GROWTH OF JUVENILE FAT SNOOK *Centropomus parallelus* IN CAGES AT THREE STOCKING DENSITIES

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ABSTRACT

Survival and growth parameters were evaluated in juvenile fat snook *Centropomus parallelus* held at different stocking densities in floating cages. Juveniles of 156 Days After Hatching (DAH) (5.7± 1.27 g wet weight; 8.5 ± 0.69 cm total length: mean ± SD) stocked at 50, 100 and 200 fish/m^3, in 1m^3 cages, presented no difference in survival and growth as wet weight, total and standard length, specific growth rate, and coefficient of variation for weight and total length, after 59 days of experiment (P> 0.05). Specific growth rate and food conversion ratio were near 0.9 %/day, and 1.6, respectively, at the densities tested (P>0.05). Feeding behavior of fat snook was directly related to light condition as higher feed consumption occurred at hours of lower sunlight exposure on the fish cages. From the results obtained in the present study, the use of stocking densities up to 200 fish/m^3 did not affect survival, growth performance and food conversion ratio of juveniles of fat snook. However, final biomass and production per area were significantly different, being higher at 200 fish/m^3, density considered among the stocking densities tested, more adequate for growing fat snook at the juvenile phase in cages.

Key words: fat snook, *Centropomus parallelus*, growth, stocking density, cages

CRESCIMENTO DE JUVENIS DE ROBALO-PEVA *CENTROPOMUS PARALLELUS* EM TANQUES-REDE EM TRÊS DENSIDADES DE ESTOCAGEM

RESUMO

Sobrevivência e parâmetros do crescimento foram avaliados em juvenis de robalo-peva *Centropomus parallelus* cultivados em diferentes densidades de estocagem em tanques-rede. Juvenis de 156 Dias Após a Eclosão (DAE) (5,7± 1,27 g peso úmido; 8,5 ± 0,69 cm comprimento total: média ± DP) estocados em 50, 100 e 200 peixes/m^3, em tanques-rede de 1m^3, não apresentaram diferenças na sobrevivência e crescimento como peso úmido, comprimento total e padrão, taxa de crescimento específico, e coeficiente de variação para peso e comprimento total após 59 dias de cultivo (P>0,05). Taxas de crescimento específico e conversão alimentar foram próximas a 0,9 %/dia, e 1,6, respectivamente, nas densidades testadas (P>0,05). O comportamento alimentar do robalo-peva foi diretamente relacionado à condição luminosa uma vez que o maior consumo de alimento ocorreu em horas de mais baixa exposição da luz solar nos tanques-rede. A partir dos resultados obtidos no presente estudo, o uso de densidades de estocagem ate 200 peixes/m^3, não afetou a sobrevivência, o crescimento e a conversão alimentar de robalo-peva. Entretanto, a biomassa final e a produção por área foram significativamente diferentes, sendo maiores em 200 peixes/m^3, densidade considerada mais adequada entre as densidades de estocagem testadas para a engorda de robalo-peva na fase de juvenil em tanques-rede.

Palavras-chave: robalo-peva, *Centropomus parallelus*, crescimento, densidade de estocagem, tanques-rede

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INTRODUCTION

The fat snook *Centropomus parallelus* is a commercially important fish species naturally distributed from Florida, USA, to Florianópolis, South Brazil (FRASER, 1978). Fat snook has been recognized as a candidate species for aquaculture (TEMPLE *et al.*, 2004) due to the quality of its flesh and high market price, being resistant to husbandry procedures and variations in water quality, and tolerant to a wide range of salinities (MACIEL, 2006; TSUZUKI *et al.* , 2007).

Several works have dealt with aspects of reproduction and larviculture of fat snook (CERQUEIRA *et al.*, 1995; ALVAREZ-LAJONCHÈRE *et al.*, 2002a, b; FERRAZ *et al.*, 2002; TEMPLE *et al.*, 2004), and nowadays a massive production of juveniles is already obtained under laboratory conditions (ALVAREZ-LAJONCHÈRE *et al.*, 2002b). So far, fat snook growth is done at a discontinuous and non quantified approach by small producers in earthen ponds, tanks and floating cages, in different regions of the country (CERQUEIRA and TSUZUKI, 2003).

In this context, there is an increasing interest in growing fat snook in cages in Brazil, using high quality water bodies available in coastal, estuarine and freshwater areas. As cages tend to utilize higher stocking densities to maximize productivity, and as stocking density is an important factor affecting fish welfare, a balance between the optimization of the use of cages and animal needs is essential.

Several authors have shown that stocking density may affect behavioral or social interactions, and intraspecific competition for food (BROWN *et al.*, 1992; KAISER *et al.*, 1995; PAPOUTSOGLOU *et al.*, 1998; IRWIN *et al.*, 1999; KRISTIANSEN *et al.*, 2004), in some cases developing dominance hierarchies (BRETT, 1979; SCHRECK, 1981) and cannibalism (KATAVIC *et al.*, 1989; MOORE and PRANGE, 1994; HATZIATHANASIOU *et al.*, 2002), resulting in differential survival and growth rates of fish. As fat snook is a carnivorous fish with gregarious habit, the development of hierarchical classes may appear at inappropriate stocking densities, possibly affecting growth performance and animal health. Nevertheless, the effect of different stocking densities on fat snook growth and survival has never been evaluated. Furthermore, growout studies are still necessary in order to determine the viability of its production at a commercial level.

Therefore, the aim of the present work was to identify optimum stocking densities for juvenile fat snook survival and growth in cages.

MATERIALS AND METHODS

The experiment was held at the Marine Fish Culture Laboratory (LAPMAR), Universidade Federal de Santa Catarina, Florianópolis, SC, Brazil, from March to May, 2005.

Juveniles of the fat snook *Centropomus parallelus*, obtained by natural spawn of hormonally induced animals (FERRAZ *et al.*, 2002), were kept until the start of the experiments at 25 °C, salinity of 35 g/L, natural photoperiod, fed a commercial diet with 40 % of Crude Protein (CP), 10 % fat.

Juveniles of 156 Days After Hatching (DAH) (5.75± 1.27 g wet weight; 8.5 ± 0.69 cm total length and 7.0 ± 0.57 cm standard length: mean ± SD) were stocked at 50, 100 and 200 fish/m^3, in floating cages for 59 days.

Nine square shaped cages with submerged volume of 1m^3 (1m x 1m x 1m), 2 mm mesh size, were uniformly distributed in one outdoor rectangular concrete tank (40,000 L) covered with a black shade cloth (Sombrite, 50% shade factor). Aeration was continuously provided by two perforated PVC tubes running parallel to the tanks, connected to a central air compressor. Every day, 70 % of the water was replaced (flow rate of approximately 20 L/s), and the bottom of the concrete tank was siphoned.

Water temperature and dissolved oxygen were daily measured with a YSI Model 51 oxygen meter (Yellow Springs Instrument Company, Yellow Springs, Ohio, USA). Total ammonia (TAN) and salinity were weekly monitored with a Tetratest® Kit (Tetra Werke, Melle, Germany), and a Bernauer Model F3000 optical refractometer (Bernauer Aquacultura, Blumenau, Brazil), respectively. Water temperature and salinity during the experimental period were 24.8 ± 1.15 °C (mean ± SD), and 35.0 ± 1.20 g/L, respectively. Dissolved oxygen was kept at 6.0 ± 1.50 mg/L, and total ammonia at 0.08 ± 0.14 mg/L. There was no variation in water quality parameters among the cages (P > 0.05), and water quality parameters were within acceptable ranges for fish cage culture (BEVERIDGE, 1996).

As previous work demonstrated that at this age, feeding fat snook one or two times per day did not affect fish growth parameters (P>0.05) (BERESTINAS, 2006), fish in the present study were fed to satiation once a day (between 15:00 and 18:00 h) (See Results and Discussion Section) with a commercial extruded diet (40 % CP, 10 % fat; 2-2.5 mm diameter). Fish behavior was monitored at feeding. Every week, the amount of food consumed in each cage was recorded for food conversion ratio calculation (FCR = weight of feed in g/biomass gain in g).

Thirty fish were sampled at the beginning of the experiment, and all fish were measured and weighed at the end of the growth period. Animals were rapidly anesthetized with benzocaine (84 g of benzocaine per 1L alcohol 96 %), weighed to the nearest 0.1 g and measured (total and standard length) to the nearest 1 mm. Feeding was discontinued 24 h prior to measurements.

The following rates were determined: Specific-growth rate (SGR, %/day) = 100 X (ln final weight - ln initial weight)/ number of days; coefficient of individual body weight and total length variations as (CV weight, %) = 100 X (standard deviation/ mean body weight) and (CV length, %) = 100 X (standard deviation/ mean total length), respectively. Final biomass (kg) and production per area (fish/m^3) were also calculated.

All treatments were run in triplicate. Differences between replicates and treatments were analyzed by one-way analysis of variance (ANOVA) with subsequent Tukey test. Statistical significance was assumed at $P < 0.05$.

RESULTS AND DISCUSSION

In several species, growth rate is characterized by an inverse correlation with stocking densities as observed in rainbow trout *Onchorhynchus mykiss* (PAPOUTSOGLOU *et al*., 1987), turbot *Scophthalmus maximus* (IRWIN *et al*., 1999), European sea bass *Dicentrarchus labrax* (HATZIATHANASIOU *et al*., 2002; SAILLANT *et al*., 2003) and jundiá *Rhamdia quelen* (BARCELLOS *et al*., 2004), possibly due to social interactions leading to intraspecific size variation and feeding dominance (YAMAGISHI *et al*., 1974; JOBLING, 1985), competition (IRWIN *et al*., 1999), space limitation (EWING *et al*., 1998), insufficient food (ANDREW *et al*., 2004) and low dissolved oxygen (YI *et al*., 1996). On the other hand, higher growth occurred at higher densities in the Arctic charr *Salvelinus alpinus* (BROWN *et al*., 1992), and in the European sea bass (PAPOUTSOGLOU *et al*., 1998), result generally attributed to a decreased social interactions or lack of aggressive actions at the increased densities.

Juvenile fat snook, within the stocking densities tested in this study (50 to 200 fish/m^3), does not belong to the fish category which is characterized by an inverse or positive correlation between stocking density and growth rate as previously cited, as no difference in survival and growth as wet weight, total and standard length, specific growth rate, and CV for weight and total length was observed after 59-days of cultivation in cages (P> 0.05) (Table 1). PASPATIS *et al*. (2003) found that a stocking density of up to 1,000 fish/m^3 does not affect European sea bass juveniles (5.3 g) kept in tanks. ROWLAND *et al*. (2004) found that growth and condition were not affected by stocking density in silver perch *Bidyanus bidyanus* fry reared at 50, 100 or 200 fish/m^3 in cages for 140 days. CAVERO (2003) showed that growth of pirarucu *Arapaima gigas* juveniles in floating cages was not affected by stocking densities or by intraspecific interactions.

Table 1 – Growth of fat snook *Centropomus parallelus* held at different densities in floating cages during 59 days. Data shown as mean ± SD. Minimum and maximum values are presented in brackets. Different letters at the same column are statistically different (P<0.05).

Density (fish/m^3)	Weight (g)		Total length (cm)		Standard length (cm)		SGR[1]	CV[2] Weight (%)	CV Length (%)	FCR[3]	Final Biomass (kg)
	Initial	Final	Initial	Final	Initial	Final					
50	5.8 ±1.18 (3.3-8.7)	10.1 ±0.47 (4.2-16.9)	8.6 ±0.66 (7.1-9.9)	9.9 ±0.97 (7.4-12.1)	7.0 ±0.56 (5.7-8.1)	8.2 ±0.99 (6.0-10.0)	0.9 ±0.05	27.4 ±3.93	9.9 ±1.87	1.7 ±0.09	0,50 ±0,31a
100	5.7 ±1.14 (2.6-8.5)	9.8 ±0.59 (4.1-15.8)	8.6 ±0.66 (6.6-10.1)	9.9 ±0.87 (7.6-11.8)	7.0 ±0.55 (5.2-8.0)	8.1 ±1.49 (6.0-10.0)	0.9 ±0.04	24.8 ±0.42	8.08 ±0.48	1.5 ±0.06	0,97 ±0,50b
200	5.8 ±1.50 (2.4-12.7)	9.8 ±0.72 (3.6-20.9)	8.5 ±0.76 (5.7-11.0)	9.9 ±1.25 (4.8-13.3)	6.9 ±0.61 (5.1-9.0)	8.3 ±1.81 (5.9-11.0)	0.9 ±0.14	27.6 ±3.80	12.1 ±2.41	1.5 ±0.12	1,68 ±0,93c

[1] *SGR: Specific-Growth Rate;* [2] *CV: Coefficient of Variation;* [3] *FCR: Food Conversion Ratio*

In the present study, survival rates were excellent (100% for 50 fish/m^3; 99% for 100 and 200 fish/m^3) at the end of the growth period in all treatments. Mean specific growth rate was 0.9 %/day, and food conversion ratio was around 1.6 at the densities tested. Similar growth and food conversion rates have been obtained for younger fat snook juveniles fed with different commercial diets, non-specific for marine fish (BERESTINAS, 2006). The determination of the nutritional requirements and the development of a more appropriate diet may improve growth performance of fat snook.

When compared to a similar species, the common snook *Centropomus undecimalis*, fat snook presented lower growth and less efficient feed utilization. TUCKER (2000) reported for common snook a food conversion ratio of 0.7 and around 80 g weight gains at 5- month age. Although fat snook grows slower than common snook, it has been already produced at constant and stable levels in laboratory (ALVAREZ-LAJONCHÈRE *et al*., 2001, 2002b), and therefore, technology for massive production of juveniles has been already established. On the other hand, there is a need to increasing knowledge on common snook larvae and juvenile production (SANCHEZ *et al*., 2002, ALVAREZ-LAJONCHÈRE, 2004). Additionally, due to its sporting and culinary attributes, and a high market price, fat snook can be commercialized as a "plate size fish" (around 300 g, whole fish) and used for recreational fisheries purposes.

Although no difference in survival and growth performance was detected, final biomass was significantly higher at the highest stocking density (Table 1). As mortality rates were close to 100 %, production per area also showed a positive relation with stocking density (50.0 ± 0.0; 99.0 ± 1.3; 198.0 ± 3.4 fish/m^3 at 50, 100 and 200 fish/m^3, respectively) ($P<0.05$).

Feeding behavior of fat snook was directly related to light condition as higher feed consumption occurred at hours of lower sunlight exposure on the fish cages. Initially, fish were fed 2-times a day (morning and afternoon). However, in the cages with higher sunlight incidence in the morning period, fish tended not to eat. In the afternoon, as all the cages were in the shade, feed consumption increased and was uniform. Apparently, early morning and late afternoon are the best hours for fat snook feeding, suggesting that they are low-light feeders as reported for the common snook, that presents two feeding peaks per day, one approximately 2 hours before sunrise, and the second 2-3 hours following sunset (ECKELBARGER *et al*., 1980).

From the results obtained in the present study, the use of stocking densities up to 200 fish/m^3 did not affect survival, growth performance and food consumption of juveniles of fat snook *Centropomus parallelus*. However, final biomass and production per area were significantly different, being higher at the highest stocking density (200 fish/m^3).

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