Food and Growth of Age–0 Hybrid Striped Bass in Ross Barnett Reservoir, Mississippi

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Abstract: Food and growth of age–0 hybrid striped bass (*Morone saxatilis* x *M. chrysops*) were examined during June–November 1988–1989 in Ross Barnett Reservoir, Mississippi. Shads (*Dorosoma* spp.), especially threadfin shad (*D. petenense*), made up about 70%–90% of the diet by weight. Other fish made up about 3%–20% of the diet and were eaten primarily by hybrids <150 mm total length. Invertebrates constituted a small percentage of the diet, and were eaten mostly by fish <100 mm and not by those >150 mm. By November, the length of age–0 fish averaged 241 mm in 1988 and 227 mm in 1989. Differences in growth between years might have been caused by differences in availability and consumption of shads. Widening of hybrid length-frequency distributions in August–September coincided with reduction of shad consumption and increased incidence of empty stomachs in fish <100 mm long, suggesting reduced availability of suitable-sized prey for smaller hybrids toward the end of the summer.

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Stocking hybrid striped bass (hybrids) has become a popular management strategy for intensifying predation on forage fish in large reservoirs (Germann and Bunch 1985). Adults have been shown to prefer shads over other forage fish (Williams 1970, Ware 1974, Crandall 1978, Germann 1982), but information on the food preferences of age–0 hybrids is limited. Hybrids provide a "put-grow-and-take" fishery that depends directly on prey availability for rapid first-year growth and survival (McDaniel et al. 1988). Thus, knowledge of prey availability and consumption is critical to the success of stocking programs.

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Since 1983, age–0 hybrids have been stocked annually in Ross Barnett Reservoir, Mississippi, at rates ranging from 0.05 to 52.00 fish/ha. The purpose of our study was to quantitatively describe the diet of age–0 hybrids during their first 6 months after stocking in 1988 and 1989 and to determine growth and its relation to diet. This research was funded by the Mississippi Department of Wildlife, Fisheries and Parks (MDWFP) through Federal Aid to Fisheries Project F–82 and by the Mississippi Agriculture and Forestry Experiment Station. We thank R. Muncy and MDWFP staff for their assistance in field collections, and P. Eschmeyer, H. Folmar, W. Kelso, R. Robinnette, and C. Young for reviewing the manuscript.

Study Area

Ross Barnett is a 12,500-ha reservoir 9.6 km northeast of Jackson, Mississippi. It was impounded in 1962 by a 9.4-m high earthen dam on the Pearl River, which by January 1965 impounded water 59 km upstream (Barkley 1971). The reservoir consists of 9,000 ha of open-water lake habitat and 3,500 ha of Pearl River lotic habitat. The Pearl River portion, which begins at Kilometer 21 and extends 38 km, is characterized by numerous bends, river cuts, and sloughs. Shoreline habitat ranges from sandy beaches to forested land. Water level in 1989 averaged 0.5 to 1.0 m above 1988 levels. Each 1-m change in water level elevation results in surface area changes of about 2,700 ha, illustrating the extensive shallow inshore habitat of this reservoir.

Standing crop of fish in the reservoir averaged 512 kg/ha in August (Folmar 1988, 1989). Gizzard shad (*D. cepedianum*) composed 62% of the total standing crop and threadfin shad, 1%. The total standing crop included 6% sunfish (*Lepomis* spp.), 4% black basses (*Micropterus* spp.), and 2% crappies (*Pomoxis* spp.). White bass (*Morone chrysops*) do not occur in the reservoir, and gars *Lepisosteus* are the only other major open-water predatory fish.

Methods

Age–0 hybrids numbering 320,000 and averaging 35 mm total length were stocked on 7 May 1988 and 650,000 more, averaging 45 mm, were stocked on 24 May 1989 at the Kilometer–39 access ramp on Ross Barnett Reservoir. Fish were obtained from the Toledo Bend Hatchery, Louisiana, and reared to fingerlings at the MDWFP's Turcotte Laboratory, adjacent to Ross Barnett Reservoir.

Field collections with a 1.8- × 9.2-m seine having 9.5-mm mesh began on 27 June 1988 and 22 June 1989, and were made every 2 weeks through November of each year. Sampling was restricted to sandy beaches upstream from Kilometer 21 after seining in other habitats throughout the reservoir proved unsuccessful. Fish were sampled at 6 stations located within 9 km (upstream or downstream) from the original stocking site. Seining began at dusk, and 2 to 4 seine hauls of about 15 m each were taken at each station. Fish were held on ice during sampling, and later frozen.

All hybrids collected were measured (total length in millimeters), weighed to the nearest 0.01 g, and examined for stomach contents. Food items were weighed to the nearest 0.01 g, and classified into 4 groups: 1) shads, 2) fish remains that were digested beyond recognition, 3) insects, consisting only of mayflies (*Hexagenia* spp.) and chironomids, and 4) other fish including sunfishes, shiners (*Notropis* spp.), and topminnows (*Fundulus* spp.), brook silversides (*Labidesthes sicculus*), and mosquitofish (*Gambusia affinis*).

Stomach data were analyzed by month to estimate 5 relations: 1) frequency of empty stomachs 2) frequency of occurrence of each food type, 3) diet composition by number, 4) diet composition by wet weight, and 5) stomach fullness computed as food weight/(fish weight − food weight). Analyses 2 to 5 excluded fish with empty stomachs. Instantaneous growth (G) was calculated by regressing the natural logarithm of mean length (and weight) on time (days), the slope of this regression being G (Ricker 1975).

Results

A total of 524 age–0 hybrids was examined in 1988 and 406 in 1989. The percentage of empty stomachs was 19 in 1988 and 26 in 1989 (Table 1) and statistically different ($P \leq 0.05$, chi-square test of homogeneity). Chi-square tests also indicated that the percent composition (number and weight) of food eaten by age–0 hybrids differed significantly between 1988 and 1989.

Shads (90% threadfin shad) were the most important food of age–0 hybrids in 1988 (Table 2). Hybrids <100 mm fed primarily on shads, along with some insects, during June and July, but other fish species replaced insects in the diet during August and September. Only 4 hybrids <100 mm long were sampled in October, all of which had empty stomachs, but none this small were collected in November. Shads made up <60% by weight of the diet in hybrids 100–150 mm long from July to October; no hybrids this small were collected in November. Insects and other fish

Table 1. Empty stomachs and stomach fullness during June–November in 524 age-0 hybrid striped bass collected in 1988 and 406 collected in 1989 in Ross Barnett Reservoir, Mississippi.

Stomach parameter	Length group (mm)			
	<100	100–150	>150	All
		1988		
Empty stomachs (%)	18.4	29.0	11.9	19.4
Stomach fullness (%)	5.8	3.5	2.9	4.2
		1989		
Empty stomachs (%)	28.9	25.7	21.2	26.0
Stomach fullness (%)	4.7	3.7	3.2	3.8

Table 2. Frequency of occurrence and composition by number and weight of food items eaten by age-0 hybrid striped bass in Ross Barnett Reservoir, Mississippi, June–November 1988 and 1989. Dots indicate fish in that length group were not collected.

	1988						1989					
Food item	Jun	Jul	Aug	Sep	Oct	Nov	Jun	Jul	Aug	Sep	Oct	Nov
Frequency of occurrence (%)												
<100												
Insects	11	11	0	0	0	·	31	13	63	29	0	·
Shads	71	70	25	17	0	·	53	57	21	0	0	·
Other fish	2	3	12	17	0	·	18	24	37	71	0	·
UFR[a]	42	24	63	66	0	·	29	31	5	14	0	·
100–150												
Insects	·	0	4	4	0	·	·	0	2	0	0	0
Shads	·	82	70	35	100	·	·	100	76	65	40	50
Other fish	·	9	0	15	0	·	·	0	31	41	60	50
UFR	·	9	44	50	24	·	·	0	22	18	33	50
>150												
Insects	·	·	0	0	0	0	·	·	0	0	0	0
Shads	·	·	63	94	100	94	·	·	80	95	94	94
Other fish	·	·	0	2	0	0	·	·	20	34	12	38
UFR	·	·	37	12	24	50	·	·	0	18	24	25
Composition by number (%)												
<100												
Insects	8	10	0	0	0	·	27	18	73	47	0	·
Shads	60	65	30	6	0	·	42	46	8	0	0	·
Other fish	1	1	10	19	0	·	11	17	16	47	0	·
UFR	31	24	60	75	0	·	20	19	3	6	0	·
100–150												
Insects	·	0	4	5	0	·	·	0	1	0	0	0
Shads	·	96	67	41	37	·	·	100	65	50	28	34
Other fish	·	2	0	20	5	·	·	0	20	28	36	33
UFR	·	2	29	34	58	·	·	0	14	22	36	33
>150												
Insects	·	·	0	0	0	0	·	·	0	0	0	0
Shads	·	·	75	94	92	80	·	·	90	73	87	76
Other fish	·	·	0	1	0	0	·	·	10	16	3	14
UFR	·	·	25	5	8	20	·	·	0	11	10	10
Composition by weight (%)												
<100												
Insects	3	2	0	0	0	·	13	2	37	13	0	·
Shads	86	86	44	32	0	·	67	64	19	0	0	·
Other fish	1	1	17	19	0	·	12	25	42	82	0	·
UFR	10	11	39	40	0	·	8	9	2	5	0	·
100–150												
Insects	·	0	1	1	0	·	·	0	1	0	0	0
Shads	·	98	81	68	88	·	·	100	77	65	50	64
Other fish	·	1	0	13	4	·	·	0	19	31	44	30
UFR	·	1	18	18	8	·	·	0	3	4	6	6
>150												
Insects	·	·	0	0	0	0	·	·	0	0	0	0
Shads	·	·	90	98	99	99	·	·	85	88	97	88
Other fish	·	·	0	1	0	0	·	·	15	11	2	11
UFR	·	·	10	1	1	1	·	·	0	1	1	1

[a]UFR = Unidentified fish remains.

species were of minor importance to hybrids 100–150 mm long. Shads composed all of the identifiable food in fish >150 mm. Size of fish eaten increased from June to November; prey length averaged 26% of the length of the hybrids (range 9%–45%) and never exceeded 68 mm.

Shads (70% threadfin shad) were also the most important food of hybrids in 1989 (Table 2). Shads composed the greatest portion of the diet of hybrids <100 mm long during June and July, but insects and other fish species were also eaten. In August, insects were the most important forage of hybrids <100 mm by number, and second to fish other than shads by weight. In September–November, shads were not eaten by hybrids <100 mm long; fish of other species and insects took their place. All fish <100 mm long sampled in October had empty stomachs, and none were collected in November. Food of hybrids 100–150 mm long consisted of all shads in July, but consumption of shads by hybrids of this size dropped steadily from August to October, replaced mostly by other fish prey. By weight, shads composed ≥85% of the food of hybrids >150 mm long through November; other fish species constituted the rest of the identifiable food. Size of fish eaten increased from June to November; their length averaged 20% (range = 12%–48%) of the lengths of the hybrids, and never exceeded 66 mm.

By number, hybrids ate a significantly greater percentage of insects in June–August 1989 and fish other than shads during June–November 1989, than in the same periods in 1988. By weight, they ate a significantly greater percentage of insects in June 1989 and fish other than shads during June–October 1989 than in the same periods in 1988. Fish composed a significantly lower proportion of the diet by weight in June 1989 than in June 1988.

Stomach fullness averaged 4.2% in 1988 and 3.8% in 1989 (Table 1). Friedman's 2-way classification tests indicated monthly estimates were not significantly different ($P > 0.05$) between years nor among size groups. However, monthly values generally decreased from June to November, possibly because as fish grew, they tended to consume a smaller percentage of their body weight.

By November, age–0 fish averaged 241 mm (193 g) in 1988 and 227 mm (170 g) in 1989 (Table 3). In 1988, when hybrids were stocked at 35 mm (0.7 g), estimates of daily instantaneous growth (and standard errors) based on length and weight were 0.0094 (0.0010) and 0.0300 (0.0027), respectively. In 1989, when hybrids were stocked at 45 mm (1.0 g), these values were 0.0083 (0.0005) and 0.0280 (0.0017), respectively. The 95% confidence limits around estimates of instantaneous growth did not overlap between years indicating growth was significantly higher in 1988. Lengths of hybrids were fairly uniform during June and July in both years, but by August they began to spread (Fig. 1).

Discussion

Food of age–0 hybrids reportedly ranges from primarily invertebrates to primarily fish. Studies in several reservoirs indicated that zooplankton, insects, crustaceans, and non-shad fishes were the main forage of hybrids <150 mm and that shads

Table 3. Sample size (*N*), mean, and standard deviation (SD) of total lengths and weights of age-0 hybrid striped bass collected on various dates at Ross Barnett Reservoir, Mississippi, 1988 and 1989.

Date	Days post-stocking	*N*	Length (mm)	SD	Weight (g)	SD
			1988			
27 May	0	320,000	35	6.4	0.7	NA[a]
27 Jun	31	237	73	9.2	3.5	1.5
9 Jul	43	26	87	10.2	6.0	2.0
20 Jul	55	28	95	7.9	9.5	3.7
2 Aug	67	23	118	26.4	24.9	15.8
16 Aug	81	44	122	6.4	27.5	19.9
1 Sep	97	45	151	37.5	54.1	34.9
15 Sep	111	54	156	32.3	57.2	34.5
1 Oct	127	28	145	40.2	50.5	47.1
13 Oct	139	20	168	44.3	76.3	61.7
1 Nov	158	11	220	12.6	154.6	75.5
14 Nov	171	8	241	25.7	193.3	42.4
			1989			
24 May	0	650,000	45	7.3	1.0	NA
22 Jun	29	62	66	11.0	2.5	1.6
8 Jul	45	44	77	7.3	4.1	1.3
24 Jul	61	55	88	6.7	7.2	2.2
8 Aug	76	53	109	13.8	16.5	7.3
24 Aug	92	41	119	25.6	24.8	16.0
7 Sep	106	36	145	34.8	47.4	30.6
22 Sep	121	51	152	31.4	52.3	33.6
9 Oct	138	24	143	40.2	49.0	46.1
24 Oct	153	16	171	43.2	82.5	62.4
9 Nov	169	14	215	43.1	149.8	71.5
25 Nov	185	10	227	28.5	169.7	50.0

[a]NA = not available.

became important in larger fish (Ott and Malvestuto 1981, Saul and Wilson 1981, Kinman 1987, Austin and Hurley 1988, McDaniel et al. 1988). In Ross Barnett Reservoir, shads were the most important forage of age–0 hybrids of all sizes. Other fish were eaten, but far less frequently than shads, and primarily by hybrids <150 mm long. Invertebrates constituted a small percentage of the diet and were eaten mostly by hybrids <100 mm and not by those >150 mm long.

Hybrids exhibited higher consumption of threadfin shad, even when 0.4-ha littoral and open-water rotenone samples suggested that age–0 gizzard shad were as abundant as threadfin shad in 1988 (Folmar 1988), and more abundant than threadfin shad in 1989 (Folmar 1989). This may be related to the tendency of age–0 gizzard shad to outgrow their predators or to differences in habitat distribution or both. Age–0 gizzard shad quickly outgrew age–0 hybrids in East Fork Lake, Ohio, resulting in restricted consumption of gizzard shad (Austin and Hurley 1988). Ott and Malvestuto (1981) reported there was little relation between prey length and age–0 hybrid length in West Point Reservoir, Alabama-Georgia, and that hybrids fed on fish about 65

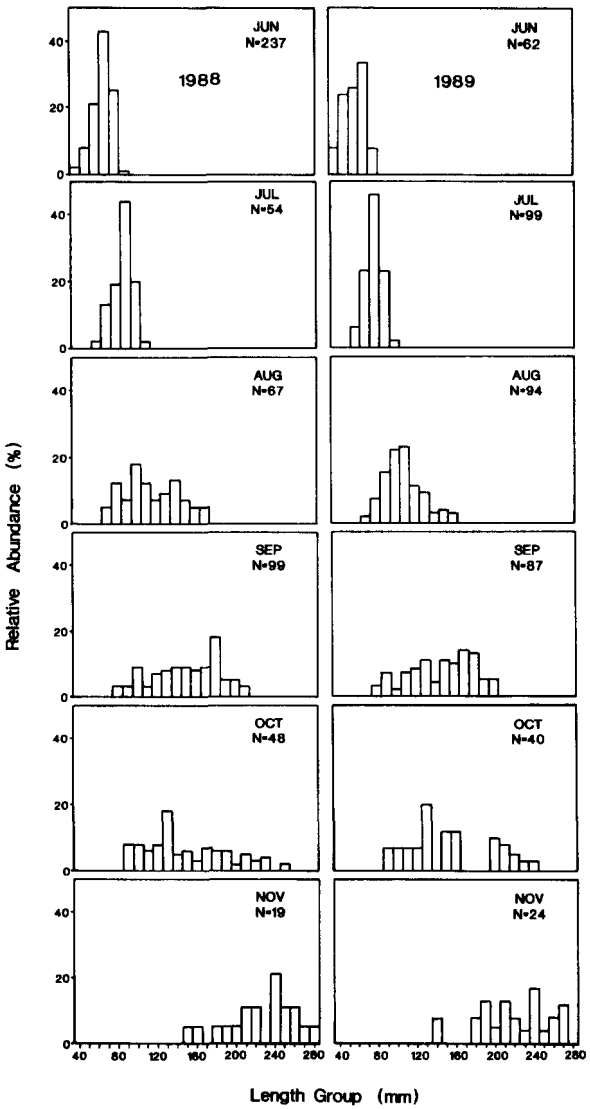

Figure 1. Length-frequency distributions of age–0 hybrid striped bass in Ross Barnett Reservoir, Mississippi, June–November 1988 and 1989.

mm long despite their ability to eat longer fish. In West Point Reservoir, hybrids >150 mm long fed to a greater extent on threadfin shad because both species were primarily pelagic (Ott and Malvestuto 1981).

The relatively minor differences in diets of hybrids between 1988 and 1989 could have been due to differences in shad abundance, stocking rates, and environmental conditions. The greater abundance of threadfin shad in 1988 (Folmar 1988, 1989) might have caused the greater rate of shad consumption in 1988; conversely, the greater abundance of gizzard shad in 1989 might have been reflected in increased

percentage of gizzard shad in the shads food category in 1989. Because the stocking rate was higher in 1989, competition for available fish food may have been intensified, perhaps leading to increased consumption of invertebrates. The higher water levels in 1989 resulted in flooding of terrestrial vegetation and littoral zone sediments, perhaps increasing invertebrate production (Cooper and Knight 1985) and consumption by hybrids.

Growth rates of age–0 hybrids in Ross Barnett Reservoir in 1988 and 1989, were equal to or higher than those estimated from published reports on Cherokee Reservoir, Tennessee (Saul and Wilson 1981), and East Fork Lake, Ohio (Austin and Hurley 1988). Development of polymodal length distributions during the first year of growth was reported for 2 of 3 year classes of age–0 hybrids in East Fork Lake (Austin and Hurley 1988). Widening of length-frequency distributions in Ross Barnett Reservoir coincided with the reduction of shad consumption by hybrids <100 mm long in August–September and the concurrent increase of empty stomachs. This indicates a possible reduction in availability of suitable-sized prey for smaller hybrids toward the end of the summer. Differences in growth between the 1988 and 1989 year classes may be explained by differences in diet. In 1988, fewer hybrids had empty stomachs, stomach fullness was generally higher, diet included a greater percentage of fish, and length of fish prey averaged a slightly larger percentage of hybrid length.

Based on observed hybrid growth, Ross Barnett Reservoir appeared to adequately support annual stocking rates of 26–52 hybrid fingerlings/ha, but long-term effects of these stocking rates on the fish community are unknown. Gizzard shad contributed little to the diet of hybrids, despite composing a high percentage of the forage in the reservoir. Thus, when gizzard shad and threadfin shad are present, the stocking of hybrids may not be a good management measure for reducing overabundant gizzard shad unless hybrids prey more extensively on gizzard shad as adults. However, adult hybrids reportedly feed predominantly on threadfin shad (Ott and Malvestuto 1981, Germann 1982, Germann and Bunch 1985). Consequently, stocking rates in Ross Barnett Reservoir should be based primarily on threadfin shad abundance. Incorporation of prestocking evaluations of potential stocking sites could aid in identifying areas with high prey abundance, and timing the stocking with threadfin shad spawning may increase the growth and survival of hybrids.

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