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Feeding Frequency Affects Growth, Not Fillet Composition, of Juvenile Sunshine Bass *Morone chrysops* × *M. saxatilis* Grown in Cages

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Abstract.—In an effort to feed sunshine bass *Morone chrysops* × *M. saxatilis* efficiently, promote optimal growth, and reduce labor costs associated with feeding, sunshine bass were grown in cages and fed one of four feeding frequencies: once/d, twice/d, once every other day (1X/EOD), and twice every other day (2X/EOD) for 21 wk. Juvenile sunshine bass were fed a commercial floating diet containing 40% protein and 11.5% lipid. One hundred fish were hand-counted and stocked into each of 12 3.5-m^3 cages with three replications per treatment. At the conclusion of the study, percentage weight gain of sunshine bass fed twice/d was significantly ($P < 0.05$) higher (1,850%) compared to fish fed all other feeding frequencies. Specific growth rate (SGR) of fish fed twice/d was significantly higher (2.1%/d) compared to fish fed all other feeding regimes, while fish fed once/d had a higher SGR (2.0%/d) compared to fish fed 1X/EOD (1.6%/d) and 2X/EOD (1.8%/d). Percentage survival was not significantly different ($P > 0.05$) among all treatments and averaged 70.4%. Feed conversion ratio (FCR) of fish fed twice/d was significantly higher (2.40) compared to fish fed all other feeding regimes. Percentage fillet weight of fish fed twice/d was significantly higher (27.8%) compared to all other treatments. Percentage moisture, protein, lipid, and ash in fillet were not significantly different among all treatments and averaged 75.7%, 19.4%, 3.5%, and 1.2%, respectively (wet-weight basis). Based upon data from the present study, it appears that producers growing juvenile sunshine bass in cages may want to feed fish twice daily. This feeding regimen allows for higher growth rates, without adverse effects on body or fillet compositions. However, economic analysis needs to be conducted to determine if feeding twice/d is profitable.

In recent years, hybrid striped bass producers have increased their production from 636,000 kg in 1990 to 3.8 million kg in 1997, and reports indicate that commercial production could reach 5.9 million kg in 2000. While there are numerous reports on the nutritional requirements and use of practical diets for hybrid striped bass (Griffin et al. 1992, 1994a, 1994b; Nematipour et al. 1992; Brown et al. 1993; Keembiyehetty and Gatlin 1993, 1997; Webster et al. 1999), there are limited data on feeding schedules for hybrid striped bass. Increased feeding frequency has been shown to improve the growth of several species. Wang et al. (1998) reported that when age-0 hybrid sunfish (female green sunfish *Lepomis cyanellus* × male bluegill *L. macrochirus*) were fed to satiation at one of four frequencies (one, two, three or four meals per day) for 30 d, fish fed three times per day showed the greatest food consumption and growth rates. Webster et al. (1992a, 1992b) reported that channel catfish *Ictalurus punctatus* fed once daily had similar growth rates as fish fed twice daily. Robinson et al. (1995) stated that when channel catfish grown in ponds were fed once daily to satiation, time of feeding had no affect on water quality, feed consumption, weight gain, or body composition.

Overfeeding is wasteful financially and could adversely affect water quality. Since diet cost represents 30–70% of the total operating cost of an aquaculture enterprise, determination of the appropriate feeding frequency required to give optimal growth and feed efficiency could reduce the amount of diet fed, decrease the amount of time involved in feeding, and may increase profits. As the hybrid striped bass industry expands, there is a need to know what feeding frequency is optimal, both financially and in terms of production.

Cage culture allows for the growing of fish in ponds that may otherwise be difficult to harvest, either due to irregularly-shaped pond bottoms, shape of the pond, or presence of debris and obstacles on the pond bottom. Sunshine bass can be grown in cages with acceptable growth rates and high (> 85%) percentage survival (Webster et al. 1995, 1997). The present study was conducted to determine the effects of different feeding frequencies on growth, body composition, and fillet proximate composition of sunshine bass grown in cages.

Materials and Methods

Juvenile sunshine bass were obtained from a commercial supplier (Keo Fish Farm, Keo, Arkansas), had an average weight of 19.0 ± 2.0 g, and were stocked on 10 May 1999 into 12 3.5-m^3 floating cages moored over the deepest area (4 m) of a 1.0-ha pond (average depth, 2.0 m) located at the Agricultural Research Farm, Kentucky State University, Frankfort, Kentucky. One hundred juveniles were hand-counted and randomly stocked into each cage. There were three replications per treatment. Sunshine bass were fed a commercial floating diet (EXT 400; Rangen, Inc., Buhl, Idaho, USA) containing 40% protein and 11.5% lipid for 21 wk. All fish were fed all they could consume in 30 min at one of four feeding frequencies: 1) once/d at 0800; 2) twice/d at 0800 and 1530; 3) once every other day (1X/EOD) at 0800; 4) and twice every other day (2X/EOD) at 0800 and 1530.

Each cage had a frame made of polyvinylchloride (PVC) tubing with a removable lid and was constructed of 10-mm polyethylene mesh. A panel of polyethylene mesh (0.2-mm mesh, 20-cm high) was installed around the top of the inside of each cage to prevent loss of floating diet. Cages were anchored to a floating dock; the distance between cages was 2 m.

After stocking, sunshine bass in all cages began to suffer mortality. Fish were treated twice during a 7-d period with a solution of $KMnO_4$ and NaCl that was poured into each cage so that a concentration of 2.0 mg/L of $KMnO_4$ per cage volume was maintained for 60 min. Fish in all cages stopped dying within 7 d post-stock and did not have any mortalities for the duration of the feeding trial.

Temperature and dissolved oxygen (DO) were monitored twice daily (0830 and 1530) outside the cages, at a depth of 0.75 m, with a YSI model 57 oxygen meter (Yellow Springs Instruments, Yellow Springs, Ohio, USA). If DO was graphically predicted to decline below 4.0 mg/L, aeration was provided with an electric paddlewheel (5 HP, S&N Sprayer Co., Inc., Greenwood, Mississippi, USA). No other water quality requirements were measured due to the constant nature of the pond water quality in previous years (Webster et al. 1992a, 1992b, 1997).

Fish were harvested on 8 October 1999 and total number and weight of fish in each cage were determined. At the conclusion of the study, 10 fish were randomly sampled from each cage. Fish were stored on ice and then placed in a freezer. Whole-body weight was measured to the nearest 0.1 g, abdominal fat was gently detached from the connective tissue and weighed, the liver was removed and weighed, and the skinned fillets were removed from the backbone and weighed. Fillets were stored in polyethylene bags and frozen for proximate analysis (moisture, protein, lipid, and ash). Protein was determined by the macro-Kjeldahl method, lipid was determined by ether extraction, moisture was determined by placing a 10-g sample in an oven (100 C) and dried until constant weight, and ash was determined by placing a sample in a muffle furnace at 600 C (AOAC 1990).

Growth performance, feed conversion, and body analyses were measured in terms

TABLE 1. *Monthly (± SD) morning dissolved oxygen (DO), morning water temperature, afternoon DO, and afternoon water temperature for pond where sunshine bass were grown in cages and fed using different feeding frequencies.*

Month	DO (am; mg/L)	Temp. (am; C)	DO (pm; mg/L)	Temp. (pm; C)
May	8.6 ± 1.5	22.7 ± 1.3	9.9 ± 1.6	22.9 ± 5.1
June	6.8 ± 1.8	26.2 ± 1.7	8.6 ± 2.7	27.5 ± 1.6
July	7.6 ± 1.9	28.6 ± 1.6	9.3 ± 1.9	29.7 ± 1.6
August	6.5 ± 0.8	25.9 ± 1.4	8.1 ± 1.2	25.9 ± 4.6
September	8.3 ± 1.1	22.1 ± 2.5	11.0 ± 2.0	23.2 ± 2.6

of percentage weight gain, percentage survival, specific growth rate (SGR, %/d), feed conversion ratio (FCR), percentage abdominal fat, percentage fillet weight, and hepatosomatic index (HSI). Growth parameters were calculated as follows: SGR (%/d) = 100[(ln Wt − ln Wi)/T)], where Wt is the weight of fish at time t, Wi is the weight of fish at time 0, and T is the culture period in days; FCR = total dry diet fed (g)/total wet weight gain (g); HSI = 100[wet weight of the liver (g)/wet weight of the fish (g)].

Data were analyzed by analysis of variance (ANOVA) on two potential factors: feed treatments and survival rate (which is correlated to the initial stocking density). Examples of dependent variables included in the analyses are percentage weight gain (wt. gain %), FCR, SGR, percentage abdominal fat, percentage fillet weight, and HSI. Although several factors could impact the dependent variable values, given that all cages were submerged in the same body of water and exposed to nearly identical water quality parameters, we assume that only feeding frequency and survival rate could differentially affect the dependent variables. The two-factor ANOVA was run using regression methods and dummy variables because the estimated regressor coefficients could simultaneously indicate significant influence of treatments on the dependent variable and quantify the magnitude by which one treatment mean differs from another treatment mean (as in a multiple comparison test) (Montgomery 1991). The following dummy variables were created with respect to the feeding treatments: TRT1 (= 1 if the observation came from cages fed once/day; 0 otherwise), TRT2 (= 1 if the observation came from cages fed twice/d; 0 otherwise), and TRT3 (= 1 if the observation came from cages fed 1X/EOD; 0 otherwise). Residuals of each regression model were tested for normality (Jarque-Bera or J-B test), autocorrelation (Durbin-Watson or D-W test), and heteroskedasticity (Breusch-Pagan-Godfey or B-P-G test) to ensure that the error terms were consistent with the Gauss-Markov assumptions (Greene 1993). All percentage and ratio data were transformed to arc sin values prior to analysis (Zar 1984). Significance was tested at the $P = 0.05$ level.

Results

Average morning dissolved oxygen (DO), morning water temperature, afternoon DO, and afternoon water temperature for each month are presented in Table 1. During the study, these averages were within acceptable limits for fish growth and health (Boyd 1979).

Table 2 provides means and standard errors of percentage weight gain (or wt. gain %) corresponding to the four feeding treatments. The highest average percentage weight gain occurred for feeding twice/d which was followed by feeding once/d, 2X/EOD, and 1X/EOD. Table 3 shows the results of regressing percentage weight gain on TRT1, TRT2, TRT3, and survival rate. Test statistics from a J-B test, D-W test, and a B-P-G test were 1.81 (P-value = 0.41), 1.80 (P-value = 0.22), and 6.96 (P-value = 0.41), respectively, indicating that the null

TABLE 2. *Means (± SE) of final individual weight, percentage weight gain, specific growth rate (SGR), amount of diet fed, feed conversion ratio (FCR), and percentage survival of sunshine bass fed one of four feeding frequencies. Values are means of three replications.*

	Feeding frequency			
	Once/d	Twice/d	1X/EOD	2X/EOD
Final wt. (g)	267.9 ± 2.2	321.7 ± 25	161.1 ± 4.2	199.8 ± 5.1
Weight gain (%)	1523 ± 13	1850 ± 151	876 ± 25	1111 ± 30
SGR (%/d)	1.96 ± 0.01	2.09 ± 0.05	1.60 ± 0.02	1.75 ± 0.02
Amount fed (g/fish)	470.6 ± 12.7	773.2 ± 54.9	267.6 ± 8.8	405.9 ± 9.0
FCR	1.73 ± 0.07	2.4 ± 0.0	1.67 ± 0.9	2.03 ± 0.09
Survival (%)	73.3 ± 5.9	62.3 ± 3.7	71.3 ± 0.3	74.7 ± 4.2

hypotheses of normality, no autocorrelation, and homoskedasticity were not violated for the error term (Greene 1993). The estimated coefficients of the "TRT" dummy variables were all significant, i.e., the average wt. gain % from TRT1 (feeding once/d), TRT2 (feeding twice/d) and TRT3 (feeding 1X/EOD) were all statistically different from the average percentage weight gain from feeding 2X/EOD. Further, the magnitude of the estimated coefficients shows that feeding twice/d is associated with the maximum percentage weight gain, which is followed by feeding once/d, feeding 2X/EOD, and feeding 1X/EOD. Survival rate exerted no significant effect on wt. gain %. The regression was re-run by replacing survival rate with three dummy variables: BLK1 (= 1 if survival rate was less than 67%, 0 otherwise), BLK2 (= 1 if survival rate was between 69% and 70%, 0 otherwise), and BLK3 (= 1 if survival rate was between 71% and 72%, 0 otherwise). Results showed that all estimated coefficient of the "BLK" dummy variables were not significantly different from zero.

TABLE 3. *Estimated coefficients,* t*-statistics and goodness-of-fit of regression models. Sample size = 12.*

Dependent variable	Intercept[a]	Independent variables			Survival rate	RSq[b]
		TRT1	TRT2	TRT3		
Wt. gain %	1587 (3.05[c])	403.83 (3.86[c])	660.38 (4.69[c])	−255.92 (−2.24[c])	−6.38 (−0.93)	0.93 (0.89)
SGR	1.89 (9.67[c])	0.20 (4.83[c])	0.31 (5.87[c])	−0.16 (−3.63[c])	−0.002 (−0.72)	0.96 (0.93)
FCR	2.55 (5.61[c])	−0.31 (−3.2[c])	0.28 (2.28[c])	−0.39 (−3.90[c])	−0.007 (−1.16)	0.91 (0.86)
Ab. fat %	4.43 (2.48[c])	2.22 (5.74[c])	2.28 (4.73[c])	−0.99 (−2.52[c])	0.013 (0.53)	0.94 (0.90)
HSI	−8.65 (−0.30)	−0.43 (−0.07)	9.77 (1.27)	0.35 (0.06)	0.16 (0.38)	0.29 (−0.12)
Fillet %	25.32 (6.31[c])	1.97 (2.27[c])	3.78 (3.48[c])	0.13 (0.15)	−0.02 (−0.39)	0.80 (0.69)
Protein %	22.72 (1.92)	0.72 (0.28)	−2.82 (−0.88)	0.21 (0.08)	−0.04 (−0.26)	0.21 (−0.24)
Fat %	7.63 (1.37)	1.06 (0.88)	0.68 (0.45)	−1.09 (−0.89)	−0.06 (−0.82)	0.44 (0.11)
Ash %	1.11 (4.26[c])	0.03 (0.61)	0.009 (0.13)	0.04 (0.63)	0.001 (0.22)	0.10 (−0.42)

[a] Test coefficient estimate and *t*-statistic values (in parentheses) are given.

[b] R^2 and the adjusted R^2 are given, the latter in parentheses.

[c] The estimated coefficient is significantly different from zero for $\alpha = 5\%$.

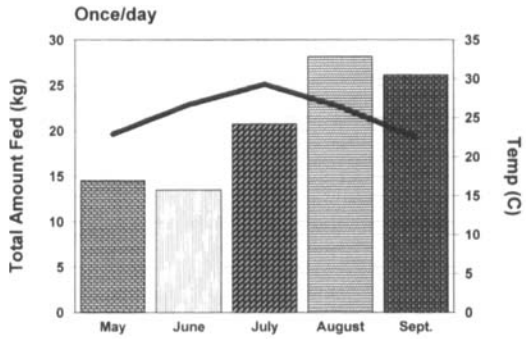

FIGURE 1. *Monthly amount of diet fed (kg) to juvenile sunshine bass grown in cages when fed once/d in relation to average monthly water temperature (solid line).*

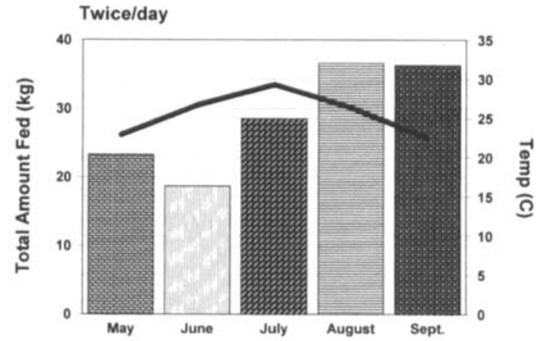

FIGURE 2. *Monthly amount of diet fed (kg) to juvenile sunshine bass grown in cages when fed twice/d in relation to average monthly water temperature (solid line).*

Table 2 shows that the specific growth rate (SGR) of fish fed twice/d was higher (2.09%/d) compared to fish fed all other feeding frequencies, while fish fed once/d had higher SGR (1.96%/d) compared to fish fed 2X/EOD (1.75%/d) and 1X/EOD (1.60%/d). Table 3 contains the results of regressing SGR on TRT1, TRT2, TRT3, and survival rate. Test statistics from a J-B test, D-W test, and a B-P-G test were 1.14 (P-value = 0.57), 1.89 (P-value = 0.28), and 6.56 (P-value = 0.16), respectively, indicating that the null hypotheses of normality, no autocorrelation, and homoskedasticity were not violated for the error term (Greene 1993). The regression results confirm our observations from Table 2, i.e., SGR from feeding once/d, twice/d and 1X/EOD are significantly different from the SGR from feeding 2X/EOD, and the SGR from feeding twice/d is the highest, which is followed by the SGR from feeding once/d, 2X/EOD and 1X/EOD. Survival rate did not significantly affect the SGR.

Feed conversion ratios (FCR) of fish fed twice/d were higher (2.40) compared to fish fed once/d (1.73), 1X/EOD (1.67), and 2X/EOD (2.03) (Table 2). Table 3 contains the results of regressing FCR on TRT1, TRT2, TRT3 and survival rate. Test statistics from a J-B test, D-W test and a B-P-G test were 0.46 (P-value = 0.79), 2.39 (P-value = 0.68), and 6.00 (P-value = 0.20), respectively, indicating that the null hypotheses of normality, no autocorrelation, and homoskedasticity were not violated for the error term (Greene 1993). The Table 3 results are consistent with the Table 2 results for FCR, i.e., FCR from feeding twice/d is the highest of all four feeding treatments and statistically different from the FCR from feeding 2X/EOD. FCR associated with feeding once/d and 1X/EOD are also significantly different from FCR from feeding 2X/EOD. Survival rate did not significantly contribute in explaining the variation of FCR across the sample. The average amount of diet fed per fish for twice/d was significantly higher (773.2 g/fish) compared to all other treatments (Table 2). When the amount of diet was plotted by average monthly water temperature, sunshine bass consumed diet readily throughout the growing season (Figs. 1–4).

The percentage of whole-body weight comprised of abdominal fat (Ab. fat %) in sunshine bass fed once/d and twice/d were higher compared to fish fed 1X/EOD (4.3%) and fish fed 2X/EOD (5.4%) (Table 4). Percentage abdominal fat was regressed on TRT1, TRT2, TRT3 and survival rate (Table 3). Test statistics for the J-B test, D-W test, and a B-P-G test were 0.86 (P-value = 0.65), 2.36 (P-value = 0.65), and 2.83 (P-value = 0.59), i.e., the null hypotheses of normal distribution, no autocorrelation,

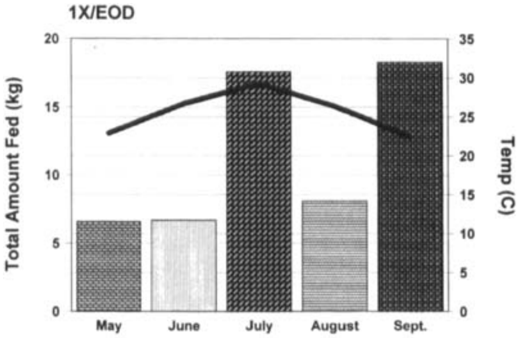

FIGURE 3. *Monthly amount of diet fed (kg) to juvenile sunshine bass grown in cages when fed once every other day (1X/EOD) in relation to average monthly water temperature (solid line).*

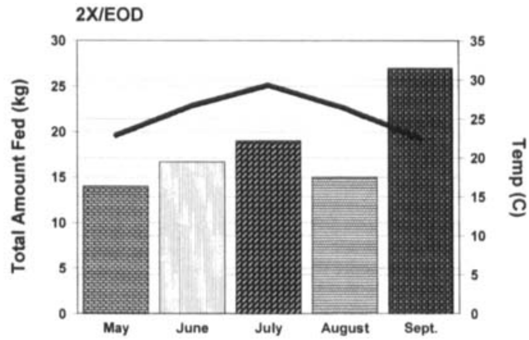

FIGURE 4. *Monthly amount of diet fed (kg) to juvenile sunshine bass grown in cages when fed twice every other day (2X/EOD) in relation to average monthly water temperature (solid line).*

and homoskedasticity were not violated for the error term (Greene 1993). Table 4 shows that the percentage abdominal fat associated with each feeding treatment was significantly different from the percentage abdominal fat of other treatments. Feeding twice/d results in the greatest mean percentage abdominal fat, which is followed by the percentage abdominal fat from feeding once/d, 2X/EOD and 1X/EOD. Survival rate did not significantly influence the percentage abdominal fat.

Regressing the hepatosomatic index (HSI) of sunshine bass on TRT1, TRT2, TRT3 and survival rate (Table 3) showed that none of the feeding treatments had a significant effect on the HSI level across the sample. Table 4 shows that the percentage fillet of sunshine bass (fillet %) fed twice/d was significantly higher (27.8%) compared to fish fed all other feeding regimes. Table 4 shows that feeding once/d and twice/d produces a mean fillet % that is significantly different from the corresponding mean fillet % from feeding 2X/EOD. The mean fillet % from feeding 1X/EOD is not significantly different from the mean fillet % from feeding 2X/EOD. Conformance of the Gauss-Markov assumptions by the error term in the fillet % regression is assured by the J-B test statistic, D-W test statistic, and the B-P-G test statistic, i.e., 0.78 (P-value = 0.68), 2.21 (P-value = 0.53), and 3.97 (P-value = 0.41), respectively.

Table 4 shows that mean percentage moisture, protein, lipid, and ash in fillets of sunshine bass among four treatments. Percentage protein (protein %), lipid (fat %),

TABLE 4. *Means (± SE) of percentage abdominal fat, hepatosomatic index (HSI), percentage fillet, and proximate composition (wet-weight basis) of fillet (moisture, protein, lipid, and ash) of sunshine bass fed one of four feeding regimes. Values are means of three replications.*

	Feeding frequency			
	Once/d	Twice/d	1X/EOD	2X/EOD
Ab. fat (%)	7.6 ± 0.4	7.5 ± 0.2	4.3 ± 0.3	5.4 ± 0.4
HSI (%)	2.27 ± 0.19	2.53 ± 0.09	2.73 ± 0.23	2.90 ± 0.17
Fillet (%)	25.8 ± 0.67	27.8 ± 0.6	24.0 ± 0.67	23.8 ± 0.26
Fillet Analysis				
Moisture (%)	76.1 ± 0.6	75.6 ± 1.1	75.4 ± 0.5	75.6 ± 0.4
Protein (%)	20.5 ± 0.5	17.4 ± 3.2	20.1 ± 0.7	19.7 ± 2.2
Lipid (%)	4.2 ± 0.6	4.5 ± 0.9	2.2 ± 0.3	3.1 ± 1.3
Ash (%)	1.2 ± 0.0	1.2 ± 0.03	1.2 ± 0.06	1.2 ± 0.03

and ash (ash %) were each regressed on TRT1, TRT2, TRT3 and survival rate (Table 3). None of the regressor coefficient estimates were significantly different from zero, in each of the three regressions.

Discussion

Based upon data from the present study, it appears that producers growing small (10–20 g) juvenile sunshine bass in cages should feed fish twice daily if a larger fish is desired at harvest. There were substantial decreases in average final weight, percentage weight gain, and SGR when fish were fed less than twice daily, especially in fish fed 1X/EOD and 2X/EOD. This is in agreement with Thompson et al. (in press) who reported that sunshine bass fed twice/d had higher percentage weight gains compared to fish fed once/d, 1X/EOD, and 2X/EOD when grown indoors. Teshima et al. (1984) reported that milkfish *Chanus chanus* fingerlings fed twice/d grew larger than fish fed once/d, while Chiu et al. (1987) stated that small milkfish fed eight times per day grew larger from when fed four times per day. Chua and Teng (1978) reported that feeding estuarine grouper *Epinephelus tauvina* 1X/EOD resulted in optimum growth, while weight gains were reduced in fish fed every 3, 4, or 5 d. Ruohonen et al. (1998), using quadratic regression analysis, reported that rainbow trout *Oncorhynchus mykiss* had higher growth rates when fed three times/d compared to fish fed once/d or twice/d, but were not different from fish fed four times/d. In hybrid sunfish, fish fed once/d were smaller than when fish were fed 2, 3, or 4 times per day; however, there were no differences among the latter three feeding frequencies (Wang et al. 1998).

The results from the present study are in contrast to reports that feeding channel catfish once/d produced similar growth (percentage weight gain and SGR) compared to fish fed twice/d when grown in cages (Webster et al. 1992a) or in ponds (Webster et al. 1992b). Robinson et al. (1995) reported that when channel catfish were fed once daily, time of feeding had no significant impact on growth, feed conversion, or body composition. While results from the present study indicate that feeding twice daily is beneficial to sunshine bass grown in cages, feeding frequency and feeding time on large commercial aquaculture farms may be influenced by the logistics of feeding large numbers of fish in many ponds (Robinson et al. 1995). Thus, while the present study indicates that feeding twice/d results in higher growth rates for sunshine bass grown in cages, it may not always be practical to feed fish that frequently if sunshine bass are grown in ponds and farm size is large.

Specific growth rate (SGR) values reported in the present study were higher than in Woods et al. (1985) and Webster et al. (1995) who reported values of 0.80%/d and 1.0%/d, respectively. This was probably due to stocking smaller (< 20 g) fish in the present study as compared to the two aforementioned studies. SGR was similar to that reported in Webster et al. (1997) who stocked similar-size palmetto bass.

In the present study, sunshine bass grown in cages fed once/d, 1X/EOD, and 2X/EOD consumed (were fed) 61%, 35%, and 53% of the amount of diet consumed by fish fed twice/d. These are similar to values reported by Thompson et al. (in press) who stated that sunshine bass fed once/d, 1X/EOD, and 2X/EOD consumed 64%, 31%, and 56% the amount of diet compared to fish fed twice/d when grown indoors. However, sunshine bass fed twice/d in the present study had significantly higher FCR compared to fish fed less frequently. This might indicate that sunshine bass fed more frequently might utilize diet less efficiently as fish fed less frequently. This is in contrast to Webster et al. (1992a) who reported that channel catfish fed once/d or twice/d had similar FCRs. Wang et al. (1998) reported that there was no difference in FCR among hybrid sunfish fed once, twice, three, or four times per day. Hepher (1988) stated that feeding frequency has little effect on FCR.

It may be that diet consumption is the growth limiting factor. Sunshine bass fed more frequently, and thus fed more diet, had higher weight gain than fish fed less frequently. In the present study, the higher FCR in fish fed twice daily may also indicate fish were overfed. During days when water temperature was 30 C, fish did not feed aggressively and may have been overfed by the initial offering. No attempt was made to collect uneaten diet as there was a desire to minimize disturbances to the fish. However, sunshine bass fed throughout the study period and water temperatures did not reach levels that would adversely affect nutrient utilization (Keembiyehetty and Wilson 1998). Sunshine bass fed once/d and twice/d consumed increasing amounts of diet as the study period progressed (Figs. 1, 2, respectively). This would be expected since larger (growing) fish would consume greater amounts of diet. However, graphs of the amount of diet fed to fish fed 1X/EOD and 2X/EOD did not show this trend.

Sunshine bass fed 1X/EOD consumed similar amounts of diet during May and June, then increased consumption by approximately three-fold in July, dramatically decreased consumption during August, and increased consumption in September (Fig. 3). Since fish were not sampled during this study, consumption data cannot be definitively related to growth; however, it could be that fish fed 1X/EOD had periods of rapid weight gain (as indicated by the dramatic increases in consumption in July and September) and periods of little weight gain (indicated by low consumption data). Fish fed 2X/EOD showed a trend for relatively stable diet consumption similar to that of fish fed once/d for May–July, but had reduced consumption during August (Fig. 4). These fish increased consumption during September to a level similar to that of fish fed once/d. However, while fish fed 2X/EOD had consumption data similar to fish fed once/d (Fig. 1 vs. Fig. 4; Table 2), final weight and percentage weight gain of fish fed once/d were significantly higher.

Survival in the present study was lower than has been reported for sunshine bass stocked into cages in a previous study (Webster et al. 1995) but was within the range reported by Woods et al. (1985) who reported that palmetto bass had survival percentages between 70% and 95%. All mortalities observed in the present study occurred within the first 7 d after stocking and were most likely due to stocking-related stressors. After two treatments with $KMnO_4$, no mortalities were recorded in any cage for the duration of the study after day-7 post-stock. Thus, the lower survival values recorded here were due to stocking stress and were not treatment related.

Conclusions

This study suggests that body composition of juvenile sunshine bass is only slightly affected by the frequency of feeding when sunshine bass are grown in cages. While sunshine bass fed once/d and twice/d had higher percentages of abdominal fat than fish fed 1X/EOD and 2X/EOD, this is probably the result of the fish being larger. The percentage of abdominal fat in the present study was similar to those reported in channel catfish when fed once or twice daily (Webster et al. 1992a, 1992b). The percentage of body weight in muscle (fillet) was higher in fish fed twice/d, probably due to the fact that they were larger than sunshine bass fed all other feeding frequencies. Noeske-Hallin et al. (1985) reported increased lipid levels in channel catfish fed twice daily compared to fish fed once daily; however, Webster et al. (1992a) reported that there were no significant differences in percentage moisture, protein, and lipid in fillet of channel catfish fed either once or twice daily. In the present study, there were no significant differences in percentage moisture, protein, lipid, and ash in the fillet of sunshine bass fed either once/d, twice/d, 1X/EOD, or 2X/EOD.

Data from the present study indicate that juvenile sunshine bass should be fed twice per day when grown in cages and stocked at the density used in this study if fish are to achieve the highest individual weight. This feeding frequency produced higher growth rates in fish while not adversely affecting body composition. However, while feeding twice/d did produce higher growth rates in sunshine bass grown in cages, detailed economic analyses needs to be conducted before this feeding frequency can be unconditionally recommended. The higher FCR values may increase diet costs when feeding twice/d compared to fish fed less often (such as once/d, which had 83% of the final weight of fish fed twice/d). The possible additional diet costs, and the potential for additional labor costs associated with feeding sunshine bass twice/d, especially if fish are grown in ponds, may or may not be economical. Research on the economics of feeding frequency for sunshine bass grown in cages, tanks, and ponds; as well as further research on the effects of feeding frequency on sunshine bass grown in commercial ponds needs to be conducted. It is imperative that as the hybrid striped bass industry grows and matures, the most cost-effective diets and feeding methods are utilized to promote the fastest, most economical growth.

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