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Effect of Stocking Density on Growth and Water Quality for Largemouth Bass *Micropterus salmoides* Growout in Ponds

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Abstract.—Juvenile largemouth bass *Micropterus salmoides*, trained to accept artificial diets, were stocked into six 0.04-ha ponds at stocking densities of either 6,175 or 12,350 fish/ha. Fish were fed a floating custom-formulated diet, containing 44% protein, once daily to satiation for 12 mo (May 1994–May 1995). At final harvest, the total yield of fish was significantly greater ($P < 0.05$) and feed conversion ratio (FCR) was significantly lower, for bass stocked at the higher density (4,598 kg/ha and 2.3, respectively) than when stocked at the lower density (2,354 kg/ha and 3.3, respectively). There was no significant difference ($P > 0.05$) in average weight, length, or survival of bass stocked at the two densities. Averaged over the study period, there were no significant differences ($P > 0.05$) in total ammonia-nitrogen (TAN), nitrite-nitrogen, or un-ionized ammonia concentrations in ponds in which bass were stocked at the two densities. These data indicate that largemouth bass of the size used in this study are amenable to pond culture at densities of at least 12,350 fish/ha and that higher stocking densities may be possible.

Largemouth bass *Micropterus salmoides* have been cultured in the U.S. since the 1890s, primarily for sportfish stocking (JSA 1983). As early as the 1960s studies were conducted on the pond culture of largemouth bass using prepared diets (Snow and Maxwell 1970). Although there are substantial data available on the culture of largemouth, the information available is largely limited to production of fish ≤15 cm (Simco et al. 1986). In recent years, interest in production of larger sizes of largemouth bass has increased (Brandt 1991) based on their increased use for corrective stocking in sportfish ponds (JSA 1983), fee fishing (Dupree and Huner 1984), managed trophy fisheries (JSA 1983), and live sales as food fish in ethnic Asian markets (Tidwell et al. 1996). Although demand for sizes ≥100 g far exceeds supply (JSA 1983), and prices of \$10–\$20/kg live weight have been reported, there has been little research on growout of largemouth bass to larger sizes (Brandt 1991). In the United States, the Joint Subcommittee on Aquaculture listed determination of efficient growout procedures, and evaluation of effects of water quality (metabolic wastes) under intensive conditions, as research priorities for largemouth bass aquaculture (JSA 1983). If this information can be generated, there appears to be a favorable financial potential for commercial production of this species. The objective of this study was to determine the effects of stocking density on growth, survival, and water quality when largemouth bass are intensively cultured to sizes >400 g using prepared feeds.

Materials and Methods

Pellet-trained juvenile largemouth bass (Northern strain) were stocked on 5 May 1995 into six 0.04-ha ponds at densities of either 6,175 or 12,350 fish/ha (three replicate ponds per density) at an initial size (mean ± SE) of 122.1 ± 2.7 g. The diet was a custom formulated 44% protein diet as described in Tidwell et al. (1996) and was extruded into floating pellets. At temperatures >5 C fish were fed once daily, 7 d/wk, all they would consume in a 30-min period. Below 5 C fish were offered feed twice weekly except during periods of ice-over (Brandt and Flickinger 1987). The weight of feed fed to fish in each pond was recorded daily. Ponds used in this study were approximately 1.5-m deep and were supplied with water from a reservoir filled

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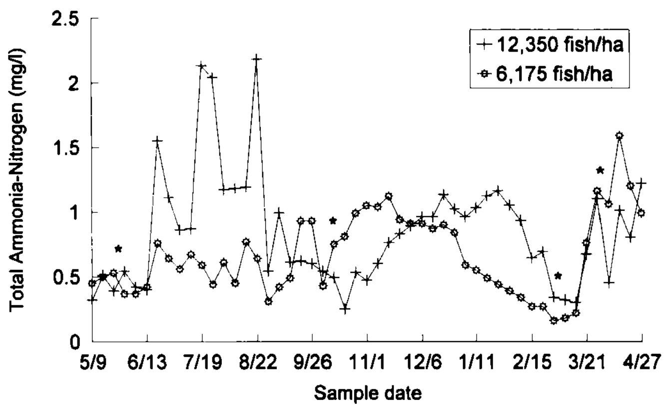

FIGURE 1. *Weekly means of total ammonia-nitrogen (mg/L) in ponds in which juvenile largemouth bass were stocked at 6,175 or 12,350 fish/ha. Each point represents four weekly samples per pond in three replicate ponds per density. An asterisk indicates a significant difference among treatments ($P < 0.05$).*

by rain runoff. Water levels in the ponds were maintained at a constant depth by periodic additions of reservoir water. Water temperature and dissolved oxygen (DO) were monitored in each pond twice daily (0900 and 1600 h) at a depth of 0.5 m using a YSI Model 57 oxygen meter (YSI, Yellow Springs, Ohio, USA). Mechanical aeration supplied supplemental oxygen if DO was predicted (by graph) (Schwedler 1983) to fall below 5 mg/L during the night. Ammonia, nitrite, and pH were determined weekly (1600 h) using a HACH DREL/2000 spectrophotometer (HACH, Loveland, Colorado, USA).

After stocking, a sample of ≥50 fish per pond were captured monthly, bulk weighed, counted, and returned to the pond for determination of average individual weights. At harvest, total number and weight of fish in each pond were determined. Fifty fish were then randomly sampled from each pond and individually weighed (g) and measured for total length (cm). Feed conversion ratio (FCR) was calculated from FCR = weight of feed fed (kg)/live weight gain (kg).

Data were analyzed using Student's *t*-test (Statistix Analytical Software 1994) to determine the effects of stocking density on growth, feed conversion, survival, and water quality variables. All percentage and ratio data were transformed to arc sin values prior to analysis (Zar 1984).

Results and Discussion

During the study period mean DO levels were < 5.0 mg/L on 14 pond-days in low density ponds and 16 pond-days in high density ponds. Due to an aerator failure, a DO of 1.6 mg/L (21% of saturation) was documented in one low density pond with no signs of fish stress or apparent detrimental effects. Overall means for total ammonia-nitrogen (0.75 ± 0.17 mg/L), nitrite-nitrogen (0.028 ± 0.010 mg/L), and un-ionized ammonia (0.126 ± 0.142 mg/L) were not significantly different ($P > 0.05$) among ponds in which largemouth bass were stocked at 6,175 or 12,350 fish/ha. There were some statistically significant differences ($P < 0.05$) in water quality measurements between the two treatments at some individual sample dates (Figs. 1, 2, 3). However, relationships to stocking densities or seasonal temperature variations were not consistent.

At harvest, there was no significant difference ($P > 0.05$) in weight gain or average weight of largemouth bass stocked at 6,175 or 12,350 fish/ha (Table 1). These data differ from those reported by Tidwell et al. (1994) for hybrid bluegill (also a centrachid) for whom increasing stocking den-

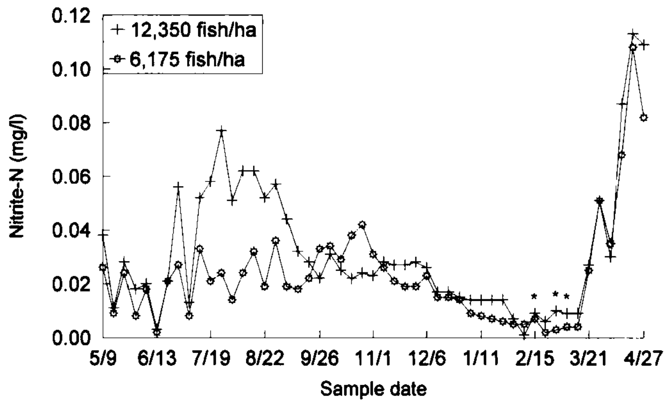

FIGURE 2. *Weekly means of total nitrite-nitrogen (mg/L) in ponds in which juvenile largemouth bass were stocked at 6,175 or 12,350 fish/ha. Each point represents four weekly samples per pond in three replicate ponds per density. An asterisk indicates a significant difference among treatments ($P < 0.05$).*

sity from 6,175 to 12,350/ha significantly decreased weight gain and average weight at harvest. Tucker and Robinson (1990) stated that for channel catfish increasing fish density normally decreases average fish size. Survival did not differ significantly ($P > 0.05$) between treatments and averaged 93%, overall.

Total yield was significantly greater ($P < 0.05$) for largemouth bass stocked at 12,350/ha than at 6,175/ha (4,598 and 2,354 kg/ha, respectively). Also, at the higher stocking density feed was more efficiently utilized, as indicated by a significantly lower ($P < 0.05$) feed conversion ratio (FCR) (2.3) compared to the low stocking density (3.3). These results differ from those of hybrid bluegill in which differences in stocking densities did not result in differences in FCR (Tidwell et al. 1994). Results also differ from those for catfish, where higher stocking densities usually result in higher feed conversion ratios due to reduced feed intake and decreased efficiency of feed conversion (Tucker and Robinson 1990).

Tidwell et al. (1996) reported that the most active feeding period for largemouth bass was June–July (>25 C). However, in this study fish stocked at the lower density gained weight more rapidly during the fall

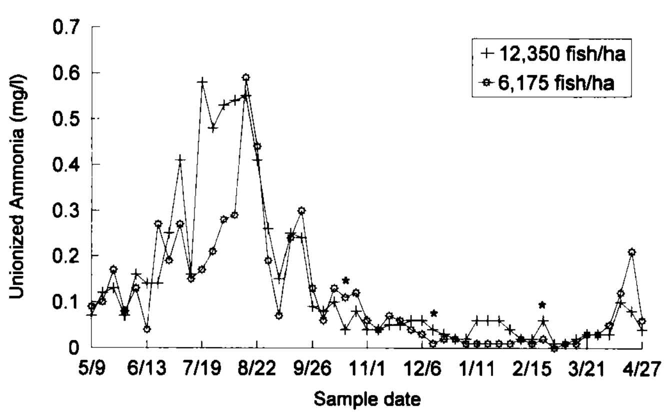

FIGURE 3. *Weekly means of total un-ionized ammonia (mg/L) in ponds in which juvenile largemouth bass were stocked at 6,175 or 12,350 fish/ha. Each point represents four weekly samples per pond in three replicate ponds per density. An asterisk indicates a significant difference among treatments ($P < 0.05$).*

TABLE 1. *Initial individual weight (mean ± SE), final individual weight, final lengths, percentage, survival, average individual gain, total yield and feed conversion ratio (FCR) for largemouth bass fed prepared diets for one year in ponds. Means within a row followed by the different letters are significantly different (P < 0.05).*

	Stocking rate (fish/ha)	
	6,175/ha	12,350/ha
Stocking weight (g)	124 ± 4	122 ± 2
Final weight (g)	406 ± 32	406 ± 22
Weight gain (%)	282 ± 29	283 ± 23
Final length (cm)	29.3 ± 0.8	29.1 ± 0.5
Survival (%)	93.9 ± 8.5	91.7 ± 6.7
Total yield (kg/ha)	2,354 ± 242b	4,598 ± 418a
FCR	3.3 ± 0.3a	2.3 ± 0.2b

period of declining water temperatures (Sept.–Nov.), while those stocked at high density gained weight more rapidly during the rising water temperatures of spring (March–May) (Fig. 4). At final harvest average weights of fish in the two treatments were similar.

Stocking largemouth bass juveniles at the higher density (12,350/ha) resulted in higher net and gross yields and more efficient feed conversion than stocking at low density, without decreasing average individual weights or reducing survival. The average harvest standing crop stocked at 12,350/ha in this study (4,598 kg/ha) is comparable to yield results reported in channel catfish culture (Busch 1985). Optimal stocking density is normally a compromise between higher unit production rates, reduced individual growth at higher densities, and deterioration of water quality at high stocking rates (Tucker and Robinson 1990). In this study, measured water quality variables were not significantly impacted, and average fish size at harvest was not significantly reduced, indicating that the optimal stocking density for largemouth bass growout may be greater than 12,350/ha. Further studies should be conducted to determine maximum and optimum rearing densities and estimated costs for production of largemouth bass >400 g using prepared diets.

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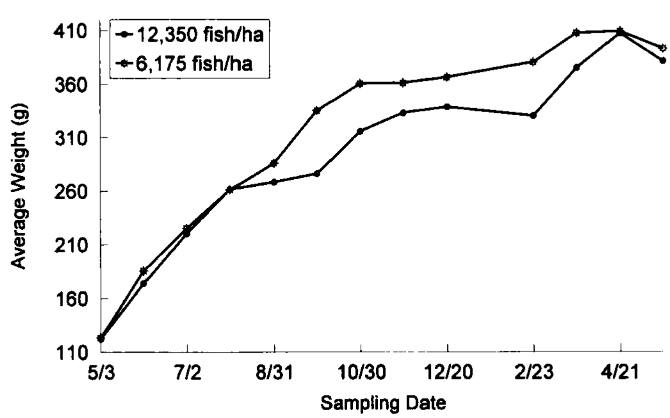

FIGURE 4. *Mean sample weights of largemouth bass stocked at 6,175 or 12,350 fish/ha. There were no significant differences (P > 0.05) in average weights at any sampling date.*

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