A COMPARISON OF THE GROWTH OF TWO HYBRID SUNFISH WITH THE BLUEGILL

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ABSTRACT

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By

John Andrew Janssen

The growth of bluegills (Lepomis macrochirus) and two varieties of hybrid sunfish stocked in small ponds was compared. Hybrids between male redear (L. microlophus) and female green sunfish (L. cyanellus) grew faster than bluegills in the absence of interspecific competition. In hybrids between male bluegills and female green sunfish the male hybrid grew faster and the female grew slower than either male or female bluegills either with or without interspecific competition. It appears that males of the latter hybrid are more aggressive and inhibit the growth of the female hybrids through social interaction.

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INTRODUCTION

Hybrid sunfish have been used in stocking programs in Michigan and other states. Three reasons for using sunfish hybrids in stocking programs may be cited. The hybrids are reportedly sterile or have reduced fertility (Hubbs and Hubbs, 1933; Childers, 1967), thus overcrowding is unlikely to occur. Childers (1967) reported that at least some hybrid sunfish varieties are more vulnerable to hook and line fishing than the parent species, thus are easily captured fish. Hubbs and Hubbs (1931, 1933) reported that hybrid sunfish generally grew faster than the parent species.

All hybrid sunfish considered in this paper are F_1's. In the name of a hybrid the male parent is listed first unless the hybrid referred to is from a natural population, in which case the sex of the parent species is not known. Thus for the redear (Lepomis microlophus (Gunther)) x green sunfish (L. cyanellus Rafinesque) hybrid, the male parent is the redear.

Hubbs and Hubbs (1931, 1933) based their conclusions about increased growth in hybrid sunfish on natural populations of pumpkinseed (L. gibbosus (Linnaeus)) x green sunfish, pumpkinseed x bluegill (L. macrochirus

Rafinesque), and bluegill x green sunfish hybrids. In the natural populations studied the parent species were more numerous than the hybrids. Because individuals of the same species are similar in behavioral, structural, and functional adaptations, intraspecific competition is usually more intense than interspecific competition (Kendeigh, 1961). Since there were fewer hybrids in the natural populations studied, there should be less intraspecific competition among the hybrids than among the parent species and increased growth might be expected. Childers (1967) could demonstrate no difference in growth of either green sunfish x redear hybrids vs. the parent species or bluegill x green sunfish hybrids vs. the green sunfish. However, stocking densities were low and thus both interspecific and intraspecific competition were probably low. Childers suggested that high density stocking with equal numbers of hybrids and parent species would be necessary to demonstrate a difference in growth.

In Michigan the redear x green sunfish hybrid and the bluegill x green sunfish hybrid are used in stocking programs. The bluegill is the largest sunfish found in Michigan. A hybrid sunfish that grows faster than the bluegill would be of great value for sport fishing. A series of experiments was designed to compare the growth of the redear x green sunfish hybrid and the bluegill x green sunfish hybrid with the bluegill. The experiments

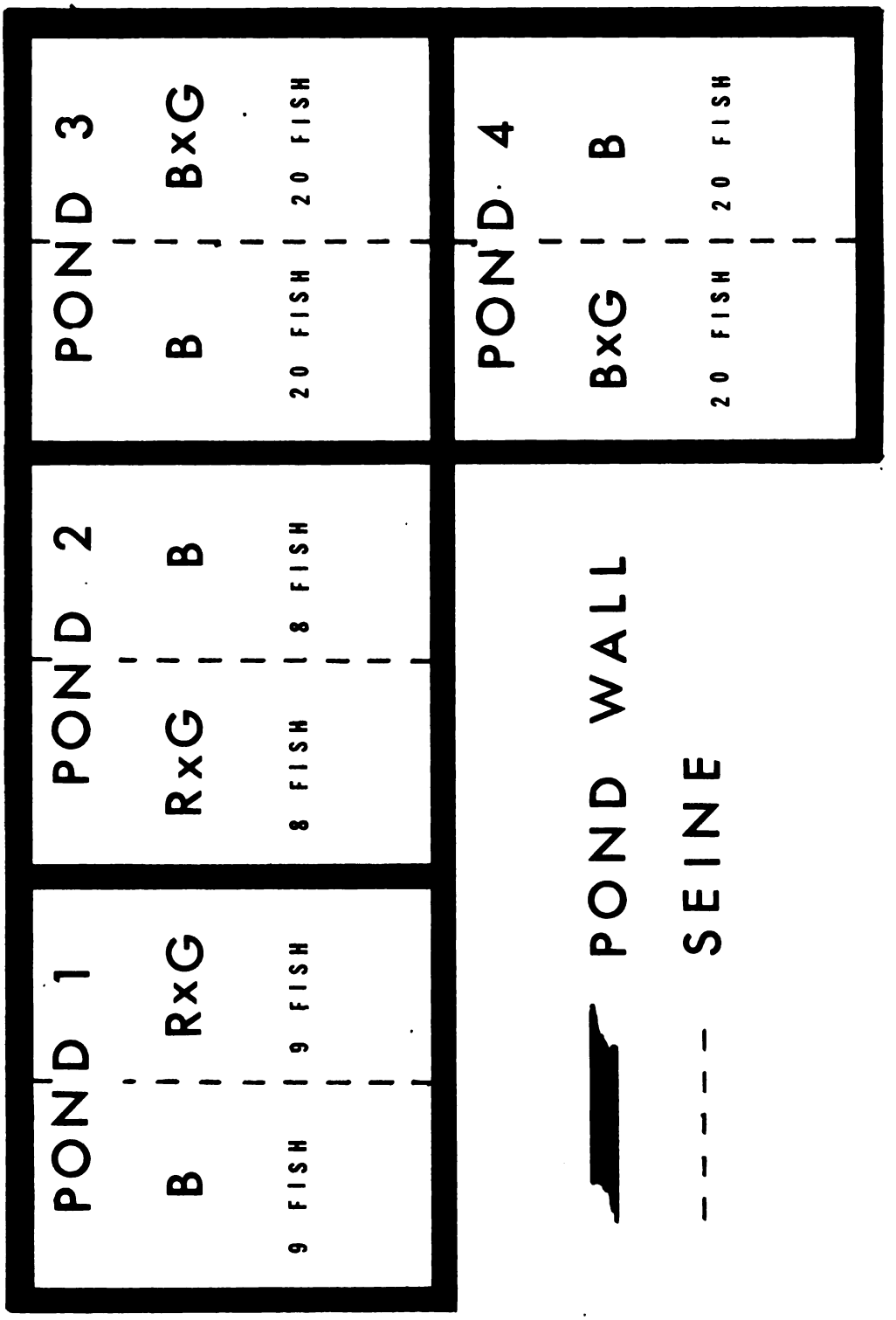
were designed so that there would be no interspecific competition between the hybrids and the bluegill.

MATERIALS AND METHODS

Ponds

Fish were stocked in concrete ponds that were 7.3 m square and filled with water to a depth of about 1.3 m. The walls of the ponds were vertical and depths were uniform throughout each pond. The bottom of each pond was covered with gravel. Ponds were divided into two equal sections by a 1/4-inch mesh seine as shown diagrammatically in Figure 1. The seine kept the varieties of sunfish separate to eliminate interspecific competition, but kept the varieties in similar water and food conditions by allowing the water to mix. Each pond was stocked with bluegills and one of the varieties of hybrid sunfish. One week before the fish were stocked (May 14, 1971) each pond was fertilized at a rate of 40 lb/acre of superphosphate (20% phosphorus as P_2O_5) and 20 lb/acre of urea (46% nitrogen as N). It was initially intended to fertilize the ponds at intervals during the summer. However, this one fertilization was sufficient to maintain algal blooms in ponds 1 and 2 through mid-August and in ponds 3 and 4 for the entire experiment.

Figure 1. Diagrammatic representation of the experimental ponds. Each pond was 7.3 m square and filled with water to a depth of 1.3 m. Fish in pond 4 became mixed so the seine was lifted. RxG = redear x green sunfish hybrid; BxG = bluegill x green sunfish hybrid; B = bluegill.


POND 1
B
RxG
9 FISH
9 FISH
POND 2
RxG
B
8 FISH
8 FISH
POND 3
B
BxG
20 FISH
20 FISH
POND 4
BxG
B
20 FISH
20 FISH
POND WALL
SEINE

Fish

Both redear x green sunfish hybrids and bluegill x green sunfish hybrids were provided by the Wolf Lake Fish Hatchery, Mattawan, Michigan. Some bluegill x green sunfish hybrids were obtained in the spring a few weeks before stocking, however, most fish were obtained the previous fall. Bluegills were seined a few weeks before stocking from an artificial pond maintained by the Fisheries and Wildlife Department at Michigan State University. All fish used in the experiments were spawned the previous year (age 1).

Twenty bluegills and twenty bluegill x green sunfish hybrids were stocked in both ponds 3 and 4 (Figure 1) on May 21, 1971. Before stocking, each fish was weighed to the nearest 0.1 g, measured to the nearest millimeter total length, and randomly assigned to one of the two ponds. If a fish was larger than 55 mm or smaller than 45 mm it was discarded. The range and mean total lengths (TL) and weights (W) when stocked were as follows:

	TL range	TL mean	W range	W mean
Pond 3	mm	mm	g	g
Hybrids	45-54	49.6	1.2-2.0	1.57
Bluegills	46-54	49.6	1.1-1.7	1.26
Pond 4				
Hybrids	46-55	50.2	1.2-2.1	1.62
Bluegills	46-53	49.6	1.1-1.5	1.27

A similar experiment was originally designed to compare the growth of the bluegill and the redear x green sunfish hybrid. However, because the hybrids suffered heavy winter mortality and few fish were available, a different experiment was designed. Seventeen pairs of fish were selected so that each pair consisted of a bluegill and a hybrid of nearly equal total length. The fish were then weighed and marked by fin-clipping. Both fish of a pair were given the same combination of fin-clips. The various fins clipped were the pelvics, soft portion of the dorsal, soft portion of the anal, dorsal lobe of the caudal, and ventral lobe of the caudal. When two fins were clipped, one was a pelvic fin and the other a medial fin. Fins were not removed entirely so that the fins could regenerate at least partially. Each pair of fish was randomly assigned to either pond 1 or 2 and stocked on May 21, 1971. As shown in Figure 1, pond 1 contained nine pairs of fish and pond 2 contained eight pairs of fish. Initial sizes are given in the results.

Four weeks after the fish were stocked and at approximately two-week intervals thereafter, the ponds were seined and the total length of the fish recorded. Seining provided checks for any mixing of fish and regeneration of clipped fins. Fish were measured and returned to the water as quickly as possible. During the first of these seinings it was found that the bluegills and the bluegill x green sunfish hybrids in pond 4 had become mixed.

Since a size difference between the hybrids and the bluegills was already apparent and mixing was extensive, the divider seine was lifted at this time and the fish were allowed to mix freely. Therefore, interspecific competition may have been a factor in pond 4.

Physical and Chemical Data

Maximum and minimum daily temperatures were recorded at least five times per week with a maximum-minimum thermometer suspended at mid-depth in the ponds. Occasional surface and bottom temperatures were also taken.

Basic chemical data were recorded for the ponds at approximately two-week intervals. These included pH, alkalinity, hardness, and oxygen concentrations. Water samples were taken at mid-depth of each pond with a 1-liter Kemmerer sampler at mid-afternoon. Water samples were also taken at dawn of the next day for additional oxygen measurements. A Beckman Zeromatic II pH meter was used for pH determinations; hardness and alkalinity were determined by titration. Oxygen concentrations were determined by the azide modification of the Winkler method. When oxygen concentrations were high, interference was suspected so measurements were also made with a Beckman Oxygen Analyzer. Both methods yielded similar results.

Biological Data and Food Organisms

Samples of plankton, benthos, and organisms attached to the walls of the ponds were taken at approximately two-week intervals beginning with the third week. The primary purpose of these data was to find what organisms were available as fish food and determine gross differences in the effect of the fish varieties on the food organisms.

Benthos samples were initially taken with an Ekman dredge (15 x 15 cm) with two samples per benthos sample. This proved unsatisfactory on the gravel bottom, so thereafter samples were taken with a Peterson dredge (25 x 27 cm). Benthos samples were washed on a series of screens, the smallest being 12 meshes/cm, and sorted by hand-picking.

Plankton samples were taken at night with a single vertical haul of a #25 Wisconsin "small net." Samples were immediately preserved in ethanol and the organisms in an aliquot of the sample counted on a Sedgewick-Rafter counting cell. The total number of each class of organisms was then estimated from the numbers in the aliquot. Larger organisms such as mosquito larvae and Chaoborus (Diptera: Culicidae) were counted for the whole sample. Small organisms such as Rotifera were not counted.

Wall samples were taken with a long-handled rectangular net with a screen mesh (4 meshes/cm) at night by scraping the wall from the bottom of the pond to the waterline. The width of the net was 61 cm, thus an area 61 cm x

1.3 m (pond depth) was sampled. This technique was not very quantitative and captured only rather large organisms and organisms caught in any filamentous algae scraped from the walls. However, this technique did reveal many potential food items not found in benthic or plankton samples.

Termination of the Experiments

On October 11, 1971 the experiments in ponds 3 and 4 (comparing growth of bluegill x green sunfish hybrid with bluegill) were terminated. Fish, collected by seining at night and anesthetized in MS 222 (Tricaine Methanesulfonate) solution, were immediately weighed to the nearest 0.1 g and measured to the nearest 1 mm total length. Fins were clipped so that individual fish could be recognized later. The fish were then preserved in 10% formalin.

The experiments in ponds 1 and 2 (comparing growth of redear x green sunfish hybrid with bluegill) were terminated on October 12, 1971. The fish were treated in the same manner as the fish in ponds 3 and 4, except the combination of finclips made at the beginning of the experiment was recorded and the fins were not reclipped. The fins were nearly fully regenerated, but clips could be distinguished because the fin rays were slightly distorted.

Sex determinations and stomach analyses were done later. Stomach analyses were made in an effort to determine what organisms were being used as food. Data were recorded only as counts because the total volume of food in the

stomachs was small. These data are discussed in the results along with data from benthos, plankton, and wall samples.

The gonads of hybrid sunfish are often poorly formed. The testes of hybrids usually consisted of two thin strands of tissue. Ovaries were more definitely formed, but contained few distinguishable eggs. These conditions pertained for both hybrids. Hubbs and Hubbs (1933) reported similar conditions of gonads in hybrids they examined.

RESULTS AND DISCUSSION

This section includes pond descriptions, a discussion of food items, and results and discussion of growth of the fish.

Pond Descriptions

The water temperature at the beginning of the experiment (May 21) was 15 C. Temperatures increased to a peak of 27 C on July 1 and thereafter cooled to an average of 21 C until mid-September. At the conclusion of the experiments the temperature was 12 C. On warm, calm days there was as much as a 4 C difference in temperature between the surface and the bottom. The ponds were well protected from winds and this resulted in little vertical mixing of water, allowing the ponds to stratify. This lack of mixing had strong effects on the oxygen concentrations and pH of the ponds.

Pond 1 had a high pH for the entire experiment; measurements were as high as 9.8. Total alkalinity averaged about 150 ppm as $CaCO_3$ and hardness averaged about 140 ppm as $CaCO_3$. Oxygen concentrations in the ponds were usually supersaturated, even at dawn. Apparently, because the water was not mixing, oxygen formed in the pond (and in the other

ponds) could not readily escape to the atmosphere. In August the pond developed a heavy covering of duckweed (Wolffia) which apparently shaded out the phytoplankton and resulted in oxygen levels less than 3 ppm. Thereafter the duckweed was periodically removed to thin it. The necessity of removing the duckweed was unfortunate because many food organisms, particularly mosquito larvae, were removed with the duckweed.

Pond 2 had pH values as high as 9.8. Total alkalinity averaged about 150 ppm and hardness averaged about 145 ppm. Oxygen concentrations were usually quite high, often supersaturated even at dawn. On sunny, calm days in early August the pond developed a heavy scum of Euglena. This disappeared at the end of August. At this time the predawn oxygen concentrations dipped below 2 ppm. This condition lasted only a few days and no mortality resulted.

Pond 3 usually had pH values near 10. Total alkalinity averaged about 150 ppm and hardness averaged about 145 ppm. Oxygen concentrations were quite high, often supersaturated even at dawn. The lowest reading was 3.4 ppm at dawn during August. On calm, sunny days during August, Euglena formed a covering of scum.

The pH values for pond 4 remained near 10 for the entire experiment. Alkalinity averaged about 140 ppm and hardness averaged about 125 ppm. There was an algal bloom during the entire experiment and oxygen concentrations were

always high. The lowest value recorded was 6 ppm near the end of August.

Available Food and Stomach Analyses

Results from benthos, plankton, and wall samples showed no apparent differences in food items between the hybrid and bluegill sides of the ponds. Stomachs contained mostly unidentifiable material and plant material. General descriptions of foods consumed and food items available are given below. However, the foods consumed the last day the fish were alive may not be typical of food habits during most of the experiment.

Etnier (1971) reported the food habits of natural populations of bluegills, green sunfish, and their hybrids. Bluegills fed mainly on midge larvae (Diptera: Chironomidae), small Trichoptera larvae, Amphipoda, and Cladocera. Hybrids also consumed these items, but depended heavily on larger food items including snails, Odonata naiads, and large Trichoptera larvae, presumably because the hybrids have larger mouths than the bluegills. There are no reports on the food habits of the redear x green sunfish hybrid, but they would presumably consume larger food items than the bluegill because they also have larger mouths than the bluegill.

In the present experiments, bluegills consumed midge larvae almost exclusively except in pond 3 where midge larvae and Chaoborus were consumed in similar numbers.

Midge larvae were less important as a food item for the hybrids. Redear x green sunfish hybrids in pond 1 consumed mostly mosquito larvae. The redear x green sunfish hybrids in pond 2 and the bluegill x green sunfish hybrids in pond 3 consumed a wide variety of food items including midge larvae and various plankters. Bluegill x green sunfish hybrids in pond 4 consumed mostly midge larvae.

In all ponds the midge larvae were numerous during June, uncommon or absent in benthos samples during July and August, and were again numerous during September and October. The decline in midge larva numbers during July and August was presumably due to predation; egg cases were often found in the ponds, and adjacent ponds without fish maintained high numbers of midge larvae.

The larger food items that Etnier (1971) found in stomachs of bluegill x green sunfish hybrids from natural populations were not found in my experimental ponds. This was apparently due to predation because adjacent ponds without fish contained large numbers of Odonata naiads and Odonata adults were commonly observed laying eggs in the experimental ponds. No Odonata naiads were found in fish stomachs, however, when the food study was made.

Plankton consisted mostly of Cladocera, Ostracoda, and Copepoda usually in numbers from several hundred to several thousand per sample. Pond 1 contained large numbers of mosquito larvae. Except for Chaoborus in bluegill

stomachs in pond 3 and mosquito larvae in redear x green sunfish hybrids in pond 1, plankters were uncommon in fish stomachs. One redear x green sunfish hybrid in pond 2 contained 141 Cladocera. The plankters were probably an important food item when the fish were small.

Pond 2 developed a heavy growth of filamentous algae (Rhizoclonium) on the walls during August and this harbored large numbers of Amphipoda and Ephemeroptera naiads (Siphlonurus). These did not appear in fish stomachs.

Growth of Fish

Table 1 shows the growth of the redear x green sunfish hybrids in ponds 1 and 2. The number 8 bluegill (pond 1) was never found during the final seining or after subsequent draining of the pond. Neither was this fish seen in seine hauls during the experiment, so it presumably died early in the experiment. Of the remaining eight pairs in pond 1, the hybrids grew more in length in six of the pairs and more in weight in five of the pairs. In pond 2 the hybrids grew more in length and weight in seven of the eight pairs.

Results were analyzed statistically with Wilcoxin's signed-ranks test for paired observations (Sokal and Rohlf, 1969). Hybrids grew more in total length ($P<0.02$) and weight ($P<0.05$) than bluegills. Hybrids averaged 6.3 mm longer and 5.1 g heavier than bluegills. Because pond 1 contained more hybrids than bluegills it might be suspected

Table 1. Lengths and weights of redear x green sunfish hybrids (RxG) and bluegills (B) stocked in ponds 1 and 2. M = male; F = female; IL = initial length; LI = length increment; IW = initial weight; WI = weight increment.

Pair		Sex	IL mm	LI mm	Diff.* mm	IW g	WI g	Diff.* g
Pond 1								
1	RxG	M	67	83	+5	3.7	68.8	+12.7
	B	M	67	78		3.3	56.1	
2	RxG	M	68	76	+8	4.1	53.0	+ 4.7
	B	M	68	68		3.8	48.3	
3	RxG	F	68	75	+22	4.4	49.8	+22.5
	B	M	68	53		3.7	27.3	
4	RxG	M	65	66	-5	3.4	35.3	-9.5
	B	F	64	71		3.0	44.8	
5	RxG	M	66	78	+3	3.3	57.7	+5.4
	B	F	65	75		3.1	52.3	
6	RxG	M	60	66	+13	2.9	31.0	+7.8
	B	M	60	53		2.7	23.2	
7	RxG	M	61	66	-2	3.0	34.2	-1.6
	B	F	61	68		2.5	35.8	
8	RxG	M	65	87	-	3.5	67.2	-
	B	-	-	-		-	-	
9	RxG	M	59	66	+3	3.1	29.4	-2.4
	B	M	59	63		2.6	31.8	

Continued

Table 1. Continued

Pair		Sex	IL mm	LI mm	Diff.* mm	IW g	WI g	Diff.* g
Pond 2								
10	RxG	M	60	89	+29	2.5	55.3	+27.8
	B	F	60	60		2.3	27.5	
11	RxG	M	62	63	+6	3.6	28.5	+2.9
	B	F	62	57		2.7	25.6	
12	RxG	M	63	70	+4	3.3	36.6	+1.6
	B	M	63	66		2.7	35.0	
13	RxG	M	62	60	+3	3.7	25.8	+0.2
	B	F	62	57		3.0	25.6	
14	RxG	M	70	78	+6	4.4	55.0	+3.8
	B	M	70	72		3.8	51.2	
15	RxG	M	58	58	-9	3.0	22.5	-6.8
	B	M	58	67		2.4	29.3	
16	RxG	M	71	69	+11	4.7	42.2	+9.8
	B	F	71	58		4.0	32.4	
17	RxG	M	71	77	+4	4.6	51.5	+2.0
	B	M	71	73		4.2	49.5	

* Difference is the increment for the hybrid minus the increment for the bluegill.

that growth of the hybrids would be somewhat inhibited by intraspecific competition resulting from the extra fish.

Sex of the fish is also shown in Table 1. There were nine male bluegills and seven females. Of the 17 redear x green sunfish hybrids only one was a female. Low percentages of females is common for sunfish hybrids. Childers (1967) reported that laboratory reared redear x green sunfish hybrids were 69% males. Lewis and Heidinger (1971) reported only one female in more than 2000 redear x green sunfish studied. Of 60 hybrids obtained from a pond stocked with fish from the same stock as the fish used in this experiment, I found only four females.

Figure 2 shows the final lengths and Figure 3, the final weights of the bluegill x green sunfish hybrids and bluegills in ponds 3 and 4. The weights were rounded off to the nearest gram for ease in graphing. Table 2 shows the means of the lengths and weights of the same fish. In pond 3, 19 hybrids and 18 bluegills were recovered. In pond 4, all 20 hybrids and 18 bluegills were recovered. The missing fish were never recovered subsequent to draining the ponds and presumably died sometime during the experiment.

The data were analyzed statistically with the Mann-Whitney U-test for two samples (Sokal and Rohlf, 1969). When stocked, the bluegill x green sunfish hybrids averaged between 0.3 and 0.4 g heavier than the bluegills, therefore 0.3 g was added to the final weight of each bluegill before

Figure 2. Distribution of final total lengths of bluegills (B) and bluegill x green sunfish hybrids (BxG) in ponds 3 and 4. M = male; F = female.

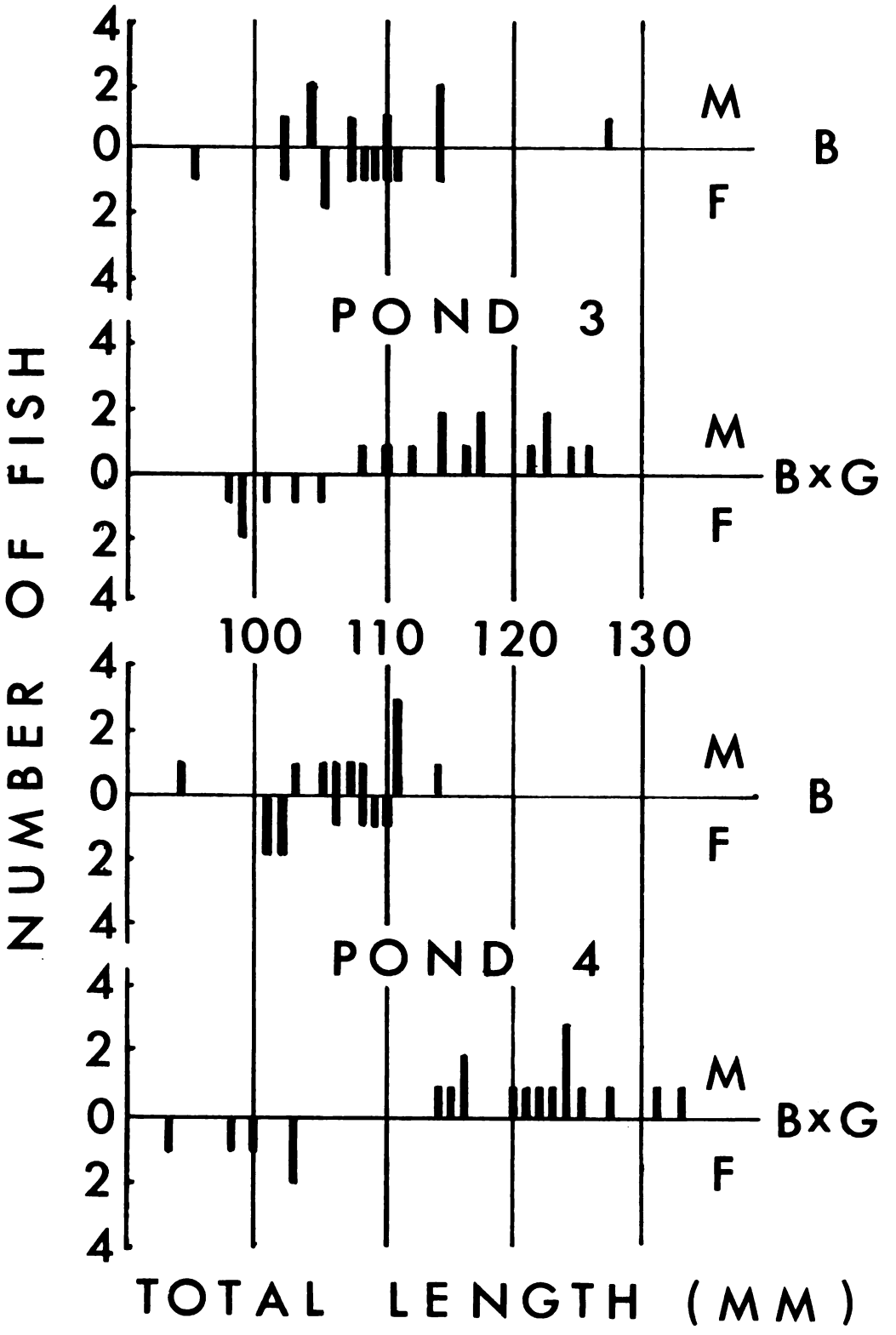

NUMBER OF FISH
4
2
0
2
4
M
F
B
POND 3
BxG
100
110
120
130
POND 4
TOTAL LENGTH (MM)

Figure 3. Distribution of final weights of bluegills (B) and bluegill x green sunfish hybrids (BxG) in ponds 3 and 4. Weights are rounded off to the nearest gram. M = male; F = female.

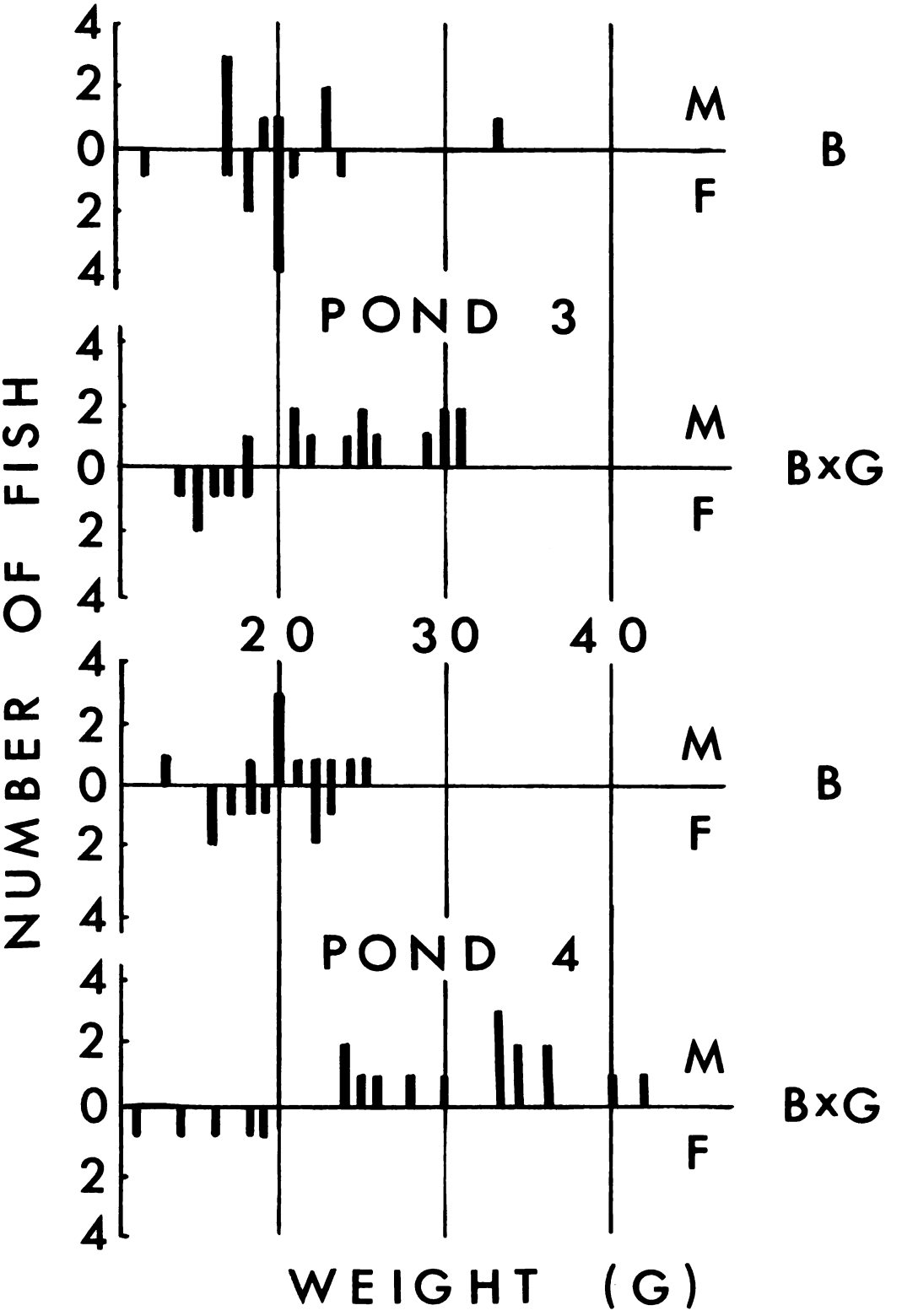

NUMBER OF FISH
4
2
0
2
4
M
F
B
POND 3
BxG
20
30
40
POND 4
WEIGHT (G)

Figure 3. Distribution of final weights of bluegills (B) and bluegill x green sunfish hybrids (BxG) in ponds 3 and 4. Weights are rounded off to the nearest gram. M = male; F = female.

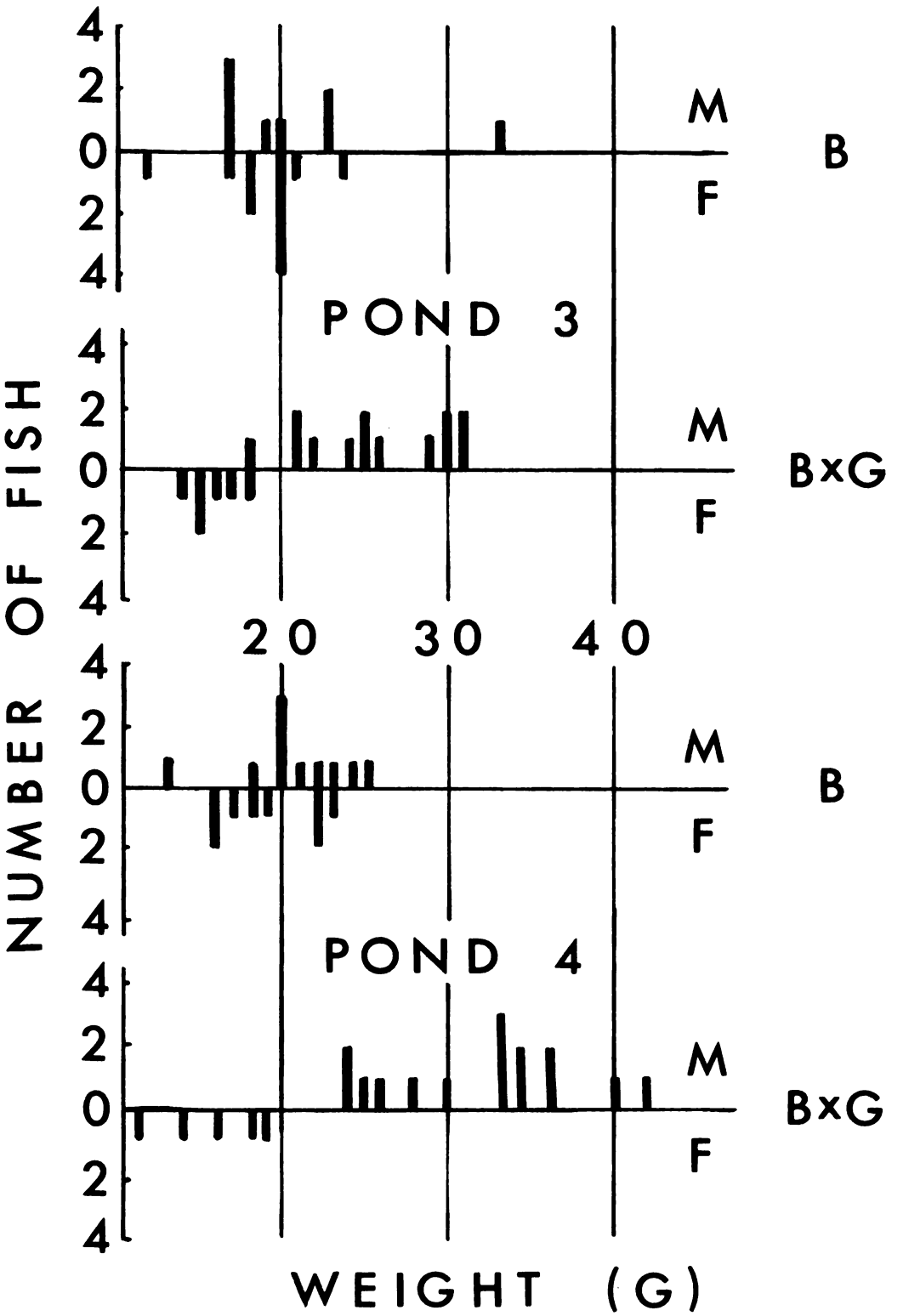

NUMBER OF FISH
4
2
0
2
4
M
F
B
POND 3
BxG
20
30
40
POND 4
WEIGHT (G)

Table 2. Mean final total length and weight of bluegill x green sunfish hybrids and bluegills in ponds 3 and 4. Statistical analyses were made with the Mann-Whitney U-test (Sokal and Rohlf, 1969). M = male; F = female.

	Number	Mean length (mm)	Mean weight (g)
Pond 3			
M hybrid	13	117.1	25.82
F hybrid	6	102.5	15.85
M bluegill	8	110.2	21.22
F bluegill	10	106.6	19.09
Pond 4			
M hybrid	15	122.2	31.81
F hybrid	5	99.4	15.42
M bluegill	10	107.0	20.67
F bluegill	8	104.9	19.35

Summary of statistics	Significance level			
	Pond 3		Pond 4	
Comparison	Length	Weight	Length	Weight
M hybrid and F hybrid	0.002	0.002	0.002	0.002
M bluegill and F bluegill	N.S.	N.S.	N.S.	N.S.
M hybrid and M bluegill	0.05	0.05	0.002	0.002
M hybrid and F bluegill	0.002	0.002	0.002	0.002
M bluegill and F hybrid	0.01	0.01	0.02	0.01
F bluegill and F hybrid	0.02	0.02	0.10	0.05

statistical analysis. The summary of statistics is given in Table 2. Differences at the 0.05 level were judged to be significant. In both ponds male hybrids averaged significantly larger than male or female bluegills, and female hybrids averaged significantly smaller than male bluegills. In pond 3 female bluegills were significantly larger than female hybrids but in pond 4 the difference was significant only for weight data. The weight of female bluegills in pond 3 was significantly larger than female hybrid weight even if 0.3 g was not added to the weight of each bluegill. In pond 4 the difference was not significant.

Scale samples were examined to see if the male bluegill x green sunfish hybrids were larger than the female hybrids when stocked. Size at annulus formation was probably a good estimate of size at stocking because the fish grew little if at all between collecting and stocking. The Dahl-Lea direct-proportion method (Lagler, 1970) was used to calculate fish size at annulus formation. This method underestimated the size of the fish but was probably satisfactory for comparative purposes. No significant difference was found in the average length of males and females at the time of stocking using the Mann-Whitney U-test.

There was a high proportion of males among the bluegill x green sunfish hybrids; combined data for ponds 3 and 4 give a value of 72% males. Childers (1967) reported

97% males in laboratory produced bluegill x green sunfish hybrids. W. C. Latta (personal communication) found 82% males in fish that had been stocked in lakes in Michigan.

Discussion

No definite conclusions about hybrid vigor can be made for the redear x green sunfish hybrids because neither parent species was used in the experiments.

Under conditions of no interspecific competition (pond 3) and interspecific competition (pond 4) the male bluegill x green sunfish hybrid grew larger than bluegills of either sex. It is interesting that in pond 3 the largest fish is a male bluegill. This fish was considerably larger than any other bluegill (Figures 2 and 3).

Based on evidence to be cited, I will offer a suggestion that may help explain why the male bluegill x green sunfish hybrid would grow faster than the male or female bluegill while the female hybrid grows slower. Hubbs and Cooper (1935) reported that male green sunfish grew faster than females and Hubbs and Hubbs (1933) reported that in natural populations of bluegills and pumpkinseeds and their hybrids the male grew faster than the female. In my experiments male bluegills averaged larger than females (Table 2), but not significantly so. Because males of the parent species grow faster than females, it might be expected that male hybrids would grow faster than the females.

Increased growth of one sex relative to another could be due to a physiological difference in which the male may assimilate food more efficiently than the female, or a behavioral difference in the sense that the male locates food more efficiently or consumes more food than the female, or a behavioral difference in the sense that the male displays aggressive dominance over the female and thus inhibits her growth. The evidence to be cited supports one or both of the last two conclusions.

Lewis and Heidinger (1971) found that male green sunfish x bluegill hybrids (reciprocal cross of that used in this experiment) grew faster than female hybrids when raised with supplemental feeding. They suggested that the female was less responsive than the male to supplemental feeding. In their experiments fish were stocked at a rate of 3000 and 1500 fish per acre. In my experiments bluegill x green sunfish hybrids were stocked at a rate of about 3000 fish per acre and the conclusion about the relative growth of the males and females was the same. Lewis and Heidinger (1971) cited unpublished data for green sunfish x bluegill hybrids raised in pond conditions with no supplemental feeding in which there was no difference in the growth of males and females. However, the fish were stocked at a density of only 500 fish per acre. Data from Michigan lakes stocked with bluegill x green sunfish hybrids

at a density of about 500 fish per acre also showed no difference in growth of males and females (W. C. Latta, personal communication). Thus when the density of either hybrid (bluegill x green sunfish or reciprocal cross) is high there is a difference in growth of the males and females while under low densities no differential growth is apparent.

If the female bluegill x green sunfish hybrids are less able to find food than the male hybrid, then under conditions of crowding, when food is relatively scarce, the females would gather less food and thus grow slower. Because the female hybrid grew slower than the bluegills it might be suggested that it is less able to find food than the bluegill. An attractive alternative to this is that the female is less socially aggressive than the male and under crowded conditions the males inhibit feeding by the females. Because the female hybrid also grew slower than the bluegill under conditions of interspecific competition (pond 4) it is possible that the female hybrid is less aggressive than the bluegill. This would depend on the importance of interspecific social interaction in the pond. Greenberg (1947) found that male green sunfish were usually dominant over the females in aquarium conditions. The males were also larger than the females so the results were to some extent confounded. The importance of dominance type social interaction in natural populations of sunfish is unknown.

CONCLUSION

Both the redear x green sunfish hybrid and the bluegill x green sunfish hybrid are attractive as a fish to be used in stocking programs based on their growth potential. The value of the latter hybrid is somewhat complicated by a differential growth of males and females when fish densities are high.

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APPENDIX

Table A-1. Initial total lengths and weights of bluegills and bluegill x green sunfish hybrids in ponds 3 and 4.

	Bluegills		Hybrids	
	Length mm	Weight g	Length mm	Weight g
Pond 3	46	1.1	45	1.2
	48	1.1	46	1.3
	48	1.1	47	1.3
	48	1.1	47	1.4
	48	1.2	48	1.3
	48	1.2	48	1.4
	48	1.2	48	1.4
	49	1.1	48	1.4
	49	1.2	48	1.4
	49	1.2	48	1.4
	49	1.2	49	1.5
	49	1.3	50	1.5
	50	1.3	50	1.6
	50	1.3	52	1.8
	51	1.3	52	1.8
	51	1.4	52	1.8
	51	1.4	52	1.8
	52	1.4	54	1.9
	53	1.5	54	1.9
	54	1.7	54	2.0
Pond 4	46	1.1	46	1.2
	47	1.1	47	1.2
	48	1.1	47	1.3
	48	1.1	47	1.4
	48	1.2	48	1.4
	48	1.2	48	1.4
	49	1.2	49	1.4
	49	1.2	49	1.5
	49	1.2	49	1.5
	49	1.3	49	1.5
	49	1.3	49	1.5
	50	1.3	49	1.6
	50	1.3	50	1.6
	50	1.3	51	1.6
	50	1.4	53	1.8
	51	1.4	54	2.0
	52	1.4	54	2.0
	52	1.4	54	2.1
	53	1.5	55	2.1
	53	1.5	55	2.1

Table A-2. Final total lengths, weights, and sex of bluegills and bluegill x green sunfish hybrids in ponds 3 and 4. M = male; F = female.

	Bluegills			Hybrids		
	Sex	Length mm	Weight g	Sex	Length mm	Weight g
Pond 3	M	102	16.8	M	108	18.4
	M	104	17.0	M	110	20.9
	M	104	17.1	M	112	21.1
	M	107	19.3	M	114	22.2
	M	110	20.0	M	114	24.8
	M	114	23.3	M	116	24.3
	M	114	23.3	M	117	25.5
	M	127	33.0	M	117	26.4
	F	95	12.5	M	121	29.8
	F	102	16.8	M	122	30.2
	F	105	18.0	M	122	31.4
	F	105	18.5	M	124	29.4
	F	107	19.6	M	125	31.3
	F	108	20.0	F	98	14.8
	F	109	20.0	F	99	14.4
	F	110	20.5	F	99	15.0
	F	111	21.1	F	101	15.8
	F	114	23.9	F	103	16.7
				F	105	18.4
Pond 4	M	94	13.3	M	114	23.5
	M	103	18.5	M	115	23.6
	M	105	19.7	M	116	24.6
	M	106	20.0	M	116	26.1
	M	107	20.3	M	120	28.0
	M	108	21.4	M	121	33.1
	M	111	21.6	M	122	30.3
	M	111	23.1	M	123	34.5
	M	111	23.7	M	124	33.0
	M	114	25.1	M	124	33.0
	F	101	16.9	M	124	35.6
	F	101	18.1	M	125	33.7
	F	102	16.5	M	127	36.1
	F	102	17.4	M	131	40.5
	F	106	19.4	M	133	41.6
	F	108	21.5	F	93	13.7
	F	109	23.4	F	98	11.1
	F	110	21.6	F	100	16.3
				F	103	17.5
				F	103	18.8