Utilization of Alewives and Gizzard Shad by Striped Bass in Smith Mountain Lake, Virginia.

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Abstract: Alewives (*Alosa pseudoharengus*) and gizzard shad (*Dorosoma cepedianum*) were the principal prey items in the stomachs of 708 striped bass (*Morone saxatilis*) collected in Smith Mountain Lake, Virginia, from April to December 1983 and 1984. Alewives comprised 51% and 39% of ingested prey items by number and weight, respectively; comparable values for gizzard shad were 38% and 58%. Stomach contents differed significantly between habitats (upper and lower reservoir) and among seasons. Regression analyses between size of consumed clupeids and total length of striped bass indicated a greater morphological availability of alewives to all sizes of striped bass.

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The striped bass has been introduced into many reservoirs of the southeastern United States to utilize and control abundant clupeid populations, specifically gizzard shad and threadfin shad (*Dorosoma petenense*) (Bailey 1974, Axon and Whitehurst 1985). However, gizzard shad are vulnerable to predation mainly as young-of-

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the-year (Dendy 1946, Ranthum 1969, Jester and Jensen 1972, Carver et al. 1976) and quickly become morphologically unavailable to the smaller size classes of striped bass. Threadfin shad seldom exceed 175 mm in length (Noble 1981), but are unable to survive in waters where winter water temperatures drop below 9° C (Strawn 1963). These constraints prompted consideration of the alewife (*Alosa pseudoharengus*) as an alternative forage for pelagic piscivores in large reservoirs. Introduced alewives have become a successful prey species in many lacustrine systems, most notably the Great Lakes (Ney et al. 1982). Kohler and Ney (1980) determined that the alewife was the primary food of striped bass in Claytor Lake, Virginia, where it is the only resident clupeid. More commonly, alewives in southeastern reservoirs co-occur with gizzard shad. Whether and to what degree alewives are utilized by striped bass in the presence of an abundant gizzard shad population has not been clearly determined.

Objectives of this study were to (1) determine seasonal consumption of alewives by striped bass in Smith Mountain Lake, Virginia, a reservoir where alewives and gizzard shad are both abundant, and (2) compare food habits between striped bass collected from 2 distinct habitats, the upper and lower portion of the reservoir.

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Methods

Smith Mountain Lake is a 8,400-ha, hydroelectric reservoir, located in southeastern Virginia. Formed by the impoundment of the Blackwater and Roanoke Rivers, Smith Mountain Lake has a mean depth of 16.8 m, is eutrophic and riverine in the upper Roanoke River and Blackwater River arms, and becomes progressively more mesotrophic and lacustrine downstream (Va. State Water Control Bd. 1980). For purposes of this study, the reservoir was considered to consist of 2 distinct habitats, the upper and lower reservoir, arbitrarily divided at the Hales Ford Bridge.

Striped bass have been stocked annually in Smith Mountain Lake since 1963. Other major predators include walleye (*Stizostedion vitreum vitreum*), largemouth bass (*Micropterus salmoides*), and smallmouth bass (*M. dolmieui*). Alewives, introduced in 1965, and gizzard shad are the principal forage species.

Striped bass were collected from Smith Mountain Lake from April to December in both 1983 and 1984 using gill nets and electroshocking equipment. Samples were supplemented with angler catches. Experimental gill nets, 61 m long by 2 m deep and consisting of panels with bar meshes 38 to 76 mm, were fished overnight weekly from April through September of each year and once a month in October, November, and December in both the upper and lower portions of the reservoir. Electrofishing was conducted periodically in April, May, August, and November 1983, and April to August, November, and December 1984. Collections were limited to the Roanoke River arm and main area of the lake, below the confluence of the Blackwater and Roanoke Rivers.

Stomachs were excised from all striped bass collected in gill nets and from anglers and preserved in 10% buffered formalin. Hollow plastic tubes of various diameters were used to remove stomach contents from electroshocked fish (Van Den Avyle and Roussel 1980). Fish were then released alive, and stomach contents were preserved in formalin.

In the laboratory, stomach contents were identified to the lowest possible taxa. Partially digested gizzard shad and alewives were identified on the basis of the presence (or absence) of a gizzard and the color of the peritoneum (Manooch 1973). Food items were blotted dry and weighed to the nearest 0.1 g. Stomach content data were tabulated by location and season: winter (December-February); spring (March-May); summer (June-August); fall (September-November), and were expressed as percent of the total number of food items and percent of total food weight. Total, standard, and backbone lengths of identifiable piscine prey items were measured to the nearest millimeter. Standard and backbone lengths of consumed alewives and gizzard shad were converted to total lengths by using regression equations developed for these species collected in the reservoir. The relation between total lengths of consumed clupeids and striped bass from which they were taken were calculated and compared by linear regression.

Results and Discussion

Of the total 708 striped bass stomachs examined from collections between April 1983 and December 1984, 49% contained food; of these, 122 came from the upper reservoir and 225 from the lower portion.

Alewives and gizzard shad were the principal food items found in striped bass stomachs (Table 1). Alewives comprised 51% of diet items and 39% of stomach contents by weight. The respective values for gizzard shad were 38% and 58%. As judged by general clupeoid body shape, most of the unidentified fish were either alewives or gizzard shad. Crayfish (*Orconectes* spp.) occurred consistently in stomachs but nearly always at frequencies of <10%. Crayfish have been found in stomachs of striped bass collected from the tailwaters of Keystone Reservoir, Oklahoma (Combs 1978), and Lake Powell, Arizona-Utah (Hepworth et al. 1977). Miscellaneous food items, which occurred relatively infrequently, included minnows (*Notropis* spp.), sunfishes (*Lepomis* spp.), darters (*Etheostoma* sp.), burrowing mayflies (*Hexagenia* sp.), and chironomid larvae. Relatively low utilization of non-clupeid fish and gamefish was also documented in previous studies (Stevens 1957, Ware 1970, Combs 1978, and Matthews and Hill 1982).

Stomach contents of striped bass were significantly different between habitats and among seasons in Smith Mountain Lake (χ^2, $P \leq 0.05$). In the upper reservoir, gizzard shad dominated alewives in the diet (% weight) by nearly a 100:1 ratio in winter; alewives were predominant in spring and summer by roughly 3:1 and 90:1, respectively; and the ratio of alewives to gizzard shad in the fall was almost even. In the lower lake, alewives dominated gizzard shad in spring, summer, and fall by

Table 1. Percent of total number of prey items (N) and percent of total food weight (W) contributed by different types of prey consumed by striped bass in Smith Mountain Lake, 1983–1984.

Location and Season[a]	Striped bass		Alewife		Gizzard shad		Unidentified fish		Crayfish		Miscellaneous	
	Examined	With Food (%)	*N*	W	*N*	W	*N*	W	*N*	W	*N*	W
Upper												
Winter	74	57	1	1	97	99	1	T[b]	1	T	T	T
Spring	46	33	60	75	26	22	5	2	2	T	7	2
Summer	86	40	82	95	12	2	2	1	4	2	1	T
Fall	86	40	48	46	28	43	15	3	10	8		
Total	292	43										
Lower												
Winter	9	0										
Spring	161	59	83	91	1	2	11	5	1	1	3	1
Summer	163	55	71	74	15	18	4	2	8	6	2	T
Fall	83	54	73	63	9	28	10	2	6	7	2	T
Total	416	55										

[a]Hales Ford Bridge was the boundary between the upper and lower lakes.
[b]Trace (T) = <0.5

roughly 40:1, 5:1, and 6:1 ratios, respectively. Nine striped bass stomachs collected from this location in the winter were empty.

Predominance of alewives in the diet may simply reflect relative abundance. Although estimates for gizzard shad standing stocks for Smith Mountain Lake are available (Whitehurst 1984), none exist for alewives. Hart (1978) and La Roche (1981) assumed the gizzard shad was the most abundant forage species in Smith Mountain Lake prior to 1981. Because of possible interspecific interactions, a complete reproductive failure of gizzard shad in 1978 (La Roche 1981) may have allowed for an expansion of the alewife population. When threadfin shad were stocked in reservoirs containing gizzard shad, they partially displaced them (Noble 1981).

The dietary importance of alewives may reflect the differential morphological availability of the 2 clupeids. Regressions between total lengths (mm) of consumed clupeids and total lengths (mm) of striped bass indicate a stronger linear relationship between total length (TL) of consumed gizzard shad and striped bass:

$$\text{gizzard shad TL} = .05\ (\text{striped bass TL}) + 75.06,\ N = 456,\ r^2 = 0.19\ (\text{Fig. 1});$$

than between consumed alewives and striped bass:

$$\text{alewife TL} = 0.27\ (\text{striped bass TL}) + 73.98,\ N = 682,\ r^2 = 0.05\ (\text{Fig. 2}).$$

On the average, larger striped bass consumed larger gizzard shad, indicating that gizzard shad can rapidly grow beyond the size that could be swallowed by the smaller striped bass. If striped bass are capable of consuming prey equal to 60% of their body length (Manooch 1973), young-of-the-year (y-o-y) striped bass (<180 mm TL) could consume gizzard shad up to 108 mm TL. Only 7% of the gizzard shad collected by electroshocking in early March 1985 were this size or smaller.

The weaker linear relationship between TL of consumed alewives and striped bass TL indicated a greater availability of alewives to striped bass of all sizes. Alewives do not grow rapidly in Smith Mountain Lake. One-year-old alewives reach average lengths of 86 mm and 2 year olds approach 112 mm. Striped bass of 150 to 200 mm TL are consuming, on the average, alewives 45 to 110 mm TL in the lake, a size range also heavily utilized by striped bass 700 to 800 mm TL.

Distributional patterns of alewives, gizzard shad, and striped bass may also explain the differential seasonal utilization of the 2 clupeids by striped bass. The alewife is more pelagic and tends to inhabit the broad, deeper waters characteristic of the lower reservoir (Ney et al. 1982), whereas the gizzard shad is found in the upper more riverine and fertile portion of a reservoir (Rainwater and Houser 1982). A concurrent study in Smith Mountain Lake indicated a complete segregation of spawning habitat for these clupeids; larval gizzard shad were found only in the upper lake and larval alewives only in the lower reservoir (M. Tisa and J. Ney un-

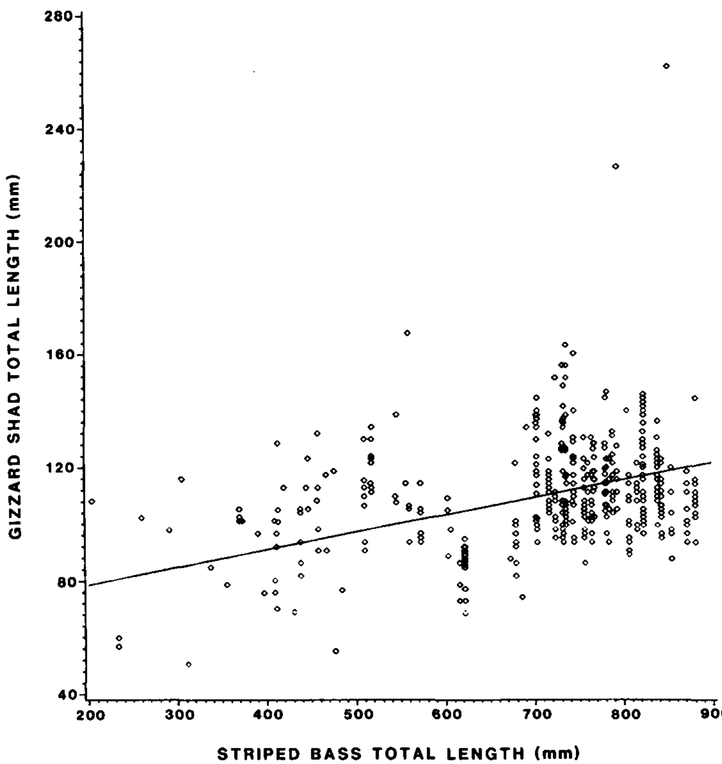

Figure 1. Relationship between size of consumed gizzard shad and size of striped bass.

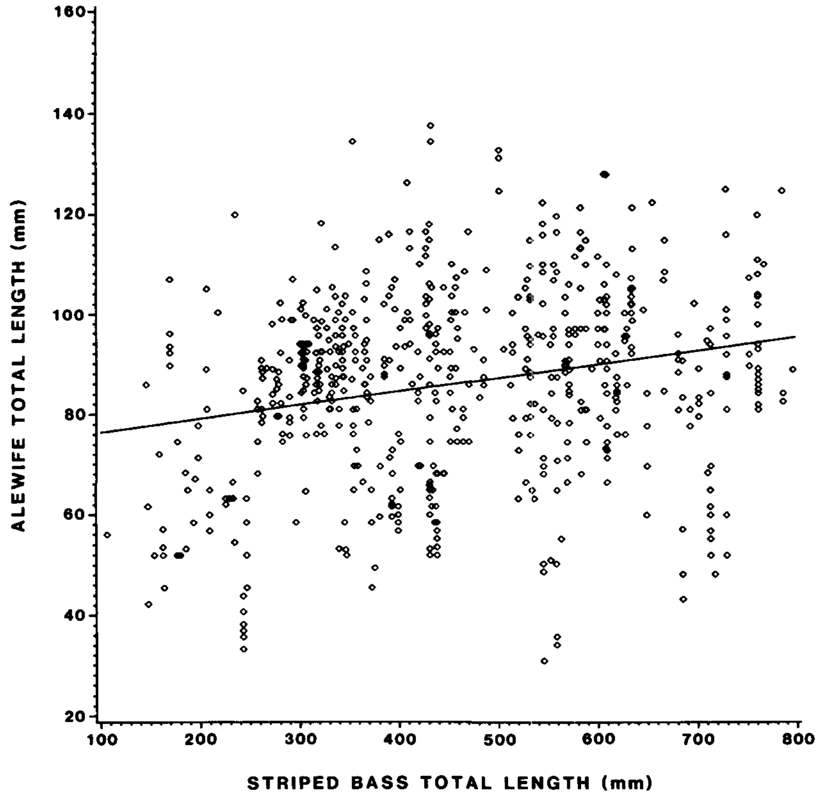

Figure 2. Relationship between size of consumed alewives and size of striped bass.

publ. data). This segregation of clupeids was also evident in the stomach data. Stomachs of striped bass collected in and above Beaverdam Creek in the upper reservoir did not contain alewives whereas those collected below the confluence did not contain gizzard shad.

Predominance of gizzard shad in the winter diet of striped bass in the upper reservoir may reflect spatial availability; y-o-y gizzard shad were observed to congregate in the upper Roanoke River arm of the reservoir during winter. No alewives were collected from this area. Striped bass also concentrated in this area and may co-occur to take advantage of this abundant forage.

Striped bass are known to concentrate in the lower, deep regions of reservoirs during late spring and summer (Combs and Peltz 1982) and are possibly thermally isolated from y-o-y shad (Coutant and Carroll 1980). Because alewives tend to concentrate in deep, coolwater areas, striped bass may simply have eaten the clupeid they encountered most frequently, thus explaining the dominance of alewives in the diet in these seasons. Declining temperatures in fall, which eliminate upper temperature restrictions to striped bass movements, together with abundance of underyearling gizzard shad, may explain greater utilization of gizzard shad in autumn.

This study indicates that the presence of alewives in Smith Mountain Lake has increased forage availability for striped bass. Alewives are morphologically available to juvenile and adult striped bass throughout the year because of their slower growth and spatial distribution. They are especially important as forage for y-o-y striped bass which can only consume y-o-y gizzard shad for a brief period during late summer and early fall. Although alewife introductions may prove beneficial for pelagic piscivores in southeastern reservoirs, they can have potentially adverse impacts on other forage and game species through trophic competition and/or predation (Ney et al. 1982). The benefits and risks should be carefully evaluated before alewife introductions are considered for any reservoir.

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