Revista Brasileira de Zootecnia
© 2012 Sociedade Brasileira de Zootecnia
ISSN 1806-9290
www.sbz.org.br

R. Bras. Zootec., v.41, n.6, p.1550-1554, 2012

Short Communication

Feeding level and frequency for freshwater angelfish

Felipe de Azevedo Silva Ribeiro[1], Leonardo Avendaño Vasquez[2], João Batista Kochenborger Fernandes[2], Nilva Kazue Sakomura[3]

[1] *Universidade Federal Rural do Semi-Árido.*
[2] *Centro de Aquicultura da Unesp.*
[3] *Faculdade de Ciências Agrárias e Veterinárias, Universidade Estadual Paulista.*

ABSTRACT - The objective of this study was to determine the optimal feeding level and feeding frequency for the culture of freshwater angelfish (*Pterophyllum scalare*). A randomized block design in a factorial scheme (3 × 2) with three feeding levels (30, 60 and 90 g/kg of body weight (BW)/day) and two feeding frequencies (1x and 2x/day) was set up in duplicate, representing 24 experimental units. Data were analyzed using two-way ANOVA and the Tukey test for comparison between means. After 84 days, results indicated that both factors influenced fish performance. No interaction between these factors was, however, observed. Increased feeding level and feeding frequency resulted in increased feed intake. The feed conversion ratio was negatively affected by feeding level, but not affected by feeding frequency. Final weights were higher when fish were fed twice daily, at levels of 60 or 90 g/kg BW/day. Specific growth rate was higher when fish received 60 or 90 g/kg BW/day, regardless of the feeding frequency. Survival was not affected by any treatment, with mean survival rates higher than 90%. It is recommended that juveniles be fed at a level of 60 g/kg BW/day with a minimum of two meals per day, to attain optimal survival, growth and feed efficiency.

Key Words: aquarium fish, feed conversion rate, feed intake, nutrition, ornamental fish, specific growth rate

Introduction

Exports of ornamental fish have increased at a rate of 8% per year for the past ten years and world exports reached over U$312 million in 2010 (FAO, 2011). Freshwater angelfish (*Pterophyllum scalare*), an Amazon Basin cichlid, is regarded as one of the most beautiful and marketable ornamental fish (Chapman et al., 1997).

Compared with food fish, growth and nutrition of ornamental species has received little attention (Degani, 1993) and feeding of ornamental fish is based on extrapolations of nutrient requirements from food fish (Sales & Janssens, 2003). Few studies on nutritional requirements and diet for *P. scalare* are available (Degani, 1993; Ribeiro et al., 2007; Rodrigues & Fernandes, 2006; Zuanon et al., 2006; Norouzitallab et al., 2009) and none relates to feeding levels or feeding frequency for *P. scalare*. Feed represents over 50% of costs in aquaculture operations, so applying optimal feeding strategies can optimize profit (Lovell, 2002).

Feeding frequency is one of the most important factors for adequate feeding management. Insufficient frequency leads to poor growth and high mortality, especially in intensive systems. Conversely, increasing the frequency requires more labor and increases production costs (Carneiro & Mikos, 2005). Some studies (e.g. Thomassen & Fjaera, 1996; Lee et al., 2000; Carneiro & Mikos, 2005; Biswas et al., 2006; Flood et al., 2011) have proposed that the benefits of optimizing feeding frequency are insignificant. Other studies have found feeding frequency to be positively correlated to growth performance; thus more feeding per day results in greater benefits (Wang et al., 1998; Dwyer et al., 2002)

Of all feeding practices, the feeding level is the most important variable influencing fish growth and feed conversion (Lovell, 2002). Feed unavailability leads to heterogeneity and mortality (Wang et al., 1998; Tesser & Sampaio, 2006) and overfeeding may lead to a negligible increase in growth rate (Tsevis et al., 1992; Thomassen & Fjaera, 1996) and a decrease in digestive efficiency (Fernandez et al., 1998), which has a detrimental effect on water quality (Johnston et al., 2003).

Obtaining optimum feeding frequency and level depends on factors that can also interact with each other, such as feed quality, developmental stage and culture system (Ruohonen et al., 1998; Lovell, 2002). The focus of the present study is to determine the optimal feeding levels and feeding frequency for juvenile freshwater angelfish.

Received July 4, 2011 and accepted March 13, 2012.
Corresponding author: felipe@ufersa.edu.br

Material and Methods

Juvenile freshwater angelfish were obtained from the Laboratory of Ornamental Fish (Sao Paulo State University - Aquaculture Center).They were acclimatized in a 500 L tank (at 27.0±0.1 ºC and pH 7.2±0.4) for one week prior to the start of the experiment, and fed a commercial diet containing 320 g of crude protein per kg. Fish were divided in two groups according to weight (0.7-1.2 g and 1.3-1.7 g) and randomly stocked (at a density of 15 fish per experimental unit) in 24 plastic tanks holding 60 L of water. Tanks were continuously aerated with an air stone, and cleaned prior to feeding sessions, to remove feces. After thirty minutes, each tank was siphoned, to remove residual feed, in order to calculate real feed intake. The siphoning of tanks did not affect fish feeding activity.

About 50% of the tank water was replaced daily and the most important water parameters (pH 7.9±0.7, pH meter YSI pH100; dissolved oxygen > 5.0 mg/L, DO meter YSI 55; and total ammonia < 0.3 mg/L, spectofotometry) were monitored every five days. In all treatments, the most important water parameters were within the normally range accepted and the water temperature was maintained at a level close to the thermal preference of this species (at 27.8±0.01 ºC; Pérez et al., 2003).

Nutritional and energy composition analyses for feed ingredients were performed, prior to diet formulation, according to methods of the AOAC (2000) (Table 1). The experimental diet was formulated using available ingredients by the Least Cost method (Microsoft Excel 2003). Nutritional requirements were based on available data on crude protein requirements of Freshwater Angelfish (Zuanon et al., 2006; Ribeiro et al., 2007; Zuanon et al., 2009) and digestible energy of Nile Tilapia (Pezzato et al., 2002; Boscolo et al., 2002).

The ingredients were hand-mixed with 400 g/kg of hot water, pelletized at low temperature in a meat grinder and then oven-dried (60 ºC, 72 hours). Pellets were broken and standardized to a 0.7 mm diameter.

A randomized block design with two weight levels, in a factorial arrangement (3 × 2) was set up using three feeding levels and two feeding frequencies. Each unit was replicated, thus corresponding to 24 experimental units. Fish feeding frequencies were once (at 1700) and twice (at 0900 and 1700) per day. Feeding levels, of 30, 60 and 90 g/kg of body weight per day (BW/day), were distributed according to feeding frequency. Fish fed two times received 50% in the first and 50% in the second meal. Amounts were adjusted every two weeks, after weighing all the fish in each experimental unit individually. Before weighing, fish were subjected to a 24-hour fasting and handled with care using a saline solution of 4 g NaCl/L to prevent stress.

After 84 days, growth performance parameters - including final weight (FW), total feed intake (FI), feed conversion rate (FCR), specific growth rate (SGR), and survival - were evaluated. These indicators were calculated as follows:

FI (g) = initial feed weight – final feed weight – residual feed

Residual feed was obtained siphoning the bottom of the fish tank 30 minutes after each meal. The residues were seined and frozen at -4 ºC. In the end of the experiment the frozen residuals were defrost and dried at 60 ºC for 72 hours to calculate the residual dry matter. All fish tanks were siphoned before each meal to reduce the contamination of residual feed by fish feces.

SGR (%/day) = [ln (final BW) – ln (initial BW)]/time × 100

FCR = FI/FW

Survival (%) = final number of fish /initial number of fish × 100

As data were normal and homocedastic, analyzed using two-way ANOVA ($\alpha = 0.05$) and new multiple range test of Tukey for comparison between means ($\alpha = 0.05$). Data expressed as percentages were transformed in arc sin ($x^{1/2}$) before analysis, but the original means are presented.

Table 1 - Chemical composition of ingredients and experimental diet

Ingredients	g/kg of diet	DM g/kg	CP g/kg	DE kcal/kg	CF g/kg	CL g/kg	MM g/kg	Ca g/kg	P g/kg	NFE g/kg
Corn	277.0	887.6	78.9	3,266.1	43.7	41.2	10.5	0.3	2.8	713.6
Wheat meal	65.0	885.0	134.8	3,033.7	95.7	41.1	45.2	0.4	3.7	568.2
Rice meal	52.0	897.4	121.0	3,991.6	90.5	121.3	99.8	0	0	464.8
Soybean meal	412.0	905.9	490.0	3,064.1	84.6	17.0	55.3	3.0	6.5	259.0
Fish meal	150.0	924.1	547.1	2,738.8	13.2	53.4	277.7	52.0	30.0	32.7
Soybean oil	34.0		0	8,485.0	0	100	0	0	0	0
Vitamin and mineral supplement[1]	10.0									
Experimental diet[2]	1000	861.9	320.7	3,271.18	59.8	69.4	75.4	7.9	5.5	263.6

DM - dry matter; CP - crud-e protein; DE - digestible energy; CF - crude fiber; CL - crude lipid; MM - mineral matter; NFE - nitrogen-free extract.

[1] Vitamin and mineral supplement (unit per kg): vit A: 500,000 UI; vit, D3 - 200,000 UI; vit, E - 5,000 UI; vit K3 - 1,000 mg; vit B1 - 1,500 mg; vit B2 - 1,500 mg; vit B6 - 1,500 mg; vit B12 - 4,000mg; vit C - 15,000 mg; folic acid - 500 mg; pantothenic acid - 4,000 mg; biotin - 50 mg; choline - 40 g; cobalt - 10 mg; copper - 500 mg; iron - 5,000 mg; iodine - 50 mg; manganese - 1,500 mg; selenium - 10 mg; zinc - 5,000 mg; excipient q.s. - 1,000 g. 200 mg of vit C/kg were added to the diet.

[2] Calculated composition.

Results and Discussion

Interaction between frequency and level was not significant between the parameter evaluated (Table 2). Growth performance of juvenile fish was significantly affected by both treatments. Increasing the feeding level and the feeding frequency both resulted in increased feed intake (P<0.05). Feed conversion ratio was negatively affected by feeding level (P<0.05), but not by feeding frequency. Final weights were higher when fish were fed at 60 or 90 g/kg BW/day and twice a day (P<0.05). Specific growth rate was higher when fish received 60 or 90 g/kg BW/day (P<0.05), regardless of frequency. Survival was not affected by any treatment and the mean survival rate was higher than 90%.

The results of this study indicated that both factors influenced the performance of freshwater angelfish juveniles. No interaction between these factors was, however, observed at the levels that were tested. This species can be fed at 30 g/kg BW/day without developing nutritional disease or health problems. Nevertheless, the lowest final weight and specific growth rate obtained in this treatment indicates that this low feeding level is not suitable for growing out, regardless of whether feeding takes place once or twice per day.

Feed intake results suggest that the angelfish can consume more than 9 g/kg BW/day. Growth rate results indicate, however, that they will probably not grow any faster than the fish fed 60 g/kg BW/day. Fish growth rate is usually positively related to feeding level (Zuanon et al., 2004), reaching a maximum at the point of maximum feed intake (Tesser & Sampaio, 2006). From that point on, a growth plateau is reached and diets in excess of the maximum may lead to a decreased digestive efficiency, which has a detrimental effect on water quality (Johnston et al., 2003). The optimum feeding level depended on several aspects, such as developmental phase, culture system, water quality and feed quality. Zuanon et al. (2004), who conducted tests on blue gourami (*Trichogaster trichopterus*) at the same feeding levels as those used in the present study, concluded that fish fed at 90 g/kg BW/day showed the best growth performance. Tesser & Sampaio (2006), who tested feed levels from 40 to 200 g/kg BW/day, concluded that the optimum feeding level for *Odontesthes argentinensis* juveniles is 90 g/kg BW/day. Khan & Abidi (2010) suggest 58-69 g/kg BW/day to *Heteropneustes fossilis* fingerlings.

It is well known that feed efficiency is higher - with no significant reduction of growth rates - in fish that are fed at levels below satiation. Shimeno et al. (1997) found that carp fed at levels of 18.5 g/kg BW/day obtained similar weight gain, attained better feed efficiency, and had less fat accumulation than carp fed at satiation rate (23 g/kg BW/day). Fernandez et al (1998) concluded that *Sparus aurata* had a better digestibility coefficient when fed at lower levels. Tesser & Sampaio (2006) obtained lower feed efficiency for pejerrrey *Odontesthes argentinensis* feeding at levels greater than 90 g/kg BW/day. Results from the present study concur with the above-mentioned findings, i.e., high consumption led to high FCR and lower feed efficiency. Only the FCR result obtained when fish were fed at 90 g/kg BW/day was very high when compared with that of other studies on the same species (Rodrigues & Fernandes, 2006; Zuanon et al., 2006; Ribeiro et al., 2007). This could be because the feeding level was not fixed and

Table 2 - P values, coefficient of variation (CV) and means ±SE for final weight (FW), survival (S), feed conversion ratio (FCR), specific growth rate (SGR) and feed intake (FI) of freshwater angelfish juveniles under three feeding levels and two feeding frequencies for 84 days

	FW (SL cm*), g	S, %	FCR	SGR, %/day	FI, g
P value					
Level	0.013	0.253 ns	<0.001	0.026	<0.001
Frequency	0.006	0.111	0.882 ns	0.062	0.004
Block	<0.001	0.001	0.882 ns	0.371 ns	<0.001
Rep(block)	0.124 ns	0.388 ns	0.787 ns	0.071 ns	0.366 ns
Level × frequency	0.803 ns	0.395 ns	0.327 ns	0.504 ns	0.760 ns
CV%	9.59	7.29	16.14	17.16	14.09
Means					
Level g/kg BW/day					
30	2.17±0.20 (3.6)B	96.43±2.17	1.63±0.07A	1.14±0.14B	4.71±0.54C
60	2.46±0.28 (3.8)A	95.83±2.48	2.63±0.27B	1.38±0.18A	8.89±1.06B
90	2.54±0.25 (3.8)A	97.98±2.20	3.90±0.31C	1.47±0.04A	12.97±1.31A
Frequency meal/day					
1	2.24±0.28 (3.6)B	95.80±2.38	2.71±0.53	1.24±0.13	7.98±1.96B
2	2.54±0.20 (3.8)A	97.70±2.07	2.73±0.54	1.42±0.15	9.73±1+98A

ns - not significant (P<0.05).
Values followed by different letters within each level and frequency in each column are significantly different (P<0.05, by the Tukey test).
*Standard length (SL) calculated with the formula SL = 0.489FW + 2.547

fish were kept under various experimental conditions in terms of diet formulation, stocking density and water quality.

One feed per day is sufficient for some fish species, such as *Cirrhinus mrigala* and *Labeo rohita* (Biswas et al., 2006), *Ramdhia quelen* (Carneiro & Mikos, 2005) or *Heteropneustes fossilis* (Khan & Abidi, 2010). Two or more meals are, however, usually recommended for omnivorous fish (Pannevis & Earle, 1994; Wang et al., 1998; Dwyer et al., 2002). In the present study, feeding fish two times per day resulted in better performance compared with that attained when feeding once a day. This is consistent with findings of Fujimoto et al. (2002) who suggested that freshwater angelfish are omnivorous-carnivorous. During the experimental period, hierarchic behavior and fighting for the feed was observed among fish. Even though the competition did not lead to any significant mortality, feed disputes demand energy and this can be pronounced in fish that are fed once per day, in comparison with those fed twice daily. Social dominance hierarchies affect feeding behavior of fish fed in groups and this probably affects the optimal number of feeding sessions per day (Jobling, 1983). According to Wang et al. (1998), higher feeding frequencies may increase opportunities for subordinate fish to feed because dominant fish may become satiated and less aggressive, resulting in a reduction of inter-individual size variation. Feeding frequencies higher than those used in this study could possibly result in better performance, as only two levels of this factor were tested.

Conclusions

Juvenile freshwater angelfish should be fed at least two times per day at levels of 60 g/kg BW/day to ensure good survival, growth and feeding efficiency.

Acknowledgements

The authors would like to thanks CAPES and CNPq for their fellowship grants, which enabled the study for Masters and Doctorate degrees.

References

ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTRY - AOAC. **Official methods of analysis**. 17.ed. Gaithersburg: AOAC International, 2000. 1025p.

BISWAS, G.; JENA, J.K.; SINGH, S.K. et al. Effect of feeding frequency on growth, survival and feed utilization in mrigal, *Cirrhinus mrigala*, and rohu, *Labeo rohita*, during nursery rearing. **Aquaculture**, v.254, p.211-218, 2006.

BOSCOLO, W.R.; HAYASHI, C.; MEURER, F. Apparent digestibility of the energy and nutrients of conventional and alternatives foods for Nile Tilapia (*Oreochromis niloticus*, L.). **Revista Brasileira de Zootecnia**, v.31, p.539-545, 2002.

CARNEIRO, P.C.F.; MIKOS, J.D. Feeding frequency and growth of silver catfish, *Rhamdia quelen*, fingerlings. **Ciência Rural**, v.35, p.187-191, 2005.

CHAPMAN, F.A.; FITZ-COY, S.; THUNBERG, J.T. et al. United States of America Trade in ornamental fish. **Journal of the World Aquaculture Society**, v.28, p.1-10, 1997.

DEGANI, G. Growth and body composition of juveniles of *Pterophyllum scalare* (Lichtenstein) (Pisces; Cichlidae) at different densities and diets. **Aquaculture and Fisheries Management**, v.24, p.725-730, 1993.

DWYER, K.S.; BROWN, J.A.; PARRISH, C. et al. Feeding frequency affects food consumption, feeding pattern and growth of juvenile Yellowtail flounder (*Limanda ferruginea*). **Aquaculture**, v.213, p.279-292, 2002.

FERNANDEZ, F.; MIQUELA, A.G.; GUINEAB, J. et al. Digestion and digestibility in Gilthead Sea bream (*Sparus aurata*) the effect of diet composition and ration size. **Aquaculture**, v.166, p.67-84, 1998.

FLOOD, M.J.; PURSER, J.; CARTER, C.G. The effects of changing feeding frequency simultaneously with seawater transfer in Atlantic salmon *Salmo salar* L. smolt. **Aquaculture International**, v.20, p.29-40, 2012.

FOOD AND AGRICULTURE ORGANIZATION OF UNITED NATIONS - FAO. **FISHSTAT Plu**s: universal software for fishery statistical time series. Fisheries Department, F.I., Data and Statistics Unit FAO, Rome, 2011.

FUJIMOTO, R.Y.; CRUZ, C.; FIGUEIREDO JÚNIOR, A.M. et al. Características histológicas do estômago e do intestino do acará-bandeira *Pterophyllum scalare*. In: SIMPÓSIO BRASILEIRO DE AQUICULTURA, 12., 2002, Goiânia. **Proceedings...** Goiânia: Associação Brasileira de Aquicultura, 2002. p.382.

JOBLING, M. Effect of feeding frequency on food intake and growth of Arctic charr, *SalÍelinus alpinus* L. **Journal of Fish Biology,** v.23, p.177-185, 1983.

JOHNSTON, G.; KAISER. H.; HECHT, T. et al. Effect of ration size and feeding frequency on growth size distribution and survival of juvenile Clownfish, *Amphiprion percula*. **Journal of Applied Ichthyology**, v.19, p.40-43, 2003.

KHAN, M.A.; ABIDI, S.F. Optimum ration level for better growth, conversion efficiencies and body composition of fingerling *Heteropneustes fossilis* (Bloch). **Aquaculture International**, v.18, p.175-188, 2010.

LEE, S.M.; HWANG, U.G.; CHO, S.H. Effects of feeding frequency and dietary moisture content on growth, body composition and gastric evacuation of juvenile Korean rockfish (*Sebastes shlegeli*). **Aquaculture**, v.187, p.3099-4009, 2000.

LOVELL, R.T. Diet and fish husbandry. In: HALVER, J.D.; HARDY, R.W. (Eds.) **Fish nutrition**. 3.ed. San Diego: Academic Press, 2002. p.704-755.

NOROUZITALLAB, P.; FARHANGI, M.; BABAPOUR, M. et al. Comparing the efficacy of dietary α-tocopherol with that of DL-α-tocopheryl acetate, both either alone or in combination with ascorbic acid, on growth and stress resistance of angelfish, *Pterophylum scalare*, juveniles. **Aquaculture International**, v.17, p.207-216, 2009.

PANNEVIS, M.C.; EARLE, K.E. Nutrition of ornamental fish: water soluble vitamin leaching and growth of *Paracheirodon innesi*. **Journal of Nutrition**, v.124, p.2633-2635, 1994.

PEZZATO, L.E.; MIRANDA, E.C.M.; BARROS, M.M. et al. Apparent digestibility of feedstuffs by Nile Tilapia (*Oreochromis niloticus*). **Revista Brasileira de Zootecnia**, v.31, p.1595-1604, 2002.

PÉREZ, E.; DIAZ, F.; ESPINA, S. Thermoregulatory behavior and critical thermal limits of Angelfish *Pterophyllum scalare* (Lichtenstein) (Pisces: Cichlidae). **Journal of Thermal Biology**, v.28, p.531-537, 2003.

RIBEIRO, F.A.S.; RODRIGUES, L.A.; FERNANDES, J.B.K. Desempenho de juvenis de acará-bandeira (*Pterophyllum scalare*) com diferentes níveis de proteína bruta na dieta. **Boletim do Instituto de Pesca**, v.33, p.195-203, 2007.

RODRIGUES, L.A.; FERNANDES, J.B.K. Influence of the feed processing on production performance of Angelfish (*Pterophyllum scalare*). **Acta Scientiarum Animal Science,** v.28, p.113-119, 2006.

RUOHONEN, K.; VIELMA, J.; GROVE, D.J. Effects of feeding frequency on growth and food utilization of Rainbow trout *Oncorhynchus mykiss* fed low-fat herring or dry pellets. **Aquaculture**, v.165, p.111-121, 1998.

SALES, J.; JANSSENS, G.P.J. Nutrient requirements of ornamental fish. **Aquatic Living Resources**, v.16, p.533-540, 2003.

SHIMENO, S.; SHIKATA, T.; HOSOKAWA, H. Metabolic response to feeding rates in Common carp, *Cyprinus carpio*. **Aquaculture**, v.151, p.371-377, 1997.

TESSER, M.B.; SAMPAIO, L.A. Rearing of pejerrey (*Odontesthes argentinensis*) juveniles at different feeding rates. **Ciência Rural**, v.36, p.1278-1282, 2006.

THOMASSEN, J.M.; FJAERA, S.O. Studies of feeding frequency for Atlantic salmon (*Salmo salar*). **Aquaculture Engineering**, v.15, p.149-157, 1996.

TSEVIS, N.; KLAOUDATOS, S.; CONIDES, A. Food conversion budget in Sea bass, *Dicentrarchus labrax*, fingerlings under two different feeding frequency patterns. **Aquaculture**, v.101, p.293-304, 1992.

WANG, N.; HAYWARD, R.S.; NOLTIE, D.B. Effect of feeding frequency on food consumption, growth, size variation, and feeding pattern of age-0 hybrid Sunfish. **Aquaculture**, v.165, p.261-267, 1998.

ZUANON, J.A.S.; SALARO, A.L.; MORAES, S.S.S. et al. Dietary protein and energy requirements of juvenile Freshwater Angelfish. **Revista Brasileira de Zootecnia**, v.38, p.989-993, 2009.

ZUANON, J.A.S.; SALARO, A.L.; BALBINO, E.M. et al. Dietary crude protein levels of freshwater angelfish fry. **Revista Brasileira de Zootecnia**, v.35, p.1893-1896, 2006.

ZUANON, J.A.S.; ASANO, M.; FERNANDES, J.B.K. Performance of Tricogaster (*Trichogaster trichopterus*) submitted to different feeding levels and stocking densities. **Revista Brasileira de Zootecnia**, v.33, p.1639-1645, 2004.