Food Selection by Walleye Fry

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Abstract

Plankton samples and walleye fry were collected from two rearing ponds during the first week of life of the fry. The ponds, borrow pits created in construction of Interstate 75, are located in Roscommon County, Michigan. Fry were stocked in the ponds on May 14, 1975, while in the yolk-sac stage, and were first sampled the following day. The fry collected ranged in size from a mean of 9.17 mm in the first collection to 9.56 mm at the end of one week.

Pond 1 contained a mixed population of zooplankton, and the fry indicated a positive selection of *Bosmina*, but the selection was more a function of size than species.

Pond 2 contained almost a monoculture of *Daphnia*, and as a result they were the dominant organism in the diet of the fry. The average size of the *Daphnia* in the zooplankton population was significantly larger than the size in the diet of the fry. Apparently the fry were forced to seek the smaller individuals in the population.

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[1] Contribution from Dingell-Johnson Project F-35-R-3, Michigan.

Introduction

The walleye (Stizostedion vitreum vitreum) is one of the most popular sport fish in Michigan, but it is not abundant statewide. Strong and weak year classes are common phenomena. Many populations are limited by insufficient natural reproduction. In lakes with suitable spawning conditions food may be the limiting factor. Fry survival, and consequently year-class size, may be determined by the food supply during their first week of life. Walleye fry will starve to death within 9 days after they begin feeding if they do not have a proper food supply (Beyerle 1974).

Food and feeding of walleye fingerlings have been extensively studied, however few people have reported on the food habits of the fry because of the difficulty in capturing them. Larvae are pelagic for approximately the first 60 days of life until they attain a mean length of 35 mm (Forney 1976). The pelagic existence of walleye fry also has been observed in Oneida Lake by Houde (1967), in Lake Erie by Hohn (1966), in Wisconsin lakes by Faber (1967), and in Minnesota lakes by Johnson (1969).

Hohn (1966) found that fry 7 to 9 mm long fed exclusively on diatoms. Fry larger than 9 mm consumed Bosmina and copepods in addition to diatoms. Other workers have not confirmed this early dependence on diatoms. Houde (1967) and Johnson (1969) reported larval walleyes (7 to 9.5 mm) feeding on copepods and cladocerans before the yolk sac was completely absorbed.

The causes of variations in year-class size remain obscure. Forney (1976) followed eight year classes from estimated numbers of eggs through larval, fingerling, and yearling stages. Mortality always exceeded 99% from egg production until the fry were 9 - 10 mm long. He felt that most of this mortality occurred during the egg stage. Houde (1967) found that the number of zooplankters consumed by larval walleyes was independent of the zooplankton density--an indication that food supply may not be a mortality factor. Forney (1976) believed predation by yearling perch was a more likely explanation for the density-independent mortality during early fry development. However, he could not account for the strong year classes of walleye that developed during years of abundant yearling perch populations.

Most workers have attempted to demonstrate a selection of food items from the available plankton. Houde (1967) used the Electivity Index as devised by Ivlev (1961), and found that the copepod Epischura was positively selected over other species of copepods. Cladocera were negatively selected.

The possibility of size selection of food items by walleye fry has not been thoroughly studied. It is possible that the electivity seen by various workers is the result of size selection rather than species selection. The purpose of this study was to observe the abundance and size of food organisms available in the plankton and utilized by walleye fry during their first week of life.

Methods

Two freeway borrow pit ponds (T. 23 N., R. 2 W., Sec. 34 [Pond 1] and Sec. 33 [Pond 2]) were used to rear walleye fry from the yolk-sac stage to a length of 50-70 mm. Both ponds have a surface area of approximately 8 ha, a maximum depth of 2 m, and an average depth of 1 m.

The ponds were fertilized with hay and brewer's yeast. Hay was spread on the ice during January at a rate of approximately three bales per acre. Each pond received five bi-weekly applications of 30 pounds per acre of yeast. The first application of yeast was made 2 weeks before the walleye fry were planted. Walleye fry were planted on May 14, 1975, at a rate of approximately 135,000 per hectare. The water temperature at the time of planting was 18 C. Fry samples were collected on May 16, 17, 18, and 20, and plankton samples were taken on May 15 and 20. The plankton sample of May 15 was considered representative of the plankton available to the fry on May 16 and 17, and the May 20 plankton was considered to be available on May 18 and 20.

Fry were collected at night with a Student Plankton Net Sampler with No. 80 Nitex nylon mesh. The fry were attracted to a sealed-beam headlight operating off a 12-volt battery. They were preserved in formalin for later examination in the laboratory.

The entire digestive tract was dissected from the fry, and the contents were teased out of the tract with watchmaker's forceps under a compound microscope. Both the fry and food organisms were measured with an ocular micrometer. The stomach contents were mounted in Turtox CMCP-9AF stain-mountant for ease in measuring and identification. Twenty stomachs were examined from each sample of fry. All food items were measured if the degree of digestion allowed an accurate measurement. Plankton samples were collected during the day with the same plankton net used for the fry. A plankton sample consisted of one vertical lift of the net.

Weekly measurements were made from March 20 to August 10, of air and water temperatures, dissolved oxygen, total hardness, secchi disc transparency and pH. From May 14 through June 17, additional water samples were taken weekly for analysis of total phosphorus, soluble phosphorus, nitrates, ammonia, total alkalinity, organic nitrogen, calcium, magnesium, total carbon, and chlorophyll a.

Results

Chemical analysis of water samples indicated that the ponds remained very low in productivity despite attempts at fertilization. Soluble and total phosphorus values were almost always 10 $\mu g/l$ or less. Chlorophyll a values were always less than 5 $\mu g/l$ and were mostly less than 2 $\mu g/l$. Bridges (1971) found that total phosphorus and chlorophyll a were directly proportional in Lake Erie, and that total phosphorus values less than 20 $\mu g/l$ were associated with chlorophyll a values less than 5 $\mu g/l$. Chlorophyll a values less than 4 $\mu g/l$ indicate that these ponds are comparable in productivity to very unproductive oligotrophic lakes (Dobson et al. 1971; Rooney 1972). The scarcity of phytoplankton indicates that the biweekly applications of yeast were probably essential to the zooplankton production in the ponds.

The common zooplankton organisms in the ponds were Daphnia pulex, Ceriodaphnia reticulata, Chydorus sphaericus, and Bosmina longirostris. Percentages of empty stomachs and frequency of occurrence of the most common food items are contained in Table 1. The fry collected on May 16 were still carrying approximately 50% of their egg yolk, however more than half of them had started feeding. In Pond 1 Bosmina were the most common organisms in the fry ration during the first week of life. In Pond 2 Daphnia were eaten almost exclusively, but this was due to the almost complete dominance of Daphnia in the plankton of Pond 2. They made up 76% of the plankton on May 15 and 97% on May 20.

Sizes of organisms eaten by fry 8.68 to 10.4 mm in total length are shown in Figure 1. These data indicate that fry cannot utilize food organisms above a certain size. Fry less than 9.0 mm ate nothing over 0.60 mm, those under 9.4 mm ate nothing over 0.90 mm, and fry below 10.0 mm were restricted to food items 1.0 mm or less. There does not appear to be a restrictive minimum size food particle except possibly among fry larger than 10.0 mm. They ate nothing less than 0.50 mm.

Numbers and sizes of organisms in plankton samples and walleye fry stomachs are given in Tables 2 and 3. Most Daphnia in the stomachs were digested beyond the point of being measurable. Consequently our sample size is small for these organisms in stomachs, and the confidence limits tend to be broad. Apparently Daphnia digest more rapidly than Bosmina, Chydorus, and copepods. Seldom were these organisms unmeasurable in the stomachs.

Bosmina constituted 62 to 68% of the ration of the walleye fry in Pond 1 despite the fact that Daphnia were always more abundant in the plankton. Daphnia completely dominated the plankton in Pond 2, and consequently they also were almost the only food item utilized by the fry.

The index of selection (Ivlev 1961) indicated significant positive selection of Bosmina in Pond 1. In Pond 2, since Daphnia were dominant in both the plankton and stomachs, there was little indication of selection.

The positive selection for Bosmina in Pond 1 probably represents a size selection. The sizes of individuals being consumed simply were not available within the Daphnia population. Ceriodaphnia were available within the preferred size range, however they were never found in the fry stomachs. The strong positive selection of Bosmina was probably responsible for reducing their abundance from 11% of the total plankton on May 15, to 2% on May 20.

The average size of the Bosmina eaten in Pond 1 was larger than the mean size in the plankton, indicating that there was a selection for larger Bosmina. The data indicate that the Daphnia eaten in Pond 2 were larger than the Bosmina consumed in Pond 1 (Table 3). The fry in Pond 1 probably were able to utilize a larger particle than the Bosmina that they were eating, however the Daphnia were beyond their size range.

The Daphnia in the ration in Pond 2 were considerably smaller than in the plankton. The average size of Daphnia eaten was smaller than any of the individuals measured in the plankton. The fry were obviously forced to select the smaller Daphnia in the population. This may explain why the fry stomachs were essentially all empty on May 20, By that date the plankton consisted of almost a monoculture of Daphnia with an average size of 1.11 mm. All fry exceeded 10.0 mm by May 20 and should have been able to utilize these Daphnia (Fig. 1). However, it seems that they had consumed all of the smaller preferred individuals and had ceased feeding. Since it was the purpose of this study to determine food habits of walleye fry during their first week of life, they were not sampled beyond that time.

A satisfactory food source undoubtedly returned to Pond 2 since there was a significant survival of fry. Fingerlings were harvested by seining in July. It was estimated that only one-third to one-half of the fingerlings were harvested from Pond 2 due to excessive macrophytes and filamentous algae. The fingerling harvest was 209.4 kg (132,579) from Pond 1 and 83.0 kg (51,577) from Pond 2.

Acknowledgments

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Table 1.--Size of walleye fry (mm) and percent occurrence of food items in stomachs, May 1975[a]

Pond and date	Mean size of fry with 95% confidence limits	Food items				
		Empty	Daphnia	Bosmina	Chydorus	Copepods
Pond 1						
May 16	9.41 ± 0.15	40	8	83	25	0
May 17	9.46 ± 0.17	15	55	75	6	0
May 20	10.25 ± 0.19	25	20	67	27	0
Pond 2						
May 16	9.30 ± 0.13	30	86	0	0	0
May 17	9.22 ± 0.15	15	94	<1	1	0
May 18	9.86 ± 0.24	5	95	1	0	2
May 20	10.45 ± 0.16	85	67	0	0	33

[a] Fry without food not used in computing percentage of occurrence.

Table 2.--Abundance and size (mm) of organisms in plankton samples from walleye rearing ponds, May 1975

Organism, pond, and date	Number per sample	Percent of total fauna [a]	Mean size with 95% confidence limits
Daphnia			
Pond 1			
May 15	1,437	34	0.80 ± 0.06
May 20	13,450	64	1.00 ± 0.11
Pond 2			
May 15	2,575	76	1.04 ± 0.22
May 20	7,450	97	1.11 ± 0.09
Bosmina			
Pond 1			
May 15	402	11	0.33 ± 0.03
May 20	349	2	0.39 ± 0.07
Pond 2			
May 15	227	7	[b]
May 20	50	<1	[b]
Ceriodaphnia			
Pond 1			
May 15	806	22	0.46 ± 0.03
May 20	6,101	29	0.44 ± 0.02
Pond 2			
May 15	[b]		
May 20	[b]		
Copepods			
Pond 1			
May 15	837	23	0.48 ± 0.16
May 20	900	4	0.60 ± 0.14
Pond 2			
May 15	597	18	0.56 ± 0.13
May 20	200	2	0.45 ± 0.32

[a] Total fauna excludes copepod nauplii which were not utilized by the walleye fry.

[b] Numbers insufficient for measurements.

Table 3.--Abundance and size (mm) of organisms in walleye fry stomachs from rearing ponds, May 1975

Organism, pond, and date	E[a]	Mean number per stomach	Percent of total ration	Mean size eaten with 95% confidence limits
Daphnia				
Pond 1				
May 16	-0.077	0.05	0.5	[b]
May 17	-0.28	0.94	22.0	1.02 ± 0.33
May 20		0.20	11.0	[b]
Pond 2				
May 16	+0.10	1.0	92.0	0.50 ± 0.23
May 17	+0.13	2.0	98.0	0.73 ± 0.07
May 18	-0.02	3.5	93.0	0.85 ± 0.08
May 20	[b]	<0.1	[b]	[b]
Bosmina				
Pond 1				
May 16	+0.71	1.2	62.0	0.67 ± 0.35
May 17	+0.73	2.9	68.0	0.55 ± 0.04
May 20	+0.95	1.2	67.0	0.48 ± 0.15
Pond 2				
May 16	[b]	none		
May 17	[b]	0.05	2.0	
May 18	[b]	0.1	3.0	
May 20	[b]	none		
Copepods				
Pond 1				
May 16	-1.0	none		[b]
May 17	-0.96	0.1	0.1	[b]
May 20	+0.3	0.1	0.8	[b]
Pond 2				
May 16	[b]	none		
May 17	[b]	none		
May 18	+0.25	0.15	4.0	0.73 ± 0.35
May 20	[b]	none		

[a] E = electivity as calculated by Ivlev (1961).

[b] Numbers of organisms too few for meaningful estimates.

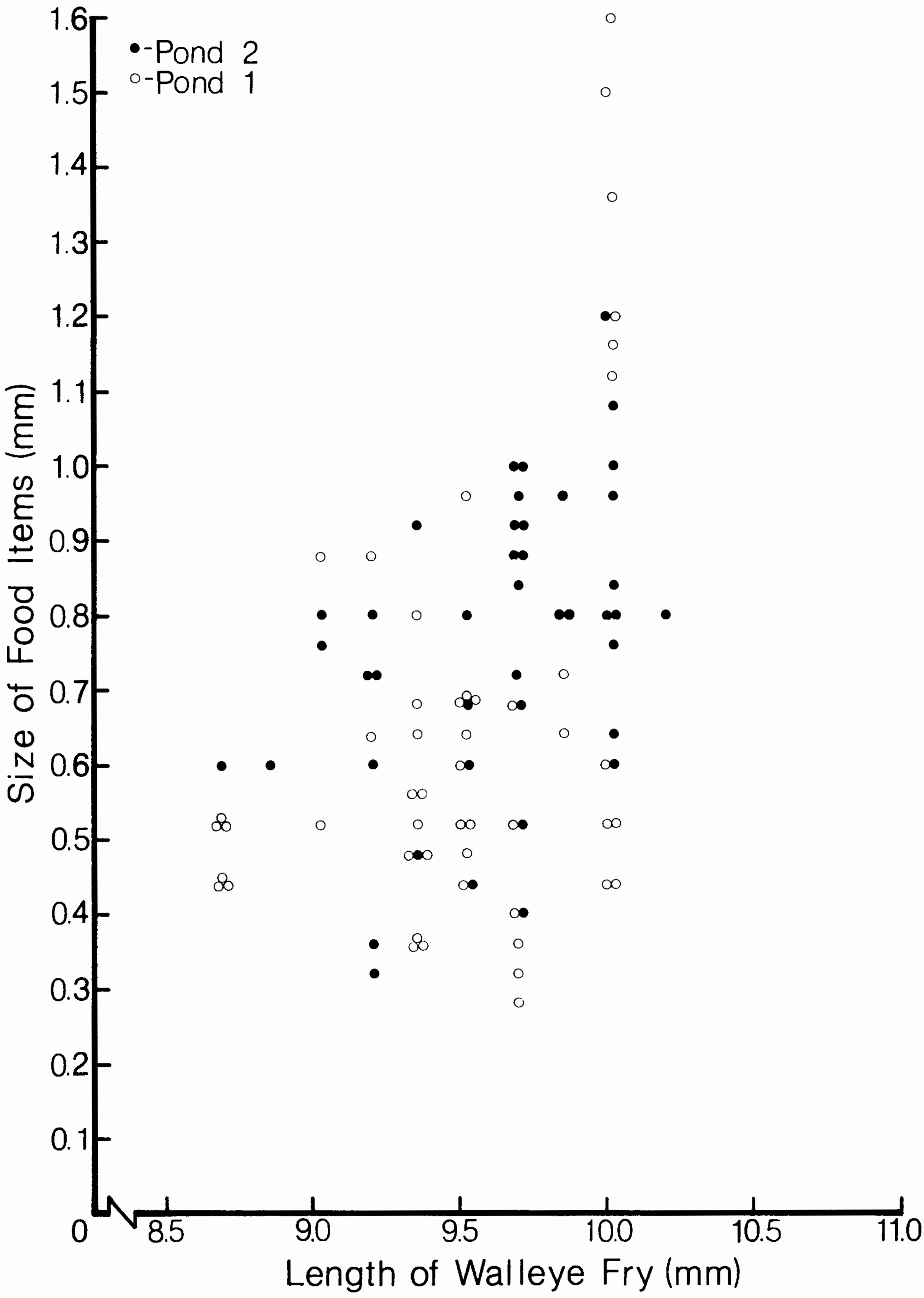

Figure 1.--Size frequency of food items eaten by walleye fry 8.68 to 10.40 mm total length.

Literature cited

Beyerle, George B. 1974. Propagation of warmwater predatory fishes. Michigan Department of Natural Resources, Dingell-Johnson Annual Progress Report July 1, 1973-June 30, 1974, F-29-R-8, Michigan, pp. 67-70.

Bridges, T. G. 1971. Chlorophyll "a" -- total P relationships in Lake Erie. Proc. 14th Conf. Great Lakes Research, Univ. Toronto, Ontario, pp. 185-190.

Dobson, H. F. H., M. Gilbertson, and P. G. Sly. 1974. A summary and comparison of nutrients and related water quality in Lakes Erie, Ontario, Huron, and Superior. J. Fish. Res. Board Can. 31(5): 731-738.

Faber, Daniel J. 1967. Limnetic larval fish in northern Wisconsin lakes. J. Fish. Res. Board Can. 24(5): 927-937.

Forney, J. L. 1976. Year class formation in the walleye (*Stizostedion vitreum vitreum*) population of Oneida Lakes, New York, 1966-73. J. Fish. Res. Board Can. 33(4, Part 1): 783-792.

Hohn, Matthew H. 1966. Analysis of plankton ingested by *Stizostedion vitreum vitreum* (Mitchill) fry and concurrent vertical plankton tows from southwestern Lake Erie, May 1961 and May 1962. Ohio J. Sci. 66(2): 193-197.

Houde, Edward D. 1967. Food of pelagic young of the walleye, *Stizostedion vitreum vitreum*, in Oneida Lake, New York. Trans. Am. Fish. Soc. 96(1): 17-24.

Ivlev, V. S. 1961. Experimental ecology of the feeding of fishes. Translated from Russian by Douglas Scott. Yale Univ. Press, New Haven, 302 pp.

Johnson, Fritz H. 1969. Environmental and species associations of the walleye in Lake Winnibigoshish and connected waters, including observations on food habits and predator-prey relationships. Minn. Fish. Invest. No. 5, Minn. Dep. Conserv., pp. 5-36.

Rooney, Robert C. (ed.) 1972. Water quality criteria 1972. A report of the committee on water quality criteria. National Acad. Sci., U.S. Gov. Printing Off., Washington, D.C. 594 pp.

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