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Dietary protein and energy requirements of juvenile freshwater angelfish

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ABSTRACT - Dietary protein and energy requirements of juvenile freshwater angelfish (*Pterophyllum scalare*) were evaluated. A 3 × 2 factorial design was used, with three dietary crude protein levels being tested (26, 30, and 34% of CP) combined with two digestible energy levels (3,100 and 3,300 kcal DE/kg of diet) in three replicates. Juveniles averaging 2.33 ± 0.26 g were reared in a 25L-aquarium with controlled temperature (26 ± 1°C), biological filter and stocking density of six fish/aquarium. Fish were fed *ad libitum* at 09:00 a.m., 2:00 p.m. and 4:30 p.m. The following performance parameters were evaluated: final weight, final length, weight gain, feed intake, feed conversion ratio, specific growth rate, protein efficiency ratio and condition factor. Fish fed diets with 26% CP showed greater protein efficiency values when compared to those fed diets with 34% CP. Diets with 26% of CP and 3100 kcal DE/kg could meet the nutritional requirements of juvenile freshwater angelfish.

Key Words: growth, ornamental fish, productive performance, protein/energy ratio, *Pterophyllum scalare*

Exigências nutricionais de proteína e energia em juvenis de acará-bandeira

RESUMO - Avaliaram-se as exigências nutricionais de proteína e energia em juvenis de acará-bandeira (*Pterophyllum scalare*). Utilizou-se delineamento inteiramente casualizado, em esquema fatorial 3 × 2, com três níveis de proteína bruta (26, 30 e 34%), dois de energia digestível (3.100 e 3.300 kcal/kg de ração) e três repetições. Juvenis com peso médio de 2,33 ± 0,26 g foram distribuídos em aquários contendo 25 litros de água, temperatura controlada (26 ± 1°C) e filtro biológico, na densidade de estocagem de seis animais por aquário. Os peixes foram alimentados à vontade às 9, 14 e 16h30. Na análise do desempenho produtivo, foram avaliados o peso final, o comprimento final, o ganho de peso, o consumo de ração, a conversão alimentar, a taxa de crescimento específico, a taxa de eficiência protéica e o fator de condição. As dietas contendo 26% PB proporcionaram maiores valores para taxa de eficiência protéica apenas em relação às dietas contendo 34% PB. As exigências nutricionais de proteína e energia em juvenis de acará-bandeira podem ser atendidas com dietas contendo 26% PB e 3.100 kcal ED/kg.

Palavras-chave: crescimento, desempenho produtivo, peixes ornamentais, *Pterophyllum scalare*, relação proteína/energia

Introduction

Ornamental fish culture is a rapidly expanding segment of aquaculture and is one of the most profitable sectors of Brazilian fish culture (Lima et al., 2001). However, little attention is paid to ornamental species rearing in South America probably because the export trade is based on collection of fish from the wild (Conroy, 1975).

Freshwater angelfish (*Pterophyllum scalare*) is one of the most popular and accessible species from the *Cichlidae* family, mainly because of its beauty, various colors and fin shapes (Swann, 1999).

Knowing the nutritional requirements of different fish species is one of the first steps to create new technologies for fish production. Nevertheless, there are few data and studies on the nutritional requirements of ornamental fish species (Blom et al., 2000; Sales & Janssens, 2003), and they are not conclusive enough to formulate proper balanced diets (Boonyaratpalin & Lovell, 1977).

Proteins are the main organic constituent of fish tissues. Thus, these animals need to ingest protein to obtain amino acids to synthesize new proteins (growth) or replace existing ones (maintenance). The optimum protein levels in the diet for fish, as for other animals,

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are influenced by the dietary protein and energy balance, amino acid composition, protein digestibility and availability of non-protein energy sources (carbohydrates and lipids) in the diet (Wilson, 2002).

It has been demonstrated that a diet with energy deficiency or excess can reduce the fish growth rate. An energy-deficient diet would result in the use of protein as energy source for maintenance in detriment to animal growth. However, a diet with energy excess, compared to protein would lead to less food intake and consequently less protein and other nutrient ingestion, essential for maximum animal growth (NRC, 1993).

Thus, the aim in the present study was to assess the nutritional protein and energy requirements for juvenile freshwater angelfish.

Material and Methods

The present study was carried out in the Fish Nutrition Laboratory in the Pisciculture Sector of the Department of Animal Biology at the Federal University of Viçosa, Brazil.

A complete randomized design was used in a 3 × 2 factorial experiment, with diets containing three crude protein levels (26, 30 and 34%) and two digestible energy levels (3,100 and 3,300 kcal/kg of diet) in three replications. Diets (Table 1) were formulated based on the chemical composition of the feedstuffs (Rostagno et al., 2005) and nutrient digestibility for Nile tilapia (Miranda et al., 2000, Pezzato et al., 2002).

Juvenile freshwater angelfish (*P. scalare*) were stoked at six fish per aquarium (2.33 ± 0.26 g) into 25-L polyethylene aquaria, fitted with biological filter, aeration and controlled temperature (26 ± 1ºC). The aquaria were periodically siphoned for feces removal.

For diet preparation, ingredients were ground into fine powder, mixed by hand, moistened with water (50 ± 5ºC), pelleted and oven-dried for 24 hours at 55 ± 5ºC. After drying, diets were broken up and sieved to obtain proper pellet size (0.75 – 1.30 mm). Fish were fed *ad libitum* at 9:00 a.m., 2:00 p.m. and 4:30 p.m. for a period of 50 days.

At the end of the experiment, the following productive performance parameters were assessed: final weight (FW),

Table 1 - Feed ingredients and calculated proximate composition of the experimental diets

	Experimental diet					
Ingredient	26/3900	26/4100	30/3900	30/4100	34/3900	34/4100
Meat meal	13.80	13.80	13.80	13.80	13.80	13.80
Soybean meal	30.50	31.50	42.00	43.00	52.70	54.40
Wheat meal	20.00	20.00	16.00	15.00	16.00	11.00
Corn meal	34.17	29.18	26.99	23.40	16.35	16.24
Soybean oil	_	4.00	_	3.60	_	3.40
DL – Methionine	0.35	0.36	0.34	0.34	0.32	0.33
L-Lysine	0.35	0.33	0.04	0.03	-	-
Vitamin and mineral premix[1]	0.50	0.50	0.50	0.50	0.50	0.50
Salt (NaCl)	0.25	0.25	0.25	0.25	0.25	0.25
Vitamin C	0.06	0.06	0.06	0.06	0.06	0.06
BHT[2]	0.02	0.02	0.02	0.02	0.02	0.02
	Computed proximate composition					
Gross energy (kcal kg^{-1})	3910.82	4136.67	3925.26	4128.48	3941.69	4134.60
Digestible energy (kcal kg^{-1})[3]	3119.36	3328.53	3108.59	3298.52	3083.61	3268.15
Crude protein (%)	26.09	26.12	30.12	30.11	34.09	34.09
Digestible protein (%)[3]	22.74	22.77	26.42	26.42	30.06	30.07
CP/GE (mg protein $kcal^{-1}$)	66.73	63.09	76.64	72.91	86.52	82.54
Crude fiber (%)	4.44	4.40	4.62	4.52	5.04	4.69
Ether Extract (%)	3.91	7.71	3.68	7.10	3.46	6.68
Calcium (%)	2.11	2.11	2.14	2.14	2.17	2.17
Available phosphorus (%)[4]	0.96	0.96	0.95	0.95	0.96	0.94
Methionine (%)	0.60	0.60	0.60	0.60	0.60	0.61
Lysine (%)	1.43	1.43	1.43	1.43	1.63	1.65

[1] Vitamin and mineral premix (Supre Mais): guaranty levels of the product: Vitamins: A = 1,200,000 IU; D_3 = 200,000 IU; E = 12,000 mg; K_3 = 2,400 mg; B_1 = 4,800 mg; B_2 = 4,800 mg; B_6 = 4,000 mg; B_{12} = 4,800 mcg; Folic acid = 1,200 mg; Ca pantothenate = 12,000 mg; C = 48,000 mg; biotin = 48 mg; choline = 65,000 mg; niacin = 24,000 mg; Minerals: Fe = 10,000 mg; Cu = 600 mg; Mn = 4,000 mg; Zn = 6,000 mg; I = 20 mg Co = 2 mg and Se = 20 mg.
[2] Buthyl hydroxide toluene.
[3] Calculated values for Nile tilapia (Pezzato et al., 2002).
[4] Calculated values for Nile tilapia (Miranda et al., 2000).

final length (FL), weight gain (WG), feed intake (FI), feed conversion ratio (FCR), specific growth rate (SGR), protein efficiency ratio (PER) and condition factor (K). The productive performance parameters were compared among treatments by analysis of variance, and when the F test was significant, Tukey test at 5% probability was used.

Results and Discussion

No significant differences were observed for the productive performance parameters among protein and energy levels, except for the protein efficiency ratio (Table 2). Diets containing 26% CP showed similar values for PER compared to diets with 30% CP, and higher values when compared to diets containing 34% CP. Similar values for protein efficiency ratio were obtained by Ribeiro et al. (2007) for freshwater angelfish fry fed diets with 26, 28, 30 and 32% CP, but no differences were detected among diets. Chong et al. (2000) assessed protein requirements for discus (*Symphysodon* spp.) and obtained lower values than those detected in the present study for PER (0.57 to 1.02), using diets containing 35, 40, 45, 50 and 55% CP. Higher values for PER were observed here for freshwater angelfish, when compared to other species, which may indicate that this species can be fed diets with low protein levels.

The improve in efficiency protein utilization could be also associated with decreases in the amounts of nitrogen wasted by fish into the water (Ruohonen et al., 1999), which are especially important for ornamental fish, which are frequently raised in small tanks.

The weight gain values obtained in the present study were similar to the mean value (1.31 g) observed by Rodrigues & Fernandes (2006) for fry from the same species. Luna-Figueroa (2003) reported weight gains of 0.63, 0.68 and 0.78 g for freshwater angelfish fry fed commercial diets with 27, 43 and 45% CP, respectively. This variation in weight gain for the same species may be related to factors including quality of the protein used (amino acid composition and digestibility), feeding frequency, amount of diet supplied and the animal development stage.

The low values observed for the specific growth rate (SGR) of fish from the present study can be explained by the fish development phase, since the SGR decreases as fish increases in size (Sunde et al., 1998). Higher SGR values were reported by Luna-Figueroa (2003), Rodrigues & Fernandes (2006) and Zuanon et al. (2006) (4.34, 2.04 and 2.47%/day, respectively), for fish of the same species, but smaller sizes than the fish from the present study.

The feed conversion ratio was not affected by dietary protein and energy content in juvenile angelfish. Probably, the diet protein and energy levels had not intervened with feed intake regulation for this fish species, and consequently they had not affected the feed conversion ratio. Possibly, the variation range in the dietary energy content, in the tested diets was not enough

Table 2 - Performance of freshwater angelfish fed diets with three crude protein levels (26, 30 and 34%) and two digestible energy levels (3,100 and 3,300 kcal/kg) over 50 days[1]

Crude protein levels (%)	Digestible energy levels (kcal/kg)	FW[2] (g)	FL[3] (mm)	WG[4] (g)	FI[5] (g)	FCR[6]	SGR[7] (%/day)	PER[8]	K[9]
26	3,100	3.70	41.34	1.37	3.07	2.25	0.93	1.71	1.52
	3,300	3.73	42.06	1.64	3.08	2.24	0.93	2.06	1.57
30	3,100	3.86	41.82	1.53	3.21	2.14	1.02	1.58	1.56
	3,300	3.96	42.20	1.62	2.89	1.81	1.05	1.86	1.56
34	3,100	3.85	42.38	1.53	2.91	1.92	1.03	1.55	1.50
	3,300	3.79	41.64	1.45	2.82	1.98	0.96	1.51	1.54
CV (%)		10.90	3,69	15.05	8.08	14.76	19.20	11.57	3.22
Protein level effect		n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	0.05	n.s.
26		3.71	41.70	1.51	3.08	2.24	0.93	1.88a	1.55
30		3.91	42.01	1.57	3.05	1.98	1.04	1.72ab	1.56
34		3.82	42.01	1.49	2.86	1.95	1.00	1.53b	1.52
Energy level effect		n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
3100		3.76	41.74	1.51	3.12	2.21	0.99	1.61	1.55
3300		3.86	42.08	1.53	2.87	1.90	0.98	1.81	1.53
Effect of protein and energy levels interaction		n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

[1] Means in the same column followed by different letters are significantly different, [2] Final weight, [3] Final length, [4] Weight gain, [5] Feed intake, [6] Feed conversion ratio, [7] Specific growth rate, [8] Protein efficiency ratio, [9] Condition factor.

to influence the feed intake, as reported by Meyer and Fracalossi (2004) in *Rhamdia quelen* fingerlings.

In the present study, no protein sparring effect was observed by energy supplementation in the diets for juvenile freshwater angelfish. The absence of protein sparring effect might have occurred due to the small difference (200 kcal) in the energy levels among the experimental diets. Similar results were obtained by Arzel et al. (1998) for triploid brown trout fry (*Salmo trutta*), by Ali & Jauncey (2005) for African catfish (*Clarias gariepinus*) and by Peres and Oliva-Teles (1999) for juvenile European sea bass (*Dicentrarchus labrax*). However, several authors have reported the protein sparring effect in response of an increase in energetic content in the diet for several fish species (Shiau & Lan, 1996; McGoogan & Gatlin III, 2000; Ai et al., 2004; Meyer & Fracalossi, 2004; Kim & Lee, 2005).

The conflicting results on the protein sparring effect by energetic supplementation of diet reported in literature may be related to the protein and energy levels assessed (Mercer, 1982), digestibility and composition of the ingredients used (Ai et al., 2004), and fish species. The fish protein requirement determination has been influenced by the feed intake ratio of *Sciaenops ocellatus* (McGoogan and Gatlin III, 1998) and *S. truta* fry (Arzel et al., 1998), and can also affect the protein sparring effect.

Juvenile freshwater angelfish fed diet with 26% CP, 3100 kcal DE/kg with protein/energy ratio of 83.87 mg protein/kcal presented growth equivalent to those fed diets with higher protein and energy contents, with protein/energy ratios ranging from 72.91 to 86.52 mg of protein/kcal^{-1}. Ribeiro et al. (2007) using isoenergetic diets (3338.84 kcal DE/kg) containing 26, 28, 30 and 32% CP concluded that the requirements for freshwater angelfish fry could be met with diets containing 32% CP with 95.84 mg of protein/kcal^{-1}. The low protein requirement by juveniles obtained in present study, compared to that of the fry from the same species, might be supported by the fact that the protein requirement decreases with fish growth (Dabrowski, 1986).

Freshwater angelfish presents low protein requirement and efficient use of the diet protein, indicating that low-cost complete diets can be elaborated and used, thus decreasing the feeding costs with this fish species production.

Conclusions

Diets with 26% of crude protein and 3100 of digestible energy/kg can meet the nutritional protein and energy requirements for juvenile freshwater angelfish.

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