Comparison of Bass-Bluegill and Bass-Redear Sunfish Stocking In Oklahoma Farm Ponds[1]

CHARLES R. GASAWAY

Oklahoma Fishery Research Laboratory, Norman

Introduction

In Oklahoma, as in most other states, fishery managers are faced with the problem of providing farm-pond fishing which will be satisfactory for more than three to five years after the initial stocking. There has been no previous research aimed at finding the best stocking combination for Oklahoma farm ponds. From 1961 through 1964 fish propagation took from 26 to 57% of the total cost of operation of the Fisheries Division of the Oklahoma Department of Wildlife Conservation (Oklahoma Department of Wildlife Conservation, 1962, 1964), and most of these fish went to farm ponds. To help determine if the plantings are resulting in the maximum return in sport fishing for the money spent, the Oklahoma Fishery Research Laboratory initiated a farm pond fish research program during the spring of 1964.

The purpose of this project was to evaluate the present and past stocking policies of the Oklahoma Department of Wildlife Conservation. Largemouth bass, *Micropterus salmoides,* and bluegill, *Lepomis macrochirus,* were used for stocking prior to 1958; since that time largemouth bass and redear sunfish, *Lepomis microlophus,* have been used. Many ponds have also been stocked with channel catfish *(Ictalurus punctatus.).*

Grateful acknowledgment is made to Michael Bross, Byron Moser, and Dr. Frank Sonleitner for critically reviewing the manuscript, and Charles Bennett and Mickey Kernodle for doing a large part of the field work.

Methods

Counties in which ponds were to be studied were randomly selected from the five fisheries management regions of the state. One county was randomly selected from each region except that two were selected from the southeast region because of its larger size. In addition, three counties were nonrandomly selected, and two ponds on the Ft. Sill Military Reservation (Comanche County) were used. Hence ponds within the following counties were used in this study with numbers of ponds in parentheses: southwest region — Caddo (9), Tillman (4) and Comanche (2); northwest region — Major (4) and Beaver (2); northeast region — Muskogee (6); southeast region — Carter (2) and Haskell (2); central region — Hughes (3) and McClain (7). Ponds within each county were selected by random sampling according to the owner's last initial. Only ponds meeting the following three requirements were used: (1) stocked since 1955; (2) owner had only one pond on the stocking records (it was common practice for owners of several ponds to divide their fish allotments between several ponds, even though they had requested and received fish for only one pond); (3) ponds not stocked with "bream" or crappie.

Actually, the selection was not entirely random, since 1964 was a dry year, and many of the ponds selected were unusable. This seemed to affect some parts of the state more than others, leaving us with very few study ponds in some counties. However, usable ponds were evenly scattered over the state, and therefore provided a reasonably valid estimate of the success of fish populations resulting from the stocking methods used.

Usable samples were secured from 38 ponds during the summer of 1964. A one-night survey was conducted on each pond, using a 230-volt, A. C., 3-phase, 180-cycle, boom-type electric shocker (Ming, 1964). A 4-ft x 20-ft x ¼-inch square-mesh minnow seine was used to sample young-of-the-year fish to determine if reproduction had taken place. After each trip around the pond with the shocker,

[1]Contribution No. 163 of the Oklahoma Fishery Research Laboratory, a cooperative unit of the Oklahoma Department of Wildlife Conservation and the University of Oklahoma.

all fish captured were measured and released. The shocking was continued for several hours, until additional sampling seemed to yield results entirely consistent with previous samples.

In analyzing the population structure of each pond, the fish of each species were divided into small, intermediate, and large (harvestable) size groups (Surber, 1959). The numbers in each size group were converted to weights using state-average length-weight formulas (Houser and Bross, 1963).

To find out if significant differences in population structure existed between the fish populations resulting from stocking with the largemouth bass-redear sunfish combination and those resulting from stocking with the largemouth bass-bluegill combination, various statistics were computed for each pond, and arithmetic means of these statistics were derived for each group of ponds and compared. The following statistics were used for making comparisons: (1) percent of the total weight of the fish population composed of fish of harvestable size; (2) percent of the total weight of the fish population made up by each species; (3) percent of the total weight of each species contributed by each size group. In addition, the percent of the ponds of each group in which the various species occurred and reproduced was compared. Some of these relationships are very similar to those cited by Swingle (1950). However, the above statistics are useful only for comparisons between the ponds used in the present study, and they cannot be compared to values obtained by using gear other than the electric shocker because of the different size and species selectivity of the shocker compared to seines, rotenone, etc.

Since the data for many of the variables were not normally distributed, these data were transformed for statistical analyses using the arc sin transformation. In some cases nonparametric tests were required.

Results and Discussion

Stocking — In making comparisons of various means between the two groups of ponds, only those ponds stocked 4½ to 7½ years prior to the study were used. This was necessary since most of the bluegill stocking was discontinued in 1958, and there were very few ponds that had been stocked with bluegill for less than 4¼ years. At the time these ponds were studied, the 12 usable bass-redear ponds had been stocked an average of 6.22 years, while the 12 usable bass-bluegill ponds had been stocked an average of 6.18 years. However, the redear were stocked at a higher rate per acre than were the bluegill (Table I).

Differences between the largemouth bass populations — No statistically significant differences could be found between the two groups of ponds in the mean percent of the total weight of the largemouth bass populations consisting of the various size groups of bass (Table II), nor in the mean percent of the total weight of the entire fish population made up of harvestable-size largemouth bass or all sizes of bass combined (Table III).

Among the ponds stocked with bass and redear sunfish, there was found to be a highly significant negative correlation for the percent of the total weight of the fish population consisting of largemouth bass against the number of years since the ponds had been stocked (Table IV)[1]. This indicates that as the ponds stocked with the bass-redear combination aged, the percent of the populations consisting of bass declined. The coefficient of determination, r^2, was 0.5032, indicating that 50.3% of the variation in the percent of the total weight consisting of bass could be attributed to the variation in the number of years since the ponds were stocked. Even though the sampling variation in r is quite large for small sample sizes, the high significance level ($P<0.001$) in this instance indicates that there is probably significant correlation.

[1]This can be considered a bivariate distribution for purposes of computing a correlation coefficient, because the ponds were selected without regard to the number of years since stocking, except that ponds stocked more than 10 years prior to the study were not used.

TABLE I. FISH STOCKED IN THE PONDS USED IN THIS STUDY. THESE FIGURES PERTAIN ONLY TO THOSE PONDS STOCKED 4½-7½ YEARS PRIOR TO THE TIME THEY WERE STUDIED.

Fish Species Combination					
Largemouth Bass-Bluegill			Largemouth Bass-Redear Sunfish		
	Mean	Range		Mean	Range
No. Stocked Per Acre			No. Stocked Per Acre		
Bass	72.8	34-100	Bass	75.3	30-100
Bluegill	51.2	17-100	Redear	73.3	30-100
Ratio (Bass: Bluegill)	1.56:1	1:1 to 2.3:1	Ratio (Bass: Redear)	1.06:1	0.8:1 to 1.5:1
No. of Ponds = 12			No. of Ponds = 12		

TABLE II. PERCENT OF THE TOTAL WEIGHT (lb.) OF EACH SPECIES CONSISTING OF THE SMALL, INTERMEDIATE, AND LARGE SIZE GROUPS.

Stocking Combination								
Size Group	Bass-Redear				Bass-Bluegill			
	Bass		Redear		Bass		Bluegill	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Small (S)	1.23	0-4.7	16.92	0-100.0	0.32	0-1.5	17.75	0-100.0
Intermediate (I)	19.92	0-100.0	16.88	0-62.8	18.81	0-93.6	26.28	0-55.4
Large (L)	78.89	0-100.0	66.20	0-100.0	80.88	0-100.0	55.97	0-100.0

TABLE III. PERCENT OF THE TOTAL WEIGHT (lb.) OF THE FISH POPULATION CONSISTING OF VARIOUS SPECIES.

Stocking Combination	Largemouth Bass				Stocked Forage Species				All Panfish*	
	All Sizes		Harvestable Size		All Sizes		Harvestable Size		All Sizes	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
					(Redear)		(Redear)			
Bass-Redear	48.84	0-93.3	42.91	0-93.3	7.8	0-35.2	4.79	0-22.5	36.17	1.6-69.1
					(Bluegill)		(Bluegill)			
Bass-Bluegill	47.71	0-86.7	39.83	0-83.8	10.1	0-45.4	7.20	0-41.30	28.70	2.6-91.8

* Includes redear sunfish, bluegill, green sunfish, orangespotted sunfish, longear sunfish, white crappie.

TABLE IV. CORRELATION OF PERCENT OF THE TOTAL WEIGHT (lb.) OF THE FISH POPULATION CONSISTING OF LARGEMOUTH BASS AGAINST THE NUMBER OF YEARS SINCE THE PONDS WERE STOCKED WITH BASS-REDEAR OR BASS-BLUEGILL.

	Species Combination		Test of Difference	
	Bass-Redear	Bass-Bluegill	z	P
r	-0.7094	0.1490	2.5350	$0.02>P>0.01$
Deg. Freedom	14	12		
t	5.3433 ($P<0.001$)	0.5278 ($P>0.5$)		

By comparison, there was no significant relationship in this respect for the ponds stocked with the bass-bluegill combination (Table IV). Even though r in this instance was not significantly different from 0, there was a significant difference between the correlation coefficents for the ponds stocked with the two different species combinations (Table IV). Therefore, it appears that the largemouth bass-bluegill combination may be superior in this respect, since there was at least no evident decline in the percent of the total weight of the fish population made up of largemouth bass as those ponds aged.

Largemouth bass had reproduced in 1964 in 8 of 16 (50%) of the ponds in which they had been stocked with the redear sunfish; in 6 of 13 (46%) of the ponds where they were stocked in combination with the bluegill; and 4 of 5 (80%) of the ponds where they were stocked without any other species. Too few ponds in the latter category were sampled to determine if bass reproduction was occurring in a significantly higher percentage of these ponds than in those in which the bass were stocked in combination with a forage species.

Bass were found in 14 of 16 (87.5%) of the ponds in which they had been stocked in combination with redear, and in 12 of 14 (85.7%) of the ponds in which they had been stocked with bluegill.

Differences between the redear sunfish and bluegill populations — It is generally felt that if a large percent of the forage fish population consists of the intermediate size group, then the forage fish are tending toward overpopulation, resulting in stunted growth and curtailed reproduction. However, no statistically significant differences could be found between the two groups of ponds in the percent of the total weight of the redear and bluegill populations made up of any of the three size groups (Table II), nor in the mean percent of the total weight of the entire fish populations made up of harvestable-size redear and bluegill (Table III).

The redear constituted a mean of 7.8% of the total weight of the fish populations in ponds in which they had been stocked, while the bluegill constituted a mean of 10.1% of the fish populations in ponds where they had been stocked, indicating very little difference between the two groups in this respect (median test, adjusted $X^2 = 0.1667$, $0.75 > P > 0.5$). However, four of the 12 ponds that had been stocked with redear contained only a few large specimens indicating that no successful reproduction had taken place for several years. So although redear were present in these particular ponds, they appeared to be approaching extinction. In three additional ponds of this group, no redear at all were taken. In the group of 12 ponds stocked with bass and bluegill, one bluegill population was represented by only a few large fish, and three of the ponds contained no bluegill of any size.

Redear sunfish were found in 10 of the 16 (62%) ponds in which they had been stocked (includes all ponds stocked with redear, regardless of how long since they had been stocked), and it is interesting that blugill and green sunfish (*Lepomis cyanellus*) were taken in 10 (62%) and 13 (81%), respectively, of these same ponds, even though they had not been stocked in them.

Bluegill were found in 10 of the 14 (71%) ponds in which they had been stocked (again includes all ponds in which bluegill had been stocked), while redear were found in 4 (29%) and green sunfish in 10 (71%) of these same ponds.

During the spring of 1964, redear reproduced in only 5 of the 16 (31%) ponds in which they had been stocked, and bluegill reproduced in 9 of 13 (69%) ponds in which they had been stocked. It appears that redear may be less successful at reproducing in Oklahoma's farm ponds than are bluegill. This was the most important difference found between the two groups of ponds.

Differences between the entire populations of ponds stocked with the two species combinations—In the ponds stocked with the bass-redear combination, the mean percent of the total weight made up of harvestable-sized fish of all species (A_t) was 7.26% (range 14.9-87.6%), while the mean for the bass-bluegill ponds was 77.7% (range 59.5-99.6%). This was a nonsignificant difference according to the median test (adjusted $X^2 = 0.1667$, $0.75 > P > 0.5$).

Within both groups of ponds, the mean percent that the bass contributed to the total weight of the population was slightly greater than that contributed by the several species of panfish combined (Table III). The panfish group consisted of redear sunfish, bluegill, green sunfish, orangespotted sunfish (*Lepomis humilis*), longear sunfish (*L. megalotis*), and white crappie (*Pomoxis annularis*). Within each group of ponds, however, these differences between the percent consisting of bass and the percent consisting of panfish were not statistically significant.

Channel catfish populations—Channel catfish were found in 8 of 20 (40%) of the ponds where stocked 4½ to 7½ years prior to this study, and they were reproducing in 3 (15%) of the ponds (Table V).

The boom-type electric shocker is sometimes inefficient for collecting catfish, so it is possible that we failed to collect channel catfish in some ponds where they did exist.

There was no significant difference between the two stocking combinations in the percent of the total weight of the fish populations consisting of channel catfish (Table VI). Because of the asymmetrical distribution of these percentages, the medians, rather than the means, probably provide the best indications of the central value. However, the median test of difference between the means gave an adjusted X^2 of 0.0525 ($0.90 > P > 0.75$).

Occurrence of nonstocked sunfish—Green sunfish were very widely distributed in the state and seemed to have an amazing ability for finding their way into many small ponds. They were found in 32 of 40 (80%) of the ponds studied, even though they had not been intentionally stocked in any of them. Jenkins (1958) found green sunfish in 86% of the 42 ponds he studied in Oklahoma and noted that it was the most common species.

The mean percent of the total fish population consisting of green sunfish in ponds stocked with the bass-redear combination was 7.7%, while that for the bass-bluegill ponds was 13.6%. These differences were not statistically significant ($t = 0.929$ with 19 degrees of freedom, $0.4 > P > 0.3$).

Thirty-five of the 41 ponds studied (85.4%) contained at least one species of sunfish that had not been intentionally stocked in the pond. Therefore, at least under Oklahoma's present pond stocking and management program, I agree with Jenkins' (1958) statement, "Until better methods of controlling the access of 'wild' fish to ponds are developed, concern over the presence of adequate numbers of forage fishes should be greatly lessened."

Interspecies relationships — Correlation coefficients of the catches per unit of sampling effort of one species against those of another species were calculated for studying the possible relationships between the various species in all ponds where they occurred. In computing the correlation coefficient between two species, all ponds were considered in which the two species were present or had been stocked. Primarily, the correlations were expected to show that optimum conditions for one species were or were not optimum conditions for another species (Carlander, 1955). These data might also indicate some degree of competition (or predator-prey relationship) between the species.

Shocking in the pond for one hour constituted one unit of effort. Since the data were not normally distributed, Spearman's coefficient of rank correlation (r_s) was used (Steel and Torrie, 1960).

There was a significant positive correlation between the catches per unit of effort of largemouth bass and bluegill (Table VII), which agrees with the findings of Jenkins (1958) and Carlander (1955) concerning the standing crops of these two species. In contrast, no significant correlation was indicated between largemouth bass and redear sunfish or green sunfish. A slightly positive correlation existed between the catches per unit of effort of bass and channel catfish, although the correlation was not significant at the 95% confidence level. Jenkins found a smaller average standing crop of largemouth bass in ponds where channel catfish were present, although the differences he found were not statistically significant either.

TABLE V. NUMBER OF PONDS IN WHICH CHANNEL CATFISH WERE EXISTING AND REPRODUCING. INCLUDES ONLY PONDS STOCKED 4½-7½ YEARS.

Species Stocked In Combination With Channel Catfish	Total No. of Ponds Considered	No. of Ponds in Which Channel Catfish Reproducing	No. of Ponds in Which Channel Catfish Existing
Bass-Redear	10	1 (10%)	3 (30%)
Bass-Bluegill	10	2 (20%)	5 (50%)
Total	20	3 (15%)	8 (40%)

TABLE VI. PERCENT OF THE TOTAL WEIGHT OF THE FISH POPULATIONS CONSISTING OF CHANNEL CATFISH.

Species Stocked in Combination With Channel Catfish	Mean	Median	Range
Bass-Redear	7.80	0	0*-70.0
Bass-Bluegill	9.60	2.3	0*-34.3

*Ponds in which no channel catfish were taken were included in these figures since they were originally stocked in these ponds, and, therefore, at least present at one time.

TABLE VII. RANK CORRELATION OF CATCH PER UNIT OF EFFORT FOR VARIOUS SPECIES.

Species	r_s	n	P
Redear Sunfish vs. Bluegill	0.14	17	>0.5
Redear Sunfish vs. Green Sunfish	–0.055	18	>>0.5
Bluegill vs. Green Sunfish	0.2446	25	0.3>P>0.2
Largemouth Bass vs. Bluegill	0.46**	30	0.02>P>0.01
Largemouth Bass vs. Redear	0.052	23	>>0.5
Largemouth Bass vs. Green Sunfish	–0.1755	31	0.4>P>0.3
Largemouth Bass vs. Channel Catfish	0.270	33	0.2>P>0.1

**Significant at the 0.01 level

There seemed to be very little relationship between the catches of redear sunfish, bluegill, and green sunfish.

Because of unsuccessful reproduction of the redear sunfish in so many ponds, at least at the present stocking rates used in Oklahoma (Table I), it appears that the largemounth bass - bluegill combination may provide more desirable fish populations, even though bluegill are sometimes known to become overpopulated in ponds. However, it seems logical that redear sunfish, now being stocked on a 1:1 basis with largemouth bass, should be stocked at a much higher rate than bass, and under these conditions it is possible that the resulting redear populations would be acceptable. It is usually recommended that even the highly prolific bluegill be stocked at rates of 400 to 1000 per acre in combination with largemouth bass stocked at rates of 30 to 100 per acre, which is approximately a 10 to 1 ratio of forage fish to bass (Cobb, 1963; Fuller, 1963; Summers, 1963; Swingle, 1952). However, Tiemeier (1957) recommended that both bass and bluegill be stocked at 100 fish per acre in Kansas, and Krumholz (1952) recommended the same rates for both bass and redear sunfish in Indiana.

Another disadvantage of the redear sunfish concerns the apparent difficulty, in comparison with bluegill, that many sport fishermen have in catching it (Louder and Lewis, 1957).

Future studies should be conducted to evaluate the success of redear sunfish stocked in larger numbers, and the possibility of using green sunfish as a forage species in combination with largemouth bass should also be considered.

Summary

1. Thirty-eight ponds from ten counties in the state were sampled with a boom-type electric shocker and a minnow seine for the purpose of comparing the fish population structure of ponds stocked with largemouth bass and redear sunfish with those stocked with largemouth bass and bluegill.

2. Over the past ten years largemouth bass and redear have been stocked at an average ratio of 1.1:1, and bass and bluegill were stocked at an average ratio of 1.6:1.

3. There was a tendency for the percent of the populations consisting of bass to decline as the ponds aged when stocked with the bass-redear sunfish combination, but this decline was not evident in the ponds stocked with the bass-bluegill combination. No other differences in the structure of the bass populations could be found between the two groups of ponds.

4. Redear sunfish had reproduced during the spring of 1964 in only 31% of the ponds in which they had been stocked, while the bluegill had reproduced in 69% of the ponds in which they had been stocked.

5. Channel catfish were found in 40% of the ponds in which they had been stocked and had reproduced during the spring of 1964 in 15% of them.

6. Green sunfish were found in 80% of the ponds studied, and at least one species of sunfish not stocked was found in 85% of the ponds.

7. A significant positive correlation was found between the catches per unit of effort of largemouth bass and bluegill, but no significant correlations between any of the other species were indicated.

8. These studies indicate that in ponds stocked at an approximate 1:1 ratio of bluegill or redear sunfish to largemouth bass and in quantities of somewhat less than 75 fish of each species per acre, the bass-bluegill combination is capable of providing more satisfactory fish populations.

Literature Cited

Carlander, Kenneth D. 1955. The standing crop of fish in lakes. J. Fish. Res. Bd. Canada 12 (4):543-570.

Cobb, Eugene S. 1963. The management of Tennessee farm ponds. Tenn. Game and Fish Comm., Nashville. 38 p.

Fuller, Jefferson C., Jr. 1963. Management of farm ponds in South Carolina. S. C. Wildlife Resour. Dept., Columbia. 16 p.

Houser, Alfred and Michael G. Bross. 1963. Average growth rates and length-weight relationships for fifteen species of fish in Oklahoma waters. Okla. Fish. Res. Lab., Rep. 85. 75 p.

Jenkins, Robert M. 1958. The standing crop of fish in Oklahoma ponds. Okla. Fish. Res. Lab., Rep. 65. 15 p.

Krumholz, Louis A. 1952. Management of Indiana ponds for fishing. J. Wildlife Manage. 16 (3):254-257.

Louder, Darrell E. and William M. Lewis. 1957. Study of a stocking of the redear and bluegill in Southern Illinois. Prog. Fish-Cult. 19 (3):140-141.

Ming, Arvil. 1964. Boom-type electro-fishing device for sampling fish populations in Oklahoma's waters. Okla. Fsh. Res. Lab. Semiann. Rep., Jan.-June, 1964. p. 22-33.

Oklahoma Department of Wildlife Conservation. 1962. Bien. Rep. July 1, 1960-June 30, 1962. 63 p.

————. 1964. Bien. Rep. June 30, 1962-July 1, 1964. 40 p.

Steel, Robert G. D., and James H. Torrie. 1960. *Principles and Procedures of Statistics.* McGraw-Hill Book Co., Inc., New York. xvi + 481 p.

Summers, Max W. 1963. Managing Louisiana fish ponds. La. Wildlife and Fish Comm., New Orleans. 64 p.

Surber, Eugene W. 1959. Suggested standard methods of reporting fish population data for reservoirs, prepared for the Reservoir Committee, Southern Division of the American Fisheries Society. Proc. Thirteenth Annu. Conf. S. E. Ass. Game and Fish Comm. 313-325.

Swingle, H. S. 1950. Relationships and dynamics of balanced and unbalanced fish populations. Agr. Exp. Sta. Ala. Polytech. Inst. Bull. 274. 74 p.

————. 1952. Farm pond investigations in Alabama. J. Wildlife Manage. 16 (3): 243-249.

Tiemeier, Otto W. 1957. Notes on stunting and recovery of the channel catfish. Trans. Kans. Acad. Sci. 60 (3): 294-296.