POPULATION DYNAMICS OF THE GREEN SUNFISH ♂ × REDEAR SUNFISH ♀ HYBRID AS COMPARED WITH ITS RECIPROCAL CROSS AND PARENTAL SPECIES[1]

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ABSTRACT

A study was made on the growth and survival rates, sex ratios, and vulnerability to angling of the green sunfish ♂ × redear sunfish ♀ (G ×R) hybrid as compared with its reciprocal cross and parental species. The G × R hybrid had the highest mean annual absolute growth rate while the redear sunfish ♂ × green sunfish ♀ (R × G) hybrid had the highest mean annual relative growth rate. The G × R hybrid generally had the highest mean annual survival rate, while the green sunfish had the lowest. The sex ratios were: G × R hybrids, 99% males; R × G hybrids, 88% males; green sunfish, 83% males; and redear sunfish, 45% males. The G × R hybrid, R × G hybrid, and green sunfish were more vulnerable to angling than the redear sunfish. Abundant F_2 offspring were observed in the pond containing pairs of R × G hybrids, while no F_2 offspring were observed in the pond containing pairs of G × R hybrids.

INTRODUCTION

The hybrid resulting from the cross of the male green sunfish, *Lepomis cyanellus*, and the female redear, *Lepomis microlophus*, has become an increasingly important sport fish in Texas and in many other states. Presently it is the only centrarchid other than black basses, *Micropterus* spp., that is propagated for stocking purposes by the Texas State Fish Hatcheries (Henderson and Winckler, 1968). The usefulness of this hybrid in ponds related to its low reproductive capabilities (Hubbs, 1955; Henderson and Winckler, 1968; Tinsley, 1971; and Hiedinger and Lewis, 1972) which seems to be a good solution to over-population and consequent stunting of fishes.

Conflicting reports that growth rates of hybrid sunfish are greater than growth rates of parent species have appeared in the literature (Hubbs and Hubbs, 1931; Childers and Bennett, 1961). Further study of the population dynamics of this hybrid, as compared with its reciprocal cross and parent species, was needed because of the importance in developing future propagation and stocking procedures for ponds.

The objectives of this study were to determine and compare (1) the growth and survival rates of the hybrids and the parent species under (a) intraspecific competition, (b) a combination of intraspecific and interspecific competition, and (c) a combination of intraspecific and interspecific competition with largemouth bass predation; (2) the sex ratios of the hybrids and the parent species; and (3) the vulnerability of the hybrids and the parent species to angling.

We wish to thank Drs. W. C. Young and D. G. Huffman for constructive criticism of the manuscript and Mr. W. H. Henderson and the Texas Parks and Wildlife Department for permission to use four Texas State Fish Hatchery Ponds.

METHODS AND MATERIALS

The four ponds used in this study for fry production were located at the State Fish Hatchery, San Marcos, Texas. Each pond had a surface area of approximately 0.06 ha. Nine additional ponds used for growth and survival studies were located at the Aquatic Station, Southwest Texas State University, San Marcos, Texas. The surface areas of these ponds were: Pond C, 0.05 ha; Pond D, 0.09 ha; Pond E, 0.10 ha; Pond 5, 0.26 ha; Pond 6, 0.30 ha; Pond 7, 0.08 ha; Pond 8, 0.23 ha; Pond 10, 0.44 ha; and Pond 11, 0.34 ha.

The following abbreviations will be used to denote the four types of sunfishes in this study: G sunfish refers to green sunfish, R sunfish refers to redear sunfish, G × R hybrid refers to the hybrid

[1] Research completed at Aquatic Station, Southwest Texas State University, San Marcos, Texas 78666, for partial fulfillment of the requirements for the degree of Master of Science, 1972.

offspring of a green sunfish male and a redear sunfish female, and R × G hybrid refers to the hybrid offspring of a redear sunfish male and a green sunfish female.

Each one of the four possible combinations of G sunfish and R sunfish was stocked in a separate pond at the State Fish Hatchery on March 25, 1970 at the rate of two pairs per pond. The G sunfish, R sunfish, G × R hybrids and R × G hybrids obtained from these combinations were stocked in nine Aquatic Station ponds. Delay in removal of debris deposited by flooding necessitated the stocking of ponds on different dates during the first growth period. All river water pumped into ponds was filtered through a Saran filter to prevent contamination by other fishes (Buck and Whitacre, 1960).

Ponds C, D, and E were chosen for the intraspecific competition experiments. They were partitioned into four equal sections using 0.64cm square mesh hardware cloth. On January 29, 1971, each type of offspring was stocked in a separate randomly chosen section of each pond at the rate of 1,140 to 1,235 per ha.

Ponds 6, 7, and 8 were chosen for the combination interspecific-intraspecific experiments and were stocked on November 6, 1970 with all four types of offspring at the rate of 370 per ha. This stocking rate was chosen to coincide with the rate used by the Texas State Fish Hatcheries when stocking only hybrids (W.H. Henderson, Regional Fish Culturist, Texas Parks and Wildlife Department, personal communication).

The combination interspecific-intraspecific-largemouth bass predation experiments were conducted in ponds 5, 10, and 11. They were stocked on November 6, 1970 with all four types of offspring at the rate of 247 per ha plus 247 largemouth bass per ha. This is the same stocking rate used by the Texas State Fish Hatcheries when both bass and hybrids are stocked.

Hubbs and Hubbs (1932) stated that it is apparently impossible to morphologically differentiate between hybrids of reciprocal crosses. For this reason the left pelvic fins of the G ×R hybrids were clipped before stocking in order to separate them from their reciprocal cross. A side study was initiated to determine the magnitude of the effects that fin clipping might have on the growth and survival rates of experimental fish by placing 50 fin-clipped and 50 non-clipped G × R hybrids in a large concrete raceway during each of the growth periods. The difference in the growth and survival rates of fin-clipped and non-clipped hybrids for each of these growth periods was used in adjusting the growth and survival rates for the fin-clipped G × R hybrids of comparable ages.

It was necessary to drain the nine Aquatic Station ponds in August, 1971 because some of the offspring of the original F_1 stock were approaching the sizes of some of the smaller F_1 fishes, which would have made separation difficult at a later date. After draining, all ponds were allowed to dry in order to kill small fishes and aquatic vegetation. Those ponds that did not dry completely were treated with rotenone to kill all remaining small fishes. The ponds were stocked in August, 1971 for the second growth period with F_1 fishes from the first growth period plus F_1 fishes from the 1970 spawnings which had been held in the State Fish Hatchery ponds. The stocking rates for the second growth period were the same as for the first growth period with two exceptions. (1)The stocking rate of Pond D was decreased to one-half the number used in the initial stocking because the fishes measured at the end of the first growth period appeared stunted. (2) Ponds 7 and 10 were stocked with three times the number used in the initial stocking to observe the effects of increased competition. Pond 7 represented a combination of intraspecific and interspecific competition, while Pond 10 represented a combination of intraspecific and interspecific competition as well as largemouth bass predation. The stocking rate of ponds containing only intraspecific competition was not increased over that used in the initial stocking because the initial stocking rate was higher than the stocking rates in ponds involving the other two types of competition. The stocking rate of the remaining ponds was not increased over the initial rate because of a shortage of F_1 hybrids. The G × R hybrids were fin-clipped again before stocking because most had regenerated the clipped fin during the first growth period. All ponds were drained at the end of the second growth period in March, 1972.

Individual total length (mm) and weight (g) were recorded at stocking and at draining for each of the growth periods. At the end of the study 100 individuals of each type were randomly selected and dissected for the determination of sex ratios.

Mature F_1 hybrids obtained from the ponds after the second growth period were placed in separate ponds in March 1972, to observe the abundance of F_2 offspring produced. Seven pairs of R × G hybrids were stocked in Pond 5, and 3 pairs of G × R hybrids were stocked in Pond 7. Observations were made twice weekly around the shorelines of each pond until July 11, 1972.

Survival rate estimates for the growth periods ($\hat{s}$) were calculated using the equation:

$$\hat{S} = \frac{N_1}{N_0}$$

where N_1 = the number of fish present at the time of draining, and N_0 = the number of fish initially stocked. Estimates of the total instantaneous mortality rates ($\hat{i}$) were calculated by the equation:

$$\hat{i} = -\ln(\hat{s})$$

where ln = natural logarithm. Annual survival rate estimates ($\hat{s}_a$) were calculated using Ricker's (1958) equation:

$$\hat{s}_a = e^{-\hat{i}t}$$

where e = base of natural logarithms and t = 365 days divided by the number of days in the growth period.

Estimates of mean instantaneous growth rates ($\bar{g}$) were calculated using the equation by Eipper (1964):

$$\bar{g} = \ln(\bar{w}_1 / \bar{w}_0)$$

where $\bar{w}_1$ = mean weight of fish at the time of draining, and $\bar{w}_0$ = mean weight of fish at the time of stocking. Estimates of mean annual relative growth rates ($\bar{h}_a$) were calculated from Ricker's (1958) equation:

$$\bar{h}_a = e^{\bar{g}t} - 1.$$

Estimates of mean annual absolute growth rates (AG_a) were calculated by the equation:

$$AG_a = (\bar{w}_1 - \bar{w}_0)\ t.$$

RESULTS AND DISCUSSION

At least two spawns were obtained from each of the parental combinations of G sunfish and R sunfish by June with the exception of the R sunfish male and G sunfish female cross. Since no spawn appeared from this combination, the pond was drained and refilled on June 5, 1970, and two different pairs of R sunfish males and G sunfish females were stocked. Only one spawn appeared in this pond by July.

The spawning ponds were drained in January, 1971 and the following F_1 numbers were obtained: 11,700 G sunfish, 10,800 R sunfish, 9,200 G × R hybrids, and 7,450 R × G hybrids. The number of F_1 hybrids produced from G × R hybrids appeared to be higher than those produced by the R × G hybrids which is not consistent with the findings of the State Fish Hatchery at San Marcos, Texas (W. H. Henderson, Personal communication). This can probably be explained by the fact that it was very late in the spawning season when the R sunfish males and G sunfish females were restocked, and only one spawn was obtained. Because of this late spawn the offspring were smaller at draining than the other F_1 offspring. This is important because the differences in the sizes of the F_1 offspring affected the results of the growth rates.

Both absolute and relative growth rates were calculated to give a more objective view of the growth rates. Absolute growth rate shows the weight gained by a fish in a given period of time, whereas relative growth rate shows the increase in weight per unit of time in relation to the initial weight of the fish. A correction factor was not added to the G × R hybrid growth rates because no substantial difference in growth rates was found between the fin-clipped and non-clipped hybrids.

When the absolute and relative growth rates of the F_1 sunfishes are compared (Tables 1 and 2), a trend can be seen. In most instances, the two types of hybrids had the greatest and next to greatest growth rates, while the R sunfish had the least. However, in pond D the G sunfish had the greatest absolute growth rate which was probably due to its larger size upon initial stocking. Its relative growth rate in this pond was lower than that for the two hybrids. In ponds 6 and 11 the R sunfish had the greatest mean annual absolute growth rate (Table 1). This was probably due to the fact that the R sunfish is predominantly a mollusk feeder and bottom forager, while the G sunfish may feed on mollusks but utilizes mostly insects and fish (McClane, 1970). We observed that the hybrid sunfish in this study had very aggressive feeding habits which were similar to the G sunfish. Consequently, there was very heavy interspecific competition among the G sunfish and the two hybrids as well as intraspecific competition, while the R sunfish primarily experienced intraspecific competition. This might account for the high growth rate of the R sunfish in ponds 6 and 11 in which they were subjected to very light competition for food. When the R sunfish was faced with heavy intraspecific competition, its growth rate was low (Table 2). The G sunfish had very low absolute and relative growth rates when in the presence of bass predators (Table 2). Based on our observations, we believe that the G sunfish has feeding habits similar to the largemouth bass. The low growth rate for the G sunfish in those ponds with bass suggest that the bass were competing with the sunfish for food.

A comparison of growth rates of the four types of sunfishes showed that in general, the G × R hybrid had the greatest mean annual absolute growth rate, while the R × G hybrid had the greatest mean annual relative growth rate (Tables 1 and 2). This difference can be accounted for by the fact that the R × G hybrid was smaller than the G × R hybrid upon initial stocking.

Table 1. Mean annual absolute growth rates (AG_a) in grams and mean annual relative growth rates ($\bar{h}_a$) of the F1 sunfish in each pond.[a] The $\bar{h}_a$ values are given in parentheses.

Ponds	*G sunfish*	*G × R hybrids*	*R sunfish*	*R × G hybrids*
C	154 (23)	196 (42)	62 (12)	108 (40)
D	161 (17)	130 (23)	80 (7)	125 (42)
E	81 (28)	112 (34)	64 (8)	100 (73)
5	119 (77)	235 (87)	240 (19)	241 (268)
6	102 (18)	127 (26)	138 (19)	106 (65)
7	164 (18)	197 (33)	152 (15)	183 (56)
8	279 (203)	321 (297)	190 (39)	271 (568)
10	135 (10)	178 (22)	113 (20)	164 (39)
11	147 (27)	216 (29)	226 (25)	213 (35)

[a] Growth rates are based on fish from both growth periods.

Table 2. Mean annual absolute growth rates (AG_a) in grams and mean annual relative growth rates ($\bar{h}_a$) of the F1 sunfish in different types of competition and all ponds combined.[a] The $\bar{h}_a$ values are given in parentheses.

Types of Competition	*G sunfish*	*G × R hybrids*	*R sunfish*	*R × G hybrids*
Intraspecific	133 (22)	146 (31)	69 (8)	111 (54)
Intraspecific & Interspecific	182 (92)	215 (95)	160 (26)	187 (238)
Intraspecific & Interspecific With Predators	134 (16)	210 (28)	193 (18)	206 (54)
All Ponds Combined	149 (35)	190 (45)	141 (16)	168 (93)

[a] Growth rates are based on fish from both growth periods.

Mean annual survival rates of the F1 sunfishes based on fishes from each pond for both growth periods are shown in Table 4. Fin-clipping correction factors of 0.10 and 0.09 were added to the survival rates of the G × R hybrids during the first and second growth periods, respectively. The G × R hybrid, in most instances, had the highest mean annual survival rate, while the G sunfish had the lowest (Tables 3 and 4). The morphological structures of the G sunfish offer one possible explanation to its low survival rates when in the presence of bass predators (Table 4). The relatively short dorsal spines and slender body would allow easier ingestion by bass predators than the other three types of sunfishes. Also, their feeding habits are similar to those of bass and would result in increased competition for the G sunfish.

Louis and Heidinger (1971) found that males of the G sunfish × bluegill *(Lepomis macrochirus)* hybrid had a significantly greater growth rate than did females. Therefore a population with a greater number of males than females could be desirable because they might grow faster and larger than females, and the population could have a lower reproductive potential. Hubbs (1955) suggested that

Table 3. Mean annual survival rates of the F_1 sunfish in each pond.[a]

Ponds	*G sunfish*	*G × R hybrids*	*R sunfish*	*R × G hybrids*
C	0.78	0.92	0.94	0.83
D	0.94	0.97	0.93	0.84
E	0.78	0.93	0.88	0.94
5	0.68	0.97	0.84	0.95
6	0.84	1.00	0.81	0.90
7	0.69	0.95	0.77	0.96
8	0.53	0.56	0.66	0.51
10	0.59	0.79	0.68	0.66
11	0.56	0.88	1.00	0.79

[a] Survival rates are based on fish from both growth periods.

Table 4. Mean annual survival rates[a] of the F_1 sunfish in different types of competition and in all ponds combined.

Types of Competition	*G sunfish*	*G × R hybrids*	*R sunfish*	*R × G hybrids*
Intraspecific	0.85	0.95	0.91	0.90
Intraspecific & Interspecific	0.77	0.96	0.76	0.89
Intraspecific & Interspecific With Predators	0.61	0.83	0.79	0.74
All Ponds Combined	0.75	0.90	0.82	0.84

[a] Survival rates are based on fish from both growth periods.

hybrid sunfish are particularly suited to rapid growth because they are generally infertile and for that reason should not be able to overpopulate any pond in which they are the only type of fish present. A comparison of sex ratios showed that G × R hybrids were 99% males, R × G hybrids were 88% males, G sunfish were 83% males, and R sunfish were 45% males. The unusually high percentage of G sunfish males was initially thought to be due to sampling error, but another sample of 100 individuals showed 81% males. Childers (1967) found that G × R hybrids were 48% males and R × G hybrids were 69% males in Illinois ponds. This conflict in sex ratios can be explained by Louis and Heidinger's (1973) statement that there is some indication of genetic differences in parental fish from different locations. Both Ricker (1948) and Hubbs and Hubbs (1933) found that the characteristics of predominant maleness of F_1 hybrids was carried on into the F_2 generation. We observed abundant F_2 offspring in the pond containing pairs of R × G hybrids, while no F_2 offspring were observed in the pond containing pairs of G × R hybrids.

Childers and Bennett (1967) have reported that hybrid sunfish are much more vulnerable to angling than the parent species. They stated that hybrids were more aggressive, less wary, and less able to learn by observation how to avoid being caught than their parent species. Just before the final draining an experiment was conducted on the vulnerability of hybrids to angling. The senior author fished ponds 6, 7, and 8 in March, 1972, fifteen minutes each for two mornings and one afternoon. Spinner lures were fished at different depths and speeds. During the two and one-fourth man-hours of fishing in these ponds, 10 G × R hybrids, 8 R × G hybrids, 7 G sunfish, and no R sunfish were taken. The fact that the G sunfish were caught almost as often as the hybrids might be explained on the basis of the stimulus to feed created by the voracious feeding activity of the more numerous hybrids. Childers and Bennett (1967) stated that most fish are in competition for food, and the fact that one species apparently feeds voraciously and without hesitation might decrease the normal wariness of another species. Some fishing by poachers took place during the first growth period in pond 8. This pond contained 22 F_1 sunfish of each kind, but upon draining there were only 12 R sunfish, 5 G sunfish, 3 G × R hybrids, and 2 R × G hybrids. The higher number of R sunfish recorded might have been expected because being a bottom forager, it is less susceptible to artificial lures than are the other sunfishes. From the two examples above an absolute conclusion cannot be drawn, but it seems to point out the greater vulnerability of the hybrids to angling pressures. To discourage further fishing during the second growth period, wire was stretched along the edge of the pond about 3m from the bank and 0.3m below the surface to entangle lures. Upon draining the pond the second time, 100% of the fish stocked were recovered, compared to the 25% recovery after the first draining.

With the high percentage of males, relatively low production of F_2 offspring, and high vulnerability to angling, it might be possible to completely eliminate the G × R hybrid from a pond with heavy fishing and improper management. However, in a pond with proper management the G × R hybrid would be more desirable than its reciprocal cross and parental species for increasing fishing yields and for population control in Texas ponds.

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