Relationship of Planktivory by Shad and Diet Shifts by Young-of-year Largemouth Bass in a Southern Reservoir[1]

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Abstract: The ability of shad populations to impact the density and composition of zooplankton populations has led to the suggestion that planktivorous shad may compete with young-of-year bass for plankton food resources and influence bass recruitment. We studied the feeding dynamics of concurrent year classes of threadfin shad (*Dorosoma petenense*), gizzard shad (*D. cepedianum*), and largemouth bass (*Micropterus salmoides*) in a North Carolina reservoir to determine the nature of feeding interactions among the species. Shad planktivory was found to be confined to a brief period early in the growing season coincidental with peak zooplankton densities, after which both shad species shifted to detritivory. Only limited correlations between shad diets and zooplankton dynamics were identified. Patterns of feeding and growth in young-of-year bass showed no indication that plankton resources were limiting cohort development. Our study provides evidence that young-of-year bass are not directly impacted by shad populations through feeding interactions.

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Largemouth bass are an important sport-fish in southern reservoirs, yet factors controlling recruitment and population growth in these systems are poorly understood (Jenkins 1975). Evaluation of reservoir bass populations is frequently based on

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principles developed in smaller impoundments, but the dynamic nature of the physical processes and relative complexity of species assemblages in reservoirs may impose limits on the applicability of these principles (Davies et al. 1982). Management of forage species is a common practice aimed at improving the food supply available to piscivorous sport fish; gizzard and threadfin shad have been widely introduced as forage in many southern systems (Noble 1981). Studies have demonstrated the potential importance of shad in bass diets, and positive responses in growth and condition of yearling and adult bass following shad stocking are common (von Geldern and Mitchell 1975). However, the effects of shad populations on first year growth and recruitment of native species has been less predictable (Kirk and Davies 1985, Ziebell et al. 1986). A better understanding of these interactions is essential if fisheries managers are to make wise decisions concerning predator-prey manipulations.

Predator-prey relationships in reservoir communities frequently involve interactions among several trophic levels, and clearer definitions of these relationships are necessary for the formation of effective management strategies (Noble 1986). The ontogeny of larval and juvenile fishes usually involves sequential changes in the composition of the diet, and the presence of adequate forage during ontogeny may be a primary determinant of survival and year class strength (Balon 1984, Werner and Gilliam 1984). Zooplankton predominate in the diets of small bass, with insects and ultimately fish becoming more important at larger sizes (Kramer and Smith, 1960, McCammon et al. 1964, Lemly and Dimmick 1982). Inadequate levels of suitable prey at a given stage of development can result in slow growth, increased predation, and mortality (Timmons et al. 1980, Keast and Eadie 1985, Wicker and Johnson 1987). Because populations of shad have the potential to alter the abundance, species composition, and size structure of zooplankton assemblages (Cramer and Marzolf 1970, Drenner et al. 1982, Ziebell et al. 1986), and because poor bass recruitment is often observed in systems with high shad densities, many researchers have suggested that competitive interactions may exist between shad and planktivorous young-of-year bass (Cramer and Marzolf 1970, von Geldern and Mitchell 1975, Jahn 1983, Kirk et al. 1986, Ziebell et al. 1986).

Our paper describes aspects of the feeding dynamics of concurrent cohorts of young-of-year bass and shad in B. Everett Jordan Lake, an eutrophic reservoir in North Carolina. Annual surveys of adult bass have indicated large variations in recruitment since the reservoir filled in 1983. Studies of young-of-year bass during the years 1987–1989 have shown substantial annual differences in growth and abundance. Our study evaluates the potential for competitive feeding interactions between young-of-year bass and shad by examining the timing of zooplanktivory and subsequent shifts to larger food items in bass as they relate to observed shad diets and seasonal changes in the zooplankton community.

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Methods

B. Everett Jordan Lake is a 5,720-ha reservoir in the Piedmont region of central North Carolina. At full pool, the lake has 240 km of shoreline and an average depth of 5 m. The dam lies at the confluence of the Haw and New Hope rivers and incorporates a watershed which drains approximately 4,420 km^2. The reservoir is used primarily for flood control; seasonal water level fluctuations typically limit development of aquatic macrophytes in the littoral zone. Native fish fauna in the lake is typical of southern systems. Limited numbers of *Morone* hybrids have been stocked in the lake since 1983. Threadfin shad, presumably from an upstream stocking, were first reported in the lake in 1987. Both gizzard and threadfin shad have successfully reproduced each year since larval fish sampling was initiated in 1987.

All fish for the current analysis were collected from a 64-ha bay at the southeastern end of the lake. Larval and juvenile shad were collected every 2 weeks from 14 April to 25 October 1988 with a 1-mm mesh neuston net mounted on a 1- × 2-m frame and fitted with a General Oceanics model 2030 digital flowmeter. The net was towed in a circle behind the boat to avoid interference from the boat wake. Tows lasted approximately 5 minutes at a speed of 0.7 m/second and sampled an average of 400 m^3. Shad that were collected for diet analysis were captured 2 hours before sunset; estimates of shad densities were based on 2 replicate night tows. All shad samples were preserved in denatured ethanol immediately following capture. Shad >20 mm total length were identified to species by anal fin ray counts; smaller shad were identified as *Dorosoma*. Zooplankters in shad stomachs were identified and measured with a dissecting microscope attached to a computer-based caliper system (Sprules et al. 1981). When adequate numbers were available, shad were separated by species, and guts from 10 fish in 5-mm size classes from 15 mm to 35 mm were analyzed.

Zooplankton was sampled in conjunction with larval shad collections. Density estimates for zooplankton were based on 2 replicate surface samples with a 30.6-liter Schindler-Patalas trap fitted with a 70-micron net. Zooplankton was also sampled by vertical tows with a 70-micron Wisconsin net. Zooplankton samples were subsampled with a Hensen-Stempel pipet; at least 200 individuals were counted from each sample. Due to slight differences in selectivity by the 2 gears for less common taxa, descriptions of temporal shifts in community composition were based on pooled data on each sampling date. Zooplankton was preserved in 10% formalin solution immediately following collection and processed with the caliper system described above.

Young-of-year-bass were collected from 2 June to 27 October 1988 by shoreline seining and electrofishing. Zooplanktivory by small bass was initially characterized with diet analysis of fish collected by daytime seine hauls with a 9-m bag seine. Due to increasing sampling bias towards smaller individuals in seine hauls through time, length frequencies and diet analyses of larger fish were subsequently based on night shoreline electrofishing. Fish were put on ice and later preserved in denatured ethanol until diet analyses were made. A total of 182 bass stomachs were examined for this study. Diet items in bass stomachs were identified and enumerated with dissecting microscopes.

Comparisons of zooplankton densities and species composition were made with a 1-way ANOVA. Statistical significance was declared at the level of $P < 0.05$.

Results

Shad were the most common species in neuston net catches throughout the sampling period. The spring pulse of shad larvae was first observed in samples collected on 12 May, with peak densities recorded on 26 May (Fig. 1). Observed densities remained high through 21 June as larvae <20 mm continued to be recruited into neuston samples. Juvenile gizzard shad were common in samples only through late June. Length frequencies indicated that threadfin shad spawned somewhat later than gizzard shad (Fig. 2); threadfin shad juveniles were collected throughout the sampling season. Zooplankton densities peaked in late May samples, concurrent with the highest observed shad densities (Fig. 1). June fluctuations in zooplankton densities were followed by a steady decline through the remainder of the summer.

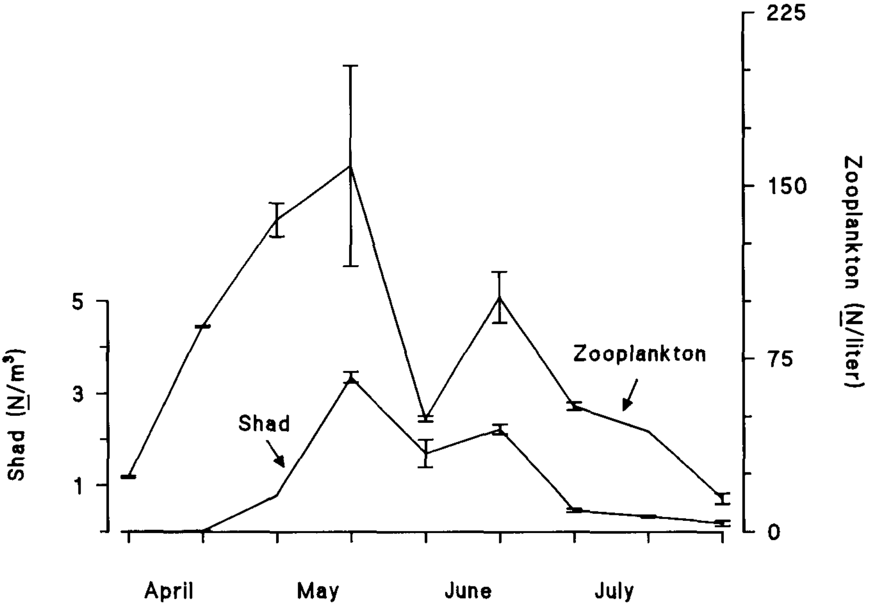

Figure 1. Densities (±1 SE) of shad and zooplankton in a bay of B. Everett Jordan Lake, 1988.

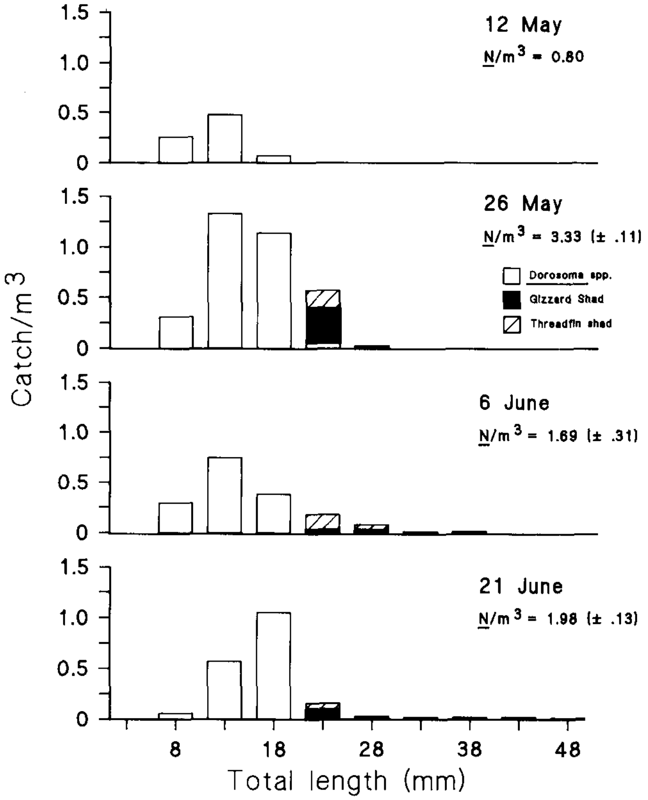

Figure 2. Catch frequencies of shad by 5-mm size classes in a bay of B. Everett Jordan Lake, 1988.

Observed planktivory in larval and juvenile shad was confined to a brief period early in the growing season, coincidental with the spring zooplankton peak. Both average number of plankton organisms per stomach (20) and percentage of stomachs with food (83) peaked in the 26 May sample. Unidentified organic matter, presumed to be detritus based on the presence of sand particles, was the principal diet item in all fish sampled from 21 June through the remainder of the growing season. Consequently, shad diet analysis is presented only for 26 May.

Gizzard shad demonstrated a size-related shift in feeding selectivity at lengths ≥25 mm (Fig. 3). Shad 20–24-mm had a more diverse diet and contained more larger copepod taxa compared to shad ≥25 mm, which fed primarily on *Bosmina*, a small cladoceran. Nearly identical size-related feeding patterns were observed in threadfin shad, which were represented only by fish <30 mm (Fig. 3).

Changes in species composition (Fig. 4) and total density (Fig. 1) of zooplankton were observed through the sampling period. However, comparisons of the zooplankton community during the period of shad planktivory (12 May–6 June) to

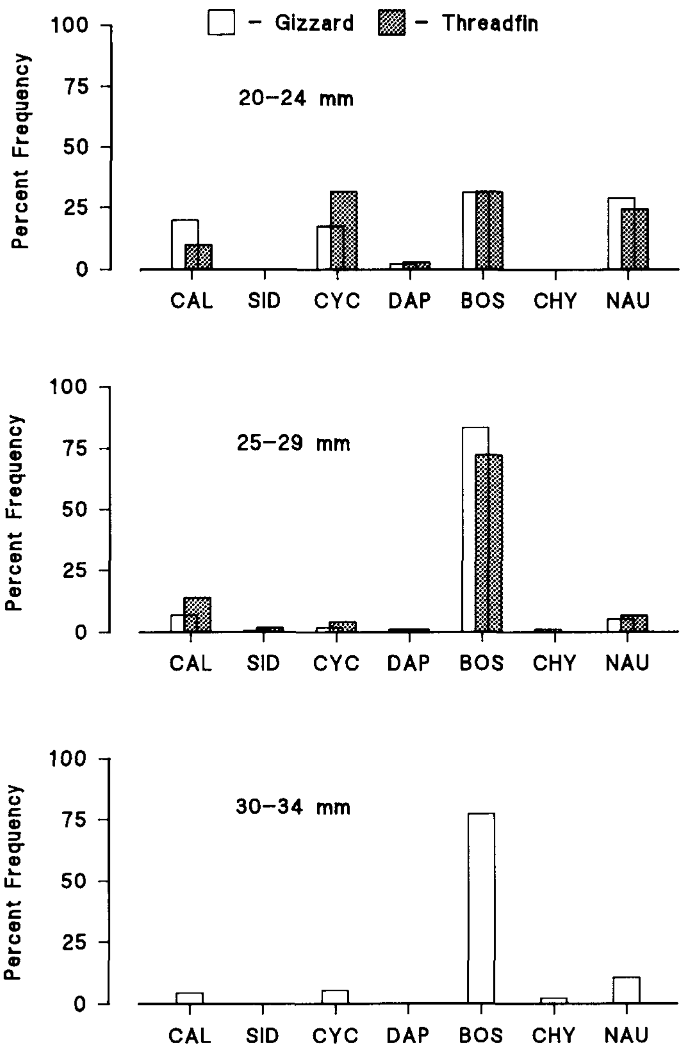

Figure 3. Proportional occurrence of calanoid copepods (CAL), sidid cladocerans (SID), cyclopoid copepods (CYC), *Daphnia* (DAP), *Bosmina* (BOS), chydorid cladocerans (CHY), and copepod nauplii (NAU) in stomachs of 3 size groups of shad in a bay of B. Everett Jordan Lake, May 1988.

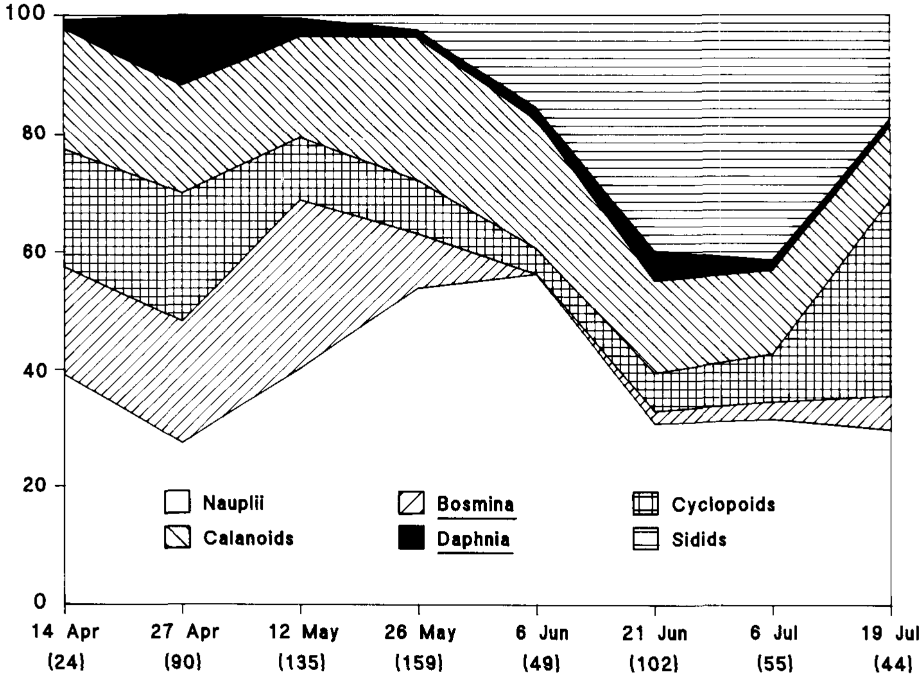

Figure 4. Proportional seasonal abundance of common zooplankton groups and total plankton density (in parenthesis) in a bay of B. Everett Jordan Lake, 1988.

the period immediately following peak shad predation (21 June–19 July) indicated that the impacts of shad predation were focused on 2 taxa. Significant reductions in density between the 2 periods were observed only in *Bosmina* (P = .003) and copepod nauplii (P = .0001). Other taxa that occurred in shad diets did not show significant declines in density between the 2 periods.

Juvenile largemouth bass began recruiting into shoreline samples in early June. Bass catch per unit effort for both seining and electrofishing increased through June and peaked in early July. Daily growth in length through this period was nearly linear, averaging 0.6 mm per day between 13 June and 5 July and 0.65 mm between 5 July and 25 July (Fig. 5). Stomach analyses of bass showed zooplankton to be an important part of the diets of bass <45 mm, becoming less important for larger sizes (Fig. 6). Planktivorous bass were most abundant in the June and early July samples. An average of 67 zooplankton organisms were found in the stomachs of small bass during this period. Sidid cladocerans and calanoid copepods were the most common taxa in bass stomachs during this period, accounting for 85% of ingested zooplankters (Fig. 7). Cyclopoid copepods and various small cladocerans were found in smaller quantities throughout the study period. Empty stomachs were rare (0%–10%) in samples of bass at sizes when plankton was the principal component in the diet.

Shifts to larger food items as bass grew were generally well-defined (Fig. 6).

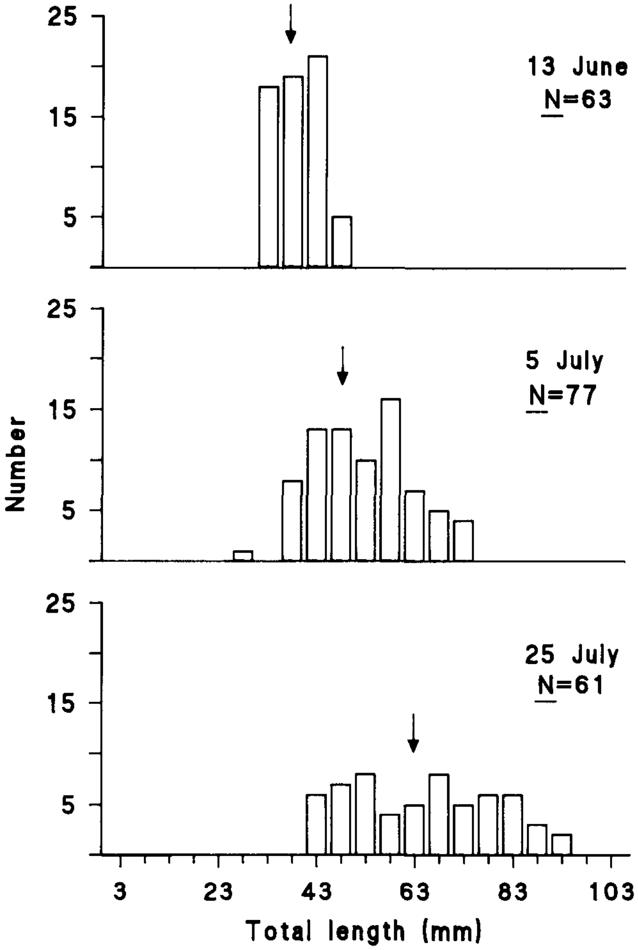

Figure 5. Shoreline electrofishing catches of bass by 5-mm size groups and mean lengths (arrows) in a bay of B. Everett Jordan Lake, 1988.

Insects occurred in the diets of bass at all sizes sampled, replacing zooplankton as the most common food when bass reached 45 mm. Piscivory was observed in bass as small as 38 mm, and fish became the principal food item in bass >55 mm. Percentage of stomachs found to be empty was consistently near 10% except for an upward trend in the largest sizes of bass sampled.

Discussion

The chronology of planktivory in young-of-year shad and bass creates a situation where shad impacts on plankton communities could negatively affect availability of

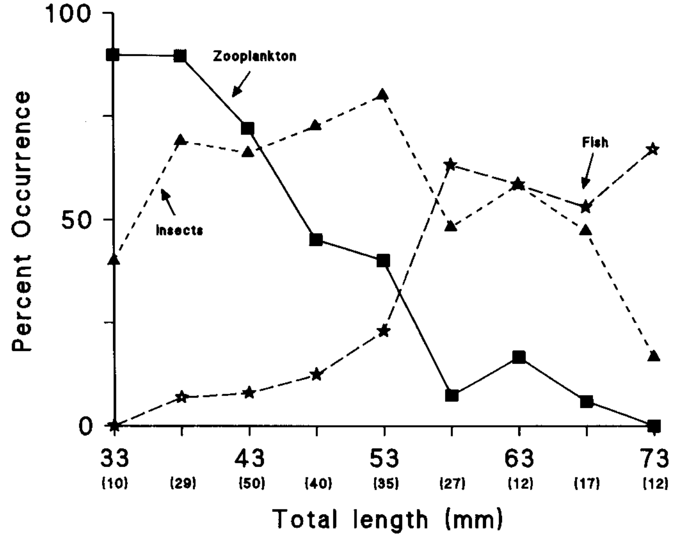

Figure 6. Frequency of occurrence of zooplankton, insects, and fish in diets of young-of-year bass in a bay of B. Everett Jordan Lake, June–July 1988.

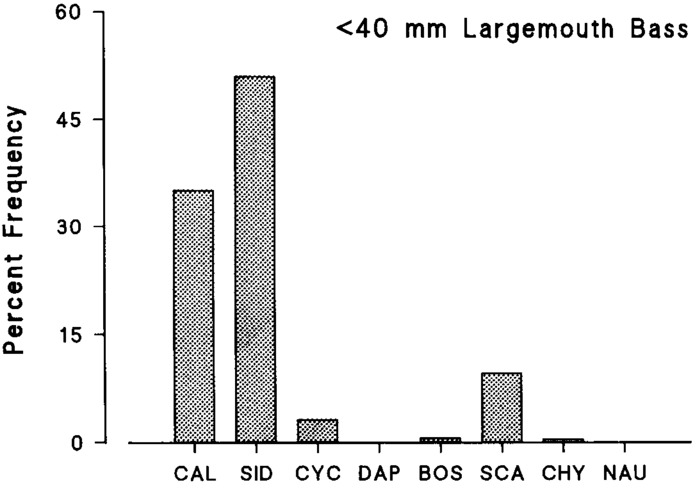

Figure 7. Proportional occurrence of calanoid copepods (CAL), sidid cladocerans (SID), cyclopoid copepods (CYC), *Daphnia* (DAP), *Bosmina* (BOS), *Scapholeberis* (SCA), chydorid cladocerans (CHY), and copepod nauplii (NAU) in stomachs of juvenile bass collected in seine samples from a bay of B. Everett Jordan Lake, June–July 1988.

prey for planktivorous bass. Peak shad abundance in Jordan Lake preceded the highest observed juvenile bass catches by 6 weeks. Planktivory in shad overlapped with the onset of planktivory in juvenile bass. While the potential for competitive interactions is clear, data from our study were not indicative of a strong relationship between planktivory in shad and the feeding dynamics, growth, or abundance of young bass.

Diet data showed that planktivory in shad was restricted to a brief period coincidental with the spring zooplankton bloom. Declines in total zooplankton density and wide variations in community structures were observed, but only 2 taxa common in shad diets, *Bosmina* and copepod nauplii, declined significantly in abundance coincident with shad planktivory. Other zooplankton taxa which occurred in shad diets did not exhibit significant responses to shad predation.

Planktivorous bass fed successfully throughout the sampling period as evidenced by the large numbers of plankton organisms per fish and the rarity of empty stomachs. Comparisons of the zooplankton found in bass and shad revealed that bass made frequent use of taxa that were not important in shad diets. Sidid cladoceran densities peaked after the period of planktivory by shad and were an important component of bass diets. Primarily littoral microcrustacean taxa such as *Scapholeberis*, which did not occur in shad diets, were also common in bass stomachs. Cyclopoid and calanoid copepods, which comprised 35% of the plankton found in bass, were also found in shad diets. However, copepods were found primarily in the stomachs of smaller shad, and copepod densities did not decline significantly during the period of shad planktivory.

Spatial distribution of planktivorous bass and shad was likely an important factor in limiting the potential for competitive feeding interactions. Larval and juvenile shad were collected almost exclusively in the limnetic zone during the time when they were planktivorous. Juvenile shad did occur in littoral samples late in the summer, but this inshore movement occurred after shad diets indicated a shift to detritivory. Planktivory by shad was therefore focused on limnetic zooplankton taxa and did not include littoral taxa which were found to be important in the diets of planktivorous bass.

The effects of shad planktivory on the Jordan Lake zooplankton community did not appear to deter successful planktivory or subsequent feedings shifts by young bass. The mean daily growth rates of juvenile bass recorded early in the season were similar to growth rates reported in southern impoundments without shad (Isely and Noble 1987), providing evidence that plankton resources were not limiting. Bass shifted to larger food items at sizes comparable to or smaller than those reported in similar diet studies (Kramer and Smith 1960, McCammon et al. 1964).

Feeding interactions between young-of-year bass and shad early in the growing season appeared to be negligible in Jordan Lake. No evidence was found that planktivory in shad directly impacted growth or feeding dynamics of juvenile bass. Relationships of shad with adult bass and other native species in the lake have not been determined, but the data presented indicate that first year growth and survival of bass not directly influenced by feeding competition with shad.

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