Fish Predation and Other Distinctive Features in the Diet of Nogies Creek, Ontario, Largemouth Bass, *Micropterus salmoides*

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Fresh and back-calculated lengths and weights of fish prey pumped from 1252 Largemouth Bass (*Micropterus salmoides*) aged one to eight (95 to 500 mm TL) produced GM regressions of Y = .27x – 3.6 (lengths) and Y = .03x – 3.3 (weights) in the Nogies Creek sanctuary, 1977. The fish prey averaged only 3% of the predator's body weight, well below average available sizes, and below sizes reported elsewhere. Of the six main forage species, four showed a wide length range (15 to 125 mm TL) and significant positive correlation with their predator length. Contrarily, very narrow length ranges of 70 to 80 mm TL for Golden Shiner (*Notemigonus crysoleucas*), and 25 to 55 mm TL for basses, were consumed. Pumpkinseed (*Lepomis gibbosus*) was the most abundant prey, followed by Rock Bass (*Ambloplites rupestris*), perch (*Perca flavescens*), and several cyprinids. Next to the consumption of "small-packaged" fish prey, the most distinctive feature of Nogies Creek Largemouth Bass diet was the high predation on tadpoles. An inverse relationship was found between frog and fish diets; when frogs and tadpoles were important (up to 34% by weight, ages three to seven), fish were not. A small crayfish component (maximum 13%, at age six) and very small insect component (except for age one), characterised the Nogies Creek diet in 1977. Ages one and two took Ephemeroptera, Odonata, Pumpkinseed, and Yellow Perch, and their diet was distinct from older bass which were primarily fish/frog feeders. Bass fed from mid-April to mid-October, ceasing at 10°C water temperature.

Key Words: Largemouth Bass, *Micropterus salmoides*, fish predation, diet.

The feeding of Largemouth Bass (*Micropterus salmoidas*) in lentic habitats has been well described but only three U.S. reports deal with lotic populations, only two with fish predation, and there are few studies of the species in its northern range. In fact, only one other published study (Keast 1970) examines Largemouth Bass feeding in Canadian waters.

The food and growth of juvenile or young-of-year (YOY) Largemouth in Nogies Creek has already been described (Hamilton and Powles 1979). The object of the present study was to describe food of the adults, ages 1 to 8 and over, with emphasis on fish prey sizes ingested with increasing age. Lewis et al. (1974), described sizes of fish prey ingested by Largemouth Bass in the field and Lawrence (1958) and Tarrant (1960) showed a positive relationship between sizes of forage fish and the bass predator. But Wright (1970) failed to demonstrate this in the laboratory. Our studies were designed to document predation on Nogies Creek forage fish species to allow a future comparison with Muskellunge, and to test the validity of the "optimal foraging theory" within an open weeded lotic habitat for Largemouth Bass.

Methods

Nogies Creek is an Ontario provincial sanctuary in which environmental parameters and the fish community have been studied for some years. Specific past research projects have focussed on Muskellunge, Rock and Largemouth Bass (Crossman 1956, and Muir 1960). The sanctuary's size and characteristics have been described in Hamilton and Powles (1979). Its eutropic waters support dense aquatic plant growth and algal blooms throughout the summer, and oxygen may occasionally become low at the bottom (1 mg/L), but not limiting to fish life in the rest of the water column.

Trap net and seining studies were already available to evaluate the relative abundance of fish prey species in the community.

Field Methods

Bass were captured live, by boat-mounted electroshocker, similar to that of Novotny and Priegel (1974). Standard 6- and 8-foot trap nets were also employed during April 1977 to October 1976 and 1977. In the winter of 1977, gill nets were set under ice.

Bass, hand-netted after shocking, were anaesthetized in 1:10 000 parts $MS_{222\,TM}$ to facilitate the stomach pumping procedure. After loss of equilibrium, they were removed from the bath, weighed, measured and subjected to gastric lavage (Crossman and Hamilton 1978) and a scale removed for aging. The fish were allowed to recover and then returned to the water.

Partially digested fish species were identified by use of a reference collection of skeletons from the locality. A bone possessing unique characteristics (as the operculum in Newsome 1977) was removed from partially digested prey, and compared to a collection of disarticulated skeletons from Nogies Creek. The prey was then identified to species. Using various regression of bones on total length, a back-calculated original length of fish prey was obtained as in Newsome and Gee (1978), and Pikhu and Pikhu (1970). Lengths of fish prey were plotted as original lengths (mm TL), and weights were computed from previous records to allow direct comparison with other studies.

To determine changes in diet with size, each Largemouth Bass was assigned to a length group corresponding to an age-class.

Stomach samples were obtained from a total of 1252 Largemouth Bass, from one to eight years of age and over. The oldest fish captured was 12 years. A number of bass were captured more than once but all data were included in the analysis. Identification of prey was to species for all samples used in the partitioning analysis; otherwise, to Family or Order, in the case of partially digested organisms (except for fish). Largemouth and Smallmouth Basses were grouped together as one prey type "basses".

To compare the diet of Nogies Creek largemouth to diets in other communities, frequency and weight were chosen as a common denominator. Our samples were broken down by frequencies, and lengths were converted to wet weights. Weights of invertebrates were taken from Cummins and Wuycheck (1971) using average weights. Thus, an Ephemeropteran weight of 0.009 g and a Cladoceran weight of 3.5×10^{-5} were used to estimate weights of such small invertebrates. The weights of frogs ingested by bass were calculated from a length/weight series of formalin-preserved specimens, since all frogs were discarded from the stomach contents at the time of the gastric lavage.

Results

Fish predation

Of the 20 fish species in Nogies Creek, Pumpkinseed, *Lepomis gibbosus*, Rock Bass, *Ambloplites rupestris* and Yellow Perch, *Perca flavescens* were most abundant in 1977 along with Largemouth Bass (Table 1). Less numerous in the catches were Golden Shiners, *Notemigonus crysoleucas*, and Smallmouth Bass, *Micropterus dolomieu*. Occasionally, Carp and Yellow Bullheads, *Cyprinus carpio* and *Ictalurus natalis* occurred, along with 3 species of *Notropis*, though not all these species were trapped in 1977. Four species of frogs are common and numerous, and the invertbrate fauna (typical for the region), are quite diverse (see Hamilton and Powles 1979).

Largemouth Bass from 95 to 500 mm TL consumed fish prey ranging from 19 to 170 mm TL (Figure 1). A GM regression analysis (Ricker 1973) between length of bass and length of fish prey yielded the equation

TABLE 1. Relative numbers of the common fishes taken over 428 trap-net-days in Nogies Creek, Ontario in 1977.

Pumpkinseed	*Lepomis gibbosus*	6655
Rock Bass	*Ambloplites rupestris*	3832
Yellow Perch	*Perca flavescens*	2170
Largemouth Bass	*Micropterus salmoides*	479
Muskellunge	*Esox masquinongy*	387
Golden Shiner	*Notemigonus crysoleucus*	321
Brown Bullhead	*Ictalurus nebulosus*	75
Smallmouth Bass	*Micropterus dolomieu*	7
Common Shiner	*Notropis cornutus*	6
Yellow Bullhead	*Ictalurus natalis*	1

$Y = 0.27X - 3.6$, where Y is the total length of the prey and X the total length of the Largemouth Bass, both in mm. The correlation coefficient ($r = 0.67$) was significant at the 0.01 level and the 95% C.L. on $V = \pm 0.021$. For all fish prey, a linear regression characterized Nogies Creek Largemouth Bass. For Illinois, the shad prey relationship was curvilinear.

Largemouth Bass, varying from 12 to 2100 g, showed the GM relationship between predator and weight of fish prey of $Y = 0.03X - 3.3$, where Y is wet weight of the prey and X, the weight of the Largemouth Bass in grams (Figure 2). This relationship was statistically significant ($p < 0.01$, $r = 0.62$) with the 95% C.L. on $V = \pm 0.002$. Within the size range examined, an average Largemouth Bass consumed a fish prey 3% of its own body weight in Nogies Creek. Again, the mixed prey line of Nogies Creek was linear relationship, while that for shad of Illinois (the only other comparable field data available) was curvilinear. Furthermore, the average weight of shad was for above the prey line for mixed prey of Nogies Creek.

When Nogies fish prey consumption of Largemouth Bass was broken down by length for each species (Figure 3), three clusters were apparent: 1) The length distribution of one group of prey species (Pumpkinseed, Rock Bass, Perch and Shiners) showed a uniform increase with predator size from 25 to 120 mm TL; 2) only intermediate sizes of Golden Shiner (70 to 90 mm) were consumed, and 3) the lower size-range of the Basses were ingested, from 20 to 60 mm TL. Poor positive correlations with length were thus obtained between both Golden Shiner ($r = 0.42$) and Basses ($r = 0.28$), as opposed to Pumpkinseed, Rock Bass, Perch and Shiners ($r = 0.98$, 0.87 and 0.73 respectively).

The most numerous fish species in the community was Pumpkinseed and these headed the prey list. There were 174 Pumpkinseed ingested by 753 Largemouth Bass over the 1977 feeding season (Table 2). Yellow Perch was the second most common fish prey species in spite of Rock Bass being more numerous in the waters (Table 1).

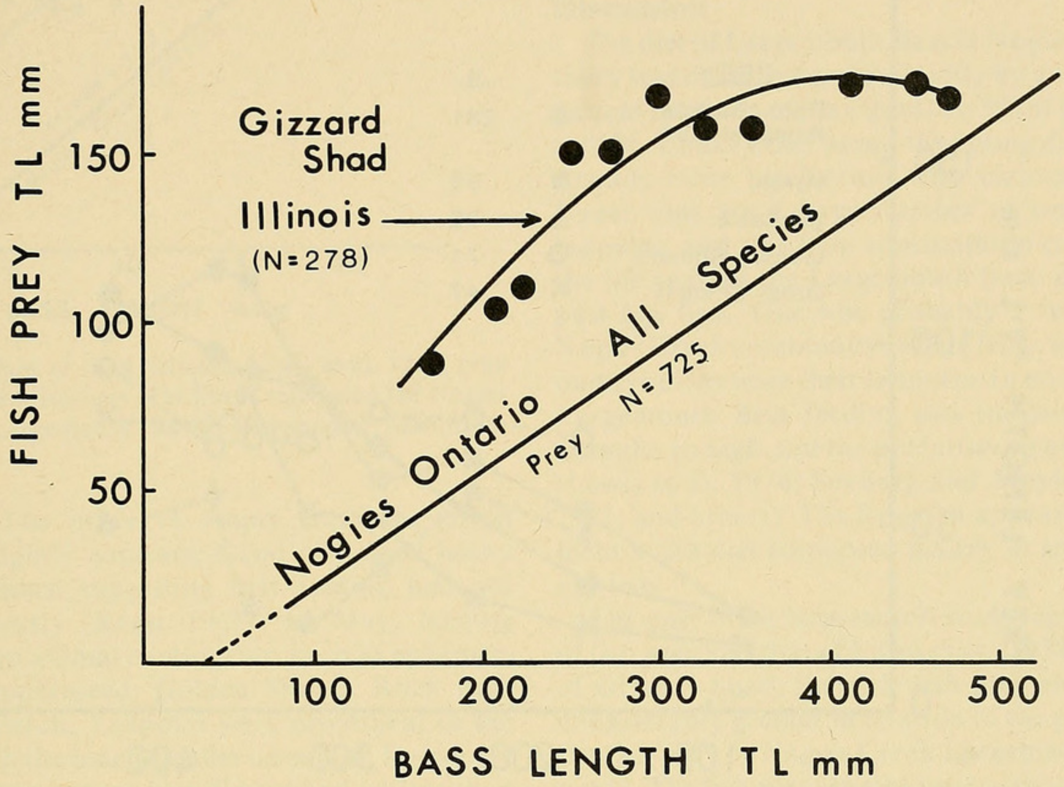

FIGURE 1. GM regression (Nogies Creek) and eye-fitted regression (Illinois) for fish prey and lengths of predator, the Largemouth Bass, *Micropterus salmoides*. (Gizzard Shad prey data from Lewis et al. 1974.)

Predation on perch was characteristic of all sizes of Largemouth, but 2- and 3-year olds (128 to 260 mm TL) ate slightly more perch than the larger sizes. Rock Bass were not eaten in quantities relative to their apparent abundance, but ranked third in importance by frequency. There was a tendancy for Rock Bass to be taken by the larger Largemouth Bass (over 305 mm TL). Of the less common species of fish prey (Table 1), Golden Shiners were taken reqularly by all ages except 1's, somewhat more frequently than would be suggested by their relative abundance in the community.

Other Food Organisms

Next to the "smallness" in the size of the fish food, the most distinctive feature of the diet of the Nogies Creek Largemouth Bass was the high frog component, particularly tadpoles (Table 2). All but the young (2- and 3-year olds) fed heavily on frogs, but ages 3 to 7 ate the most. Ages four and five were highest, with 76 tadpoles in 175 stomachs.

An interesting inverse relationship in the Largemouth Bass diet existed between frogs (tadpoles) and fish in this community (Figure 4.). In the stomachs of younger fish, tadpoles were a low component, 6%. As tadpoles built up in the diet with increasing age, the fish component decreased until age 5. Past age 5 the importance of frogs diminished and the fish contingent again became high.

The third principal component, insects, (particularly Ephemeroptera) were taken in large numbers by Largemouth Bass, but only by 1- and 2-year old bass. Older M. salmoides of Nogies Creek did not utilize this resource, nor did they consume many crayfish (25 in 753 stomachs, all ages), a common bass food.

Food Resource Overlap with Size

The type of food items ingested by different age groups of Largemouth Bass in Nogies Creek were compared statistically (Table 3), and the degree of overlap in the diets was assessed by the similarity coefficient, C_λ, as by Kislalioglu and Gibson (1977)

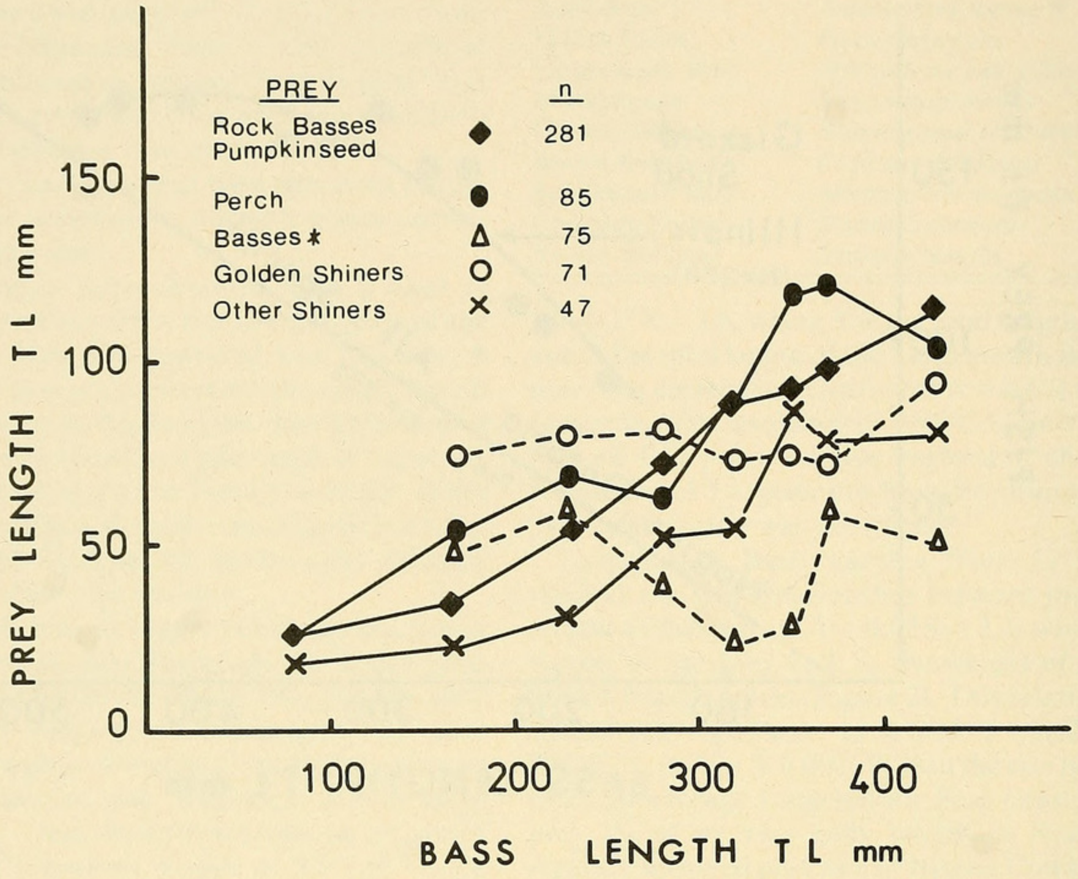

FIGURE 2. Relationships of individual prey species' lengths to length of predator, the Largemouth Bass, *Micropterus salmoides* in Nogies Creek, 1977. *Includes: largemouth and smallmouth.

and others. This coefficient varies from zero, when diets are completely distinct, to one, when the diets are similar in proportions of the prey groups or species. Thus, any value greater than 0.60 is accepted as indicating an overlap in diet.

Table 3 revealed that 1- and 2-year olds, while feeding on similar food, ate substantially different proportions of prey from all of the other age groups. From age 3 onwards, however, Largemouth Bass fed on similar proportions of the 12 main food items. The younger Largemouth Bass were responsible for most of the predation on Ephemeroptera and Odonata, as well as Pumpkinseed and Yellow Perch (Table 2). One other major difference was that age 3 fish and older ate crayfish, while the 1- and 2-year olds did not.

In summary then, 0-age largemouth from Nogies Creek ate mainly small and varied invertebrates (Hamilton and Powles 1979); 1- year olds ate tadpoles, small fish and invertebrates, and from age 3 onwards, the diets overlapped, being characterized by intake of six species of "small-sized" fish prey, a high proportion of frogs and tadpoles, followed by crayfish (of low importance).

Composition Through the Feeding Season

With regard to the length of the feeding season, some food was present in the guts from April to October (Table 4). Before the end of October (and before freeze-up) less than 50% of the stomachs contained food (52% empty in 1976, 70% empty in 1977). At mid-April, only four stomachs (20%) contained food, which was mostly vegetation. The length of the feeding season was thus estimated at about six months, mid-April through mid-October. The gill nets which we set under the ice in winter caught no Largemouth Bass, and so this conclusion is naturally

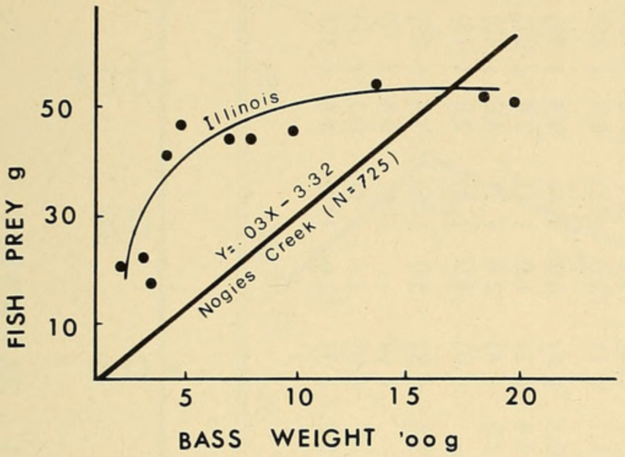

FIGURE 3. Weight of shad (Illinois, Lewis et al. 1974) prey and mixed fish-prey GM linear regression for Nogies Creek Largemouth Bass, *Micropterus salmoides*, 1977.

provisional. The other 16 empty stomachs (from April) were tightly contracted and contained heavy mucus secretions, suggesting that feeding had not occurred recently (Keast 1965). In May, feeding commenced on animal contingents, such as ephemeropterans Pumpkinseed, Golden Shiner, Rock Bass and Yellow Perch. Tadpoles were prominent in the diet along with the much smaller odonatan larvae. By June, ephemeropterans had diminished to less than 2% of the total number of food items that month, whereas tadpoles constituted 24% of the food items. Bolstered by large broods of free-swimming 0-year-old Largemouth Bass, the incidence of mixed large and Smallmouth Bass in the diet rose to 15% in June. Unidentified fishes, Pumpkinseed, Rock Bass, Golden Shiner and crayfishes were also important items in June (21.6%). In July, tadpoles (17.5%) and Pumpkinseed (17.8%) were the main food items, although Yellow Perch, Golden Shiners and Rock Bass were all of some importance. Gut contents in August were similar to those in July, although Pumpkinseed were much more important (26.1%) than tadpoles (9.4%). Fragments of vegetation were somewhat common in the diet of bass in August, amounting to 5.1% of a all food items in that month. In September, Pumpkinseed and tadpoles were again the two most frequently ingested food items (21.2 and 14.3% respectively), although Rock Bass and plant fragments represented a combined total of 25% of all stomach items.

In summary, the combined food frequencies (Table 4) over the study period indicated that ephemeropterans (all life stages, 18.8%) were the most frequent food items ingested by adult and juvenile bass in May. Tadpoles and older frogs (16.1%) represented the second most frequent food item, and these were eaten in June, July, September and October, but particularly June and October '76 and '77. Pumpkinseed (13 to 29%) were eaten mainly from July onward.

Discussion

The diet of Largemouth Bass in Nogies Creek Sanctuary was characterized primarily by a high fish component made up of prey less than 3% of the predator's weight. Unlike other areas, the young did not become steadily more piscivorous with increasing age. The 1-year olds ate a large number of small frogs and tadpoles, and this frog consumption continued over the life span of the Largemouth Bass, declining only past age five. This was probably a function of the Nogies Creek community, where frogs were extremely numerous, as were their tadpoles. In no other study of Largemouth Bass feeding was the consumption of tadpoles so high, nor the predation on crayfish so low. (Lewis et al. 1974; Seaburg and Moyle 1964; Snow 1971; and others). The frog diet appeared to complement a fish diet composed mainly of small-sized forage fish.

The only other largemouth study reporting lengths of fish prey was that of Lewis et al. (1974). The lengths of Gizzard Shad, the only fish prey measured, were considerably greater in relation to the predator, than the fish prey of Nogies Creek Largemouth Bass (Figure 1). The fish prey lengths were almost double those of Nogies Creek at the 300 mm TL predator length. The regression line for Gizzard Shad was curvilinear, whereas for our fish species it was linear for fish prey, as a whole, and for 4 of the six major prey species. The Gizzard Shad prey data of Lewis et al. (1974) when plotted on the same graph in fact, fell far above the Nogies' fish prey regression line, except beyond predator weight 1500 g. At a Largemouth Bass weight of 1800 g, the two prey regressions for Nogies and Crab Orchard Lake intersected, suggesting that the larger Gizzard Shad in Illinois waters were becoming increasingly unavailable, unattainable or not preferred. (Sevino and Stein 1982).

The other quantitative fish predation study directly comparable to ours (Lewis et al. 1974) showed that as Largemouth Bass increased in size, the prey (shad) length increased proportionately. The prey weight, expressed as a percentage of the predator weight, however, gradually decreased from 10% at 270 g to 3% at 1500 g. In the study by Lewis et al. (1974) this proportional reduction was probably a function, not of the maximum size of the prey (48 cm), but possibly of increased swimming speed of the prey as the size increased, or change in habitat of the larger shad. Within the length range of 175 to 484 mm TL, the average shad consumption was 6.2% of predator weight (Lewis et al. 1974).

TABLE 2. Percentage and numbers of organisms found in the stomachs of Largemouth Bass, *Micropterus salmoides*, in Nogies Creek, 1977, by size (age) group.

	Bass size mm TL (Age in bracket)																	
	50-127 mm (1)		128-203 mm (2)		204-260 mm (3)		261-304 mm (4)		305-336 mm (5)		337-360 mm (6)		361-380 mm (7)		380 mm 8 & over		Total	
Food items	%	Nos	%	Nos	%	Nos	%	Nos	%	Nos	%	Nos	%	Nos	%	Nos	%	Nos
FISH	60.0	(9)	78.0	(142)	83.9	(94)	51.1	(46)	50.6	(43)	49.6	(55)	75.9	(44)	92.0	(92)	69.7	(525)
Pumpkinseed	26.7	(4)	20.3	(37)	28.6	(32)	24.4	(22)	21.2	(18)	12.6	(14)	36.2	(21)	26.0	(26)	23.1	(174)
Yellow Perch	6.7	(1)	19.2	(35)	15.2	(17)	2.2	(2)	8.2	(7)	4.5	(5)	3.4	(2)	10.0	(10)	10.5	(79)
Rock Bass	6.7	(1)	6.0	(11)	4.5	(5)	3.3	(3)	10.6	(9)	10.8	(12)	20.7	(12)	33.3	(33)	11.4	(86)
Largemouth and Smallmouth Bass	—	(0)	3.8	(7)	11.6	(13)	2.2	(1)	3.5	(3)	2.7	(3)	1.7	(1)	3.0	(3)	4.2	(32)
Golden Shiner	—	(0)	4.4	(8)	11.6	(13)	11.1	(10)	2.4	(2)	9.1	(10)	10.3	(6)	9.0	(9)	7.7	(58)
Blackchin Shiner	—	(0)	2.7	(5)	4.5	(5)	4.4	(4)	3.5	(3)	—	(0)	1.7	(1)	2.0	(2)	2.7	(20)
Other fish species	—	(0)	7.7	(14)	8.0	(9)	2.2	(2)	4.7	(4)	4.5	(5)	5.2	(3)	6.0	(6)	5.7	(43)
Unidentified fish	20.0	(3)	21.4	(39)	18.8	(21)	6.7	(6)	3.5	(3)	9.9	(11)	8.6	(5)	13.0	(13)	13.4	(101)
FROGS	6.7	(1)	6.0	(11)	24.1	(24)	42.2	(38)	44.7	(38)	24.3	(27)	22.4	(13)	25.0	(25)	23.9	(177)
Tadpoles	6.7	(1)	5.5	(10)	19.6	(22)	41.1	(37)	41.2	(35)	19.8	(22)	20.7	(12)	13.0	(13)	20.2	(152)
Adult & juvenile	—	(0)	0.5	(1)	4.5	(2)	1.1	(1)	3.5	(3)	4.5	(5)	1.7	(1)	12.0	(12)	3.7	(25)
INSECTS	33.3	(5)	12.1	(22)	8.0	(9)	11.1	(10)	3.5	(3)	8.1	(9)	10.3	(6)	6.0	(6)	9.3	(70)
Ephemeroptera	26.7	(4)	7.1	(13)	0.9	(1)	2.2	(2)	—	(0)	3.6	(4)	3.4	(2)	1.0	(1)	3.6	(27)
Odonata	—	(0)	2.7	(5)	6.3	(7)	8.9	(8)	1.2	(1)	4.5	(5)	7.0	(4)	2.0	(2)	4.2	(32)
Other insects	6.7	(1)	3.3	(6)	0.9	(1)	—	(0)	2.4	(2)	0.9	(1)	—	(0)	4.0	(4)	2.0	(15)
CRAYFISH	—	(0)	—	(0)	0.9	(1)	2.2	(2)	2.4	(2)	6.3	(7)	13.8	(8)	5.0	(5)	3.3	(25)
Other invertebrates	—	(0)	1.1	(2)	2.7	(3)	1.1	(1)	—	(0)	—	(0)	—	(0)	—	(0)	0.8	(6)
Mammals	—	(0)	—	(0)	—	(0)	—	(0)	1.2	(1)	—	(0)	—	(0)	1.–	(1)	0.3	(2)
Vegetation	—	(0)	2.2	(4)	2.7	(3)	2.2	(3)	5.9	(5)	5.4	(6)	5.2	(3)	12.0	(12)	4.6	(35)
No. of Bass with food Items	15		182		112		90		85		111		58		100		753	

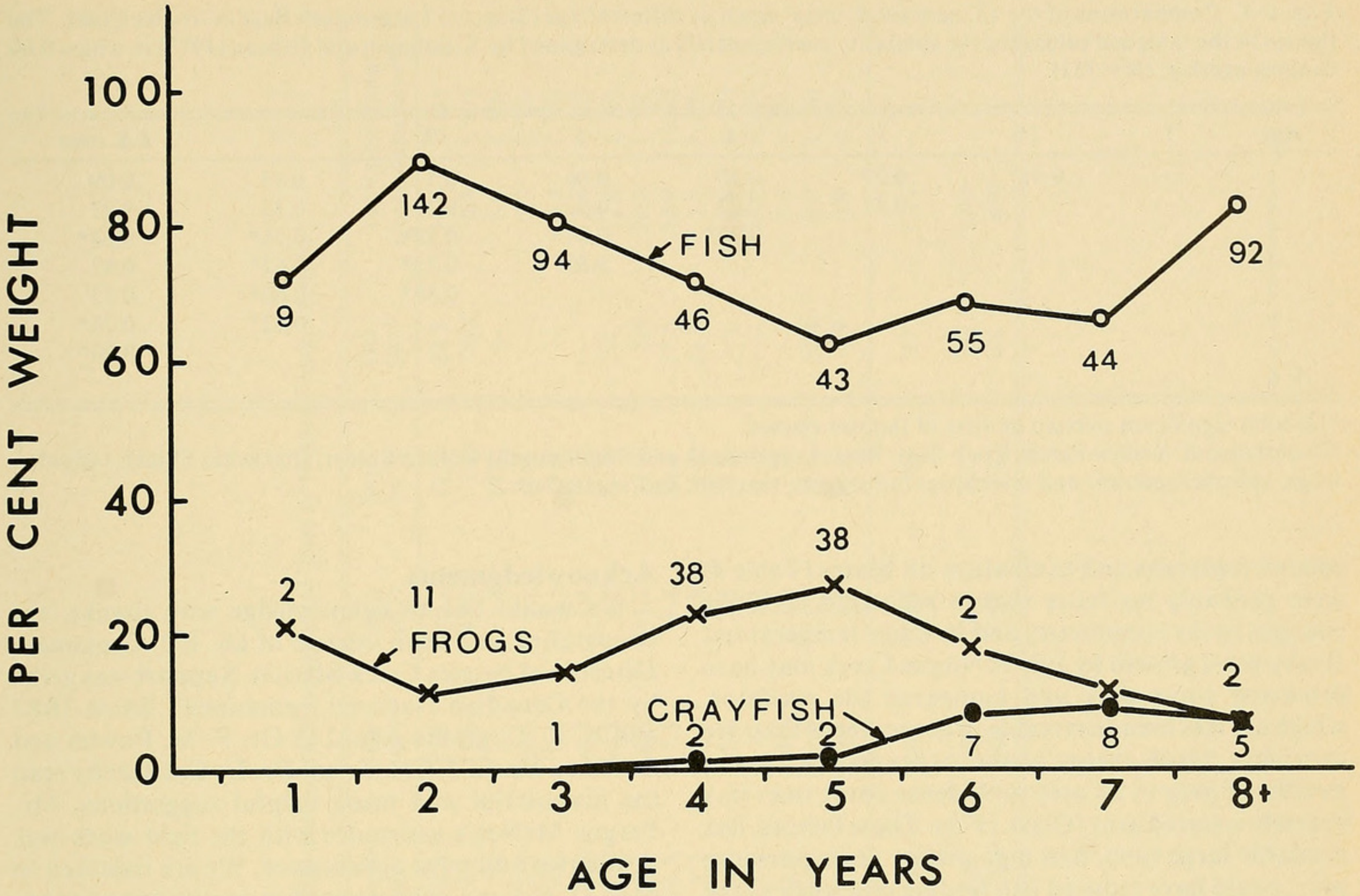

FIGURE 4. Relative weights of fish, frogs, and crayfish in the diet of Nogies Creek Largemouth Bass, *Micropterus salmoides*, 1977, by size and age-group.

In an experimental study, Werner (1977) reports that Largemouth Bass were able to consume fish 6.5% their own body weight, and obviously Lewis et al.'s (1974) samples verified this. Our Nogies Creek sampling suggested that the proportional weight of fish prey fell far below this level. Largemouth Bass of 1000 g took fish of only 2.5% of their own body weight, and bass of 2000 g consumed fish of 2.9% their body weight. Thus, it would appear that Nogies Creek bass did not feed at Werner's (1974) "maximum efficiency" (optimal foraging theory) level for fish prey. Unfortunately, there are no other field data published on prey size consumption for Largemouth Bass. Snow (1971) found prey to be mainly Bluegill, Bullheads and perch, but the weights of the fish prey organisms were not separated by predator size group, and more than half of the total food was crayfish, both by weight and frequency of occurrence. In Nogies Creek, frogs and tadpoles represent a high calorie diet (5 kcal per gram) as opposed to crayfish, at 2 kcal per gram dry weight (Cummins and Wuycheck 1971). The population thus ate small packages of high energy food rather than consuming the more typical higher weight components offered by crayfish. Snow (1971), for example, found 54.6% by weight (50% by frequency) of crayfish in Wisconsin Largemouth Bass. Generally, crayfish are not abundant in areas with detritus bottoms (Berrill 1978) such as Nogies Creek. Abundance of frogs and scarcity of crayfish probably explain the relatively heavy utilization of frogs and fish in 1976.

It is possible, though purely speculative, that the fast-growing muskellunge of the Nogies sanctuary, may "skim off" the larger prey species (Hourston 1952) leaving the smaller prey for Largemouth Bass. The other possibility is that predator success is reduced in the heavy vegetation (Savine and Stein 1982) and the smaller prey are relatively more numerous than the larger (older) fish prey.

The most efficient feeding would be achieved by ingesting larger forage as Largemouth Bass grow larger. Perhaps the tadpoles and frogs are relatively rich calorifically, and more easily digestible than centrarchids (no scales, thin skin), and being plentiful and slow, were easy to capture. This would have compensated for prey handling and smaller size of the food package in the energetics budget.

Seasonal feeding trends were rather usual or typical for bass populations. For example, spring feeding of

TABLE 3. Comparisons of the 12 main food items[1] eaten by different age classes of Largemouth Bass in Nogies Creek. The figures in the table are values for the similarity coefficient (C) as determined by Kislalioglu and Gibson (1977) in which 0.60 denotes overlap. (N = 753)

Age	1	2	3	4	5	6	7	8 & over
1	—	0.91*	0.07	0.10	0.06	0.11	0.13	0.09
2			0.31	0.23	0.22	0.30	0.33	0.27
3				0.77*	0.84*	0.89*	0.76*	0.64*
4					8.80*	0.72*	0.61*	0.47
5						0.86*	0.60*	0.52
6							0.82*	0.76*
7								0.90*
≤ 8								—

*Denotes significant overlap in diets of the size classes.
[1]Pumpkinseed, Yellow Perch, Rock Bass, Bass (Largemouth and Smallmouth) Golden Shiner, Blackchin Shiner, tadpoles, frogs, ephemeropterans and odonatons (all stages), crayfish, and vegetation.

ephemeropterans and canibalism on basses (Table 4) were probably no more than a reflection of biotic changes in the community and in water temperature. Heavy weed growth by July in Nogies Creek may have protected some prey and hampered the predator, which are less manoeuvreable in dense weeds than are cyprinids. More energy is also expended by bass in pursuit of prey in an area with dense cover than in a sparsely covered area (Glass 1971). These factors, less available large food, and high energy costs pursuing prey, could have reduced fish feeding efficiency of the Nogies Creek bass, explaining the heavy exploitation of slow tadpoles from June to September.

Numbers, or frequency of prey items, while useful in qualitative comparisons characterizing a community's food resource, often produce a false proportion or account in terms of bulk diet constituents. For example, although in May ephemeropterans ranked 18% by frequency, they amounted to only 1.6% by weight in the total diet for that month.

In the case of fish prey, frogs and tadpoles, their importance was accentuated by documentation of weights. The fish component ranged from 91 to 66% by weight throughout the season, and frogs from 7.7 to 34% by weight, depending upon the sizes of the predator.

The length and weight breakdown of fish prey in this study certainly makes us cautious in supporting the "optimal foraging" concept for Nogies Creek Largemouth Bass. The community is of intermediate complexity, and productive, which should encourage predator stability (Glass 1971). Modified behaviour tactics are suggested on the part of basses and Golden Shiners, but we have no records on Muskellunge's fish predation. This study demonstrates the need for more community-based and controlled feeding behavioural studies for prediction and interpretation of feeding data.

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TABLE 4. Monthly percentage frequency of food items consumed by 1252 adult and juvenile Largemouth Bass in Nogies Creek, Ontario

Food items	Oct. 1976	Apr. 1977	May 1977	June 1977	July 1977	Aug. 1977	Sept. 1977	Oct. 1977	Total percentage (Actual frequency)
Pumpkinseed	—	—	6.7	10.4	17.8	26.1	21.2	23.5	14.6 (191)
Yellow Perch	—	—	2.6	1.1	11.6	15.6	5.4	5.9	6.9 (91)
Rock Bass	26.4	—	4.9	7.9	7.8	5.4	12.5	—	6.9 (90)
Basses*	—	—	—	15.8	4.1	6.2	5.4	—	5.7 (75)
Golden Shiner	4.3	—	5.1	4.0	9.0	5.1	1.8	—	5.4 (71)
Blackchin Shiner	—	—	0.8	2.5	6.3	1.4	1.8	—	2.4 (32)
Other fish	—	—	2.4	0.4	4.5	4.7	—	—	2.8 (36)
Unidentified fish	4.3	—	2.8	21.6	9.3	11.2	17.9	5.9	10.6 (139)
Tadpoles	17.4	—	6.7	24.3	17.5	9.4	14.3	17.6	13.9 (182)
Adult frogs	47.6	—	0.3	2.2	0.4	1.8	2.8	11.8	2.1 (27)
Crayfish	—	—	0.3	3.6	2.6	2.2	1.8	—	1.9 (25)
Ephemeroptera } all stages	—	—	61.2	1.4	—	1.4	—	—	18.8 (247)
Odonata } all stages	—	—	4.9	2.5	4.5	2.5	—	—	3.4 (45)
Vegetation	—	100.0	—	0.4	1.9	5.1	12.5	29.4	2.7 (36)
Other	—	—	1.3	1.9	2.7	1.5	3.6	5.9	1.9 (23)
Total No. food items	23	4	389	278	268	276	56	17	1311
Total No. largemouth bass examined	42	20	136	208	290	384	103	69	1252
Total No. of empty stomachs	21	16	33	75	108	155	50	41	499

*Largemouth and smallmouth combined

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