EARLY PISCIVORY IN POSTLARVAE OF THE WHITE BASS

AARON L. CLARK[a], Water Resources Laboratory, University of Louisville, Louisville, KY 40208
WILLIAM D. PEARSON, Water Resources Laboratory, University of Louisville, Louisville, KY 40208

Abstract: Gut content analysis of postlarval white bass (*Morone chrysops*) collected from the Ohio River near Louisville, Kentucky, revealed that prolarval carp (*Cyprinus carpio*) were the major food item for postlarvae of 7-12 mm standard length (SL), although no larval fish were found in the stomachs of postlarvae 12-13 mm SL. The frequency of occurrence of zooplankton (primarily copepods and cladocerans) in the diet increased steadily from 20 to 100% as the postlarvae grew from 6.5 to 13.0 mm SL. The ecological implications of such early piscivory are discussed.

Proc. Ann. Conf. S.E. Assoc. Fish & Wildl. Agencies 32: 409-414

Year-class strength in fishes is apparently established by events taking place early in the life history. Hjort (1926) suggested that the most important cause of larval fish mortality during the "critical period" (the life history stage when subsequent strength of the year-class is set) might be the absence of suitable food.

May (1974) suggested that both starvation and starvation-enhanced mortalities resulting in death by predation are significant causes of death in larval fishes. Freshwater fishes are subject to greater fluctuations in physical environment (temperature, wave actions and currents, turbidity, water quality, etc.) than are marine fishes. Kramer and Smith (1962) suggested that these physical factors may be important as direct causes of mortality and in synergism with food-related mortalities. Changes in physical factors which prolong incubation time, reduce swimming ability, and alter metabolic rates of larval fish or their prey could all contribute to mortality rate.

Hunter (1976) also identified starvation and predation as the major causes of mortality in larval fishes, and indicated that there may be significant interactions between them. He also described some of the mechanisms by which density-dependent mortality rates could increase the effectiveness of predators as larval fish densities increase. Hunter also commented on the difficulty in examining stock and recruitment relationships in holistic fashion given the number of variables to be considered.

We (Clark and Pearson 1978) recently reported that freshwater drum (*Aplodinotus grunniens*) larvae have specialized morphological and behavioral adaptations for feeding on other larval fishes during their late prolarval and early postlarval developmental stages. These morphological adaptations include a high maxilla/SL ratio and well-developed, decurved teeth on both the maxilla and mandible. In this paper we present data establishing that similar morphological adaptations may also allow larval white bass to exploit an abundant but ephemeral food resource, namely prolarvae of the carp and perhaps other fishes.

The authors wish to thank E. R. Mancini for his critical review of the manuscript, R. G. Farmer for help in maxilla and standard length measurements, and B. D. Steele for help in collecting the larval fishes. This research was made possible by a grant from the Kentucky Institute for Mining and Minerals Research.

MATERIALS AND METHODS

Larval fishes were collected weekly from March through July 1977 at Ohio River Mile 571 between Louisville, KY, and Cincinnati, OH. Surface and bottom samples were collected at each of 4 sampling stations along a transect across the river during afternoon and night periods. Samples consisted of 5-min upstream tows using 0.5-m diameter, 361

[a]Present address: Woodward-Clyde Consultants, 3489 Kurtz Street, San Diego, CA 92110.

μm mesh, cone-shaped plankton nets. A digital flow meter was suspended in the mouth of each net. Samples were stored in 10% formalin and returned to the laboratory for analysis.

Measurements of standard length (SL) and maxilla length were recorded to the nearest 0.01 mm using a dissecting microscope with calibrated ocular micrometer. Larvae were separated into 1-mm SL size classes for analysis of food habits.

Stomachs were teased from 92 white bass using a pair of finely-sharpened dissecting needles. Larval fishes consumed by the postlarval white bass were identified using keys in May and Gasaway (1967) and Hogue et al. (1976).

RESULTS

Larval white bass appeared only in the weekly samples taken on 9 May and 16 May 1977. Most white bass larvae were collectd over rocky substrates near the Indiana shore. Larval white bass densities were low compared to those of many other larval fishes in the river, reaching a maximum mean density of 8.3 larvae/ 100m^3 on 9 May. Larval carp, the major food of postlarval white bass, were abundant throughout the river from 25 April to 20 June 1977, and reached a maximum mean density of 25.0/ 100 m^3 on 16 May 1977.

The smallest white bass larva examined was 6.5 mm SL and it contained a full complement of yolk. Generally, feeding was initiated when the larvae reached 7.0 mm SL, although 40% of the larvae examined in the 7-8 mm SL size class had empty guts and a full complement of yolk (Table 1). None of the larval white bass we examined had initiated feeding while endogenous food reserves were still available. The largest white bass postlarva examined was 13.0 mm SL.

Table 1. Frequency of occurrence of food items in the guts of postlarval white bass from Ohio River Mile 571.

Standard Length (mm)	*Number Examined*		*Food Items (% Frequency)*				
			Fish		*Invertebrates*		
	With food	*Empty*	*Cyprinus carpio*	*Unidentified Fish*	*Copepoda*	*Cladocera*	*Chironomidae*
7- 8	6	4	40	0	20	0	0
8- 9	16	0	75	12.5	0	3.7	12.5
9-10	24	0	91.7	4.2	25	16.7	8.3
10-11	16	0	75	12.5	25	0	0
11-12	10	0	40	60	20	0	0
12-13	16	0	0	0	75	12.5	12.5

Prolarval carp were the most frequently encountered food item in the guts of postlarval white bass from 7-12 mm SL (Fig. 1). Forty percent of the 7-8 mm SL size class had consumed prolarval carp, while piscivory occurred in 88% of the 8-9 mm SL size class, 96% of the 9-10 mm SL size class, and reached 100% of the 11-12 mm SL size class. No piscivory was noted in the 16 individuals exceeding 12 mm SL. Although most of the white bass contained only 1 larval carp, a few individuals contained 2 larval carp each. Invertebrates, primarily copepods and cladocerans with a few chironomid larvae, were found in 16-50% of the white bass larvae between 6.5 and 12.0 mm TL. In the 12+ mm SL group the frequency of occurrence of copepods increased to 75%. Larval catostomids and cyprinids (other than carp) were also present in the river in large numbers according to our sampling results (mean maximum densities on 9 and 16 May 1977 = 36.0 and 61.2/ 100 m^3, respectively), but were not consumed by white bass postlarvae.

Since mouth size is an important determinant of the foods a fish is able to eat and its mode of feeding (Keast and Webb 1966), we measured the apparent maxilla length of

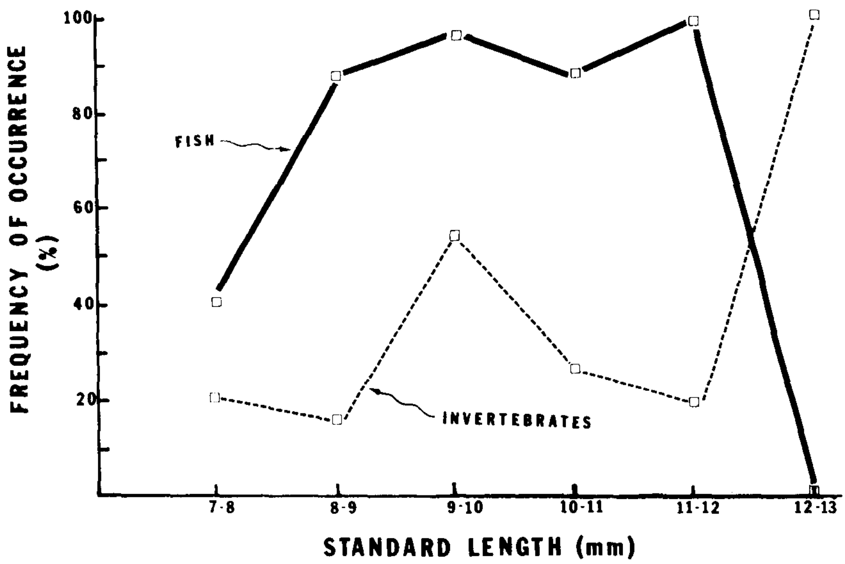

Fig. 1. Frequency of occurrence of fish and invertebrates in the diet of postlarval white bass 7-13 mm TL.

each larval white bass, 10 young-of-the-year (40-85 mm SL) white bass, and 10 yearling (85-180 mm SL) white bass. The young-of-the-year and yearling specimens were obtained from the University of Louisville Collection of Fishes and had been captured at several locations in Kentucky. The ratio of apparent maxilla length to standard length (maxilla/SL) varied from 0.09 to 0.13 for postlarval white bass and there was no evident trend of either increase or decrease with SL within the size range encountered (Table 2). The maxilla/SL ratios of young-of-the-year and yearlings were slightly higher (0.14 and 0.13, respectively) than the mean values for postlarval white bass.

DISCUSSION

The food habits of white bass have been described by Ewers and Boesel (1935), Sigler (1949), Bonn (1953), McNaught and Hasler (1961), Webb and Moss (1967), Priegel (1970), Ruelle (1971), Voigtlander and Wissing (1974), and Bulkley et al. (1976). Most authors who have examined the stomach contents of adult white bass agree that other fishes are the most important item in the diet (Sigler 1949, Webb and Moss 1967), although some authors have reported that large zooplankters were the most important items in the diet of all size groups (McNaught and Hasler 1961, Priegel 1970).

Voigtlander and Wissing (1974) reviewed the literature on food habits of white bass and concluded that fish in their first 2 summers of life fed primarily on zooplankton in the northern portion of the species range, while in the southern portion of the range they fed more extensively on other fishes. They also suggested that this dietary difference may account for the higher growth rates observed in the southern portion of the range.

Almost all of these authors agree that zooplankton are either the most important, or the sole food of very young white bass. Psicivory in white bass has first been reported at total lengths of 60-87 mm (Webb and Moss 1967), 51-110 mm (Priegel 1970), 23-125 mm

Table 2. Maxilla/SL ratios of piscivorous postlarvae, yearling, and adult white bass from the Ohio River.

Size Class (SL)	*N*	*Mean Length* (mm)	*Maxilla/SL Ratio*
7-8 mm	10	7.26	.11
8-9 mm	16	8.34	.13
9-10 mm	24	9.55	.09
10-11 mm	16	10.01	.11
11-12 mm	10	11.46	.11
12-13 mm	16	12.32	.09
40-85 mm	10	69.38	.14
85-180 mm	10	120.50	.13

(Bonn 1953), 48-120 mm (Voigtlander and Wissing 1974), and 21-30 mm (Ruelle 1971). Only ranges are given because the authors did not indicate the individual lengths of piscivorous fishes included within the given size groups. Only Webb and Moss (1967) found fish to be more important than zooplankton in the diet of white bass 60-100 mm TL. In the only previous studies in which larval white bass were examined, Bulkley et al. (1976) found that mixed samples of white and yellow bass (*M. mississippiensis*) larvae 4-15 mm TL consumed only zooplankton in Clear Lake, Iowa; while Ruelle (1971) reported the same results for white bass of 4-20 mm TL in Lewis and Clark Lake, SD. We examined 69 white bass larvae (7.3-14.0 mm SL) collected in 1975 from Lake Oahe, SD, and found them containing only copepods and cladocerans. Our findings of 7.0-12.0 mm SL white bass feeding on 4.2 mm SL larval carp represent piscivory at the smallest size yet reported for this species. However, as we have previously reported (Clark and Pearson 1978), larvae of the freshwater drum are piscivorous at an even smaller size of just 3.3 mm SL (3.8 mm TL).

In many fishes the mouth is initially small compared to body size and increases relative to body size as the fish becomes older and larger. Wong and Ward (1972) plotted the ratio of gape width/total length versus total length for young yellow perch (*Perca flavescens*) and showed that the ratio was very low at 5-12 mm TL, increased to a maximum at 17 mm TL and then tapered gradually to an intermediate value at 50+ mm TL. This pattern seems common to many percids and centrarchids which feed on zooplankton as larvae and become piscivorous only as juveniles and adults. We have previously shown that the freshwater drum is unusual in that it is one of the few freshwater fishes in which the mouth to body ratio (actually maxilla/SL ratio) is very high (0.16) at the time of yolk-sac absorption, reaches a maximum value in the postlarvae (0.19 at 10 mm SL), and then declines gradually (to 0.09) in juveniles and adults. In drum the period of maximum ratio corresponds to the period of piscivory observed in the larvae.

In white bass the maxilla/SL ratio is approximtely 0.11 for all size groups of postlarvae and then increases gradually to 0.13 in juveniles and adults. Therefore, it appears that the mouth to body size ratio begins and remains fairly high in this species and piscivory can be expected at all life history stages. The mandible of the white bass postlarva is equipped with a row of decurved, needle-like teeth which are certainly of use in grasping and manipulating the prey.

The white bass is a very abundant gamefish in many reservoirs of the United States. This species also seems to be one of the piscivorous gamefish which is capable of maintaining large populations as reservoirs age and other gamefish (i.e. largemouth bass) populations decline. The significance of adult white bass as predators on small shad, centrarchids, cyprinids and other forage fishes has been emphasized by many authors (i.e., Olmsted and Kilambi 1971). The abundance and relatively high fecundity of the white bass in many waters means that larval and young-of-the-year white bass may represent the most abundant piscivores present. Our observations of postlarval white bass just 7-12 mm TL feeding on larval carp, together with our previous observations of larval drum preying on other larval fish, indicate that the predator-prey relations of fishes should be examined at a much earlier life-history stage than has heretofore been attempted. The results of such examinations may prove to be valuable in manipulating both predator and prey stocks to achieve human objectives.

LITERATURE CITED

Bonn, E. W. 1953. The food and growth rate of young white bass (*Morone chrysops*) in Lake Texoma. Trans. Am. Fish. Soc. 82:213-221.

Bulkley, R. V., V. L. Spykerman, and L. E. Inmon. 1976. Food of the pelagic young of walleyes and five cohabiting fish species in Clear Lake, Iowa. Trans. Am. Fish. Soc. 105:77-83.

Clark, A. L., and W. D. Pearson. 1978. Early piscivory in larvae of the freshwater drum. Proc. Freshwater Larval Fish Workshop. TVA. Norris, Tenn. Feb. 21-22, 1978. In press.

Ewers, L. A., and M. W. Boesel. 1935. The food of some Buckeye Lake fishes. Trans Am. Fish. Soc. 65:57-68.

Hjort, J. 1926. Fluctuations in the year classes of important food fishes. J. Cons. Int. Explor. Mer. 1:5-28.

Hogue, J. J., R. Wallus, and L. K. Kay. 1976. Preliminary guide to the identification of larval fishes in the Tennessee River. Tech. Note B-19, TVA, Norris, Tenn. 67 p.

Hunter, J. R. 1976. report of a colloquium on larval fish mortality studies and their relation to fishery research, January 1975. NOAA Tech. Rept. NMFS Circ-395, 5 p.

Keast, A., and D. Webb. 1966. Mouth and body form relative to feeding ecology in the fish fauna of a small lake, Lake Opinicon, Ontario. J. Fish. Res. Board Can. 23:1845-1874:

Kramer, R. L., and L. L. Smith, Jr. 1962. Formation of year classes in largemouth bass. Trans. Am. Fish. Soc. 91:29-41.

May, R. C. 1974. Larval mortality in marine fishes and the critical period concept, Pages 3-19 *in* J. H. S. Blaxter, ed., The early life history of fish. Springer-Verlag, New York, N.Y.

May, E. B., and C. R. Gasaway. 1967. A preliminary key to the identification of larval fishes of Oklahoma, with particular reference to Canton Reservoir, including a selected bibliography. Oka. Fish. Res. Lab. Bull. No. 5, 42 p.

McNaught, D. C., and A. D. Hasler. 1961. Surface schooling and feeding behavior in the white bass, *Roccus chrysops* (Rafinesque), in Lake Mendota. Limnol. Oceanogr. 6:53-60.

Olmstead, L. L., and R. V. Kilambi. 1971. Interrelationships between environmental factors and feeding biology of white bass of Beaver Reservoir, Arkansas. Pages 397-409 *in* G. E. Hall, ed., Reservoir fisheries and limnology. Am. Fish. Soc. Spec. Publ. No. 8.

Priegel, G. W. 1970. Food of the white bass, *Roccus chrysops*, in Lake Winnebago, Wisconsin. Trans. Am. Fish. Soc. 99:440-443.

Ruelle, R. 1971. Factors influencing growth of white bass in Lewis and Clark Lake, Pages 411-423 *in* G. E. Hall, ed., Reservoir fisheries and limnology. Am. Fish. Soc. Spec. Publ. No. 8.

Sigler, W. G. 1949. Life history of the white bass, *Morone chrysops* (Rafinesque), of Spirit Lake, Iowa. Iowa Agric. Exp. Stn. Res. Bull. 366:203-244.

Voigtlander, C. W., and T. E. Wissing. 1974. Food habits of young and yearling white bass, *Morone chrysops* (Rafinesque) in Lake Mendota, Wisconsin. Trans. Am. Fish. Soc. 103:25-31.

Webb, J. F., and D. D. Moss. 1967. Spawning behavior and age and growth of white bass in Center Hill Reservoir, Tennessee. Proc. Annu. Conf. Southeast. Assoc. Game Fish. Comm. 21:343-357.

Wong, B., and F. J. Ward. 1972. Size selection of *Daphnia pulicaria* by yellow perch *(Perca flavescens)* fry in West Blue Lake, Manitoba. J. Fish. Res. Board Can. 29:1761-1764.