

Preliminary Studies on the Optimum Feeding Rate for Pirarucu *Arapaima gigas* Juveniles Reared in Floating Cages

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Abstract This study aimed at testing the feeding rates on growth performance of pirarucu juveniles, *Arapaima gigas*, reared in cages. A 210-day experiment was conducted in four cages installed at the Pereira de Miranda reservoir (Pentecoste, Ceará, Brazil). Pirarucu juveniles (1550.0±85.0 g and 59.2±1.15 cm) were stocked at 40 fish/cage and fed four times a day with a commercial extruded feed with 40% crude protein. Fish were fed at rates of 2.0% and 3.0% body weight/day during the experiment. Growth performance was investigated in a designed experiment employing two different feeding rates and each treatment had two replicate cages. Survival was high and not significantly affected by feeding rate. Mean survival rate ranged between 91.2±1.2 and 92.5±2.5%. Feeding rate not affect significantly final mean length (89.8±3.2 to 88.7±3.5 cm), final mean weight (6800.0±170.0 to 6680.0±420.0 g) and production (46.8±0.7 to 46.0±1.2 kg/m³), but FCR was significantly affected by feeding rate. Feed conversion rates were 4.32±0.08 and 2.82±0.09 for fish fed with 3% and 2% body weight/day, respectively. Therefore, the data obtained suggest that pirarucu juveniles with weight ranged from 1550.0±85.0 to 6800.0±170.0 g could be fed with feeding rate of 2.0% body weight/day.

Keywords Pirarucu; Cage; Growth performance; Feeding rate

Introduction

In the last years, the Brazilian aquaculture industry has attempted to select new species of fish in order to diversify its production (Núñez et al., 2011; Oliveira et al., 2012; Silva et al., 2012, Fiúza et al., 2013). Pirarucu is an exclusively air breathing fish native from the Amazon Basin. This species is considered to be one of the largest freshwater scale fishes in the world, as well as one of the species with the greatest potential for being cultivated in the Amazon (Roubach et al., 2003). According to Saint-Paul (1986), pirarucu reaches up to 200 kg in weight and up to 3 m in length, and is capable of living longer than 50 years. Pirarucu has the fastest growth among Amazonian cultivated fishes, growing at 27-41 g/day and reaching 10-15 kg/year (Bard and Imbiriba, 1986; Imbiriba, 2001; Pereira-Filho et al., 2003; Núñez, 2009; Rebaza et al., 2010). However, to the present there has been little research into the zootechnical and economically

feasible to this species (Ono et al., 2003; Oliveira et al., 2012). Pirarucu may be suitable for cage culture because it is a species which tolerates crowding, but to date there has been little research into the use of cages.

Fish feeding is one of the most important factors in commercial fish farming because feeding regime may have consequences on growth rate of fish (Okorie et al., 2013). Several studies have shown that growth correlates to food intake (Wang et al. 2007; Ozorio et al. 2009). Feeding rate has a pronounced effect on growth rate and feed efficiency of fishes. Therefore, optimal feeding rate is important not only for promoting best survival and growth and minimizing feed conversion rate, but also for economic and environmental reasons, preventing including water quality deterioration (Eroldogan et al., 2004; De Riu et al., 2012; Okorie et al., 2013).

Currently, there is no published information on the

effects of feeding rate on growth of pirarucu juveniles. This preliminary study aimed to evaluate the effects of feeding rate on the performance of pirarucu in cages in a reservoir located in Ceará State, Brazil.

1 Results

The water characteristics did not present any significant difference among fish densities or the two points monitored in reservoir. Water temperature averaged was 27.8°C in the morning and 28.6°C in the afternoon during the culture period. Mean dissolved oxygen concentration was 3.6 mg/L in the morning and 5.8 mg/L in the afternoon. The pH fluctuated between 7.6 and 7.8 throughout the culture period. In all cages, transparency reading ranged between 100 and 135 cm. Ammonia, nitrite and nitrate ranged between 0.01 mg/L and 0.02 mg/L, 0.00 and 0.63 and 0.00 mg/L to 1.00 mg/L, respectively.

Survival was high and not significantly affected by feeding rate. Mean survival rates ranged from

91.2±1.2% to 92.5% among fish fed at 2% and 3% body weight/day, respectively (Table 1). Feeding rate did not affect the weight and length of pirarucu juveniles. Mean final weights were 6800.0±170.0 and 6680.0±420.0 g, while mean final lengths were 89.8±3.2 and 88.7±3.5 cm in the groups fed at 2% and 3% body weight/day, respectively (Figure 1). The growth rates for pirarucu juveniles in cages submitted to different treatments are given in Table 1. Mean AGR and SGR at 2% body weight/day were 25.0±9.4 g/fish/day and 0.7±0.1%/day, respectively, compared to 24.4±4.9 g/fish/day and 0.7±0.1%/day at 2% body weight/day. Similarly, production was not significantly affected by feeding rate and ranged from 46.8±0.7 to 46.0±1.2 kg/m³ in the cages fed at 2% and 3% body weight/day, respectively. However, feeding rate did significantly affect FCR. FCE was significantly lower in the group fed at 2% body weight/day (2.8±0.1) than at 3% body weight/day (4.3±0.1).

Table 1 Survival, initial and final weights, weight gain, absolute growth rate (AGR), specific growth rate (SGR), production and feed conversion ratio (FCR) of pirarucu juveniles (initial mean weights, 1550.0±85.0 g) fed at rates of 2.0% or 3.0% body weight/day in 4 m³ cages and cultured for 210 days

Parameter	Feeding rate (% of body weight/day)	
	2	3
Survival (%)	91.2±1.2	92.5±2.5
Initial weight (g)	1550.0±85.0	1550.0±85.0
Final weight (g)	6800.0±170.0	6680.0±420.0
Weight gain (g)	5250.0±155.0	5130.0±350.0
AGR (g/day)	25.0±9.4	24.4±4.9
SGR (%/day)	0.7±0.1	0.7±0.1
Production (kg/m ³)	46.8±0.7	46.0±1.2
FCR	2.8±0.1 ^a	4.3±0.1 ^b

Note: Data are means±S.D. of two replicate cages. For each row, means with different letters as superscripts are significantly different ($P<0.05$)

2 Discussion

Throughout the experiment most physico-chemical parameters of the water were maintained within the appropriate range for cage aquaculture (Beveridge, 1996; Boyd and Tucker, 1998). Nevertheless, it is important emphasize that the pirarucu accepts low water dissolved oxygen levels, due to its obligatory aerial breathing (Ono et al., 2004; Núñez, 2009). On the other hand, there are not studies that indicate critical oxygen levels and others physico-chemical parameters in culture of pirarucu.

The feeding rates tested did not affect growth

parameters, except for FCR. Many studies have not found any significant effects of feeding rate on survival (Eroldogan et al., 2004; Silva et al., 2007; Okorie et al., 2013). Various studies with pirarucu report similar results according to the type of culture. Pereira-Filho et al. (2003), Menezes et al. (2006) and Oliveira et al. (2012) reported survival rates varying from 90 to 100% in ponds and cages culture of pirarucu. Fish appear to continuously increase in weight with feeding rate up to satiation although this increase may not correspond with the incremental feed consumption (Okorie et al., 2013). In this study, the

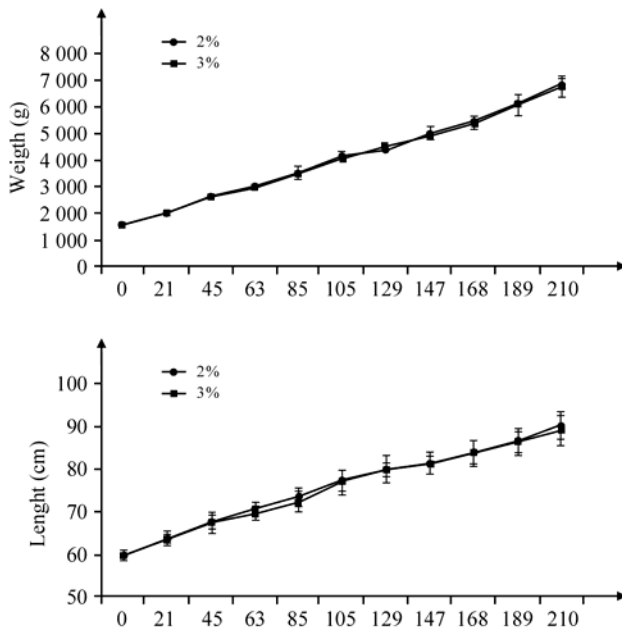


Figure 1 Growth of pirarucu fed at rates of 2.0% or 3.0% body weight/day in 4 m³ cages and cultured for 210 days. Data are means±SD of two replicate cages in Pereira de Miranda Reservoir (Ceará State, Brazil)

growth of pirarucu was not influenced with increasing feeding rate. Therefore, the data obtained suggest that feeding rate of 2.0% body weight/day could be near the level of satiation of 1550 g pirarucu juveniles. However, various authors reported similar results about growth of pirarucu. Bard and Imbiriba (1986) reported pirarucu in ponds reached weights ranging from 4037 to 4497 g in only 152 days when stocked at an initial weight of 126 to 388 g. According to Pereira-Filho et al. (2003), this species cultured under intensive production system in ponds reached a maximum weight of 7000±1100 g after 365 days. Similar stocking densities and production rates have been reported for the cage culture of other carnivorous fishes: 14.5 to 34 kg/m³ for Atlantic salmon (*Salmo salar*) in 120–2000-m³ cages (Turnbull et al., 2005; Oppedal et al., 2011), 42.0 kg/m³ for spotted wolffish (*Anarhichas minor*) in 100-m³ cages (Mortensen et al., 2007) and 35.0–61.2 kg/m³ for rainbow trout (*Oncorhynchus mykiss*) in 1.0-m³ cages (Wallat et al., 2004). However, Ono et al. (2004) reported production rates varying from 80 to 140 kg/m³ for pirarucu in 15–300-m³ cages. Growth has been reported to increase with feeding rate in several fish species (Eroldogan et al., 2004; Yuan et al., 2010; De Riu et al., 2012; Okorie et al., 2013). Under a

condition of low feeding rate, fish tend to optimize their digestion to extract more nutrients more efficiently, thus decreasing the FCR (Puvanendran et al., 2003; Van Ham et al., 2003). In the study, only the FCR was significantly affected by feeding rate. Apparently, the experiment indicates that the rate of 2.0% body weight/day could be around satiation. As several authors have indicated optimum feeding rates in fish to be below satiation (Kim et al., 2007; Okorie et al., 2013), the rate of 3.0% body weight/day in 1,500–7,000 g pirarucu appear to be actually higher than values for this size range in this species. The mean FCR of pirarucu cultured increased with increasing feeding rate. FCRs of fish in the groups fed at 2% and 3% body weight/day were higher than the FCRs determined for other studies. Pereira-Filho et al. (2003), Crescencio et al. (2005) and Oliveira et al. (2012) reported FCR of 1.2 to 1.9 to pirarucu juveniles. However, similar observations have been reported for other fish cultured in cages. Mazzola et al. (2000) reported FCR of 3.5 to Mediterranean amberjack, *S. dumerili*, fed with pellets diet. The FCR of grouper, *Epinephelus coioides*, cultured in ponds and fed with pellets diet was 3.2 (Bombero-Tuburan et al., 2001).

3 Conclusions

This study has shown that pirarucu can be efficiently grown to market-size in cages and its growth is much faster than other fish species that have the advantage of decades of research and genetic improvement. The data obtained suggest that pirarucu fed at 2% body weight/day show better zootechnical indices. However, the optimal feeding rates have not been identified and further research is necessary using several culture phases (0.1~1 kg; 1~2 kg; 2~5 kg; 5~10 kg) and feeding rates various (1, 1.5, 2, 2.5 and 3.0% body weight/day).

4 Materials and Methods

Seven-months-old pirarucu juveniles (1550.0±85.6 g; 59.2±5.5 cm; mean±SD) were obtained from Aquaculture Research Center of National Department of Works Against Droughts (DNOCS; Pentecoste, Ceará, Brazil) and were transported to Pereira de Miranda Reservoir (Pentecoste, Ceará, Brazil). Pereira de Miranda Reservoir has a surface area of 5486 ha, a volume of 395,000,000 m³ and an average depth of 7.2 m with a maximum depth of 22 m. Open fishery

and tilapia aquaculture are the main uses of the reservoir.

Pirarucu were randomly selected, counted and stocked into 4 m³ cages, each measuring 2.0×2.0×1.0 m deep, at density of 10 fish/m³ with two replicate cages for each treatment. Prior to the start of the experiment, fish were fed the commercial diet to apparent satiation for a week to acclimate them to the experimental conditions. Cage frames were made of steel pipes covered with a 30-mm galvanized wire mesh coated with UV resistant PVC. Plastic bottles, attached along the four sides of each cage, were used as floats. Cages were installed at a distance of 70 m from the reservoir margin, where water depth ranged from 4.5 to 7 m according to water level. The distance between cages was 2 m and cages were docked with anchoring poles fixed inshore.

Pirarucu juveniles were reared for 210 days and fed four times a day with a commercial pelleted feed with 40% crude protein and 14.2 MJ/kg of feed (TC 40; Purina®, São Paulo, Brazil). Feed of 6.0–8.0 mm diameter was used for the first 168 days and 12–14 mm diameter from the 169th day until termination. Fish were fed at rates of 2.0% or 3.0% body weight/day until termination. The low number of treatments and replicates occurred due to low supply of fingerlings in Ceará State. This occurs due to the absence of specific studies on plankton or other available food sources for larvae feeding, resulting in low survival in larval and fingerling stages (Carreiro et al., 2011; Núñez et al., 2011; Oliveira et al., 2012). Fish were sampled every 21 days to evaluate growth in weight and total length. For this 100% of fish in each cage were captured, anesthetized with 100 mg/L of benzocaine, weighed and measured. After each sampling period the amount of feed given was adjusted to the mean weight and biomass in each cage.

Temperature and dissolved oxygen (DO) were monitored twice daily at 08:00 h and 17:00 h with an oximeter (YSI model 55). The pH and transparency were measured daily at 12:00 h with a digital pH meter and Secchi disc, respectively. Water samples were collected from inside of all the cages and from two different points in the reservoir at a distance of 20 m from the cages. Total ammoniacal nitrogen (TAN), ammonia, nitrite and nitrate were analyzed in

the water samples according to the APHA (1995).

Fish were harvested after 210 days and survival (%), final weight and length, absolute growth rate (AGR, g/fish/day), specific growth rate (SGR = \ln final weight – \ln initial weight / days × 100, %/day), production rate (kg/m³) and feed conversion ratio (FCR, weight of feed/gain in wet weight of fish) for each cage and treatment were calculated.

Differences among the treatment groups were analyzed using Student's *t*-test. A probability level of $p < 0.05$ was considered statistically significant. The values were expressed as the mean ± SD.

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