily determined with the use of SCUBA. Stocking mortality due to stress of handling and transportation was considered minimal. Observations indicate that future stocking of muskellunge be made in areas of extensive weed cover.

INTRODUCTION

Periodic stocking of fingerling muskellunge *(Esox masquinongy)* is commonly practiced by the various states in an effort to maintain strong year-classes and ultimately the muskellunge fishery. Supplemental stocking of muskellunge is practiced in waters which may also have naturally sustaining muskellunge populations. Contribution to the creel by stocked muskellunge has been documented in Wisconsin lakes to vary from 2% to 60% (Johnson, 1969) and has averaged as high as 63% in Little Green Lake, Wisconsin (Hacker, 1966). Sampling for yearling muskellunge in the fall at Lake Chautauqua in New York State indicated that hatchery reared fish made up 88.5% of the total over a four year period (Mooradian and Shepherd, 1973). Generally, return to the creel is quite good and the stability of muskellunge populations and fishing success is dependent on hatchery fish.

Investigators in several states experiencing high initial stocking mortality (up to 70%) have been forced to reassess their programs to determine if yearly expenditures are justified. However, if mortality of hatchery fish can be reduced, the net result would be increased production at no additional program cost. To assess short-term mortality of stocked muskellunge, fingerlings were released behind a block-net and observations using SCUBA were made to determine extent of mortality and behaviour of hatchery fish.

MATERIALS AND METHODS

Pomme de Terre Reservoir, an 8,000 acre (3238 ha) Corps of Engineers flood control impoundment, located in West Central Missouri, supports the state's only muskellunge fishery. It is a clear, Ozark-plateau reservoir with secchi disk readings commonly of 6 feet (1.8m) or more. Muskellunge were first stocked in the reservoir in 1966, with yearly plantings through 1974 except in 1971 and