PERFORMANCE OF SUNSHINE BASS *MORONE CHRYSOPS* (RAFINESQUE) x *M. SAXATILIS* (WALBAUM) INTENSIVELY REARED AT THREE DENSITIES

Michael L. Brown
Department of Wildlife and Fisheries Sciences
South Dakota State University
Brookings, SD 57007

John R. Ackerson
Missouri Department of Conservation
Aurora, MO 65605

Robert J. Mauk
Texas Parks and Wildlife Department
Wichita Falls, TX 76301

ABSTRACT

A controlled experiment was conducted to evaluate the effect of stocking density on various performance characteristics (*i.e.,* relative growth, feed conversion, survival, and relative weight [*Wr*]) of sunshine bass *Morone chrysops* (Rafinesque) x striped bass *M. saxatilis* (Walbaum) fingerlings. Sunshine bass (4.2 ± 0.3 g SE) were stocked at low (45 fish/m^3), medium (136 fish/m^3), and high (273 fish/m^3) replicated densities in a recirculating aquaculture system (RAS) and fed a commercial hybrid striped bass diet for 14 weeks. Cumulative relative growth was significantly ($P < 0.05$) higher for the medium density treatment at the conclusion of the experiment. The medium density treatment had the highest overall mortality (22%) due to loss of one replicate to a water flow problem, thus mortality was not attributed to density. Mortality in the high and low density treatments were 9% and 0%, respectively. Feed conversion varied considerably among densities throughout the experiment, but differed significantly for all densities during the final three weeks of the feeding trial and was lowest for the high density treatment. Final mean *Wr* values did not differ among treatments. Ammonia levels differed among treatments and increased proportionally with density during the experiment. Density index calculations for 170-mm sunshine bass in our RAS ranged from 0.8 to 0.14 (8.8 kg/m^3 to 14.9 kg/m^3). These results indicate that intensively reared sunshine bass can be successfully grown well into the phase II stage at a density index near 0.1.

INTRODUCTION

The hybrids of striped bass *Morone saxatilis* and white bass *M. chrysops* have been of considerable interest to both fishery biologists and fish culturists since the first crosses were produced in the mid-1960s (Bayless 1968; Bishop 1968). Currently, fish culturists prefer to produce reciprocal hybrids (sunshine bass, white bass female x striped bass male) because white bass females are more readily available than are striped bass females and easier to spawn (Kerby and Harrell 1990). Hybrid striped bass have gained wide acceptance as a sportfish, particularly in the southeast United States where, in large reservoirs, much of the prey base is commonly composed of gizzard *Dorosoma cepedianum* and/or threadfin shad *D. petenense.* Regulated reduction in commercial striped bass harvests, due to declining natural stocks on both the Atlantic and Pacific coasts of the continental United States, has promoted the development of commercial hybrid striped bass production for the food fish market. This economic aspect, coupled with the heterotic attributes of the hybrid striped bass, give them great potential as aquaculture food fish and as inland sport fish (Ware 1975; Williams et al. 1981; Kerby et al. 1983).

Recent advances in hybrid striped bass culture have been made primarily in the areas of controlled propagation, nutrition, and pond culture; however, the culture characteristics of hybrid striped bass reared under intensive conditions are relatively unknown. Specific densities and related culture parameters must be known to maximize growth and minimize size variation of hybrid striped bass to facilitate economic optimization of production. Piper et al. (1982) stressed that density is important economically to maintain carrying capacity. Many fish culturists use lower stocking densities to increase quality of fish and as fish size increases, proportionally decrease fish density (Piper et al. 1982). Fish density can influence a variety of culture factors including growth, survival, and behaviors such as cannibalism and the establishment of feeding hierarchies. Also, as density increases, water quality decreases which in turn affects survival, growth, and the physical condition of fishes (Nicholson et al. 1990). The objective of this study, therefore, was to investigate performance characteristics (e.g., relative growth, feed conversion, and survival) of juvenile sunshine bass held at various densities from phase I to phase II under intensive culture conditions.

METHODS AND MATERIALS

The intensive culture system consisted of 24 110-L aquaria connected to a closed freshwater recirculating system with a delivery rate of approximately 1-L min^{-1} and a turnover rate of 13 times/d. Water quality complied with standards suggested for striped bass and hybrid culture (Bonn et al. 1976; Lewis and Heidinger 1981; Rogers et al. 1982; Nicholson et al. 1990). Water temperature was maintained at 21 oC (± 0.1 SE) and dissolved oxygen was maintained near saturation by supplemental aeration; both were monitored several times weekly with a YSI 54 temperature and oxygen meter (YSI, Yellowsprings, OH).

A light:dark cycle of 12:12 h was maintained using incandescent lighting controlled by an automatic electric timer.

Fingerling sunshine bass (4.2 g ± 0.3 SE) obtained from Southern Illinois University (Carbondale) were randomly stocked at low (45 fish/m^3; 0.25 kg/m^3) medium (136 fish/m^3; 0.47 kg/m^3), and high (273 fish/m^3; 1.02 kg/m^3) densities with four replicates for each treatment. All fish were conditioned to the recirculating system and fed for one week prior to beginning the experiment. Aquaria were cleaned and mortalities removed and documented daily through the duration of the study. Weekly backflushing of the sand filter and cleaning of the biological filter (solids removal) were done to maintain favorable water quality. Dechlorinated water was added to compensate for the loss of water due to cleaning.

Initially, weights (± 0.1 g) were obtained for individuals in each tank. At the end of each week, total tank weight and average individual fish weight were recorded. Additionally, individual fish weights were measured weekly for all fish in the low density treatment and 10 randomly selected fish from each replicate of the medium and high density treatments. Fish were not fed for a 12-h period prior to the weigh period.

Feeding frequency was done by hand three times per day until the seventh week when belt feeders were incorporated in the experiment, then feeding occurred continuously over the 12-h day period. Feed used was a commercial hybrid striped bass diet (38% protein, 5% lipid; Southern States, Farmville, NC). Sunshine bass were fed at levels nearing satiation by feeding 10% of total body weight for weeks 1 to 3, 7.5% for weeks 4 to 8, and reduced to 5% for weeks 9 to 14; rations were adjusted weekly. Feed size was fingerling crumble #4 for weeks 1-8 and 3 mm extruded pellets for weeks 9-14.

Several water quality parameters were monitored each week either for each treatment or the biological filter. Carbon dioxide, total alkalinity, and total hardness levels were determined by titrametric methods (Hach Company, Loveland, CO) with samples from the biological filter. Total ammonia (NH_3-N), nitrite (NO_2-N), and nitrate (NO_3-N) concentrations in treatment tanks were measured at least weekly using a Hach 2000 spectrophotometer, and pH with an Orion pocket tester.

Each week of the experiment, cumulative (final weight - initial weight/initial weight x 100) and incremental (week ending weight - previous week weight/previous week weight x 100) relative growth, and feed conversion (weight of feed offered/weight gain) were determined. Overall mortality (%) for each treatment and individual relative weight *(Wr)* values were determined at the conclusion of experiment. Relative weight was calculated as $Wr = W/Ws \times 100$ where W is the actual weight (g) of an individual fish and Ws is a length-specific standard weight defined by the equation $\log_{10} Ws = -5.201 + 3.139 \log_{10}$ total length (mm) (Brown and Murphy 1991). Comparisons of feed conversion, cumulative relative growth, and incremental relative growth among treatments were done with analysis of variance and Tukey's multiple comparison tests using SYSTAT (1996). Statistical significance was $P \leq 0.05$ for all analyses.

RESULTS AND DISCUSSION

Growth pattern differences among treatments began to emerge during the second week of the study (Fig. 1). From week two through week seven cumulative relative growth for the low density treatment was significantly lower. By week eight, all treatments were significantly different with highest cumulative relative growth occurring in the medium density treatment followed by high and low treatments. Throughout the final five weeks of the study fish held at the medium density exhibited significantly higher cumulative relative growth than did fish held at low and high densities. Trends in incremental relative growth were similar among treatments (Fig. 1). The most dissimilar values were observed during the first month of the study; beyond week five there were no significant differences in incremental relative growth among treatments. Overall, sunshine bass held at the medium density produced the largest proportional weight gain by the end of the study. Similarly, Stickney et al. (1972) reared channel catfish *Ictalurus punctatus* fingerlings to three densities (8, 16, 24 kg/m^3) under intensive conditions and found the best growth occurred at the lowest density. A comparable rearing density was indicated in this study with an ending density of 8.8 kg/m^3, which corresponds to the medium density.

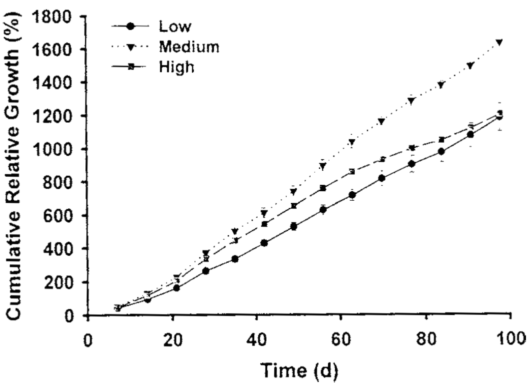

Figure 1. Cumulative relative (%) for low (45 fish/m^3), medium (136 fish/m^3), and high (273 fish/m^3) densities of sunshine bass. Vertical bars represent one standard error of the mean.

Piper (1975) proposed the density index as a guideline to determining maximum rearing densities for safe fish production in flow-through raceway systems. These indices relate fish density to fish length and are the proportion of the fish length used in determining kilograms of fish to be held per cubic meter of rearing space. Piper et al. (1982) reported that striped bass larger than 50-mm could be safely reared with a density index of 0.5, which follows the general procedures of trout culture. However, under intense recirculating conditions densities are likely to be substantially reduced depending upon the efficiency of biological and mechanical filtration. Our index calculations indicate that 170-mm sunshine bass can be reared from 8.8 kg/m^3 (medium density index = 0.08) up to 14.85 kg/m^3 (high density index = 0.14). Generally, it appears that sunshine bass can be intensively reared well into the phase II stage at a density index near 0.1 and maintain good growth.

Feed conversion (Fig. 2) differed little among treatments until week 11 of the study. During weeks 11 through 14 the high density treatment showed significantly poorer feed conversion than low and medium treatments. Similarly, Stickney et al. (1972) found that a high channel catfish density (24 kg/m³) produced the poorest feed conversion rate. Feed conversion was observed to decrease across all treatment when we switched to continuous belt feeding, as compared to three feeding periods separated by 4-h intervals during the early portion of the study.

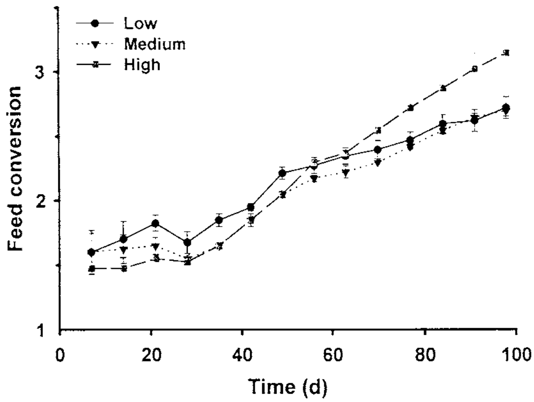

Figure 2. Feed conversion for low (45 fish/m³), medium (136 fish/m³), and high (273 fish/m³) densities of sunshine bass. Vertical bars represent one standard error of the mean.

To determine whether feeding hierarchies might have been established within tanks we examined the variability in individual weights over time (Fig. 3). Plots of weight standard errors for the three treatments indicated that by the conclusion of the study there were distinct differences that inversely corresponded with densities. For commercial producers maintaining size uniformity is an important processing and marketing aspect. Thus, selection of a culture density to achieve good growth should be balanced with a density likely to provide a fairly uniform fish size.

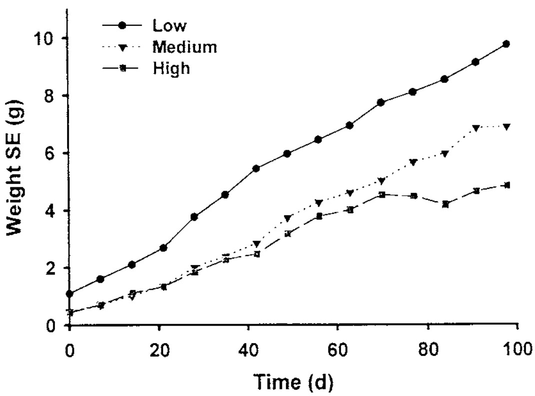

Figure 3. Mean weight standard errors (SE) for low (45 fish/m³), medium (136 fish/m³), and high (273 fish/m³) densities of sunshine bass.

With the exception of ammonia, all monitored water chemistry was acceptable for the culture of hybrid striped bass (Nicholson et. al 1990). Mean total hardness, total alkalinity, and carbon dioxide were 377.5 ppm (SE=10.7), 154.1 ppm (SE=4.6), and 26.2 ppm (SE=2.1), respectively, measured in the biological filter. Temperature and nitrate levels did not vary significantly among treatments. Striped bass have been shown to tolerate nitrate levels up to 800 ppm (Bonn et al. 1976). Nitrite concentrations increased linearly with density, but never approached a toxic level. Dissolved oxygen levels were equivalent between low (7.3 ppm, SE = 0.4) and medium (7.3 ppm, SE = 0.4) density treatments, but slightly lower (6.8, SE = 0.4) in the high density treatment. The pH remained relatively constant, between 7.7 and 7.8, across treatments for the duration of the study.

Relative total ammonia (treatment concentration — biological filter concentration) levels for each treatment are shown in Figure 4. These measurements were done in the afternoon for the duration of the experiment and prior to the last feeding through week six. Ammonia concentrations for the low density treatment deviated little from baseline levels and occasionally were lower than those determined in the biological filter. Generally, concentrations determined for the medium density treatment remained above the baseline level. Ammonia concentrations in the high density treatment were sporadically well above baseline levels; those measurements were associated with feeding and observed to decrease shortly thereafter. Unionized ammonia concentrations in the high density treatment were not determined to be potentially toxic, rarely exceeding 0.011 ppm as NH_3.

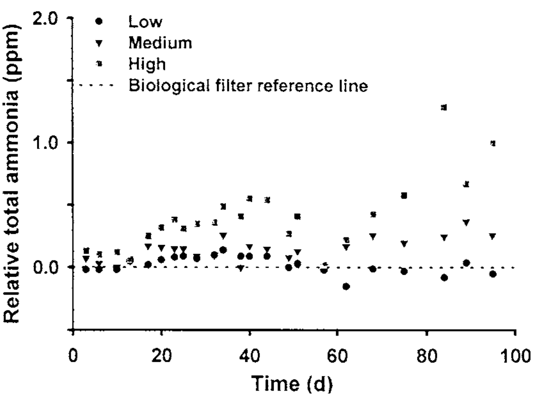

Figure 4. Total ammonia concentrations (mg/L), relative to the biological filter, for low (45 fish/m^3), medium (136 fish/m^3), and high (273 fish/m^3) densities of sunshine bass.

Although the acute ammonia toxicity level is not known for juvenile hybrid striped bass, the 96-h LC_{50} values for NH_4OH in juvenile striped bass range from 1.5 to 2.8 ppm (Lewis et al. 1981). Bonn et al. (1976) recommended maintaining total ammonia concentrations below 0.6 ppm because chronic exposure to unionized ammonia commonly predisposes fish to disease (e.g., Piper et al. 1982; Soderberg 1994). There were no overt symptoms detected in this study; yet, gill epithelial surfaces were not examined. Reduced growth and lower feed conversions of fish contained in the high density treatment may be symptoms of excessive ammonia. For example, reduced growth has been observed in juvenile channel catfish and rainbow trout *Oncorhynchus mykiss* at unionized ammonia concentrations exceeding 0.12 (Robinette 1976) and 0.017 (Larmoyeaux and Piper 1973) ppm, respectively.

Overall, the highest mortality (22%) occurred in the medium density treatment followed by the high (9%) and low (0%) density treatments. However, the mortality in the medium density treatment resulted from of a water-flow restriction on one tank. Otherwise, mortality was 0% for the medium treatment because we did not directly attribute that loss to density.

Final mean *Wr* values for ranged from 92 to 94 and did not differ among treatments. The experimental fish were considered to be in good condition considering that a *Wr* value of 100 would be the 75th percentile of standard weights for hybrid striped bass.

In conclusion, these results show that a moderate stocking density of 136 fish/m^3 at 0.47 kg/m^3 provided satisfactory performance up to 8.8 kg/m^3 under these intensive culture conditions. Further research with densities in closed recirculating systems is necessary to precisely bracket the maximum density of sunshine bass fingerlings for optimal performance and also sizes at which densities should be altered.

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