WEANING OF THE COMMON SNOOK (*Centropomus undecimalis*) EARLY JUVENILES REARED IN LABORATORY USING COMMERCIAL AND EXPERIMENTAL DIETS*

Thiago Augusto SOLIGO [1]; Alexandre Sachsida GARCIA [2]; Vinicius Ronzani CERQUEIRA [3]

ABSTRACT

Laboratory-reared early juveniles (48 days after hatching) of the common snook (*Centropomus undecimalis*) were fed for 30 days using three different diets in order to evaluate transition from live to inert diet (weaning): 1) an experimental dry diet (46% crude protein), 2) a commercial dry diet (57% crude protein), and 3) only enriched *Artemia* metanauplii, used as a control group. The fish were placed in 80 L cylindrical tanks (three replicates) equipped with aeration and flow-through water (34 ± 1 salinity), and kept at 26.0 ± 0.5 ºC. The specific growth rates obtained in treatments 1 (5.62% day^{-1}) and 2 (6.13% day^{-1}) were similar (P = 0.32) and higher than the specific growth rate verified in the control group (3.71% day^{-1}) (P = 0.002). The feed conversion ratio was more efficient with the commercial diet (0.85 ± 0.04) when compared to the experimental diet (1.41 ± 0.15) (P = 0.003). There were no significant differences among the survival rates observed in the different treatments (P = 0.05) with values of 61.00 ± 1.00%, 83.66 ± 5.77% and 77.33 ± 14.57% for experimental, commercial and control diets, respectively. This study demonstrates that the inert diets tested were appropriate for weaning the common snook early juveniles.

Key words: Game fish; specific growth; inert diet

DESMAME DE JUVENIS DO ROBALO-FLECHA (*Centropomus undecimalis*) CULTIVADOS EM LABORATÓRIO UTILIZANDO DIETAS COMERCIAL E EXPERIMENTAL

RESUMO

Juvenis de robalo-flecha (*Centropomus undecimalis*) cultivados em laboratório, com 48 dias após a eclosão, foram alimentados por 30 dias, a fim de avaliar a melhor dieta na transição do alimento vivo para o inerte, com três diferentes tratamentos: 1) dieta experimental (46% de proteína bruta), 2) dieta comercial (57% de proteína bruta) e 3) somente metanáuplios de *Artemia* enriquecidos (grupo controle). Os peixes foram mantidos em tanques cilíndricos de 80 L (três réplicas) equipados com aeração e fluxo contínuo de água (34 ± 1 de salinidade), mantida a 26,0 ± 0,5 °C. As taxas de crescimento específico nos tratamentos 1 (5,62% dia^{-1}) e 2 (6,13% dia^{-1}) foram similares (P = 0,32) e superiores a taxa de crescimento específico verificada no grupo controle (3,71% dia^{-1}) (P = 0,002). A conversão alimentar foi melhor com peixes que receberam a dieta comercial (0,85 ± 0,04) que com a dieta experimental (1,41 ± 0,15) (P = 0,003). Não houve diferença para a sobrevivência nos diferentes tratamentos (P = 0,05) com valores de 61,00 ± 1,00%, 83,66 ± 5,77% e 77,33 ± 14,57% para os tratamentos experimental, comercial e controle, respectivamente. O estudo demonstra que as duas dietas testadas são apropriadas para substituir o alimento vivo no desmame de juvenis de robalo-flecha.

Palavras chave: Peixe esportivo; crescimento específico; dieta inerte

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[1] *Programa de Pós Graduação em Aquicultura da Universidade Federal de Santa Catarina. e-mail: tsoligo@gmail.com*

[2] *Centro de Estudos do Mar - UFPR. Av. Beira Mar s/n. - CP 50002 – CEP: 83.255-971 - Pontal do Sul, Pontal do Paraná – PR - Brasil*

[3] *Professor Titular. Universidade Federal de Santa Catarina, Centro de Ciências Agrárias, Departamento de Aquicultura. CP 476 – CEP: 88.040-970 – Florianópolis – SC - Brasil. e-mail: vrcerqueira@cca.ufsc.br*

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INTRODUCTION

The common snook, *Centropomus undecimalis*, is a promising species for aquaculture, with the possibility of intensive culture mainly due to its tolerance to low concentrations of oxygen, easy adaptation to captivity and inert diets, excellent quality of meat, and tolerance to a wide range of salinity (AGER *et al*., 1976; RIVAS, 1986; TUCKER, 1987; SOUZA-FILHO and CERQUEIRA, 2003; CERQUEIRA, 2010). Besides, due to its importance as a game fish, many studies have been conducted to produce juveniles for restocking programs (BRENNAN *et al*., 2006).

For the establishment of rearing techniques for a new species such as the common snook, is paramount to ensure a stable production of juveniles in laboratory, which involves researching the stages of reproduction, larval culture, and nursery. Previous studies with this species described attempts to spawn the broodstock and to rear the larvae and juveniles (SHAFLAND and KOEHL, 1979; EDWARDS and HENDERSON, 1987; TUCKER, 1987), while more recent studies described bacterial management strategies (KENNEDY *et al*., 1998) and egg quality assessment to improve larviculture performance (NEIDIG *et al*., 2000; YANES-ROCA *et al*., 2008). According to YANES-ROCA (2006), although studies with this species have been carried out during the last 40 years, research efforts left gaps in understanding larval rearing and broodstock management of the common snook.

Recent attempts to breed *C. undecimalis* have resulted in the first production of larvae in Southern Brazil (SOLIGO *et al*., 2008), encouraging research to develop technologies to produce juveniles. Once viable eggs have been obtained and larvae have been successfully cultured through metamorphosis to juveniles, it is essential select the most appropriate inert diet to wean the juveniles (LEE and LITVAK, 1996). The weaning process is defined as the progression from live feed to a formulated diet. It is considered a critical step in the culture of carnivorous marine fish, and its success depends on factors such as feed quality and larval characteristics (DEVRESSE *et al*., 1991; SHIELDS, 2001; ALVES Jr. *et al*., 2006; CAHU and ZAMBONINO-INFANTE, 2007).

Despite the importance of the common snook, there is little information available about feeding juveniles with formulated diets. Additionally, we need to know if this species could be adapted to commercial diets and protocols originally developed for other marine fishes. In this study, the main goal was to evaluate the weaning of common snook early juveniles using an experimental and a commercial diet, and a control group (*Artemia*). The results in terms of growth, survival and feed conversion were compared among the different treatments.

MATERIALS AND METHODS

Laboratory-reared common snook, obtained as described by SOLIGO *et al*. (2008), were used in this experiment. At the age of 45 days after hatching (DAH), early juveniles were graded to get one homogeneous group, which were transferred randomly to nine black 80 L cylindrical tanks, up to a density of 1.25 juveniles L^{-1}. During three days of acclimation, juveniles were fed enriched *Artemia* metanauplii (Selco® INVE Aquaculture, Belgium).

At the beginning of the experiment, a sample of 70 juveniles was individually measured, and the mean value adopted for all tanks (0.13 ± 0.05 g and 18.6 ± 2.9 mm). Thirty juveniles from each tank were measured every 15 days, to evaluate growth. At the end of experiment, all fish were individually measured and counted to calculate the survival. Benzocaine (50 ppm) was used as anaesthetic during measurements.

The tanks were supplied with a flow through water exchange at a rate of 300% day^{-1}. Outflow standpipes were covered with a 300 µm mesh during the first 15 days, and with a 600 µm during the last 15 days. Total ammonia was checked weekly using a colorimetric kit (Tetra test® NH_3/NH_4^+, Germany). During the whole experimental period, total ammonia remained bellow 0.025 mg L^{-1}. Dissolved oxygen was measured daily with an oxymeter (YSI 55) and remained above 5 mg L^{-1} during the experimental period (mean of 5.83 ± 0.91 mg L^{-1}). Temperature was kept at 26.0 ± 0.5 ºC using electrical heaters and thermostats. The average salinity of the water used in the trial was 34 ± 1. Photoperiod was natural (14:10 light:dark) with reduced illumination provided by a shade cloth, resulting in an average light intensity of 700 lux at the water surface. Dead fish and wastes debris were collected every morning by siphoning the bottom of the tanks.

Three treatments were tested with three replicates per treatment: 1) an experimental diet (Tables 1 and 2); 2) a commercial diet for weaning of the European sea bass, *Dicentrarchus labrax* (NRD, INVE Aquaculture, Belgium, biochemical composition in Table 2) and 3) a group that continued receiving only *Artemia* metanauplii (control group) as during the acclimation period. The biochemical composition of the diets (Table 2) was determined following the protocols of the Association of Official Agricultural Chemists (SULLIVAN and CARPENTER, 1993).

Table 1. Formulation of the experimental diet used to wean *Centropomus undecimalis*

Ingredient	Percentage (%)
Fish meal[a]	62.5
Squid meal	15.0
Pregelatinized corn starch[b]	11.0
Cod liver oil	6.0
Vitamin and mineral mix[c]	3.0
CMC[d]	1.0
Soy lecithin	1.0
Vitamin C[e]	0.5

[a]Residue of skipjack tuna (Katsuwonus pelamis) processed by Leal Santos Pescados (Rio Grande, Brazil); [b]Yoki Alimentos S/A. (São Paulo, Brazil); [c]Nutron Alimentos Ltda (Campinas, Brazil), Chemical composition kg^{-1} of product: Vit. A, 1000000 UI; Vit. B12, 3750 μg; Vit. B2, 1750 mg; Vit. B6, 1125 mg; Vit. C, 25000 mg; Vit. D3, 500000 UI; Vit. E, 20000 UI; Folic acid, 250 mg; Pantotenic acid, 250 mg; Biotin, 50 mg; Copper, 2000 mg; Iron, 13750 mg; Iodine, 100 mg; Manganese, 3750 mg; Niacin, 5000 mg; Selenium, 75 mg; Zinc, 20000 mg; Antioxidant, 0.2 g; [d]Carboximetilcelulose produced by Murta Especialidades Químicas (Barra Funda, Brazil); [e]Rovimix Stay C-25 DSM Produtos Nutricionais Brasil Ltda (Jaguaré, Brazil)

Table 2. Proximate analysis (dry matter) of the experimental and commercial diets used to wean *Centropomus undecimalis*

Proximal composition	Diet	
	Experimental	Commercial
Moisture (%)	7.6	6.2
Ash (%)	14.1	12.5
Crude protein (%)	46.3	57.2
Lipids (%)	21.2	12.7
Fiber (%)	0.8	1.1
Carbohydrates[a] (%)	9.9	10.1
Vitamin C[b] (mg kg^{-1})	5000	2000
Energy[c] (kcal kg^{-1})	4158	3839

[a]Estimated by difference; [b]According to manufacturer's information; [c]Metabolizable energy estimated from physiological standard values (LEE and PUTNAM, 1973)

The particles size of the experimental diet was 300 - 500 μm during the first 15 days of the experiment, and 500 - 1000 μm during the final 15 days. The particles size of the commercial diet was 400 - 600 μm during the first 15 days and 500 - 800 μm, during the final 15 days of the experiment.

Fish were hand fed four times a day (09:00, 11:00, 14:00, and 17:00 h). The fish were co-fed with inert diet (experimental and commercial) and *Artemia* sp. during the first 15 days of the experiment. The initial *Artemia* sp. density of 1,500 metanauplii L^{-1} decreased to 1,000 metanauplii L^{-1} on the 11th day of experiment, and to 500 metanauplii L^{-1} from the 13th to 15th day. In the control treatment, the live feed was kept at 1,500 metanauplii L^{-1} all period of experiment. Inert diets were supplied at a ratio of 7% of fish tank biomass per day, provided in four portions per day.

The main variables used to evaluate growth performance were calculated using the following formulas:

Weight gain = $W_2 - W_1$;

Specific growth rate (SGR) = $[(\ln W_2 - \ln W_1)/d] \times 100$;

where W_2 and W_1 were final and initial fish weight, respectively; and "d" the experimental period.

The survival was calculated by the formula:

Survival = $(N_2/N_1) \times 100$;

where N_2 and N_1 were final and initial number of fish, respectively.

Daily feed ration for each tank was calculated from the daily amounts of feed distributed. Feed conversion ratio (FCR) was calculated using the following formula:

FCR = total feed distributed/biomass gain.

Data were tested for normality and homogeneity of variance, and survival data was arcsine transformed. Results were submitted to analysis of variance (One-way ANOVA), with 5% of significance level. When statistical differences were detected among treatments, Tukey test was used for means separation. Student's t-test was used to compare SGR between the experiment periods (0-15 and 16-30 days). Statistical analysis was performed using Statview version 5.0 software (SAS Institute, Inc., Cary, North Carolina, USA).

RESULTS

No differences (P>0.05) were found among the final survival rates from the different treatments (Table 3). The mortality observed was mainly due to cannibalism. Fish fed with the inert diets had similar weight gain (P>0.05). However, fish fed only *Artemia* metanauplii had a smaller weight gain than the other treatments (P<0.05) (Table 3 and Figure 1).

Table 3. Mean values[1] of survival, total length, weight gain, specific growth rate (SGR) and feed conversion rate (FCR) of *Centropomus undecimalis* juveniles fed two different inert diets and only *Artemia* metanauplii

	Diet		***Artemia* metanauplii**
	Experimental	**Commercial**	
Survival (%)	61.00 ± 1.00[a]	83.66 ± 5.77[a]	77.00 ± 14.51[a]
Final length (mm)	32.26 ± 3.59[a]	35.12 ± 3.93[a]	26.89 ± 2.48[a]
Weight gain (g)	0.60 ± 0.05[a]	0.72 ± 0.08[a]	0.28 ± 0.07[b]
SGR	5.63 ± 0.26[a]	6.13 ± 0.11[a]	3.70 ± 0.62[b]
FCR	1.41 ± 0.08[a]	0.85 ± 0.02[b]	-

[1]Mean ± standard deviation (n = 3). In each line, values with different superscripts indicate significant differences (P<0.05). Total inert diet distributed per treatment was 50 g.

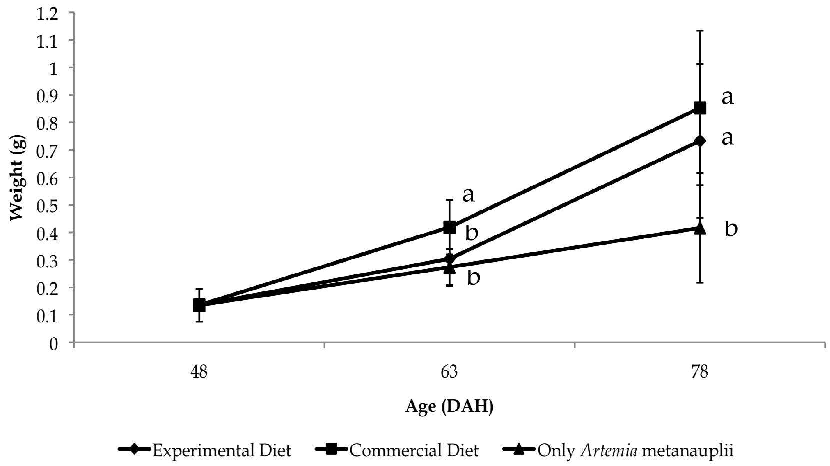

Figure 1. Mean weight of *Centropomus undecimalis* during 30 days of feeding with experimental and commercial diets, and only *Artemia* metanauplii. Different superscripts at the same age indicate significant differences (P<0.05)

At the end of the second half of the experiment, juveniles fed only *Artemia* metanauplii presented a lower growth rate than those weaned to inert diets (Table 4). On the other hand, during the first half of the experiment, the commercial diet resulted in higher growth rate and better FCR, when compared to the experimental diet.

Table 4. Mean values[1] of specific growth rate (SGR) in weight of *Centropomus undecimalis* juveniles fed with commercial and experimental diets and only *Artemia* metanauplii, during two experiment periods (0-15 and 16-30)

	Diet	Period	
		Days 0-15	Days 16-30
SGR weight (% d^{-1})	Experimental	5.38 ± 0.67^{aA}	5.86 ± 0.59^{aA}
	Commercial	7.54 ± 0.12^{aB}	4.67 ± 0.08^{bA}
	Artemia metanauplii	4.70 ± 0.26^{aA}	2.71 ± 1.10^{bB}

[1] Mean ± standard deviation (n = 3). In each line, values with different lower case superscripts indicate significant differences (P<0.05). In each row, values with different capital superscripts indicate significant differences (P<0.05)

DISCUSSION

Despite that the survival rate with the commercial diet was higher than that observed with the experimental diet, there was no significant difference between treatments. On the other hand, it is interesting to emphasize that the mortality during the experiment, was mainly due to cannibalism. Cannibalism is not uncommon among fish, and has been described in the rearing of common snook juveniles (TUCKER, 1987). Furthermore, in the rearing of a close related species, *C. parallelus*, if the fish size is heterogeneous, cannibalism can account for up 15% of mortality (CORRÊA and CERQUEIRA, 2007).

The survival rates obtained in the present study are comparable to previous studies. HONCZARYK (1993) successfully weaned fat snook larvae with 36 DAH using an experimental dry diet based on 40% shopped shark (*Carcharias taurus*), with 61% of survival. CERQUEIRA and BERNARDINI (1995) testing an experimental and a commercial diet on the weaning of 50 DAH fat snook, observed no significant differences in the survival rates, with values of 65 and 77%, respectively. On a study with the flounder *Pleuronectes americanus*, LEE and LITVAK (1996) weaned 47 DAH larvae with approximately 70% of survival.

The weaning age is considered an important factor in the process of larval rearing and for many species, it coincides with the metamorphosis from larvae to early juveniles. BORBA (1997) tested different ages in the weaning of the fat snook (35, 45 and 55 DAH), and found no significant differences in survival, although 100% survival was only obtained in 55 DAH. ALVES Jr. *et al*. (2006), studying the larval rearing of 30 DAH fat snook larvae, had over 91% of survival.

In this experiment, juvenile common snook accepted inert diets after complete metamorphosis. According to ROBERTS (1987), common snook completes the metamorphosis at 20 DAH (29 °C), while EDWARDS and HENDERSON (1987) mention that it is complete at 40 DAH (28 ± 0.5 °C). One intermediary time was observed from TUCKER (1987) suggesting that metamorphosis is finished at 35 DAH (26-30 °C). According KJORSVIK *et al*., (2004), the term juvenile is applied to fish that have already gone through the complete metamorphose and show the final phenotype of an adult despite being sexually immature. LAU and SHAFLAND (1982) described common snook with 44 DAH reared at 28 ± 1 °C, fed exclusively with live feed, as having an appearance of small adults, classifying them as early juveniles. Therefore, in the present study the fish submitted to the weaning at 48 DAH reared at 26 ± 0.5 °C can be considered juveniles, and were ready for the weaning. Additionally, the gradual increase in the amount of inert feed and the decrease in live feed (*Artemia*) led to a fast adaptation, resulting in acceptable growth and survival rates.

Fish fed only *Artemia* metanauplii, presented the lowest growth rate of all treatment. Similar results were found by ALVES Jr. *et al*. (2006) with the fat snook larvae. ROSENLUND *et al*. (1997) stated that acceptable growth rates of marine fish larvae can not be sustained solely using live food.

No differences on growth rate were observed between the commercial (57.2% crude protein) and the experimental (46.3% crude protein) diets. However, despite of the amount of feed being the same for both treatments, the experimental diet resulted in a significantly higher (less efficient) feed conversion ratio. GARCIA (2001), testing experimental diets containing 47, 52 and 57% crude protein with juveniles of the fat snook, observed that 47% resulted in a lower growth rate and a less efficient feed conversion rate than the other diets with higher protein content. It has been also observed with fat snook larvae that the inclusion of attractants in the diet could increase feed consumption and growth (HONCZARYK, 1993; BORBA, 1997). It is likely that, the commercial diet was more attractive (as evidenced by intense feeding activity) and was more digestible than the experimental diet, which could explain the difference in the feed conversion ratios observed in the present study. In a previous study with fat snook, CERQUEIRA and BERNARDINI (1995) also observed that an experimental diet resulted in a less efficient FCR than a commercial diet.

The commercial diet resulted in higher specific growth rate only during the first 15 days of experiment. In the second half, the commercial diet resulted in lower specific growth rate when compared to the co-feeding period (enriched *Artemia* and inert diet). This could indicate the importance of live food during weaning, such as LEE and LITVAK (1996) observed with the flounder *P. americanus*.

ALVES Jr. *et al*. (2006) tested three co-feeding periods (5, 10 and 15 days) with live feed (*Artemia*) for weaning of 30 DAH *Centropomus parallelus* larvae. It was observed that 35 DAH larvae began to ingest inert food efficiently, earlier than the previous protocol suggested for this specie. However, a co-feeding period of 5 days impaired growth. According to TUCKER (1987), prolonging the weaning process of common snook, *C. undecimalis*, could increase the difficulty of weaning the fish to inert food. In this study we adopted a co-feeding period of 15 days, but we suggest that the protocol for the larviculture of common snook can be improved, testing an earlier weaning age, as well as a shorter period of co-feeding.

CONCLUSION

Early juveniles of common snook could be easily adapted to feed inert diets (experimental and commercial). This study demonstrates that the inert diets tested were appropriate for weaning the common snook early juveniles.

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