

Florida, Northern, and Hybrid Largemouth Bass Feeding Characteristics in Aquilla Lake, Texas

Michael J. Maceina,¹ *Fish Genetics Laboratory, Department of Wildlife and Fisheries Sciences, Texas A&M University, College Station, TX 77843*

Brian R. Murphy, *Fish Genetics Laboratory, Department of Wildlife and Fisheries Sciences, Texas A&M University, College Station, TX 77843*

Abstract: Food habits, prey-size, and the occurrence of food in the stomachs were examined at various water temperatures among 1,152 Florida largemouth bass (*Micropterus salmoides floridanus*), northern largemouth bass (*M. s. salmoides*), and intergrade hybrids between the 2 subspecies in Aquilla Lake, Texas. Dietary composition, prey-size consumed, and the frequency of food items in the stomach were similar among the largemouth bass subspecies and their intergrade hybrid at temperatures between 8° and 31° C. A higher proportion of insects occurred in the diet of smaller (151–253 mm TL) largemouth bass compared to larger (≥ 254 mm TL) fish. When forage fish were consumed by largemouth bass, positive prey-size selection was evident. These size-dependent feeding differences conferred a foraging disadvantage to age-1 and younger resident-hatched Florida largemouth bass.

Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 42:112–119

The largemouth bass (*Micropterus salmoides*) is a popular sportfish species widely distributed throughout North America (MacCrimmon and Robbins 1975). Two distinct subspecies, the Florida largemouth bass (*M. s. floridanus*, FLMB) and the northern largemouth bass (*M. s. salmoides*, NLMB) have been recognized using meristic characters (Bailey and Hubbs 1949) and biochemical genetic traits (Philipp et al. 1983). Florida largemouth bass are native to peninsular Florida, with natural hybrid intergrade populations occurring in the southeastern United States from northern Florida to Mississippi and northward along the Atlantic coast to Maryland (Philipp et al. 1983). Stocking FLMB outside their native range has been conducted primarily to enhance sportfishing. The rationale for these stockings, as summarized

¹ Present address: South Florida Water Management District, P.O. Box 24680, West Palm Beach, FL 33416.

by Chew (1975), includes the following: 1) FLMB appear less vulnerable to angling than NLMB and successful stockings may reduce overharvest; 2) potential FLMB growth rate, and subsequent maximum size, may be greater than NLMB, thus greater numbers of larger bass could be produced; and 3) FLMB may occupy a different niche than NLMB, hence stocking could increase total bass standing crop.

Partitioning food resources is one possible aspect of niche segregation between taxa. Although feeding interactions among some of the *Micropterus* species have been examined (Dendy 1946, Smitherman 1975, Schramm and Maceina 1986), a comparison of the subspecific feeding ecology of cohabiting FLMB, NLMB, and their hybrid intergrades has not been reported. The objectives of this study were to examine food habits, prey-size selection, and the relationship between the occurrence of food items in the stomach and water temperature among these largemouth bass taxa. This relationship, which is probably indicative of feeding rate at various temperatures, may be an important consideration when FLMB are stocked into environments outside of peninsular Florida.

Financial support was provided by the Fort Worth District U.S. Army Corps of Engineers, Contract Number DACW-79-C-0410, and the study was developed as part of Texas Agricultural Experiment Station Projects S6536 and H6843, Contribution TA-22993. Further support was provided by the South Florida Water Management District. Electrophoretic facilities and supplies were provided by Ira F. Greenbaum, and funded by the National Institute of Health (GM-27014) and the National Science Foundation (DEB-8117447).

Methods

Impoundment of Aquilla Lake began on 29 April 1983, and water levels reached conservation-pool level (163.9 m msl) on 21 March 1985. A detailed morphological and limnological description of Aquilla Lake is found in Maceina and Cichra (1987). In 1982, 31,900 FLMB were stocked into excavation pits near the reservoir which were inundated in 1983. Between 1983 and 1985, 466,450 FLMB were stocked annually into Aquilla Lake. All fish came from the Texas Parks and Wildlife Department fish hatchery in Huntsville, Texas. Stocked fish ranged from 1.5 to 6.5 cm total length (TL). Maceina et al. (1988) reported that the 1982 stock was contaminated with NLMB alleles, but the 1983 to 1985 fish were pure FLMB.

Largemouth bass were collected periodically using direct-current electroshocking gear between August 1984 and April 1987. Subsurface (1 m) water temperature was taken with a YSI Temperature-Oxygen Meter. Fish were placed on ice upon capture, and transported to the laboratory. Fish were measured for TL in mm, and liver samples were excised and stored at -80° C pending electrophoretic analysis. Stomachs were removed from fish ≥ 151 mm TL, the dominant item consumed was identified, and when possible, fish prey length was measured. When complete tail digestion of prey items occurred, standard lengths were measured and converted to TL by the equations presented by Carlander (1969, 1977).

Horizontal starch gel electrophoresis was conducted for 4 liver enzyme-

encoding loci to discriminate among the 2 largemouth bass subspecies and their intergrade hybrids (Maceina et al. 1988). These loci included isocitrate dehydrogenase (Idh-B, IUBNC (1984) Number 1.1.1.42), aspartate aminotransferase (Aat-B, 2.6.1.1), superoxide dismutase (Sod-A, 1.15.1.1), and galactose-1-phosphate uridylyltransferase (Gal-B, 2.7.7.12). Allozyme migration at each locus was compared to known FLMB standards maintained at Texas A&M University. Fish were grouped into 3 electrophoretic phenotypes: 1) NLMB, 2) FLMB, and 3) first-generation (F_1) or greater (F_x) intergrade hybrids between FLMB and NLMB. Because of the recent stocking of fish dominated by FLMB, the majority (80%) of hybrids collected from Aquilla Lake were F_1 fish (Maceina et al. 1988). A detailed description of phenotype assignment and accuracy observed in this study has been given (Maceina et al. 1988).

Separate analyses of food-item occurrence were conducted on 2 size-groups of fish: small fish (151–253 mm TL) and large fish (≥ 254 mm TL; minimum legal length in 1984). To determine if phenotypic differences were evident in the numerical frequency of dominant food items consumed and in the occurrence of food items in the stomach at 4 discrete temperature ranges varying 4° C each, χ^2 analysis was used to test for homogeneity. The z-statistic (Mendenhall 1971) was then used to make pair-wise comparisons to delineate differences among phenotypes. For fish 151 to 300 mm TL pooled into 10 mm TL size-groups, the relationship between largemouth bass length and percent occurrence of insects in the diet was examined using a correlation coefficient. Insects were a negligible component in the diet of fish >300 mm TL. The index presented by Schoener (1970) was computed to assess diet overlap among the 3 phenotypes. Correlation coefficients were computed between water temperature and food occurrence and between fish prey length and largemouth bass length. Prey-length to largemouth bass-length ratio differences were tested using one-way analysis-of-variance with the Student-Newman-Keuls test (Steel and Torrie 1960).

Results

Of the 1,152 stomachs examined, 537 contained food. Largemouth bass greater than 151 mm TL were primarily piscivorous (Table 1). Percent composition of fish in the diet for larger bass (range 91% to 94% among phenotypes) was significantly greater ($z = 8.11$, $P < 0.01$) than for smaller bass (range 57% to 67%). Negligible differences were observed in the numeric percentages of dominant prey types consumed among phenotypes (Table 1). For each size-group, overlap indices ranged from 0.81 to 0.88 among phenotypes, thus demonstrating a high degree of diet similarity. The ratio of forage fish prey length to largemouth bass length did not vary among phenotypes (Table 2). However, positive correlations ($r = 0.55$ to 0.82 , $P < 0.01$) between fish prey length and largemouth bass length were evident for three prey fish categories, indicating that prey fish size-selection occurred (Fig. 1). Smaller largemouth bass consumed a higher proportion of insects than did larger

Table 1. Percent composition of dominant food items consumed by different size largemouth bass phenotypes from Aquilla Lake, Texas.

Food item	Size-group (TL)					
	151-253 mm			≥254 mm		
	NLMB ^a	F ₁ ^b and F _x ^c	FLMB ^d	NLMB	F ₁ and F _x	FLMB
Unidentified fish	14	20	25	29	37	29
Centrarchidae ^e	6	7	5	12	6	26
<i>Dorosoma cepedianum</i>	35	26	30	38	40	32
Cyprinidae ^f	1	1	2	1	0	0
Ictaluridae ^g	0	0	0	8	2	3
<i>Menidia audens</i>	1	10	4	3	6	3
Serpentes	0	0	0	0	1	0
Astacidae	1	0	4	6	0	3
Insecta ^h	42	38	30	3	8	3
N with food	162	103	56	102	65	31

^aNorthern largemouth bass.
^bFirst generation hybrids (NLMB × FLMB).
^cSecond and greater generation hybrids (NLMB × FLMB).
^dFlorida largemouth bass.
^eIncludes *L. macrochirus*, *L. cyanellus*, *L. gulosus*, *L. humilis*, *L. megalotis*, and *Pomoxis annularis*.
^fIncludes *Notemigonus crysoleucas*, *Notropis lutrensis*, and *Pimephales vigilax*.
^gIncludes *Ictalurus punctatus*, *I. melas*, and *I. natalis*.
^hPrimarily Chironomidae larvae and pupae.

Table 2. Mean ratios of prey-fish length to largemouth bass length among different phenotypes in Aquilla Lake, Texas. Mean values were not significantly different ($P < 0.05$). Sample size is in parentheses.

Type of prey fish	Phenotype		
	NLMB ^a	F ₁ ^b and F _x ^c	FLMB ^d
Gizzard shad	0.37 (45)	0.34 (37)	0.33 (12)
Sunfish ^e	0.27 (16)	0.26 (9)	0.30 (10)
Other fish ^f	0.27 (7)	0.34 (12)	0.36 (5)

^aNorthern largemouth bass.
^bFirst generation hybrids (NLMB × FLMB).
^cSecond and greater generation hybrids (NLMB × FLMB).
^dFlorida largemouth bass.
^eIncludes *Lepomis macrochirus*, *L. cyanellus*, *L. gulosus*, *L. humilis*, *L. megalotis*, unidentified *Lepomis*, and *Pomoxis annularis*.
^fIncludes *Ictalurus punctatus*, *I. melas*, *I. natalis*, *Menidia audens*, *Notemigonus crysoleucas*, *Notropis lutrensis*, *Pimephales vigilax*.

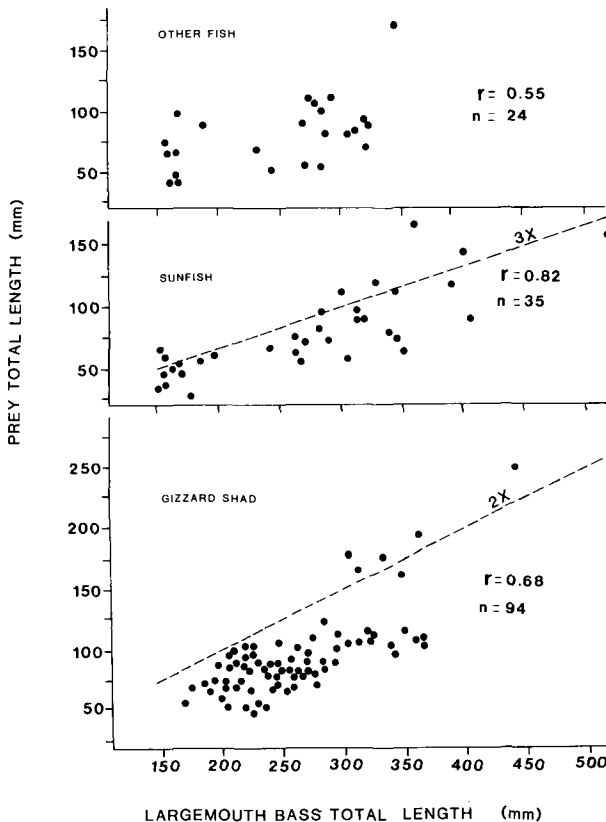


Figure 1. Relationship of consumed-prey total lengths of various fish to largemouth bass total length in Aquilla Lake, Texas. The 2X and 3X dashed lines indicate the theoretical maximum size gizzard shad (*Dorosoma cepedianum*) and sunfish that a largemouth bass can ingest (Lawrence 1957, Shelton et al. 1979). Other fish included *Ictalurus* spp., *Notropis lutrensis*, *Pimephales vigilax*, *Notemigonus crysoleucas*, and *Menidia audens*. Sunfish included *L. machrochirus*, *L. cyanellus*, *L. gulosus*, *L. humilis*, *L. megalotis*, and *Pomoxis annularis*.

bass. A negative correlation ($r = -0.83$, $P < 0.01$) between the frequency of aquatic insects in the diet and largemouth bass length was evident.

There were no statistical differences in the frequency of occurrence of food items in the stomachs among largemouth bass phenotypes at temperatures ranging from 8° to 31° C (Table 3). This suggested that phenotypic feeding rates were similar within the different temperature ranges observed. However, there was a positive correlation ($r = 0.89$, $P < 0.01$) between temperature and feeding frequency when data were pooled for all phenotypes. The seasonal availability of suitable size forage fish undoubtedly also affected this relationship.

Table 3. Frequency of stomachs containing food among largemouth bass phenotypes from Aquilla Lake, Texas, at various water temperature ranges. Frequencies were not significantly different ($P < 0.05$). Sample size is in parentheses.

Temperature range (°C)	χ^2	Phenotype		
		NLMB ^a	F ₁ ^b and F _x ^c	FLMB ^d
8–12	0.84	0.32	0.37	0.27
		(157)	(59)	(41)
13–17	0.91	0.41	0.47	0.49
		(183)	(114)	(61)
22–26	1.93	0.43	0.48	0.33
		(172)	(117)	(52)
27–31	0.24	0.78	0.75	0.70
		(102)	(57)	(37)

^aNorthern largemouth bass.

^bFirst generation hybrids (NLMB × FLMB).

^cSecond and greater generation hybrids (NLMB × FLMB).

^dFlorida largemouth bass.

Discussion

We found no evidence of subspecific niche segregation for feeding, as dietary composition was similar among largemouth bass phenotypes. Overlap indices for diet exceeded 0.60, which has been considered biologically significant (Zaret and Rand 1971, Mathur 1977). In addition, the size of forage fish consumed at specific largemouth bass lengths did not vary among phenotypes. Lawrence (1957) computed maximum-sized prey that can be consumed by largemouth bass based on throat width. Shireman et al. (1978) reported that FLMB throat widths were equivalent to those measured by Lawrence (1957) for NLMB less than 525 mm TL. Our data support this observation, as prey size did not vary between largemouth bass subspecies.

In Aquilla Lake, however, partial subspecific temporal spawning segregation and genetic differences in first-year growth did confer a phenotypic foraging advantage to NLMB from the 1986 year-class, a year when largemouth bass were not stocked. The northern subspecies successfully spawned earlier, and their progeny grew faster than the resident-hatched FLMB during the first-year of life (Maceina et al. 1988). Because of this, 1986 year-class FLMB were smaller than NLMB at age 1, and hybrids were similar in size to NLMB (Maceina et al. 1988). Mean TL among phenotypes ranged from 146 to 187 mm although some individuals reached a maximum size to 243 mm TL (Maceina et al. 1988). For fish >150 mm TL, insects were present in 67% of the stomachs of FLMB, a much higher frequency of occurrence than for hybrids and NLMB (33% and 44%, respectively) from the 1986 year-class. Largemouth bass should be primarily piscivorous at this size (Chew 1974, Carlander 1977). Shelton et al. (1979) and Maceina and Isely (1986) reported a reduction in available fish prey to the smaller members of age-0 cohorts during the

first growth season in two new reservoirs. Among 4 year-classes (1983 to 1986), phenotypic differences in food habits were not evident (Table 1) because stocked FLMB were similar in size to resident-hatched NLMB at age-1 from the 1983 to 1985 year-classes (Maceina et al. 1988).

Because progressively longer largemouth bass can consume larger forage fish, Jenkins and Morais (1976) reported greater prey biomass available to larger bass than to smaller bass in a cohort. Thus, faster growth rates could also confer a size-dependent foraging advantage when fish were consumed by largemouth bass from Aquilla Lake.

We suggest that stocking FLMB in more northern latitudes (including artificially thermal-enriched lakes) may be feasible where water temperatures do not remain below the range of values observed in this study for an extended period of time. Shireman et al. (1979) observed mean winter water temperatures of 15° C in Lake Wales, Florida, which is located in the central portion of the FLMB range (Philipp et al. 1983). Although minimum winter water temperatures in Aquilla Lake were lower than the mean observed in this Florida lake, FLMB demonstrated a feeding rate similar to NLMB at 8° to 12° C. Consonant with this information, FLMB condition and relative survival were not adversely affected by these temperatures in Aquilla Lake (Maceina and Murphy 1988, Maceina et al. 1988). Knowledge of FLMB and hybrid largemouth bass feeding rates at lower temperatures would be useful information when considering stocking sites outside of peninsular Florida. In addition, resident-hatched FLMB may have a competitive foraging disadvantage during their first-year of life in lakes which demonstrate limited forage fish abundance.

Literature Cited

- Bailey, R. M. and C. L. Hubbs. 1949. The black basses (*Micropterus*) of Florida with a description of a new species. Univ. Mich. Mus. Zool. Occas. Pap. 516 41pp.
- Carlander, K. D. 1969. Handbook of freshwater fishery biology: Vol. I. Iowa State Univ. Press, Ames. 752pp.
- . 1977. Handbook of freshwater fishery biology: Vol. II. Iowa State Univ. Press, Ames. 431pp.
- Chew, R. L. 1974. Early life history of the Florida largemouth bass. Fla. Game and Freshwater Fish Comm. Bul 7, Tallahassee. 76pp.
- . 1975. The Florida largemouth bass. Pages 450–458 in R. Stroud and H. Clepper, eds. Black biology and management. Sport Fishing Inst., Washington, D.C.
- Dendy, J. S. 1946. Food of several species of fish, Norris Reservoir, Tennessee. J. Tenn. Acad. Sci. 21:94–104.
- International Union of Biochemistry, Nomenclature Committee (IUBNC). 1984. Enzyme nomenclature 1984. Acad. Press, Orlando, Fla. 646pp.
- Jenkins, R. M. and D. I. Morais. 1976. Prey-predator relationships in the predator-stocking-evaluation reservoirs. Proc. Annu. Conf. Southeast. Assoc. Fish Wildl. Agencies 30:141–157.

- Lawrence, J. M. 1957. Estimated sizes of various forage fishes largemouth bass can swallow. Proc. Annu. Conf. Southeast. Assoc. Game and Fish Comm. 11:220-225.
- MacCrimmon, H. R. and W. H. Robbins. 1975. Distribution of black basses in North America. Pages 55-56 in R. Stroud and H. Clepper, eds. Black Bass Biology and Management. Sport Fishing Inst., Washington, D.C.
- Maceina, M. J., and J. J. Isely. 1986. Factors affecting growth of an initial largemouth bass year class in a new Texas reservoir. J. Freshwater Ecol. 3:485-492.
- and M. F. Cichra. 1987. Limnological characteristics of Aquilla Lake, Texas, during impoundment. Texas J. Sci. 39:55-69.
- and B. R. Murphy. 1988. Variation in the weight-to-length relationship among Florida and northern largemouth bass and their intraspecific hybrid. Trans. Am. Fish. Soc. 117:232-237.
- , ———, and J. J. Isely. 1988. Factors regulating Florida largemouth bass stocking success and hybridization with northern largemouth bass in Aquilla Lake, Texas. Trans. Am. Fish. Soc. 117:221-231.
- Mathur, D. 1977. Food habits and competitive relationships of the bandfin shiner in Hala-wakee Creek, Alabama. Am. Midl. Nat. 97:89-100.
- Mendenhall, W. 1971. Introduction to probability and statistics. Duxbury Press, Belmont, Calif. 466pp.
- Philipp, D. P., W. F. Childers, and G. S. Whitt. 1983. A biochemical genetic evaluation of the northern and Florida subspecies of largemouth bass. Trans. Am. Fish. Soc. 112:1-20.
- Schoener, T. W. 1970. Non-synchronous spatial overlap of lizards in patchy habitats. Ecology 51:408-418.
- Schramm, H. L., Jr. and M. J. Maceina. 1986. Distribution and diet of Suwannee bass and largemouth bass in the lower Sante Fe River, Florida. Environ. Biol. Fish. 15:221-228.
- Shelton, W. L., W. D. Davies, T. A. King, and T. J. Timmons. 1979. Variation in the growth of the initial year class of largemouth bass in West Point Reservoir, Alabama and Georgia. Trans. Am. Fish. Soc. 108:142-149.
- Shireman, J. V., D. E. Colle, and R. W. Rottman. 1978. Size limits to predation on grass carp by largemouth bass. Trans. Am. Fish. Soc. 107:213-215.
- , ———, and R. G. Martin. 1979. Ecological study of Lake Wales, Florida after introduction of grass carp (*Ctenopharyngodon idella*). Pages 44-90 in J. V. Shireman, ed. Proceedings of the Grass Carp Conference. Inst. Food Agric. Sci., Univ. Fla., Gainesville.
- Smitherman, R. O. 1975. Experimental species association of basses in Alabama ponds. Pages 76-84 in R. Stroud and H. Clepper, eds. Black Bass Biology and Management. Sport Fishing Inst., Washington, D.C.
- Steel, R. G. and J. H. Torrie. 1960. Principles and procedures of statistics. McGraw-Hill Book Co., Inc. New York. 481pp.
- Zaret, T. M. and A. S. Rand. 1971. Competition in tropical stream fishes: Support for the competitive exclusion principle. Ecology 52:336-342.