Competitive Influences of Gizzard Shad on Largemouth Bass and Bluegill in Small Impoundments

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Abstract: Studies in large and small ponds conducted on the Auburn University Fisheries Research Station from 1981 through 1983 suggest that gizzard shad (*Dorosoma cepedianum*) severely competed with largemouth bass (*Micropterus salmoides*) and bluegill (*Lepomis macrochirus*) populations. Gizzard shad introductions lowered bluegill reproductive success and caused an imbalance the first year of introduction. Gizzard shad grew rapidly through the size range where they were vulnerable to largemouth bass predation; in this 3-year study, largemouth bass were unable to control gizzard shad numbers. Within 2 years after introduction, gizzard shad comprised half the standing stock while replacing portions of the carrying capacity normally occupied by largemouth bass and bluegill. A proposed model of competition is that gizzard shad populations, even at low levels, filtered out enough food items to reduce survival of small bluegill. The process accelerated as gizzard shad populations expanded; with less bluegill reproduction available as prey, largemouth bass failed to recruit.

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Two studies on the Auburn University Fisheries Research Station attempted to document the extent and succession of competition caused by gizzard shad introductions into balanced largemouth bass/bluegill systems. Large pond experiments were used (1) to compare the changes in the structure and function of fish populations in ponds with and without gizzard shad and (2) to compare differences in the condition of fish caused by the presence of gizzard shad. Small pond experiments were used to determine if the presence of adult gizzard shad at relatively low densities lowered the reproductive success of bluegill.

Gizzard shad have frequently been introduced into balanced largemouth bass/bluegill systems to expand the forage base. Stocking gizzard shad is controversial and both those in favor of and opposed to such stockings find support in the literature. Heavy and beneficial use of gizzard shad by large predators, particularly in western impoundments, has been demonstrated (Dubets 1954, Schneidermeyer and Lewis 1956, Kutkuhn 1958, and Jester and Jensen 1972). Other studies have shown gizzard shad adversely affecting sport fish growth and recruitment (Swingle 1946, Jenkins 1957, Smith 1959, Miller 1960, Bodola 1966).

Methods

Large pond studies

In 1981, 6 research ponds (S–6, S–8, S–22, S–28, S–24, and S–14) totaling approximately 24 ha on the Auburn University Research Fisheries Station were selected for the research (Table 1). Ponds were limed, put on a regular fertilization schedule, and stocked with a ratio of 250 largemouth bass to 2,500 bluegill and redear sunfish (*Lepomis microlophus*) per hectare needed to bring the ponds into balance (balance is the ability of largemouth bass/bluegill stocked ponds to provide harvestable sized fish on a sustained basis). Additionally ponds were stocked with grass carp (*Ctenopharyngodon idella*), approximately 25- to 35-cm long, at a rate of 25 ha to control aquatic vegetation. Beginning in September 1981, gizzard shad were captured by electrofishing in West Point Reservoir, Alabama-Georgia, and transported (Anderson 1968) to treatment ponds (S–6, S–8, and S–22) for stocking; stocking continued until at least 250 gizzard shad survived per hectare.

Length/weight information from all 6 ponds was taken from July 1982 through September 1982 and May 1983 through September 1983; approximately 10 fish of

Table 1. Summary of community biomass ratios (E and A_t), standing stock fishes, and experimental status of S-series ponds drained in 1982 and 1983 on the Auburn Fisheries Research Station, Auburn, Alabama.

	S-24	S-22	S-8	S-14
Status[a]	C	T	T	C
Surface Area (ha)	0.9	0.9	3.1	5.2
Year Drained	1982	1982	1983	1983
E(LMB)	9.3	2.7	3.1	17.4
E(BG)	35.1	12.6	16.8	33.3
E(G Shad)		29.6	49.7	
E(RE)	25	36.2	7.0	26.8
E(T Shad)		1.7	9.4	
E(G Carp)	30	4.4	7.3	18.9
A_t			24	46
Total Biomass (kg/ha)	185	474	881	672
LMB (kg/ha)[b]	17	13	28	117
RE (kg/ha)	46	172	62	179
BG (kg/ha)	65	60	148	224
G Shad (kg/ha)		140	439	
Other (kg/ha)	57	89	204	152

[a]T = treatment ponds, C = control ponds.
[b]LMB = largemouth bass, RE = redear sunfish, BG = bluegill, G Shad = gizzard shad.

each species were collected monthly from each pond. Fish were measured for total length to the nearest mm and were weighed to the nearest 0.1 g. A condition factor (LeCren 1951) was determined for each fish and was used as a measure of food available to fish in treatment and control ponds. Comparisons of condition factors were made by a repeated measures design using the Statistical Analysis System (SAS). The 5% level of significance was used in all statistical comparisons.

The sequence of pond drainings provided an opportunity to view how the fish population structure evolved with time. In November 1982, S–22 and S–24 were drained. Fish were sorted by species, counted, weighed by centimeter group, and length-frequency distributions per unit area determined. Ponds S–8 and S–14 were drained in October 1983 and similarly analyzed; ponds S–6 and S–28 were sampled for length/weight information but were not drained. Community biomass ratios (Swingle 1950) were developed to determine the state of each pond's balance and hence how the population functioned. The E value (the percent species contribution to the total population biomass) and the A_t value (the percentage by weight of the fish population of harvestable size) were the biomass ratios chosen.

Small pond studies

Research to test if adult gizzard shad reduced the spawning success of adult bluegill was conducted during May through August of 1982 and 1983. Six 0.1-ha, F-series ponds which were limed and put on a regular schedule of fertilization were used each year. The time period of May through August was chosen because gizzard shad would have completed spawning and adult bluegill would be spawning. In May 1982 and 1983, all 6 ponds were stocked with 30 bluegills 9- to 15-cm long. Three treatment ponds were randomly selected yearly and adult gizzard shad were stocked until at least 125 adult gizzard shad remained alive in each treatment pond. In late August of each year, the ponds were drained and most fish were collected; the remaining small fish were collected by adding rotenone. Adult fish were counted and weighed. The weight of the bluegill reproduction in treatment versus control ponds was compared using ANOVA procedures on SAS.

Results

Large pond studies

Ponds S–22 and S–24, both approximately 1 ha, were drained in November 1982. S–22, with gizzard shad, was already going out of balance (Table 1) as defined by Swingle (1950) based on the E value for largemouth bass of 2.7% (a value of 10% is considered desirable for balance). Gizzard shad made up almost 30% of the total standing stock in S–22. Based upon E values for largemouth bass, redear sunfish and bluegill, S–24 (which was the control) was essentially in balance (Table 1). Standing stocks of largemouth bass and bluegill were similar in both ponds. Survival of largemouth bass from May until November was the same in both ponds. A_t values were not considered because a full year had not elapsed since stocking.

Figure 1 shows the length-frequency distribution for bluegill in S–22 and

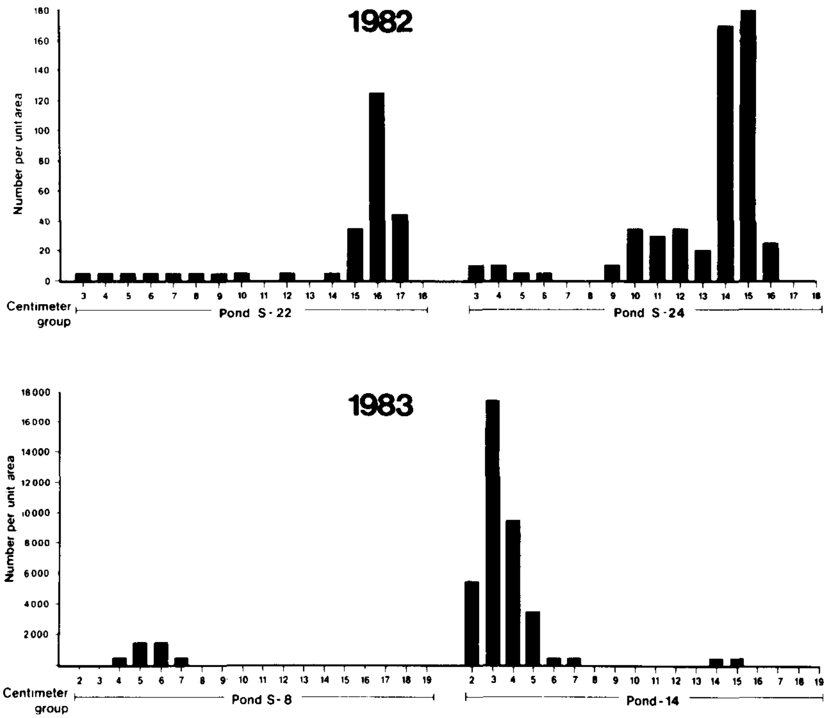

Figure 1. Length/frequency distributions of bluegill based upon fall pond drainings in 1982 and 1983 (with ponds S-8 and S-22 stocked with gizzard shad) on the Auburn University Fisheries Research Station, Auburn, Alabama.

S–24 on a per unit area basis. It appears that bluegill in S–24 had a more successful spawn as evidenced by the greater numbers of fish in the 9 to 13-cm size range. Figure 2 is the distribution of gizzard shad in S–22; while not reaching a high level of abundance, the YOY gizzard shad grew rapidly, the size range of 18 to 24 cm represented the first spawn.

Ponds S–8 and S–14 were drained during October 1983 at the end of the second growing season. Pond S–8, the treatment pond, was considered to be out of balance based upon biomass ratios; gizzard shad comprised about 50% of the standing stock (Table 1). Inadvertant contamination with threadfin shad (while in the process of stocking gizzard shad) resulted in an additional 9.4% of the biomass being threadfin shad. Together the 2 species made up almost 60% of the standing stock or 520 kg/ha out of the total standing stock of 881 kg/ha in S–8 (Table 1). On the other hand, S–14 was in balance based upon E and A_t values and had almost 5 times the standing stock of largemouth bass (117 kg/ha versus 27.8 kg/ha in S–8). Additionally, S–14 had almost 3 times the standing stock of redear and twice the standing stock of bluegill. There was a marked difference between the length-frequency

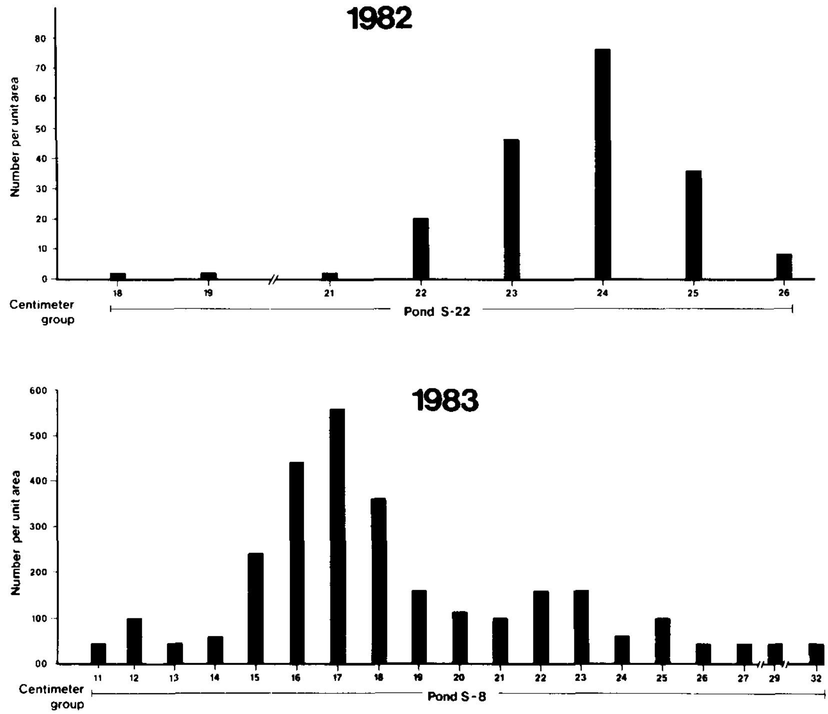

Figure 2. Length/frequency distributions of gizzard shad based upon fall pond drainings in 1982 and 1983 on the Auburn University Fisheries Research Station, Auburn, Alabama.

distributions of bluegill in S–14 and S–8 (Fig. 1). In S–14, the control pond, there were almost 10 times as many small bluegill and twice as many intermediate bluegill as in S–8. There were 3 times as many largemouth bass in S–14 with substantial numbers in the size category less than 26 cm total length (Fig. 3). Survival, reproduction, and recruitment was lower for largemouth bass in S–8. Length-frequency distributions of gizzard shad and threadfin shad, Figures 2 and 4 respectively, indicate that threadfin shad were readily available as prey while gizzard shad were usually too large to be eaten by most of the largemouth bass in S–8.

There were no significant differences in condition factors for largemouth bass, bluegill, or redear sunfish between the treatment and control ponds. These results may reflect heavy spawning that occurred in control ponds.

Small pond studies

There was significantly more bluegill reproduction in ponds without gizzard shad and the influence of year (1982 versus 1983) was not significant (Table 2). Ex-

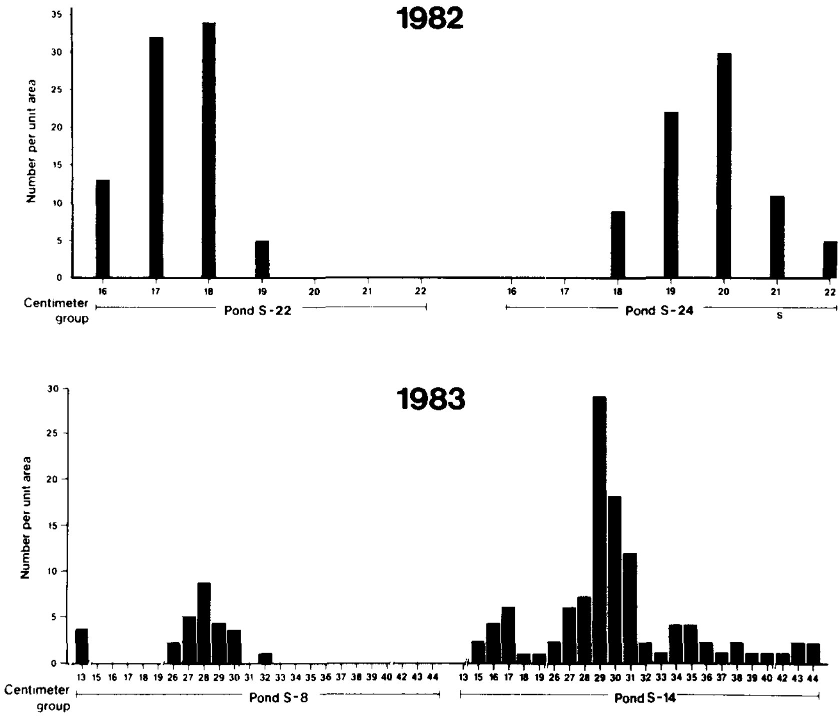

Figure 3. Length/frequency distributions of largemouth bass based upon Fall pond drainings in 1982 and 1983 (with ponds S-8 and S-22 stocked with gizzard shad) on the Auburn University Fisheries Research Station, Auburn, Alabama.

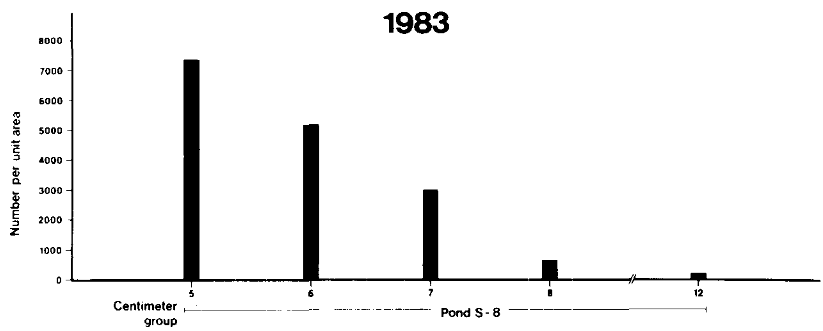

Figure 4. Length/frequency distribution of threadfin shad based upon a Fall pond draining in 1983 on the Auburn University Fisheries Research Station, Auburn, Alabama.

Table 2. Summary of F-series pond drainings to determine the influence of adult gizzard shad on bluegill reproductive success conducted on the Auburn University Fisheries Research Station, Auburn, Alabama, during the summers of 1982 and 1983.

Pond	Status	Weight of Bluegill Reproduction	Adult Bluegill Survival	Adult Gizzard Survival
		1982 Pond Drainings		
F-16	C[a]	31.1[b]	26/30	
F-17	T	7.5	11/30	79/125
F-18	C	10.9	25/30	
F-19	C	30.0	26/30	
F-20	T	8.3	30/30	85/125
F-26	T	(Contaminated with unwanted fish)		
		1983 Pond Drainings		
F-16	T	6.5	13/30	43/125
F-17	T	1.2	17/30	59/125
F-18	C	9.5	15/30	
F-19	C	25.4	14/30	
F-20	C	16.2	16/30	
F-21	T	6.2	21/30	109/125

[a]T = treatment, C = control.
[b]All weights are in Kg.

perimental ponds were stocked substantially below carrying capacity, so that food should not have been limiting to adult fish. In fact, both adult bluegill and gizzard shad grew in size during the experiment.

Discussion

Large pond drainings provided community biomass ratios and length frequency distributions demonstrating a succession of competition adversely influencing largemouth bass and bluegill in treatment ponds. Biomass ratios (Swingle 1950) showed that the pond with gizzard shad (S–22) was going out of balance by the end of the first year. Biomass ratios relate to the function of predators and prey in balanced systems and unsatisfactory values imply that the reproduction and growth of bluegill and largemouth bass may be inadequate. By the end of the second year, 1983, bluegill in treatment ponds had substantially reduced reproductive success and largemouth bass almost complete reproductive failure. Again biomass ratios confirm an imbalance.

Largemouth bass and gizzard shad may not compete directly; rather competition could be through the inhibition of bluegill reproductive success by gizzard shad. Inhibition of bluegill spawning success could come from (1) a decrease in condition and fecundity of adult bluegill, (2) gizzard shad eating small bluegill or bluegill eggs, or (3) lowered survival of small bluegill. The results of large and small pond studies suggest that competition comes from the lowered survival of small bluegill. Evidence supporting this contention comes from small pond experiments in which the presence of adult gizzard shad lowered bluegill reproduction within three months even though the ponds were stocked well below carrying capacity. Additionally in large pond experiments, examination of length-frequency distributions of bluegill in 1982 and 1983 demonstrate lowered bluegill reproductive success in treatment ponds; this lowering of reproductive success occurred even though there was not a significant difference in the condition of adult bluegill between treatment and control ponds. Drenner et al. (1982) indicated that in some reservoirs gizzard shad can filter the entire volume of water within several days and alter zooplankton communities. Collins (pers. commun.) studied food availability in the ponds used in this research and indicated that by the start of the second year, larger zooplankton appeared to be much less abundant in treatment ponds. Werner (1979) implied an energetically optimum size of food item for fish of a given size; fish tend to feed on food items of a size that maximize energy return compared to energy expended in capture. Gizzard shad may filter out optimum sized food items required by smaller bluegill, and as a result, these small bluegill cannot forage efficiently enough to survive. Juvenile largemouth bass must have a readily available diet of translucent bluegill fry all summer long in order to obtain the growth and condition necessary to survive to their first spawning season (Davies et al. 1982).

Largemouth bass were not able to control the numbers of smaller gizzard or threadfin shad. During the first summer, young-of-the-year (y-o-y) gizzard shad rapidly grew through the size range where they were vulnerable to largemouth bass predation. Most of the y-o-y gizzard shad were in the 22- to 24-cm size range by November 1982. Gizzard shad were numerous in all size ranges by the start of the second bluegill spawning season and occupied a significant portion of the total standing stock. Gizzard shad were then far too numerous to be controlled by the existing largemouth bass populations. Dense gizzard shad populations probably acted as an efficient biological filter, removing most of the food items needed by small bluegill for growth. As a result, bluegill recruitment and growth were stopped for most of the second growing season. Largemouth bass failed to successfully recruit without bluegill reproduction. Adult largemouth bass also fared poorly because of fewer intermediate bluegill produced either during the previous or current growing season. Because of these results, we recommend that gizzard shad not be stocked with largemouth bass and bluegill in fertilized, southeastern impoundments.

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