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DEPARTMENT OF NATURAL RESOURCES

RESEARCH

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FOOD HABITS OF THE 1980 COHORT OF LARGEMOUTH BASS IN SPRUCE LAKE, 1981-1982

By
Michael H. Hoff
Bureau of Research, Woodruff

ABSTRACT

The food habits of 139 largemouth bass (Micropterus salmoides) captured during 1981 and 1982 in Spruce Lake were studied to determine the importance of stocked northern redbelly dace (Phoxinus eos), fathead minnow (Pimephales promelas), and golden shiner (Notemigonus crysoleucas) in the bass diet. All of the bass were from the same cohort stocked in 1980. This work followed rotenone treatments in 1978 and 1980, an antimycin treatment in 1980, and stocking of largemouth bass, northern redbelly dace, fathead minnows, and golden shiners from 1980-82. The mean length ± standard deviation of bass sampled during 1981 was 6.7 ± 1.4 inches, and 8.7 ± 0.8 inches during 1982. Most of the food habit information (123 of 139 bass) was based on stomach-pumping of angler-caught and released largemouth bass.

Based on relative importance index values (RI), odonates (RI = 31.3), cladocerans (RI = 22.0), and terrestrial insects (RI = 14.2) were the most important largemouth bass food items during 1981. Odonates (RI = 35.9), dipterans (RI = 23.1), and terrestrial insects (RI = 16.8) were most important during 1982. Fish were unimportant food items during the study because the stocked forage fish species failed to establish self-sustaining populations. However, the largemouth bass at least partially compensated for the low densities of stocked forage fishes by consuming invertebrates regularly (only 1.4% of the bass stomachs were empty).

In 1978 and 1980 piscicide treatments did not eradicate all fish species from Spruce Lake as planned. Among other species, yellow perch (Perca flavescens) were captured in the lake following the 1980 teatments. However, there were far fewer of them than at the time of the 1978 rotenone treatment. The above average growth noted for the 1980 cohort of largemouth bass presumably resulted from reduced interspecific competition with yellow perch for invertebrate food items. This above average growth occurred in this infertile, acidic, bog lake despite relatively high intraspecific competition (27/acre in spring of 1982).

Management implications include possible fish species combinations to be stocked in acidic lakes after piscicide treatments, and the use of gastric lavage for sampling the food items of live largemouth bass.

Department of Natural Resources • Madison, Wisconsin

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INTRODUCTION

The largemouth bass (Micropterus salmoides) is one of the most abundant and widely distributed game fish in Wisconsin (Mraz et al. 1971). Historically, about 32% of Wisconsin's anglers fish for largemouth bass, and angling pressure for this species is predicted to increase approximately 12% by 1991 (Klingbiel 1981). Even though largemouth bass is the dominant game fish in some infertile, small, northern Wisconsin acidic lakes, density of the bass is often low. Frequently an accompanying large population of slow-growing panfish is blamed for the poor reproduction, recruitment, and angling yield of the largemouth bass in this type of lake. One solution to this problem is to apply a fish toxicant to remove the panfish from the lake and then stock the lake with selected species. An experiment to document the results of this strategy was conducted on Spruce Lake, Vilas County, beginning with application of rotenone in October 1978 (Hoff 1986). Since the target species, yellow perch (Perca flavescens) and black bullhead (Ictalurus melas), were not eradicated by application of this piscicide, rotenone and antimycin were applied in May 1980. However, subsequent netting showed that these 2 pisicides were not totally effective in eliminating the perch and bullheads from Spruce Lake.

After the piscicides had detoxified in 1980, the lake was stocked with largemouth bass, northern redbelly dace (Phoxinus eos), fathead minnows (Pimephales promelas), and golden shiners (Notemigonus crysoleucas). The food habits of the bass were analyzed, as part of a general evaluation study (Hoff 1986). The current study determined the importance of the introduced forage fish species in the bass diet. Throughout this work, Spruce Lake was closed to public fishing.

STUDY AREA AND METHODS

Spruce Lake is a seepage bog lake of 16.5 acres in the Northern Highland State Forest, Vilas County (for a detailed description of Spruce Lake see Serns and Hoff 1982). The lake was treated with rotenone in July 1960, October 1978, and May 1980, and with antimycin in May 1980. Fish species that survived the 1978 and 1980 piscicide treatments or moved into Spruce Lake through the fish screen in the outlet of the lake are: yellow perch, black bullhead, central mudminnow (Ubra limi), white sucker (Catostomus commersoni), brook stickleback (Culaea inconstans), and finescale dace (Phoxinus neogaeus). Upon capture, all specimens of these species were removed from the lake (Table 1). From June 1980-October 1982, the lake was stocked with largemouth bass and several forage fish species: fathead minnows, northern redbelly dace, and golden shiners (Table 2). However, the forage fish species failed to establish self-sustaining populations (Hoff 1986).

Largemouth bass were captured with fyke nets and by angling in 1981 and by angling in 1982. Of the 20 largemouth bass captured during 1981, the 3 collected during June and the 4 collected during October were captured in fyke nets, while the 13 collected during July were captured by angling. All 119 bass captured during 1982 were angler-caught. All largemouth bass captured during both years were measured (total length) to the nearest 0.1 inch. The bass captured in June and July 1981 were removed from the lake and 7 of those

TABLE 1. Fish removed from Spruce Lake using fyke nets, gill nets, and minnow traps, 1980–83.

Year	Yellow Perch 1980 Year Class	Yellow Perch 1982 Year Class	Black Bullhead	Central Mudminnow	White Sucker	Brook Stickleback	Finescale Dace
1980	15	0	46	87	0	0	0
1981	609	0	1,449	16	1	0	0
1982	291	3	1,404	5	1	0	0
1983	21	147	18	0	0	1	2
Total	936	150	2,917	108	2	1	2

TABLE 2. Fish stocked in Spruce Lake following the 1980 piscicide treatments.

Date	Species	No. Stocked		Weight (lb)		Marking Method
18–20 Jun 1980	Northern redbelly dace	1,205	(73.0)*	1.0	(0.1)**	—[a]
10 Jul 1980	Fathead minnow	6,600	(400.0)	18.0	(1.1)	—
10 Jul 1980	Largemouth bass[b]	4,125	(250.0)	9.1	(0.6)	—
5–12 May 1981	Northern redbelly dace	6,550	(397.0)	31.7	(1.9)	—
19 Jun 1981	Largemouth bass[c]	36	(2.2)	7.0	(0.4)	Floy tag
10–15 Jul 1981	Fathead minnow	20,450	(1,239.4)	76.0	(4.6)	—
2 Sep 1981	Largemouth bass[b]	3,919	(237.5)	29.3	(1.8)	Right ventral fin clip
15 Oct 1981	Golden shiner	16,954	(1,027.5)	98.0	(5.9)	—
22 Sep 1982	Largemouth bass[b]	4,126	(250.0)	145.4	(8.8)	Anal fin clip
12 Oct 1982	Golden shiner	3,088	(187.2)	18.2	(1.1)	—

*No./acre in parentheses.
**Lb/acre in parentheses.
[a]Not marked.
[b]Fingerlings.
[c]2- and 3-year-olds.

caught in July were stomach-pumped, using a modification of the pump designed by Crossman and Hamilton (1978), before stomach removal and dissection. Food habit data from the 4 largemouth bass captured in fyke nets during October 1981 and the 119 bass captured by angling from May–September 1982 were based only on organisms removed by gastric lavage; these fish were released back into the lake after stomach pumping. The released bass were tagged with a Floy FD-67C anchor tag. The stomachs dissected from the largemouth bass and food items evacuated by stomach pumping were preserved in 10% Formalin. Food items were identified (to family for odonates and dipterans and to order for other aquatic insects), counted, and blotted on paper towels after which volumetric displacement (nearest 0.1-ml) was measured. The adult stage of insects whose larvae are aquatic was pooled with terrestrial insects. Absolute (AI) and relative (RI) importance index values for food items were calculated, using modifications of the indices developed by George and Hadley (1979), as follows:

$\underline{AI}_a$ = % frequency of occurrence + % of total numbers + % of total volume of food item a in all stomachs;

$\underline{RI}_a = 100 \cdot \underline{AI}_a$/sum AI values for all food items.

RESULTS

Food Habit Data for 1981

Based on relative importance index values (RI), the most important food items for the 20 1-year-old largemouth bass (mean length ± standard deviation = 6.7 ± 1.4 inches) captured during 1981 were odonates (RI = 31.3), cladocerans (RI = 22.0), terrestrial insects (RI = 14.2), and dipterans (RI = 14.1) (Table 3). The odonates identified were mostly anisopterans of the families Libellulidae (50.9%) and Corduliidae (23.6%) (Table 4). Monthly analysis of largemouth bass food habits during 1981 indicated that terrestrial insects were most important during June (RI = 50.0) and October (RI = 62.4), while odonates (RI = 40.0) were most important in July (Table 5). Cladocerans were found only in the stomachs of the largemouth bass captured during July (Table 5).

All food items were evacuated from 6 of the 7 bass stomachs that were dissected and examined after stomach pumping in July 1981 (Table 6). Retained in 1 stomach were parts of 2 odonates that constituted 0.4 ml of volumetric displacement. Since 18 of the 20 odonates and all other food items were successfully removed from this stomach by using the stomach pump, food habit data from October 1981 and May-September 1982 were based solely on organisms removed from live fish by using this technique.

Food Habit Data for 1982

The stomachs of 119 2-year-old largemouth bass (mean length ± standard deviation = 8.7 ± 0.8 inches) were pumped during May-September 1982 (a maximum of 25/month). Odonates (RI = 35.9), dipterans (RI = 23.1), and terrestrial insects (RI = 16.8) were the 3 most important largemouth bass food items during 1982 (Table 7). The odonates identified consisted mainly of Libellulidae (82.8%) and Corduliidae (5.1%), while chironomids (93.2%) dominated the dipterans (Table 4). Monthly RI values indicated that odonates, followed by dipterans and terrestrial insects, were the most important bass food items during June-September 1982 (Table 8). Golden shiners and mudminnows ranked above terrestrial insects in RI values, but below that of dipterans and odonates in May 1982, because of the relatively high frequency of occurrence and volumetric contributions of these fish species.

Effects of Gastric Lavage

Stomach-pumped largemouth bass did not appear stressed after release, and feeding behavior probably resumed shortly after release. For example, 1 tagged bass was recaptured and stomach-pumped only 48 hours after being captured and handled similarly. On the first date this fish was angler-caught and stomach-pumped, it contained 0.2 ml volumetric displacement of food, while 48 hours later this fish contained 1.2 ml displacement of food. Another tagged largemouth bass was stomach-pumped 3 times from May-August 1982, and this fish grew 1.2 inches in length during this period. In comparison, the difference in average length of largemouth bass captured from Spruce Lake during May and September 1982 was 1.3 inches. Therefore, it would appear that the growth of this fish was not substantially affected by the handling and stomach-pumping procedures.

TABLE 3. Food habit data for fyke-netted and angler-caught largemouth bass from Spruce Lake during June, July, and October 1981.*

Food Item	Total No. of Organisms	No. of Stomachs Containing the Organism	Frequency of Occurrence (%)	% of Total Food Items	Total Volume (ml)	% of Total Volume	Absolute Importance Index** (AI)	Relative Importance Index[a] (RI)
Arachnida	1	1	5.0	0.3	–b	0.0	5.3	1.3
Crustacea								
Cladocera	250	5	25.0	65.1	–	0.0	90.1	22.0
Insecta								
Odonata	55	9	45.0	14.3	6.0	69.0	128.3	31.3
Hemiptera	1	1	5.0	0.3	–	0.0	5.3	1.3
Trichoptera	11	1	5.0	2.9	–	0.0	7.9	1.9
Coleoptera	2	1	5.0	0.5	–	0.0	5.5	1.3
Diptera	30	10	50.0	7.8	–	0.0	57.8	14.1
Unid. Insecta remains	7	4	20.0	1.8	0.2	2.3	24.1	5.9
Terrestrial Insecta[c]	23	7	35.0	6.0	1.5	17.2	58.2	14.2
Vertebrata								
Golden shiners	2	1	5.0	0.5	0.9	10.3	15.8	3.9
Unid. fish remains	2	2	10.0	0.5	0.1	1.1	11.6	2.8
Total	384				8.7		409.9	

*20 stomachs, 1 (5.0%) empty.
**AI = % of total food items in all stomachs + % of total food item volume + % frequency of occurrence.
[a]RI = 100 × AI/sum AI.
[b]Less than 0.1.
[c]Includes the adult stage of aquatic insects if present.

TABLE 4. Family identity of Odonata and Diptera ingested by largemouth bass from Spruce Lake, 1981 and 1982.

Taxon	No. Organisms 1981		1982	
Odanata				
Zygoptera				
Lestidae	1	(1.8)*	7	(0.9)
Anisoptera				
Aeshnidae	1	(1.8)	8	(1.0)
Corduliidae	13	(23.6)	40	(5.1)
Libellulidae	28	(50.9)	648	(82.8)
Unidentified	12	(21.8)	80	(10.2)
Total Odonata	55		783	
Diptera				
Chaoboridae	0	(0.0)	4	(0.3)
Ceratopogonidae	1	(3.3)	86	(6.4)
Chironomidae	29	(96.7)	1,254	(93.2)
Unidentified	0	(0.0)	1	(0.1)
Total Diptera	30		1,345	

*Percent in parentheses.

TABLE 5. Relative importance indices (RI) for food items of 20 fyke-netted and angler-caught largemouth bass from Spruce Lake, June, July, and October 1981.

	June*					July**					October[a]				
Food Item	% Frequency of Occurrence	% of Total Food Items	% of Total Volume	AI[b]	RI[c]	% Frequency of Occurrence	% of Total Food Items	% of Total Volume	AI	RI	% Frequency of Occurrence	% of Total Items	% of Total Volume	AI	RI
Arachnida						7.7	0.3	0.0	8.0	1.8					
Crustacea															
Cladocera						38.5	70.0	0.0	108.5	24.3					
Insecta															
Odonata						69.2	15.4	93.8	178.4	40.0					
Hemiptera	33.3	25.0	0.0	58.3	25.0										
Trichoptera						7.7	3.1	0.0	10.8	2.4					
Coleoptera						7.7	0.6	0.0	8.3	1.9					
Diptera	33.3	25.0	0.0	58.3	25.0	69.2	8.1	0.0	77.3	17.3					
Unid. Insecta remains						23.1	1.7	3.1	27.9	6.3	25.0	4.3	0.0	29.3	8.4
Terrestrial Insecta[d]	66.6	50.0	0.0	116.6	50.0	15.4	0.6	1.6	17.6	3.9	75.0	82.6	60.9	218.5	62.4
Vertebrata															
Golden shiner											25.0	8.7	39.1	72.8	20.8
Unid. fish remains						7.7	0.3	1.6	9.6	2.2	25.0	4.3	0.0	29.3	8.4
Total				233.2					446.4					349.9	

*3 bass stomachs, 1 (33.3%) empty; bass mean length = 4.8 ± 0.7 inches.
**13 bass stomachs, 0 empty; bass mean length = 6.7 ± 0.9 inches.
[a]4 bass stomachs, 0 empty; bass mean length = 8.3 ± 0.5 inches.
[b]AI = % of total food items in all stomachs + % of total food item volume + % frequency of occurrence.
[c]RI = 100 x AI/sum AI.
[d]Includes the adult stage of aquatic insects if present.

TABLE 6. Food habit data for 7 angler-caught largemouth bass from Spruce Lake, July 1981.

Food Item	Food Habit Data by Fish Length (inches)						
	6.1	6.2	6.5	6.5	6.8	7.6	9.4
<u>Evacuated by stomach pumping</u>							
Zygoptera		1*/-**					
Anisoptera		1/0.1	1/-		1/-	18/2.7	2/0.1
Unid. Odonata				1/-			
<u>Oecetis</u> sp.					11/-		
Ceratopogonidae						1/-	
Chironomidae larvae		1/-				8/-	
Chironomidae pupae	3/0.0	4/-			1/-	4/-	3/-
Terrestrial Arachnida						1/-	
Terrestrial Insecta[a]		1/-					1/0.1
Unid. Insecta remains					1/-		4/0.2
<u>Remaining in stomachs after pumping</u>							
Anisoptera						2/0.4	

*Numerator = number of organisms; denominator = volumetric displacement (nearest 0.1 ml).
**Less than 0.1 ml.
[a]Includes the adult stage of aquatic insects if present.

TABLE 7. Food items extracted by stomach-pumping from angler-caught-and-released largemouth bass from Spruce Lake, May-September 1982.*

Food Item	Total No. of Organisms in All Stomachs	Total No. of Stomachs Containing Organisms	Frequency of Occurrence (%)	% of Total Food Items	Total Volume of Food Items (ml)	% of Total Volume	Absolute Importance Index** (AI)	Relative Importance Index[a] (RI)
Arachnida	13	8	6.7	0.4	0.5	0.6	7.7	1.5
Crustacea					–[b]			
Caldorcera	11	6	5.0	0.4	–	0.0	5.4	1.1
Copepoda	2	2	1.7	0.1	–	0.0	1.8	0.4
Ostracoda	5	3	2.5	0.2	–	0.0	2.7	0.5
Hydracarina	8	5	4.2	0.3	–	0.0	4.5	0.9
Insecta								
Ephemeroptera	10	4	3.4	0.3	–	0.0	3.7	0.7
Odonata	779	101	84.9	25.5	65.2	72.0	182.4	35.9
Hemiptera	14	9	7.6	0.5	–	0.0	8.1	1.6
Trichoptera	50	19	16.0	1.6	0.2	0.2	17.8	3.5
Megaloptera	1	1	0.8	b	–	0.0	0.8	0.2
Coleoptera	2	2	1.7	0.1	–	0.0	1.8	0.4
Diptera	1,341	86	72.3	43.9	1.3	1.4	117.6	23.1
Unid. Insecta remains	15	12	10.1	0.5	–	0.0	10.6	2.1
Terrestrial Insecta[c]	755	66	55.5	24.7	4.8	5.3	85.5	16.8
Gastropoda	1	1	0.8	–	–	0.0	0.8	0.2
Pelecypoda	5	5	4.2	0.2	–	0.0	4.4	0.9
Vertebrata								
Amphibia	7	3	2.5	0.2	0.7	0.8	3.5	0.7
Mudminnows	11	11	9.2	0.4	8.3	9.2	18.8	3.7
Golden shiners	13	13	10.9	0.4	4.5	5.0	16.3	3.2
Perch	1	1	0.8	–	2.4	2.7	3.5	0.7
Unid. fish remains	9	9	7.6	0.3	2.6	2.9	10.8	2.1
Total	3,053				90.5		508.5	100.2

*119 bass stomachs, 1 (0.8%) empty; bass mean length = 8.7 ± 0.8 inches.
**AI = % of total food items in all stomachs + % of total food item volume + % frequency of occurrence.
[a]RI = 100 x AI/sum AI.
[b]Less than 0.1.
[c]Includes the adult stage of aquatic insects if present.

TABLE 8. Relative importance indices (RI) for monthly food items of 119 angler-caught-and-released largemouth bass from Spruce Lake, May-September 1982.

	May*				June**				July[a]				August[b]				September[c]			
	% Nos.[d]	% Freq.[e]	% Vol.[f]	RI	% Nos.	% Freq.	% Vol.	RI	% Nos.	% Freq.	% Vol.	RI	% Nos.	% Freq.	% Vol.	RI	% Nos.	% Freq.	% Vol.	RI
Arachnida	0.2	4.0	0.0	0.8	1.4	15.0	0.0	3.5	0.1	4.0	0.0	0.7	1.7	4.0	1.4	1.5	1.0	8.3	2.3	2.5
Crustacea																				
Cladocera	0.9	4.0	0.0	0.9	--	--	--	--	0.2	12.0	0.0	2.1	0.7	8.0	0.0	1.9	--	--	--	--
Copepoda	--[g]	--	--	--	--	--	--	--	0.1	8.0	0.0	1.4	--	--	--	--	--	--	--	--
Ostradcoda	--	--	--	--	--	--	--	--	0.1	4.0	0.0	0.7	1.0	8.0	0.0	1.9	--	--	--	--
Hydracarina	--	--	--	--	--	--	--	--	0.1	4.0	0.0	0.7	2.0	16.0	0.0	3.8	--	--	--	--
Insecta																				
Ephemeroptera	--	--	--	--	--	--	--	--	0.6	16.0	0.0	2.9	--	--	--	--	--	--	--	--
Odonata	24.0	80.0	45.9	27.0	59.0	80.0	73.8	44.8	14.0	96.0	78.8	33.0	51.9	84.0	96.4	49.6	44.6	83.3	78.9	44.8
Hemiptera	1.5	16.0	0.0	3.1	1.9	15.0	0.0	3.6	0.1	4.0	0.0	0.7	--	--	--	--	0.3	4.2	0.0	1.0
Trichoptera	0.5	12.0	0.0	2.2	9.0	15.0	0.8	5.2	0.5	16.0	0.0	2.9	3.0	16.0	0.7	4.2	3.8	20.8	0.0	5.3
Megaloptera	--	--	--	--	--	--	--	--	--	--	--	--	0.3	4.0	0.0	0.9	--	--	--	--
Coleoptera	--	--	--	--	--	--	--	--	0.1	4.0	0.0	0.7	--	--	--	--	0.3	4.2	0.0	1.0
Diptera	64.3	96.0	2.5	29.3	14.2	45.0	0.0	12.5	49.4	96.0	2.7	25.9	33.7	72.0	0.0	22.6	4.9	45.8	0.0	11.0
Unid. Insecta remains	0.9	12.0	0.0	2.3	1.4	15.0	0.0	3.5	0.1	4.0	0.0	0.7	1.0	12.0	0.0	2.8	0.7	8.3	0.0	1.9
Terrestrial Insecta[h]	3.1	32.0	1.2	6.5	5.7	30.0	4.6	8.5	34.4	84.0	5.0	21.6	4.7	44.0	1.4	10.7	43.6	83.3	18.0	31.4
Gastropoda	--	--	--	--	--	--	--	--	0.1	4.0	0.0	0.7	--	--	--	--	--	--	--	--
Pelecypoda	0.2	4.0	0.0	0.8	1.4	15.0	0.0	3.5	0.1	4.0	0.0	0.7	--	--	--	--	--	--	--	--
Vertebrata																				
Amphibia	--	--	--	--	3.3	15.9	5.4	5.0	--	--	--	--	--	--	--	--	--	--	--	--
Mudminnows	1.3	28.0	26.9	10.1	1.9	20.0	13.8	7.5	--	--	--	--	--	--	--	--	--	--	--	--
Golden shiners	2.4	52.0	18.6	13.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Perch	--	--	--	--	--	--	--	--	0.1	4.0	9.2	2.3	--	--	--	--	--	--	--	--
Unid. fish remains	0.7	16.0	5.0	3.9	0.9	10.0	1.5	2.6	0.1	8.0	4.2	2.1	--	--	--	--	0.3	4.2	0.8	1.1
Total				100.0				100.2				99.8				99.9				100.1

*25 bass stomachs, 0 empty; bass mean length = 8.2 ± 0.7 inches.
**20 bass stomachs, 1 (5.0%) empty; bass mean length = 8.1 ± 0.5 inches.
[a]25 bass stomachs, 0 empty; bass mean length = 8.4 ± 0.6 inches.
[b]25 bass stomachs, 0 empty; bass mean length = 9.0 ± 0.5 inches.
[c]24 bass stomachs, 0 empty; bass mean length = 9.4 ± 0.7 inches.
[d]Percent of monthly total number of food items.
[e]Percent of monthly sample of bass which contained food item.
[f]Percent of monthly total volume of food.
[g]Not found.
[h]Includes the adult stage of aquatic insects if present.

DISCUSSION

The most important food items for largemouth bass in Spruce Lake during 1981 were odonates, cladocerans, and terrestrial insects, while odonates, dipterans, and terrestrial insects were most important during 1982. The major difference between the food habits of largemouth bass captured during 1981 compared with those of 1982 was the high RI of cladocerans in 1981, since odonates, dipterans, and terrestrial insects were very important food items during both years. Cladocerans were presumably more important during 1981 because all of the largemouth bass whose stomach contents were sampled were only 1 year old and had not yet fully assumed the foraging habits of larger bass. During 1982, when the largemouth bass stomach contents samples were from 2-year-olds, cladocerans ranked eleventh in RI value.

The odonates consumed during both years consisted mainly of the benthic, non-burrowing "sprawlers," Libellulidae and Corduliidae (Pennak 1953, Needham and Westfall 1954, Hilsenhoff 1975). Only a small percentage of the odonates consumed were Lestidae and Aeshnidae, "climber" odonates that frequent aquatic vegetation (Pennak 1953, Needham and Westfall 1954, Hilsenhoff 1975). The Lestidae and Aeshnidae were presumably ingested by the bass while foraging on the underside or edge of the *Sphagnum* sp. bog mat that composes most of the Spruce Lake shoreline (Serns and Hoff 1982). Dipterans were dominated by benthic dwelling chironomids (Pennak 1953). Although benthic prey (odonates and dipterans) were important food items for the largemouth bass in Spruce Lake, terrestrial insects, which were probably ingested at the lake surface, were also very important in the bass diet during both years. Cladocerans were important for 1-year-old bass during 1981, particularly during July. Thus, the largemouth bass showed versatility in foraging behavior by consuming prey available throughout the water column.

Fish were unimportant food items for the largemouth bass in Spruce Lake compared to the diet of largemouth bass of approximately the same size range in 2 infertile northern Michigan lakes (Clady 1974), a lake in eastern Ontario (Keast 1985), and a flowage in northwestern Wisconsin (Snow 1971). Clady (1974) found that fish constituted over 60% of the food volume of juvenile (yearlings up to 9.2 inches in total length) largemouth bass from June-September, while Keast (1985) reported that fish constituted 50% of the food volume of 1-year-old and 70% of the food volume of 2-year-old largemouth bass. Snow (1971) found a 50% frequency of occurrence for fish in the stomachs of 6.0-9.9 inch (total length) largemouth bass. Thus, the versatility in foraging behavior exhibited by the largemouth bass in Spruce Lake was important, considering the absence of an established population of forage fish on which to prey.

A low incidence of fish in the diet of the largemouth bass in Spruce Lake was also noted after the 1960 rotenone treatment (Kempinger 1969). Largemouth bass fingerlings and mudminnows, the only fish identified from largemouth bass stomachs collected from angler-caught fish from 1964-67, were found with a low frequency of occurrence (volume of food items was not measured). During that period, as in 1981-82, odonate larvae ranked highest in frequency of occurrence of all food items for largemouth bass in Spruce Lake.

The above average growth of bass exhibited throughout this study by the 1980 bass cohort (Hoff 1986) was presumably due to the low degree of competition, particularly with yellow perch, for the available invertebrate food items. Compared to the estimated density of 2-year-old and older largemouth bass (4.4/acre) at the time of rotenone treatment in 1978, the density of 27/acre in the spring of 1982 was high (Hoff 1986). However, the standing crop of largemouth bass in the fall of 1978 was higher (9.5 lb/acre) than in the spring of 1982 (6.2 lb/acre). Even at the high density of largemouth bass present in 1981 and 1982, with only limited interspecific competition with yellow perch for the available invertebrate food items, the bass compensated for the lack of forage fish in their diet by consuming large numbers of invertebrates regularly (only 1.4% of bass stomachs were empty). In contrast to the low percentage of largemouth bass from Spruce Lake detected with empty stomachs during this study, 68% of the stomachs from angler-caught Murphy Flowage largemouth bass were empty (Snow 1971).

The limited evaluation of gastric lavage in this study did not include evaluation of its effectiveness in evacuating fish from the largemouth bass stomachs. However, stomach-pumping did adequately sample invertebrate food items. Fish did appear to be effectively evacuated from the stomachs of the largemouth bass. Large food items (particularly fish) could be readily detected within the bass stomachs by probing with the tip of the stomach pump and by gently squeezing the bass in the abdominal region. In all cases, these large food items were quickly removed from the largemouth bass stomachs with 1 or 2 gentle pulses of water through the stomach pump. Foster (1977) evaluated the efficiency of fish removal from the stomachs of 41 largemouth bass using a similar stomach pump, and he found this technique to be effective. He removed 95% of the spiny-rayed fish and 100% of the soft-rayed fish from largemouth bass 2.0-17.7 inches in length.

MANAGEMENT IMPLICATIONS

This study indicates that the varied use of invertebrate food items by largemouth bass can sustain above average largemouth bass growth, even in an infertile bog lake without a large population of forage fish, at least through the third year of life. The above average largemouth bass growth noted in this lake occurred under a high degree of intraspecific competition (27/acre at the beginning of the second year of study). Thus, even though some northern Wisconsin lakes may not be able to support cyprinid forage fish, chemical treatment and subsequent stocking with only largemouth bass, or with largemouth bass and mudminnows, may be a viable management alternative. Mudminnows were consumed by largemouth bass in this study and in another (Kempinger 1969), and may be the best forage species available for stocking with largemouth bass in acidic, infertile, chemically treated waters.

Use of gastric lavage may be useful for fish managers interested in sampling the diet of live largemouth bass. This limited evaluation of stomach-pumping largemouth bass did not include evaluation of its effectiveness in evacuating spiny-rayed fish. However, pumping adequately sampled invertebrate food items.

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About the Author

Michael Hoff is a fishery biologist at the Northern Highland Fishery Research Area, Bureau of Research, Box 440, Woodruff, Wisconsin 54568.

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