Size Selection of Prey by Young Largemouth Bass

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Abstract: Size selective predation has been documented in many species of fish. The majority of these studies have focused on the feeding behavior of adults. I examined the size selection predation of largemouth bass *Micropterus salmoides* ≤200 mm total length (TL), with particular emphasis on shift size bass. Shift size bass (approximately 100 mm TL) were those fish just changing from invertebrate prey to piscivory. Shift size bass were size selective and consumed prey 35% their own TL. As they grew larger, they consumed proportionately smaller sized prey. Whether the decrease was due to selection, opportunistic availability, or increased abundance of small prey is not known.

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Optimal foraging or predation theory indicates that a predator will optimize its net energy intake (Werner and Hall 1974, Savino and Stein 1982, Mills et al. 1984). Theoretically this can be accomplished by consuming the largest (most calories) prey item the predator can swallow (assuming that associated energy costs are minimal). Size selection is an active component of predation and should be considered in the steps of predation as presented by Howick and O'Brien (1983). They give prey location as the first step in predation. As a corollary to the act of locating a prey item, however, there first must be recognition of a prey item with an acceptable probability of successful predatory outcome. One dimension of that recognition is size.

Size selective predation by largemouth bass *Micropterus salmoides* and other centrarchids has been documented (Lawrence 1958, Wright 1970, Pasch 1974, Werner 1974, Timmons et al. 1980, Howick and O'Brien 1983, Michaletz 1988). In most cases these studies have provided data that confirm size selection by largemouth bass but not always at the expected energetically optimum size, i.e., the maximum size which could be consumed.

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Largemouth bass have generally been found to consume fish prey that are 30% to 50% of their total length (TL) depending on the body depth or girth of the prey (Lawrence 1958, Timmons et al. 1980, Howick and O'Brien 1983, Michaeletz 1988). Most of these studies have, however, investigated size selective predation in bass that were age 1 or older which, then, were confirmed, habitual piscivores.

Young of the year (YOY) largemouth bass shift from a diet of zooplankton/insects to energetically more favorable fish when they reach a size from 50 mm to 100 mm TL (Kramer and Smith 1960, Jackson et al. 1990, Goldstein and Anderson 1992). Little is known about size selective predation by YOY bass, a process which can have far reaching effects on the rate of bass growth and subsequent recruitment. The earlier an individual shifts to fish prey, the earlier it consumes more energy per predatory act (due to the mass of the prey). It will then have a greater potential for growth and survival during the first season of life. Differences in shift time may be due to initial spawning time or an extended spawning period of both predator and prey, the availability of suitable sized prey, and a host of metabolic and environmental factors. The advantage that early spawned or larger individuals have in obtaining food contributes to bimodality in size distributions of a year class (DeAngelis and Coutant 1982). Bimodality implies slower growth and survival rates for the smaller individuals due to intraspecific competition and is the result of food use that perpetuates and accentuates the differences in size (Aggus and Elliott 1975, Shelton et al. 1979, Timmons et al. 1980, Gutreuter and Anderson 1985, Keast and Eadie 1985). In order to maximize growth and survival, it is important for largemouth bass (or any other piscivore) to become piscivorous as soon as possible and to select the largest prey it can consume with the least energetic cost as soon as it becomes available.

Larger bass select food items smaller than the maximum size (Lawrence 1958, Wright 1970, Hambright 1991); this has also been observed in other species (Hansen and Wahl 1981, Mills et al. 1984). The potential recruitment of pre-stock bass (bass ≤200 mm TL, from Gablehouse 1984) depends upon the availability of suitably sized prey. It is necessary to know what size prey the young bass will select and if those sizes are sufficiently represented in the available forage through time.

The purpose of this study was to determine if young largemouth bass are size selective when they shift to piscivory, and if so, whether the prey they select are at the maximum size the bass can consume. Furthermore, size selection of prey by bass larger than shift size but ≤200 mm TL was also examined to determine if any changes in size selection occurred over this interval. This project was supported by funds from the Federal Aid to Sport Fish Restoration Act under Dingell-Johnson Project F-28, Georgia. The author recognizes the efforts of all the people from Region V, Georgia Department of Natural Resources Fisheries who contributed to the project including the 2 prior district biologists, Steve Quinn and Louis Berg. I also thank Dr. Steve Spigarelli, Louis Berg, and other reviewers for their helpful comments.

Methods

Young of the year largemouth bass (N = 224) were collected from Lake Walter F. George from 1987 through 1990. Lake Walter F. George is a large (18,290-ha) mainstream impoundment on the Chattahoochee River on the border between Georgia and Alabama which is operated by the U.S. Corps of Engineers for navigation and hydro-electric power generation. Sampling locations were selected based on access, and specific sampling sites were based on diversity of habitat types present (coves and sandy beaches with brushy shores, vertical structure from woody debris and macrophytes, thermal variability from inflowing streams, channel margins, rip rap, dock pilings, etc). Largemouth bass ≤200 mm TL were collected by seine and electrofishing. Seine hauls (using a 5-m seine with 3.2 mm mesh) were made at each of 3 sampling locations monthly from May through September 1987–1990. Seine hauls were made at 3 sites at a sampling location during daylight (afternoon) and then again after dark. All largemouth bass were measured to the nearest mm TL. Stomach contents were preserved in 10% formalin for laboratory analysis. Bass *100 mm TL were preserved whole after an incision was made in the body cavity. At each sampling time and location, bass were also collected by electrofishing boat. Three 10-minute (pedal time) samples were taken during daylight after the first seine hauls.

In the laboratory stomach contents were identified to the lowest taxon practicable, and any fish found in the contents were measured to the nearest mm TL.

The relationship between predatory size (TL) and prey size (TL) was determined using 3 linear regression analyses (Ostle 1963). The first included all bass ≤200 mm TL (pre-stock fish) vs. all dietary fish found in the stomach; this was to determine if an overall relationship existed. The second analysis included only bass of shift size (≤100 mm TL - Goldstein and Anderson 1992) to determine if these bass, which were just becoming piscivorous, exhibited size selection. The third analysis involved only bass 100 mm to 200 mm TL. Where a significant relationship occurred, the bass size to prey size relationship was compared to the theoretical maximum size prey. Maximum sizes of consumable prey were taken from Lawrence

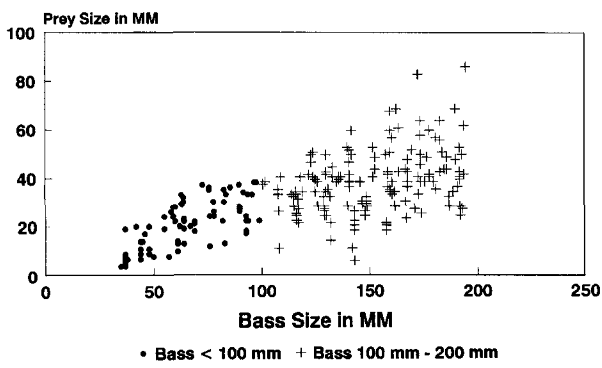


Figure 1. Sizes of prey items (TL) found in stomachs of pre-stock bass (≤200 mm TL) in Lake Walter F. George, 1987–1990.

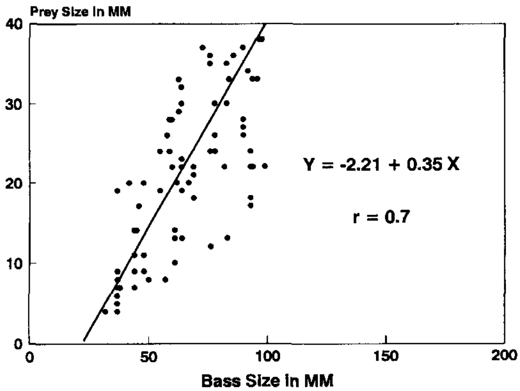


Figure 2. Sizes of prey items (TL) selected by shift size bass (TL ≤100 mm) in Lake Walter F. George, 1987–1990.

(1958) who measured the mouth width of largemouth bass and the maximum lengths of various prey species that the bass could swallow. These actual measurements were then compared graphically with the sizes of fish eaten by shift size and pre-stock largemouth bass from Lake Walter F. George. Two additional data points on size selection were taken from Hambright (1991). Hambright's standard lengths were transformed to total lengths using the appropriate factors from Carlander (1977). Only 2 data points fit within the bounds of my study since all other bass were larger then 200 mm TL: 1 each for the maximum size fathead minnow and pumpkinseed eaten by small largemouth bass.

Results

Although prey seize tended to increase as bass size increased, the slope of the regression of all bass ≤200 mm was not significant (P = 0.25; R2 = 0.08), because of the large variance at each size (Fig. 1).

When only the shift size bass were considered, the regression was significant (P = 0.0005), although only about 50% of the variability was explained by bass size (R2 = 0.49) (Fig. 2). Evidently shift size bass are more size selective or

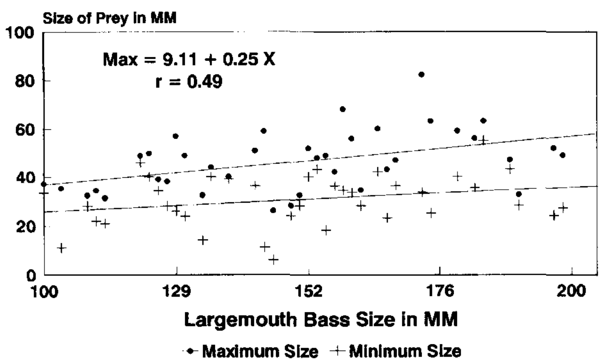


Figure 3. Maximum and minimum sizes (TL) for prey eaten by largemouth bass 100–200 mm TL in Lake Walter F. George, 1987–1990.

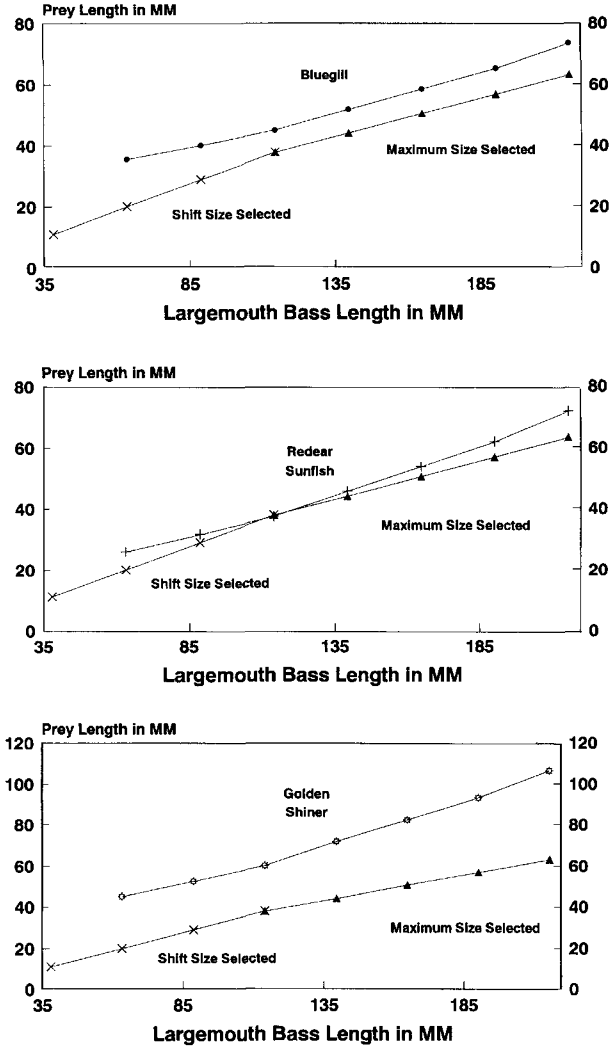
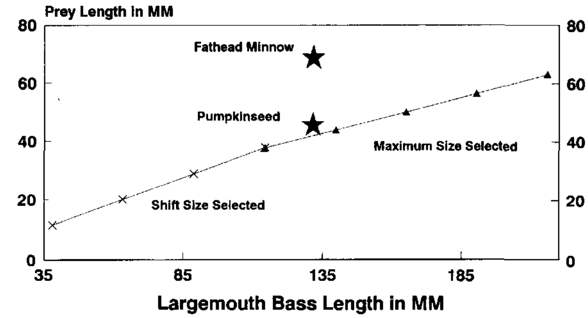
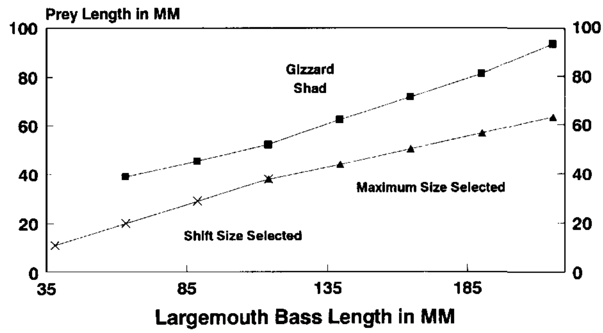


Figure 4. These five graphs depict the calculated sizes of various species consumale by largemouth bass based on mouth gape compared to mean size selected (SSS) by shift size bass (TL ≤100 mm) and maximum size selected (MSS) by bass 100–200 mm TL. Data from Lawrence (1958) and Hambright (1991).





limited in their selection than larger bass. They consumed prey 35% ± 5% (95% confidence limits) their own length. The range of sizes selected by bass 100–200 mm tended to expand with the size of the bass (Fig. 1). In the 100–200 mm size group the maximum size prey eaten was correlated (P = 0.005; R2 = 0.24) to the size of the bass (Fig. 3), but no statistically significant relationship was found with the mean or minimum size prey. For these larger bass the maximum size prey eaten averaged 25% their own length. This appears to be different from the sizes preferred by the smaller fish which selected items 35% their length and had an upper limit at about 40% their own length. Selections occurred from a forage base comprised of numerous species of sunfishes, minnows, perch, darters, shads, silversides, and stocked *Morone* hybrid fry. Reproduction from all these species (plus the stocking) provides an abundant forage base in almost all sizes throughout the spring and summer. Prey items ≥6 mm and ≤100 mm were collected in densities from 0.0 to approximately 60 items/m2 in the same areas where bass were collected (Goldstein and Anderson 1992, Goldstein and Anderson unpubl. data).

Comparisons of the theoretical maximum size prey physically consumable by bass with the sizes selected in this study indicated that bass consistently selected prey items smaller than they were capable of swallowing (Fig. 4). Shift size bass consistently selected items smaller than the maximum size bluegill, redear sunfish, golden shiner, or gizzard shad they could consume according to the data provided by Lawrence (1958). Bass 100–200 mm selected proportionately even smaller prey, although in a few instances prey items were found that were almost 50% the length of the bass. Comparison of the maximum size prey bass consumed by 100–200 mm bass in Lake Walter F. George with the maximum size consumable (data from Lawrence 1958 and Hambright 1991) indicates that larger bass also did not select the maximum prey item they are capable of swallowing (Fig. 4). Rather, the size of prey consumed, relative to the body size of bass, seems to decrease as bass get larger.

Discussion

The sizes of prey selected by all pre-stock bass were substantially smaller than the largest size item that could be swallowed. Factors such as minimal pursuit time, ease of capture, and reduced effort in handling time for smaller prey items might optimize net energy intake (Werner and Hall 1974, Mills et al. 1989). The larger size group of bass, 100–200 mm, consumed food items that ranged from 5% to 50% of their own length. They exhibited a much wider range of sizes than the smaller, younger shift size bass and may be optimizing their intake by consuming at any favorable opportunity. Their larger size allows a broader range of food items. If a predator happens upon a non-optimum or even marginal (low calorie) prey item, it is logical that the predator will consume the item because it would expend only minimum energy, increasing its net intake. This opportunistic behavior would explain the range of sizes consumed by larger bass, particularly at the lower limit.

Shift size bass may not have the option of consuming marginal prey items, or those that do may not survive. Shift size fish need to maximize their growth and this can only be accomplished by optimizing their energy intake. It is critical for young bass to shift over to piscivory as soon as possible. Failure to shift to piscivory or reversion back to invertebrate prey promotes a bimodal size distribution in the population and can have substantial effects on recruitment (Aggus and Elliott 1975, Keast and Eadie 1985). The bimodal distributions observed by Shelton et al. (1979) and Timmons et al. (1980) in West Point Reservoir, Alabama-Georgia, were attributable to different feeding behaviors. Delayed recruitment impacts the fishery as well as the population. Reduced growth and survival delay the onset of sexual maturity, the age of first reproduction, fecundity, and the number of reproducing individuals in the population. All these factors combine to reduce or impede the rate of population growth.

The size of the food items selected by both shift size bass and pre-stock bass overlap. A 100-mm TL shift size bass selects food items averaging 35 mm long, with a range of 25–40 mm. A 180-mm bass selects food items with an average maximum size 25% its own length or about 45 mm long. The overlap of prey sizes selected by the smaller shift size bass and the larger and older bass indicates that intraspecific competition for food should be a factor in the survival and recruitment of the younger bass. This will be the case unless there is another way that these bass are partitioning the resource, either through time, location, or species selection.

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