

POTENTIAL OF THE THREADFIN SHAD AS A FORAGE
FISH IN MIDWESTERN POWER COOLING RESERVOIRS^{1/}

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ABSTRACT

Threadfin shad (Dorosoma petenense) were successfully introduced into Southern Illinois Lake of Egypt in spring 1971. Adult shad overwintered for five years in the warm water discharge of a 100 megawatt fossil fuel power plant. No serious problems due to the shad introduction were encountered. Before the introduction, few white crappie (Pomoxis annularis) reached 200 g and the major diet of these crappie appeared to be insects. Within six years after introduction, a strong crappie fishery developed on the lake. After six years, the average calculated weights of white crappie were 2, 38, 100, 199, 546 and 896 g, at annulus 1-6, respectively.

White crappie between 150 to 240 mm total length fed heavily on threadfin shad only in the fall. White crappie larger than 240 mm total length utilized threadfin shad throughout spring, summer and fall.

INTRODUCTION

A particular problem in the management of crappie (Pomoxis spp.) populations has been slow growth rates resulting in a small percentage of the population attaining harvestable size. Crawley (1954) suggested three possible factors responsible for stunting of white crappie (P. annularis): (1) population

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density, (2) heredity, and (3) food supply. Rutledge and Barron (1972) reviewed the literature concerning these factors and concluded that formations of dominant year classes, producing either severe intra- or inter-specific competition, was responsible for crappie stunting.

New lakes and reservoirs are characterized by rapidly expanding fish populations with fast growth rates. Within several years, growth rates decrease and fishing success declines. Lewis (1967) summarized several studies which indicate that reduction in prey vulnerability was the principal factor in declining growth rates of predator populations. He suggested that the prey species responsible for the rapid growth rate are highly vulnerable to predation and thus are eliminated from the population.

In midwestern lakes the primary forage fish that is not eliminated is the gizzard shad (Dorosoma cepedianum), but because of its rapid growth rate it provides only a limited amount of forage to crappie and a high standing crop of non-vulnerable gizzard shad often develops. In southern lakes threadfin shad (D. petenense) have been reported to be a desirable forage fish (Myhr 1971, Range 1973, and Stevens 1959). Such findings have resulted in recommendations for stocking the threadfin shad where slow-growing crappie populations exist (Goodson 1966). However, since the threadfin shad dies at water temperatures below 10 C, they are found in Illinois streams only during the spring and fall. The warm water discharge created by the operation of fossil fuel electrical generating plants offers a unique opportunity to establish warm water stenothermic fishes in midwestern states.

The objectives of this study were to determine if an overwintering threadfin shad population could be established in a southern Illinois power cooling reservoir, to monitor the effect of this population on the existing white crappie population, and to investigate possible problems encountered due to the fall die off of the threadfin shad.

METHODS AND MATERIALS

Adult threadfin shad were stocked into Lake of Egypt and the growth rates of the shad and white crappie were monitored. In the spring of 1971, fifteen hundred adult threadfin shad that averaged 61 mm in total length were captured by seining on their spawning run in Lake Hamilton, Arkansas, and trucked to Illinois. Twelve hundred of these fish were released into Lake of Egypt, a 931-ha artificial impoundment located in Williamson County, Illinois. Lake of Egypt contains a typical warm water fish population including the gizzard shad. Southern Illinois Power Company operates three fossil fuel electrical generating units having a total capacity of 100 megawatts on Lake of

Egypt. The warm water discharge from these units keeps the impoundment's extreme northern portion ice-free throughout the winter.

Threadfin shad were sampled periodically from 1971 through 1975 with meter nets, gill nets (1.26, 1.90, 2.53, 3.80, 6.40 bar mesh), electroshocker, and from the revolving screens on the power plant intake. White crappie were sampled periodically by fishing, electroshocking and gill netting from 1969 through 1976. Since three sampling methods were employed, it is unlikely that any size class was missed. Total length to the nearest mm was recorded from representative samples of the threadfin shad. Scale samples were taken from the largest adult shad for age and growth analysis. All crappie were measured to the nearest mm total length and weighed to the nearest gram. Scale samples were taken for age and growth analyses. Stomach contents from all crappie were examined and classified into threadfin shad, other fish, or insects.

RESULTS

Threadfin shad have overwintered in the limited warm water discharge of the reservoir for five winters. Because of their thermal requirement of water temperatures 10 C or above, the shad are limited to an area of approximately 1.2 ha immediately below the warm water discharge pipe during January and February. Since warm water from the discharge pipe layers on top of the cold water in most of the 1.2 ha area, the potential threadfin shad brood stock population must remain in approximately 19,000 m³ of water for several months. During the winter numerous largemouth bass (Micropterus salmoides) and crappie move into the warm water and feed on the shad. Electrofishing and gill netting indicate that most of the threadfin shad disperse from the warm water area in the spring as soon as the lake temperature reaches 13 to 14 C.

The maximum length attained by the threadfin shad was greater the first year than it was in any of the next four years (Table 1). However, in all five years, numerous 30-35 mm young-of-the-year shad were captured in meter nets during October.

An attempt was made to age white crappie collected from Lake of Egypt a year before and for three years after the introduction of threadfin shad. Scales from 562 fish 125 to 255 mm (31-208 g) displayed two to five annuli with an almost complete overlap of age groups within this size class. Only 26 crappie were heavier than 180 g and 2 were heavier than 200 g. It was concluded that the crappie in this population were clustered in this size range. If older fish were in the population they could not be detected by scale analysis or

Table 1. Maximum total length in mm of threadfin shad in fall samples from Lake of Egypt

Year sampled	Year class				
	1971	1972	1973	1974	1975
1971	114(216) ^{1/}				
1972	132(18)	66(153)			
1973		104(12)	68(200)		
1974			106(7)	68(150)	
1975				144(25)	96(112)

^{1/}Number in parenthesis = sample size

length frequency analysis. It was impossible to obtain an average length and weight for each age group; therefore, increased spacing between the circuli was used as an indication of increased growth rate. When fish, especially small fish, are growing rapidly, there is usually considerable spacing between the circuli (Lagler et al. 1962, p. 119). Scales from fish less than 190 mm (160 g) did not appear to exhibit marked increased growth within the first three years after the shad introduction. Fish larger than 190 mm (160 g) appeared to be growing rapidly based on these criteria.

Stomach content analysis of 161 white crappie (20-208 g) taken in 1971 before the build up of a dense threadfin shad population indicate that the primary diet of all sizes of white crappie was Chaeoborus larvae. After the introduction of threadfin shad, stomach contents of crappie larger than 180 g included threadfin shad throughout the summer and fall. Further, there were only traces of Chaeoborus larvae in these larger crappie. During the summer, crappie less than 160 g continued to feed primarily on Chaeoborus. However, in the fall these smaller crappie also utilized threadfin shad (Table 2).

Age and growth analysis of white crappie collected in November 1976 did not display the clustering effect noted in the early part of the study. The average calculated weights of white crappie were 2, 37, 97, 183, 513 and 881 g at annulus 1-6, respectively (Table 3). The growth of white crappie at age group I was slower in Lake of Egypt than in other lakes at a similar latitude that do not contain threadfin shad. Growth rates of age group II-III white crappie were similar, whereas age groups IV-VI usually exhibited much faster growth rates (Table 4).

The percent frequency of occurrence of food items found in the stomachs of white crappie collected in November 1976 again demonstrated a major change in feeding habits with crappie size (Table 5). The stomach contents of white crappie

Table 2. Frequency of occurrence of preponderant food items, expressed as percent in the diet of white crappie that contained food from Lake of Egypt

Food item	Month of collection and weight range of white crappie in g									
	April 1971		July 1971		October 1971		July 1972		October 1974	
	20-160	180+	20-160	180+	20-160	180+	20-160	180+	20-160	180+
Fish										
threadfin shad	-	-	-	100(4) ^{1/}	60(57)	100(7)	-	100(6)	51(63)	90(20)
gizzard shad	-	10(10)	-	25(4)	-	14(7)	-	-	-	10(20)
or										
other fish										
Insects										
chironomidae	100(151)	100(10)	100(88)	0(4)	80(57)	0(7)	100(74)	0(6)	65(63)	5(20)

^{1/}Number of fish in parentheses.

Table 3. Calculated average total length (mm) of white crappie sampled November 1976 from Lake of Egypt, Illinois

Age group	Year class	No.	Calculated average total length (mm) at each annulus ^{1/}					
			1	2	3	4	5	6
I	1976	9	74					
II	1975	109	57	149				
III	1974	263	64	147	201			
IV	1973	66	71	169	219	247		
V	1972	7	96	212	265	310	344	
VI	1971	3	103	218	298	345	374	413
Total number			457	448	339	76	10	3
Average length			64	152	207	257	353	413
Length increment			64	88	55	50	96	60
Standard deviation			12.2	22.0	22.0	35.5	24.1	9.7
Range in length			45- 113	105- 229	146- 262	193- 347	306- 384	402- 421
Calculated weight (g) ^{2/}			2	38	100	199	546	896

^{1/}Since there was no significant difference (0.01) in the length and weight of male and female crappie, the sexes were combined.

^{2/} $\text{Log } W = -5.3460 + 3.1725 \text{ Lob TL}$ $R^2 = 0.988$

Table 4. Comparison of white crappie growth rates in Lake of Egypt and in selected midwestern lakes that do not contain threadfin shad

Impoundment	Calculated average total length (mm) at each annulus						
	1	2	3	4	5	6	7
Lake of Egypt ^{1/} (present study)	64	152	207	257	353	413	
Dale Hollow, TN (Range 1973)	80	152	189				
Horseshoe Lake, IL (Gunning 1954)	67	155	216	257	297	331	
Crab Orchard, IL (present study)	106	154	178	201	213	238	279
Red Haw, IA (Lewis 1950)	79	193	213	251	284	307	
Clear Lake, IA (Neal 1963)	71	145	185	208	234	272	323

^{1/} Six years after threadfin shad stocking.

Table 5. Stomach contents of white crappie sampled November 1976 from Lake of Egypt, Illinois

TL size range (mm)	Avg. wt. (g)	Stomach contents			Total no.
		Empty no. (%)	Insects no. (%)	Fish ^{1/} no. (%)	
120-129	21	1 (25)	3 (75)	0 (0)	4
130-139	27	5 (16)	26 (84)	0 (0)	31
140-149	33	8 (24)	25 (76)	0 (0)	33
150-159	41	4 (40)	2 (20)	4 (40)	10
160-169	50	4 (33)	0 (0)	8 (67)	12
170-179	61	9 (45)	1 (5)	10 (50)	20
180-189	72	25 (40)	4 (6)	34 (54)	63
190-199	85	24 (32)	1 (1)	51 (67)	76
200-209	100	25 (40)	0 (0)	37 (60)	62
210-219	116	10 (33)	0 (0)	20 (67)	30
220-229	134	4 (27)	0 (0)	11 (73)	15
230-239	154	19 (56)	0 (0)	15 (44)	34
240-249	176	9 (53)	0 (0)	7 (47)	15
250-259	200	4 (27)	0 (0)	11 (73)	15
260-269	226	2 (22)	0 (0)	7 (78)	9
270-279	254	1 (25)	0 (0)	3 (75)	4
280-289	284	1 (25)	0 (0)	3 (75)	4

^{1/}At least 95% of these were threadfin shad.

less than 150 mm total length consisted of Chaoborus larvae and a few chironomid larvae. White crappie 150 mm total length (approximately 33 g) and greater fed basically on threadfin shad.

In addition to determining the effect of the threadfin shad introduction on the white crappie population, several potential problems due to the fall die off of threadfin shad were also monitored. The die off occurs over a several month period, and at no time during the five winters were large numbers of threadfin shad found washed upon the shoreline. At the time of the first die off (fall 1971), large numbers of threadfin shad were impinged on the self-cleaning intake screens at the power plant, resulting in a partial clogging of the screens. This clogging was attributed to three causes. First, spot lights which were used to illuminate the intake structure caused large numbers of the photosensitive threadfin shad to concentrate in the intake area. Secondly, the water jets used on the rotating screens were not correctly aligned to remove the impinged fish, thus fish remaining on the screens fell behind them. Thirdly, fish that were washed off the front of the screen by the water jets fell into a trough that emptied into the lake beside the intake structure. Thus the dead fish were recycled onto the screens. As these shad began to decay, fewer and fewer were knocked off the screens by the water jets. By turning off the spotlights on the intake structure, re-aligning the water jets, and placing a cage under the trough discharge, the clogging problem was eliminated during the next four years of winter die off, and no power plant operation problem was encountered because of this phenomenon.

DISCUSSION

The rapid growth rate of threadfin shad from the first spawn was probably due to their relatively low density as a consequence of the limited number of brood fish initially stocked. For the next three years the maximum length of age group 0 shad stabilized around 6.8 cm. This may indicate that the overwintering population remained relatively stable. The increased growth rate during 1975 may have been due to an unusually warm period in February 1975 when most of the shad appeared to have moved out of the warm water and were subsequently killed by the following freezing temperatures. Sixteen hours of intensive electroshocking in the warm water on four days in March yielded only 123 shad.

Even though 30 mm threadfin shad were present in Lake of Egypt during most of the summer, they were not eaten by crappie less than 160 g until the fall. It is possible that the shad were stressed from reduced water temperature in the fall and became highly vulnerable to predation. Crappie larger than 180 g utilized threadfin shad throughout the summer as well as in the fall. This differential feeding

behavior probably accounts for the fact that larger crappie exhibited a substantial increase in growth rate after threadfin shad were introduced, while smaller crappie did not. Even though white crappie between 150-240 mm total length appear to utilize threadfin shad only in the fall, this short feeding period on a fish diet may be very important in moving the fish to a size where they can feed on shad all summer.

As a result of the increased growth of the larger crappie, a desirable crappie fishery has developed on Lake of Egypt. Good quantitative creel census data are not available to support this subjective observation, but it is notable that one minnow dealer has increased his distribution of minnows to Lake of Egypt five fold over the last three years.

Even though the threadfin shad is usually considered to be a desirable forage fish, several researchers have reported that a high standing crop of overwintering threadfin shad has correlated with a low year-class or slow growth of young-of-the-year largemouth bass (von Geldern and Mitchell 1975). This is thought to be caused by competition for plankton between the larval largemouth bass and young-of-the-year threadfin shad. Since in midwestern waters the largemouth spawns before the threadfin shad, and even in power cooling reservoirs most of the adult threadfin shad winterkill, there is less chance of competition either directly or indirectly with the largemouth bass.

The warm water discharge has allowed threadfin shad to overwinter in Lake of Egypt for five years. During this time a desirable crappie fishery has developed. In addition, these overwintering shad can be used each spring to stock non-cooling lakes where complete winterkills of threadfin shad occur. Heidinger and Imboden (1975) have indicated that this is feasible at midwestern latitudes, since young-of-the-year shad spawn the same year. Thus, only a small number of adult fish need to be transferred to a new lake to create a dense forage population by late summer.

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