Bluegill Populations Associated with Water Lily, Water Shield and Pondweed Stands: Management Implications

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Abstract: Small bluegills (*Lepomis macrochirus*) were collected weekly with unbaited minnow traps from stands of water lily (*Nymphaea odorata*), water shield (*Brasenia schreberi*), and pondweed (*Potamogeton nodosus*) located in Bluff Lake, Noxubee National Wildlife Refuge, Oktibbeha County, Mississippi, during July–October 1990 ($N = 15$ sample dates). Average stem density within macrophyte stands was 19.25 (SD = 2.31), 208.81 (SD = 12.92), and 866.50 (SD = 75.11) stems/m^2 for water lily, water shield, and pondweed, respectively. Pondweed exhibited significantly higher surface coverage (proportion of sample plot covered on surface, mean = 0.93, SD = 0.03) than water lily (mean = 0.72, SD = 0.06) or water shield (mean = 0.76, SD = 0.06). Catch per unit of effort (CPUE) for number of bluegill (fish/trap-night) and CPUE for weight of bluegill (g/trap-night) were significantly greater for samples from pondweed than for those from water lily or water shield. Water lily and water shield did not differ with respect to CPUE for bluegill number nor weight. Significantly longer and heavier bluegill were captured from pondweed stands, while water lily and water shield did not differ with respect to sampled bluegill length nor weight. Plant taxon appeared to have no effect on bluegill condition; while more and larger bluegill were captured from pondweed, condition of sampled bluegill remained constant among plant taxa. In small impoundments where bluegill recruitment is limited, as can be the case in clear, macrophyte-free waters, with significant predation by largemouth bass, selective management for plants such as pondweed, which have relatively dense, underwater leaf/stem complexes and relatively small interstices, may assist in the maintenance of viable bluegill stocks.

Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 48:566–574

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Most small impoundments used for fisheries purposes in the southeastern United States are stocked with combinations of largemouth bass (*Micropterus salmoides*) and bluegill (*Lepomis macrochirus*). Predator-prey relationships between these 2 species are manipulated by managers to establish a state of balance (Swingle 1950), classically characterized by self-sustenance through natural reproduction. Control (eradication) of aquatic macrophytes is traditionally a recommended component of farm pond fishery management programs.

Frequently, however, ponds are neglected and littoral zones become dominated by aquatic macrophytes. In some cases, this "neglect" is intentional; aquatic macrophytes can be aesthetically pleasing to the pond owner and may add intangible dimensions of peacefulness to the landscape and may enhance the overall angling experience (sensu Hudgins 1984).

In such ponds, aquatic macrophytes play a vital role in recycling nutrients that would otherwise be lost to bottom sediments (Kistritz 1978, Boyd 1979, Howard-Williams and Davies 1979, Raven et al. 1981). Decomposition of aquatic macrophytes provides a source of nutrients for zooplankters, boosting localized zooplankton production (Jackson and Schmitz 1987) which subsequently can serve as forage for small fishes (Duffy 1992).

Small bluegills, whether in tanks or ponds, and regardless of the presence of predators, have been found to associate with the most structurally complex cover available (Dewey et al. 1989, Lynch and Johnson 1989). Further, successful predation on bluegill by largemouth bass declines rapidly as cover becomes increasingly complex (Savino and Stein 1982, Gotceitas and Colgan 1987, Savino and Stein 1989). If access to structurally complex cover is limited, do those bluegill which inhabit the more complex cover trade nourishment for protection and in so doing sacrifice condition and overall fitness? Or do more complex macrophytes supply more zooplankton as food for small bluegills thus offsetting any crowding effect?

This study was designed to address these and related questions regarding the population dynamics of small bluegill associated with macrophytes. We compared relative abundance, size distributions and condition of small bluegill among stands of three aquatic macrophytes common to lentic environments in the southeastern United States: water lily (*Nymphaea odorata*), water shield (*Brasenia schreberi*), and pondweed (*Potamogeton nodosus*). Water lily and water shield are characterized by horizontal, floating leaves, vertical stems, and relatively large interstices between stems, while pondweed is characterized by dense underwater leaf/stem complexes and relatively small interstices. Differences among macrophyte taxa with respect to bluegill populations could suggest alternatives to traditional approaches (e.g., eradication) for managing aquatic macrophytes.

Support for this study was provided by the Mississippi Agricultural and Forestry Experiment Station, Mississippi State University. Appreciation is extended to Dr. Martin Brunson, Dr. Steve Miranda and Dr. Lou D'Abramo for critical reviews of earlier drafts of this manuscript. This paper was approved for publication as journal article No. WFA-049-1095 of the Forest and Wildlife Research Center.

Methods

This study was conducted in the north levee canal area of Bluff Lake, Noxubee National Wildlife Refuge, Oktibbeha County, Mississippi. At the outset, 7 relatively large, pure stands of each plant taxon were selected for potential sample sites. Four of these 7 were randomly chosen each week from 17 July through 24 October 1990 (15 total dates), and small bluegill were sampled to determine relative affinities for the 3 macrophyte taxa. Fish were collected using unbaited minnow traps with 5.1 mm bar mesh and which measured approximately 35 mm in diameter at the 2 entrance funnels. Traps were deployed at about 1300 hours, placed on the bottom roughly in the middle of each randomly chosen plant stand, then soaked for approximately 24 hours.

Captured fish were preserved in ethanol and returned to the laboratory, where they were weighed (to the nearest 0.01 g), measured (total length, TL, to the nearest 0.1 mm), and enumerated to determine relative abundance (catch per unit of effort, CPUE) among macrophyte taxa. CPUE was defined as number and weight of bluegill captured per trap-night. Mean bluegill weight per sample and CPUE for bluegill weight were square-root transformed prior to analysis, while mean bluegill length per sample and CPUE for number of bluegill were sufficiently normally distributed to support analysis in raw form. Two-way analyses of variance (weeks = blocks) were employed to evaluate possible differences in mean length, mean weight, and CPUE of bluegill among macrophyte taxa. Length-frequency distributions provided insight into the relative size structures of bluegill assemblages among macrophyte taxa.

Fish condition, indexed as Fulton's K and relative weight (W_r) (Anderson and Gutreuter 1983), was compared among macrophyte taxa using 1-way analysis of variance by size groups. Cone (1989) questioned the validity of Fulton's K and W_r due to perceived widespread disregard for these models' underlying assumptions. Analysis of covariance as described by Boyle (1987) using $\log_{10}$ transformations of length and weight as predictor and response, respectively, was therefore used to strengthen inferences regarding the possible influence of macrophyte taxa on fish condition.

Water temperature (to the nearest 0.1 C), dissolved oxygen concentration (D.O., to the nearest 0.1 mg/liter), and macrophyte stem density (stems/m^2) were recorded at each fish sample site on each sample date. Stem density was determined by placing a 1-m^2 PVC plastic frame on the water surface and counting all stems contained within the boundaries of the frame. Physical variables were orthogonally contrasted among macrophyte taxa using 2-way (weeks = blocks) analyses of variance.

Color slide photographs of fish sample sites taken on each sample date from atop a ladder on the bow platform of the workboat (approximate elevation = 2 m) were projected on a grid. Percent surface coverage was defined as the percent of each plant stand whose surface was covered by leaf and stem material. Surface coverage percentages were compared using 2-way (weeks = blocks) analysis of variance after data were arcsin transformed. All statistical tests were evaluated for significance at $\alpha = 0.05$.

Results

Water temperature and D.O. did not differ among the 3 macrophytes sampled during the duration of the study, suggesting uniform influence over macrophyte utilization by bluegill. Stem density differed among all 3 macrophytes. Water lily was characterized by an average stem density of 19.25 stems/m^2 (SD = 2.31). Water shield represented an intermediate level of stem density among the macrophytes, with a mean stem density of 208.82 stems/m^2 (SD = 12.92). Pondweed, by far the most dense macrophyte sampled, averaged 866.50 stems/m^2 (SD = 75.11).

Pondweed exhibited significantly higher surface coverage (mean = 0.93, SD = 0.03) than water shield (mean = 0.76, SD = 0.06) or water lily (mean = 0.72, SD = 0.06). Water shield and water lily did not differ with respect to percent surface coverage.

CPUE for number of bluegill (fish/trap-night, Fig. 1) and CPUE for weight of bluegill (g/trap-night, Fig. 2) differed significantly among macrophyte taxa. Pondweed yielded significantly greater CPUE for number and weight of bluegill than did water lily or water shield. Water lily and water shield did not differ with respect to CPUE for bluegill number nor weight.

Mean length (Fig. 3) and mean weight (Fig. 4) were significantly greater for bluegill captured in pondweed than for those captured in water lily or water shield. Water lily and water shield did not differ with respect to bluegill mean length and mean weight.

Length-frequency distributions indicated 2 distinct bluegill size groups collected concurrently in the samples (Fig. 5). CPUE for number of smaller bluegill (arbitrarily chosen as bluegill <48 mm TL, Fig. 5) did not differ among macrophyte taxa. However, significantly more larger bluegill (≥48 mm TL) were captured in pondweed than in water lily or water shield. Water lily and water shield did not differ with respect to CPUE for larger bluegill.

Plant taxon appeared to have no effect on bluegill condition (Table 1). Fulton's K and W_r of bluegill did not differ among macrophyte taxa. Results of analysis of covariance indicated that slopes and intercepts for bluegill length/weight relationships did not differ among plant taxa, thereby supporting conclusions from analyses regarding K and W_r.

Discussion

Many farm ponds in the southeastern United States tend toward bass-crowded conditions that likely result from manager neglect coupled with a dra-

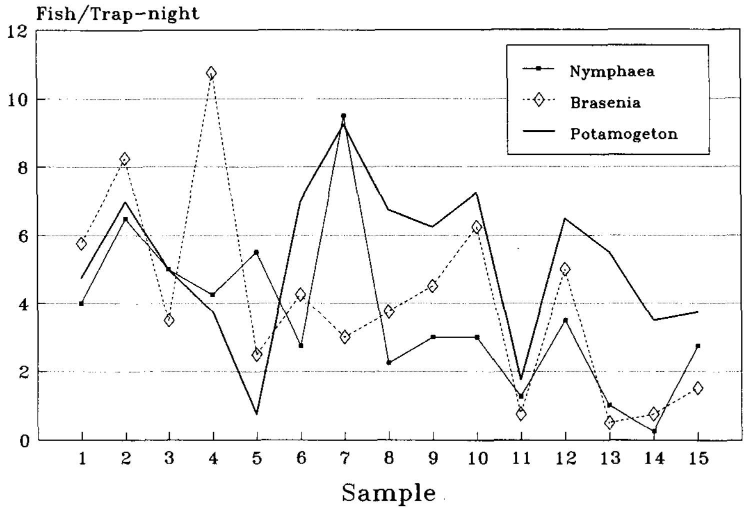

Figure 1. Catch per unit of effort (fish/trap-night) for number of bluegill captured from 3 macrophyte taxa in Bluff Lake, Noxubee National Wildlife Refuge, Mississippi (17 July–24 October 1990).

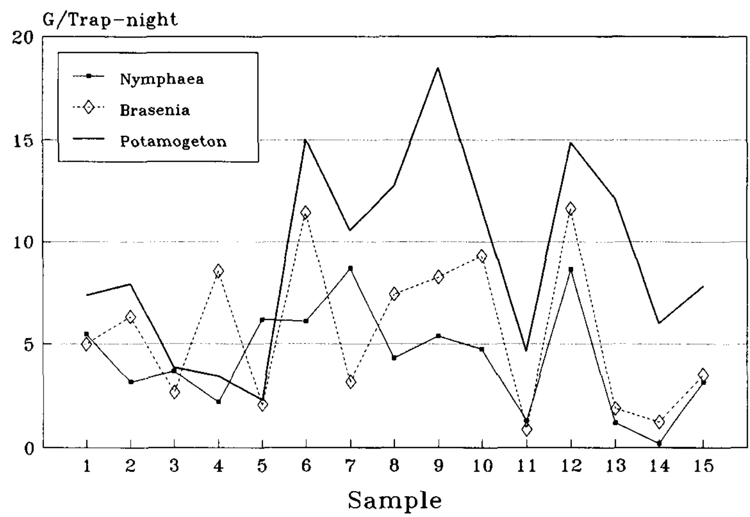

Figure 2. Catch per unit of effort (g/trap-night) for weight of bluegill captured from 3 macrophyte taxa in Bluff Lake, Noxubee National Wildlife Refuge, Mississippi (17 July–24 October 1990).

matic, widespread increase in catch-and-release bass fishing (Barnhart and Roelefs 1977). Bass-crowded ponds are generally characterized by an overabundance of small, poorly-conditioned bass; few, if any, small and intermediate-sized bluegill; and a few large, well-conditioned adult bluegill (Swingle 1950, McHugh 1990, Guy and Willis 1990). In extreme cases, bluegill anglers could

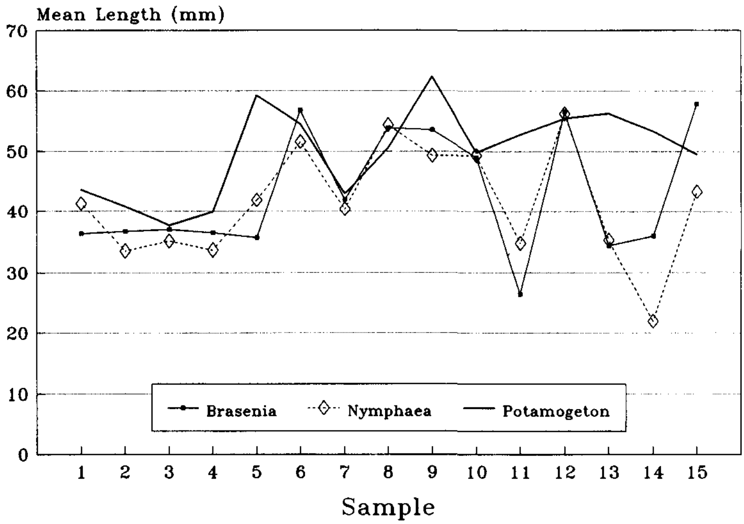

Figure 3. Mean length (mm) of bluegill captured from 3 macrophyte taxa in Bluff Lake, Noxubee National Wildlife Refuge, Mississippi (17 July–24 October 1990).

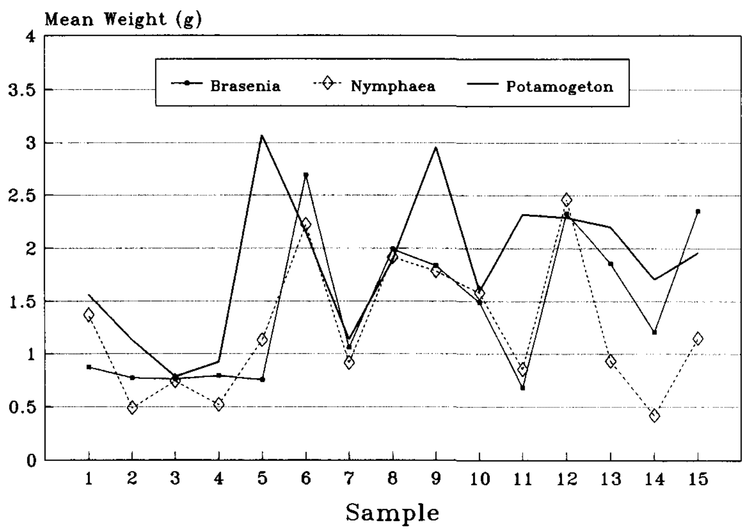

Figure 4. Mean weight (g) of bluegill captured from 3 macrophyte taxa in Bluff Lake, Noxubee National Wildlife Refuge, Mississippi (17 July–24 October 1990).

decimate the remainder of the reproducing bluegill stock (Coble 1988), irreversibly disrupting balance. Management practices designed to prevent or counteract bass crowding must decrease numbers of largemouth bass while maintaining reproducing bluegill stocks. Creative use of macrophyte cover may help managers achieve both goals.

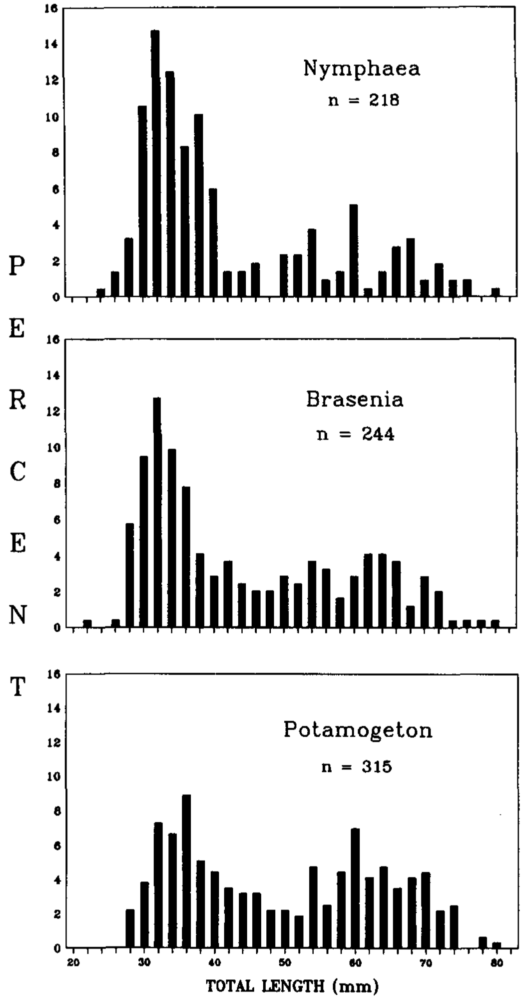

Figure 5. Length-frequency distributions for bluegill captured from 3 macrophyte taxa in Bluff Lake, Noxubee National Wildlife Refuge, Mississippi (17 July–24 October 1990).

Results of the current study indicate that bluegill may escape predation in greater numbers and at greater sizes if afforded the protection of dense macrophyte cover. Novinger (1990), while investigating slot length limits for improving bass fishing in small, bass-crowded impoundments, suggested that increases in bluegill numbers could help deplete over-abundant largemouth bass through increased nest predation. Further, in crowded ponds with fish biomass levels at or approaching carrying capacity, it is logical to assume that an increase in bluegill biomass will result in a corresponding decrease in bass biomass.

Gablehouse (1987) overlooked macrophyte management as a possible solution to bluegill protection. In his study, removal of surplus largemouth bass from a bass-crowded Kansas pond was followed by observed changes in bluegill CPUE and stock-structural indices. As bass were removed: (1) electrofishing

Table 1. Mean Fulton-type condition factor (K) and mean relative weight (W_r) for mm groups of bluegill captured from 3 macrophyte taxa in Bluff Lake, Noxubee National Wildlife Refuge, Mississippi (17 July–24 October 1990). Values in parentheses are standard deviations.

mm group	Index K B[a]	K N	K P	W_r B	W_r N	W_r P
20–29.9	1.31 (.33)	1.26 (.14)	1.25 (.16)	105.1 (25.2)	101.4 (11.6)	100.4 (9.3)
30–39.9	1.24 (.17)	1.24 (.15)	1.21 (.14)	101.1 (13.7)	101.9 (12.2)	99.6 (11.2)
40–49.9	1.16 (.15)	1.13 (.17)	1.16 (.11)	97.7 (12.8)	95.0 (14.4)	97.6 (9.2)
50–59.9	1.14 (.07)	1.19 (.20)	1.18 (.13)	98.2 (6.3)	102.9 (17.7)	102.6 (11.3)
60–69.9	1.16 (.09)	1.11 (.09)	1.15 (.13)	102.1 (8.4)	97.9 (8.7)	101.1 (11.4)
70–79.9	1.13 (.14)	1.19 (.11)	1.11 (.09)	101.3 (11.9)	106.5 (9.9)	99.5 (8.4)
80–89.9	-.— (.—)	1.16 (.—)	1.23 (.—)	—.- (—.-)	104.6 (—.-)	111.7 (—.-)

[a]B = *Brasenia*, N = *Nymphaea*, P = *Potamogeton*.

CPUE for stock- and quality-size bluegill increased 3-fold and CPUE for preferred- and memorable-size bluegill increased 4-fold over pre-treatment levels; (2) condition of bluegill remained constant, despite dramatically increased numbers of all sizes of bluegill; (3) growth rates of bluegill remained constant. Gablehouse noted that the Kansas pond used in his study was ringed by a narrow band of pondweed *Potamogeton* spp., but failed to discuss the possible significance of this characteristic.

Though in the current study significantly more and larger bluegill were found associated with pondweed than less dense macrophyte cover, bluegill condition remained constant across macrophytes. Additionally, zooplankton abundance and biomass associated with pondweed were found to be significantly greater (Duffy 1992) than those associated with water lily or water shield throughout the same sampling period. Condition and growth rates of bluegill, in Gablehouse's study and in ours, may have been maintained by enhanced forage (i.e., zooplankton) abundance afforded by the dense aquatic vegetation.

The presence of aquatic vegetation such as pondweed in small impoundments can provide fishery managers with options different from traditional approaches of indiscriminate aquatic vegetation eradication. Managers should consider the restoration or maintenance of a relatively dense aquatic macrophyte such as *Potamogeton nodosus* to assist in enhancing bluegill stocks in situations where recruitment has been limited by bass crowding and clear water.

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