Influence of Dense Hydrilla Infestation on Black Crappie Growth[1]

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Abstract: Black crappie (*Pomoxis nigromaculatus*) growth was reduced when hydrilla (*Hydrilla verticillata*) coverage exceeded 50% in Lake Baldwin, Florida, between 1977 and 1979. Black crappie did not reach harvestable size (>228 mm TL) until age 3 and 4 during periods of extensive hydrilla coverage and reduced threadfin shad (*Dorosoma petenense*) abundance. Following hydrilla removal and shad population reestablishment, harvestable size was obtained by age 2 and growth of older fish increased.

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Aquatic macrophytes are important components of aquatic ecosystems as they provide cover and support a forage base for piscivorous fish (Lantz et al. 1965, Holcomb and Wegener 1972, Ware and Gasaway 1978). Excessive submersed plant infestations, however, have been shown to alter fish community structure and cause reductions in condition factors and growth of various centrarchid species (Cope et al. 1969, Heman et al. 1969, Hickman and Congdon 1972, Barnett and Schneider 1974, Colle and Shireman 1980). The impact of dense submersed aquatic vegetation such as hydrilla, on black crappie growth has not been examined. The introduction and spread of the exotic submersed macrophyte, hydrilla, throughout Florida has caused many bodies of water to become completely infested with the plant. Although hydrilla supports substantial numbers of forage fishes (Shireman et al. 1981), this forage, due to physical limitation, may be unavailable to predation.

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Factors influencing crappie growth include turbidity, temperature and water level (Neal 1963), impoundment of rivers into reservoirs (Stroud 1948), and introduction of forage species (Beers and McConnel 1966, McGaig and Mullan 1960, Li et al. 1976). Threadfin shad introductions in southern waters have been a popular management technique (Noble 1981). The importance of fish and especially shad (*Dorosoma* spp.) in the diet of black crappie has been documented by several researchers (Reid 1950, Keast 1968, Ball and Kilambi 1973, Ager 1976).

Methods

Lake Baldwin, located in Orlando, Florida, is an 80 ha lake with a maximum depth of 7.7 m and a mean depth of 4.4 m. Lake Baldwin is a hard water lake of moderate mineral content and trophic state is classified as mesoeutrophic. Cattail (*Typha latifolia*), panicum (*Panicum hemitomon* and *P. repens*) and waterhyacinth (*Eichhornia crassipes*) fringe portions of the shoreline. Hydrilla has been the dominant submersed macrophyte in the lake since 1975.

Lake Baldwin was originally stocked in 1975 with 5,000 fingerling grass carp (125–150 mm TL) following herbicide treatment. Hydrilla became a problem again in 1977 and a population estimate was conducted on the lake to determine grass carp survival (Colle et al. 1978). A 0.1 mg/l rotenone (5% active ingredient Noxfish) was evenly applied to the lake which also caused a partial threadfin shad mortality. Hydrilla expanded in 1978, and the lake was stocked with an additional 1,865 grass carp (>304 mm TL) which eliminated hydrilla by April 1980.

Black crappie (252) were collected between January and June, 1982, utilizing electroshocking gear, gill nets, hook and line catches and a 12-m otter-trawl. The majority (180) of crappie were collected with the 12-m otter-trawl. Fish were iced, measured in total length (TL) mm and weighed to the nearest 0.1 g. Fish were dissected, sexed, and the largest otoliths, the sagitta, were removed. Otoliths were placed in glycerine ($C_3H_8O_3$) for 1 week which cleared the otolith and allowed for improved reading. Procedures for preparing and reading otoliths were followed according to Schramm and Doerzbacher (1982). An ocular micrometer mounted in a dissecting microscope was used to measure otolith radius and distance to annuli.

Body lengths and otolith radii were used to calculate a TL : otolith radius relationship. Inspection of the TL : otolith radius relationship revealed a slight sigmoid curve response. The following equation to best fit the data ($R^2 = 0.96$) was used to back calculate lengths:

$$\text{Log(TL)} = 3.6327 + 1.2204\ \text{Log(OTOLRAD)}$$

where TL is total length in mm and OTOLRAD equals the distance from the

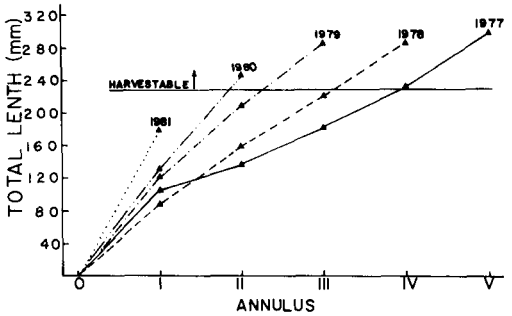

Figure 1. Hydrilla percent coverage (1977–1982) and mean black crappie growth increments (mm TL) for the 1977- to 1981-year classes.

center of the otolith to the anterior outside edge in mm. Measured distance to respective otolith annulii were log transformed to estimate total length and growth during previous years. Growth differences between sexes were tested using student's t-test and differences among calculated total lengths of age groups were tested utilizing analysis of variance and Duncan's Multiple range test. Significance levels were established at $P < 0.05$.

Hydrilla coverage in Lake Baldwin in 1977 was determined by conventional line transects. From 1978 to 1982, hydrilla coverage was calculated utilizing a DE719 Raytheon Recording Survey Fathometer. Methodology for determination of plant coverage was according to the procedures outlined by Maceina and Shireman (1980). Threadfin shad abundance was estimated by utilizing limnetic blocknets and rotenone annually from 1977 through 1981. Electrofishing was conducted quarterly during this period.

Results

Hydrilla

Appreciable amounts of hydrilla were recorded in the Spring 1977 when 15% of the lake area contained hydrilla (Fig. 1). Coverage increased throughout the Summer 1977 and was 59% by the fall. Maximum hydrilla coverage was reached in January 1979 with 79% of the lake infested. Hydrilla abundance declined steadily after this time and disappeared from the lake by June 1980. Hydrilla eradication was attributed to the second stocking of 1,865 grass carp (Shireman and Maceina 1981).

Threadfin Shad

Estimated shad density in 1977, when hydrilla coverage was 59%, was 2,048 ± 405 (±SE) fish/ha. Following the 0.1 mg/1 rotenone application to remove grass carp in 1977, large numbers of threadfin shad died. Colle et al. (1978) determined shad mortality to be 63%. By 1978, hydrilla coverage

approached 80% in the lake before declining in 1979. Although a substantially reduced population of shad remained in the lake, they were not collected with blocknets and by electrofishing until January 1981. Blocknets conducted in September 1981 indicated a population of 56,788 ± 13,854 shad/ha. Threafin shad are a pelagic species feeding chiefly in open water areas (Schmitz and Baker 1969). Thick hydrilla communities would prevent the fish from feeding effectively, thus the population would theoretically decline. One year following hydrilla removal, the threadfin shad population expanded.

Black Crappie

A total of 252 black crappie between 146 and 341 mm TL was collected for age and growth analysis. Of these fish, only 1 contained an otolith which was unreadable. Recently formed annular rings were not evident on otoliths of fish collected in January and February 1982. By the end of April, annulus formation was complete on all black crappie from the 1981 year class. By May, ring formation was in process or complete for all other year classes (1977 to 1980). Stroud (1948) observed a similar situation in Tennessee, where young black crappie completed scale annulus formation by May and older fish continued annulus formation into June.

Male crappie spawned in 1977 and 1978 were slightly larger than females after age 3, but the differences were not significant. Therefore, data for both sexes were combined to obtain growth data. Between late 1977 and early 1979 hydrilla abundance peaked and corresponding growth rates of age 1 and 2 fish of the 1977 year class and age 1 fish of 1978 year class were reduced (Table 1, Fig. 2). Following hydrilla reduction and removal in 1979

Table 1. Mean Calculated Total Lengths ($\bar{X}$ TL) and Ranges in mm and Number of Fish Collected for the 1977- to 1981-year Classes in Lake Baldwin, Florida

Year Class		Number	Annulus I	Annulus II	Annulus III	Annulus IV	Annulus V	$\bar{x}$ TL at Capture
1977	$\bar{x}$ TL		105	136	181	232	297	
	Range	46	88–125	113–159	156–212	202–268	270–327	303
1978	$\bar{x}$ TL		88	159	220	286		
	Range	42	74–110	143–173	202–268	264–311		296
1979	$\bar{x}$ TL		121	209	285			
	Range	3	107–133	184–227	253–306			289
1980	$\bar{x}$ TL		131	246				
	Range	34	99–166	231–277				264
1981	$\bar{x}$ TL		178					
	Range	114	124–221					204

and 1980, mean calculated growth increments increased for the 1977- and 1978-year classes (Fig. 1). First and second year growth progressively increased for fish spawned from 1979 to 1981. Data for 1979 fish, however, are based only on 3 individuals. Greatest first year growth was calculated for the 1981-year class. No hydrilla was present and a large population of threadfin shad inhabitated the lake in 1981. Dense hydrilla infestations coupled with shad population reduction in Lake Baldwin prevented black crappie from reaching harvestable size (>228 mm TL) until age 3–4. Following hydrilla removal and shad population reestablishment, harvestable size was obtained by age 2.

Dense hydrilla coverage and/or reduced shad abundance appeared to restrict black crappie growth. Mean calculated age group I total lnegths were significantly higher in 1979 and 1980 when compared to the calculated total lengths of 1977 and 1978 fish when hydrilla was at peak abundance. Shad were not abundant in the lake from 1977 to early 1981, which might have caused slower growth rates. Mean calculated age group II lengths significantly increased through time for the 1977- and 1979-year classes as hydrilla declined and disappeared from the lake. Examination of mean calculated growth increments for the 1977 year class indicated increased growth increments after age 2 (Fig. 1) when shad were not abundant and hydrilla was declining. Threadfish shad population reestablishment in January 1981 apparently caused increased incremental growth to occur in the 1977 fish between ages 4 and 5. Fish spawned in 1978 also demonstrated increased growth following shad population reestablishment between ages 3 and 4.

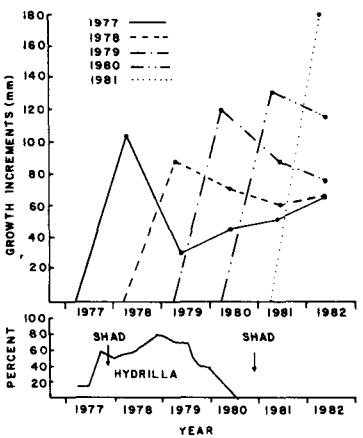

Figure 2. Estimated mean total lengths (mm) for 1977- to 1981-year classes of black crappie at annulus formation.

Discussion

Age and growth data collected on black crappie in Lake Baldwin indicated that hydrilla coverage greater than 50% between 1977 and 1979 restricted black crappie growth. Furthermore, the reestablishment of a dense threadfin shad population following hydrilla removal also increased crappie growth. Black crappie from the 1977- and 1978-year class in Lake Baldwin grew much less than crappie collected in Lake George, Florida, a non-hydrilla lake (Huish 1954). Mean calculated total lengths for ages 1 to 5 in Lake George were 112, 206, 251, 292 and 318 mm. Following hydrilla removal, however, black crappie grew faster in Lake Baldwin than in Lake George. Dense hydrilla probably retards crappie feeding efficiency. Black crappie diet (>100 mm TL) primarily consists of aquatic insect larva, other benthic invertebrates and fish (Reid 1950, Keast 1968, Ball and Kilambi 1973, Ager 1976). Hydrilla harbors large numbers of small forage fish, however, these may be inaccessible to predation. Large numbers of macroinvertebrates including immature aquatic Insecta also inhabit hydrilla (Martin and Shireman 1976). Keast (1968) postulates young black crappie (<106 mm TL) are a nocturnal midwater filter feeding fish primarily consuming crustacean zooplankton, *Chaoborus* and chironomid larva. Thus, the physical structure of dense hydrilla communities would restrict young crappie feeding activity.

Shireman et al. (1979) reported an increase in *Chaoborus* larvae density following hydrilla disappearance in the profundal zone in Lake Wales, Florida. Dense hydrilla infestations probably reduce predaceous *Chaoborus* larva populations by inhibiting nocturnal vertical migration into the water column. Reduced crappie growth in Lake Baldwin from 1977 to 1979 may be partially attributable to a reduction in *Chaoborus* larva populations during peak hydrilla infestation. Black crappie food habit data from Lake Baldwin indicated that *Chaoborus* larva and threadfin shad are important dietary food items (Shireman and Maceina 1982). Threadfin shad abundance declined during high hydrilla infestations (see earlier section). Thus, black crappie growth may indirectly be affected by increases in hydrilla coverage by reducing threadfin shad and *Chaoborus* populations. During 1979 and 1980, hydrilla abundance declined in Lake Baldwin, the forage base was released from the protection of plant cover and an increase in black crappie growth was observed.

Impact of threadfin shad introduction on black crappie growth has not been published. Beers and McConnell (1966), however, reported an increase in black crappie condition following threadfin shad introduction in a California lake. Introduction of smelt (*Osmerus mordax*) and Mississippi silverside (*Menidia audens*) into lakes improved black crappie growth after age 3,

(McGaig and Mullan 1960, Li et al. 1976). Threadfin shad introduction into Dale Hollow Reservoir improved white crappie (*Pomoxis annularis*) growth (Range 1973).

The management of freshwater game species includes maximum sustainable production of harvestable fish. Our data indicate that extreme weed infestations restrict black crappie growth and delay recruitment into the fishery by at least 1 to 2 years. Therefore, potential yield may be reduced. A certain amount of macrophytes, however, may be important to serve as a nursery area for young-of-the-year (YOY) black crappie and other centrarchids. Large numbers of YOY black crappie have been found to inhabit hydrilla communities (Shireman et al. 1981). Data on the number of black crappie caught from each year class in 1982 showed that year classes produced in 1977 and 1978 were moderately strong during peak hydrilla abundance (Table 1). The 1979-year class failed and the 1980-year class was weak during the decline and absence of hydrilla. The 1981-year class, however, was extremely large and composed the greatest percentage of the catch. Therefore, other mechanisms may be involved in determining black crappie year class strength besides aquatic macrophyte abundance. Our data demonstrate that excessive hydrilla infestation decreases black crappie growth either directly by decreasing foraging efficiency and/or indirectly by causing the decline of preferred food items. Control of dense aquatic vegetation communities should be considered in order to improve growth rates and subsequently catch of large crappie.

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