DOI: 10.5216/cab.v13i2.15421

DIET PROCESSING ON THE PERFORMANCE OF JUNDIA JUVENILES (*Rhamdia voulezi*) REARED IN NET CAGES

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ABSTRACT

The aim of this study was to evaluate the zootechnical performance and chemical composition of *Rhandia voulezi* juveniles fed with mash, pelleted and extruded diets and reared in cages. One hundred and fifty fish were distributed into 15 net cages (0.20 m³), arranged in 5m³ net cages, in the hydroelectric plant of Governador José Richa, in Iguaçu River (Paraná-Brazil). The fish were fed five times a day, with mash, pelleted and extruded diets, containing 30% of protein and 3,250 Kcal/kg of digestible energy/kg. At the end of 60 days, significant differences ($p<0.05$) were observed on fish performance. The fish that were fed with pelleted diet presented higher average of final weight (44.08g), final length (16.51cm) and weight gain (36.65g). The different processes did not influence fish survival. The averages of protein and mineral matter of carcass chemical composition did not differ statistically ($p<0.05$), while the values of humidity and lipids presented differences among treatments. The highest average of lipids (8.59%) was observed in pelleted diet. The mash diet provided fish with lower lipids (5.45%) and higher humidity (75.98%) rates. A pelleted diet is more suitable for juvenile catfish *R. voulezi* reared in cages.

KEYWORDS: Aquaculture; feeding; native species.

PROCESSAMENTO DA RAÇÃO NO DESEMPENHO DE JUVENIS DE JUNDIÁ (*Rhamdia voulezi*) CULTIVADOS EM TANQUES-REDE

RESUMO

O objetivo deste trabalho foi avaliar o desempenho zootécnico e composição centesimal de juvenis de jundiás *Rhamdia voulezi* alimentados com dietas farelada, peletizada e extrusada, cultivados em tanques-rede. Foram utilizados 150 peixes distribuídos em 15 tanques-rede (0,20m³), dispostos em tanques-rede de 5m³, no reservatório da usina hidrelétrica Governador José Richa, no rio Iguaçu (Paraná-Brasil). Os peixes foram alimentados cinco vezes por dia, com dietas fareladas, peletizadas e extrusadas, contendo 30% de proteína bruta e 3250 Kcal/kg de energia digestível/kg. Ao final de 60 dias, observaram-se diferenças significativas ($p<0,05$) no desempenho dos peixes. Os animais alimentados com a dieta peletizada, apresentaram maiores médias de peso final (44,08g), comprimento final (16,51cm) e ganho de peso (36,65g). Os diferentes processamentos não influenciaram na sobrevivência dos peixes. Em relação à composição centesimal da carcaça, as médias de proteína bruta e matéria mineral não diferiram estatisticamente ($p>0,05$), enquanto os valores de umidade e lipídeos apresentaram diferenças entre os tratamentos. A maior média de lipídeos (8,59%) foi observada nos peixes alimentados com a dieta peletizada. A dieta farelada proporcionou peixes com menor teor de lipídeos (5,45%) e maior umidade (75,98%). A dieta peletizada é mais indicada para juvenis de jundiá *R. voulezi* no cultivo em tanques-rede.

PALAVRAS-CHAVE: Alimentação; aquicultura; espécie nativa.

INTRODUCTION

Rhamdia voulezi fish is an endemic species of the Iguaçu basin which belongs to the class of *Osteichtyes*, order of *Siluriformes*, and *Heptapteridae* family (BOOCKMANN & GUAZZELLI, 2003). Catfish is the common name given to the fish of the genus *Rhamdia* (BALDISEROTTO & RADÜNZ-NETO, 2005). It is a native fish of the southern region, characterized by omnivorous feeding habits and easy reproduction, besides the good taste of their flesh and acceptability by consumers (GOMES et al., 2000).

Fish rearing in net cages enables the production in large reservoirs and in places where the implementation of conventional systems is difficult (PEDRON et al., 2008). This rearing technology has proved to be a promising because it associates sustainable use of the environment with good productivity.

Among various factors related with fish rearing, food is responsible for most part of the production cost in intensive aquaculture. A study assessing the economic performance of tilapia rearing under intensive production system showed that the feed was the item with the largest share in production costs, 41.07% of the total (CRIVELENTI et al., 2006), whereas the monoculture of common carp *(Cyprinus carpio)* generates a ratio of 38% (GRAEFF, 2004). In this context, diet processing is important as it aims to facilitate the feed intake by the fish, increasing feed efficiency and reducing losses to the aquatic system (RODRIGUES & FERNANDES, 2006), besides improving the nutritional value, the acceptance and the stability of the feed in water.

Mash, pelleted and extruded diets usually prevail in the preparation of diets in aquaculture (BOOTH et al., 2000). Diets that are exposed to the action of water for some time, before being consumed by the fish, lose valuable nutrients from the dilution of the mixture and the leaching of nutrients, which implies the need to process the ingredients mixture (RODRIGUES & FERNANDES, 2006). According to these authors, mash diet is a homogeneous mixture of finely ground ingredients with little stability in water, which undergoes leaching of nutrients. The disadvantages of mash diets are the greater losses of minerals and vitamins due to its instability in water and the allowance of selecting more palatable ingredients by the fish, resulting in less weight gain (CECCARELLI et al., 2000).

Pelleted diet undergoes an ingredient agglutination process by mechanical compression, reducing leaching losses because the pellet, which has high density, sinks in water. Pelleted diets offer advantages in transportation, storage and handling, and increase feed efficiency (FURUYA et al., 1998).

Diet extrusion involves high pressure (30 to 60 atm), humidity and temperatures between 130 and 150ºC, causing expansion of the ingredients mixture and starch gelatinization (VIEIRA et al., 2005), besides producing low density pellets that float in the water. The extrusion process causes physical and chemical changes in food, resulting in improved digestibility of the protein fraction of starch (FURUYA et al., 1998).

Feeding management is very important to the success of aquaculture activity, because it influences animal´s performance at any stage of growth, since it is directly related to feeding supply and use by the fish (HAYASHI et al., 2004). Therefore, the choice of the ration processing suitable for each species is crucial to the success of dietary management and efficiency of diet use by fish.

The development of technologies for feeding native species that have rearing potential is essential to the growth of Brazilian aquaculture. Thus, the objective of this study was to evaluate animal performance and the centesimal composition of *R. voulezi* juveniles fed mash, pelleted and extruded diets in net cages.

MATERIAL AND METHODS

We conducted the 60-day study, from February to April 2008, in experimental net cages in the reservoir of the hydroelectric power station Governor José Richa, on the Iguaçu River, Boa Vista da Aparecida – State of Paraná. We used a total of 150 *R. voulezi* juveniles with initial average weight of 7.18 ± 2.14g and initial total length of 9.05 ± 0.85 cm. These experimental facilities had 15 experimental cages, measured 0.20 m^3/ each and were made of shade nets. We placed three experimental units in five larger cages, measuring 5 m^3 / each and made of galvanized wire coated with polyethylene, forming, thus, the experimental blocks in a completely randomized design. The experimental unit was composed of a nursery with 10 fish.

Treatments consisted of feeding with mash, pelleted and extruded diet, totaling three treatments with five replicates each. Basal diet was formulated (Table 1) containing 30% crude protein and 3,250 Kcal/kg of digestible energy/kg, and being

isocalcium and isoenergetic, according to REIDEL et al. (2010).

The ingredients were ground in a hammer-type crusher with a 0.7 mm sieve. After grinding, the ingredients were weighed and mixed, and the vitamin and mineral supplement was added. This feed was considered as the mash diet. The pelletisation was carried out in a meat grinder, where the mash diet was moistened with 30% water at 60°C. The extrusion was carried out in EX-MICRO® equipment with production capacity of 10kg h^{-1}. After pelletisation and extrusion, diets were dried in a forced air oven for 12 hours at 55°C, resulting in a product with about 10% moisture.

Feeding was performed five times a day at 8:00 and 10:30 a.m., and at 1:00, 3:30 and 6:00 p.m., until apparent satiation. We weighed the ration to calculate feed intake (g) and measured the temperature daily and the physicochemical parameters of water such as pH, dissolved oxygen, electrical conductivity weekly.

TABLE 1 - Percentage (% fresh matter) and nutritional composition of the experimental diets for *R. voulezi* juveniles

Ingredients	%	Nutrientes	
Rice grits	30.07	Starch (%)	28.62
Antioxidant (BHT)	0.02	Calcium (%)	1.20
Limestone	0.35	Digestible energy (kcal / kg)	3250.00
Dicalcium	1.30	Fiber (%)	3.56
Soybean meal	34.53	Total Phosphorus (%)	1.00
Wheat bran	11.94	Fat (%)	3.99
Poultry offal meal	15.00	Histidine (%)	0.69
Corn	5.00	Isoleucine (%)	1.28
Soybean oil	1.00	Leucine (%)	2.29
Mineral and vitamin[a]	0.50	Linoleic Acid (%)	1.43
Salt	0.30	Lysine (%)	1.62
Total	100.00	Phenylalanine (%)	1.40
		Methionine + Cystine (%)	1.02
		Methionine (%)	0.49
		Crude protein (%)	30.00
		Threonine (%)	1.14
		Tryptophan (%)	0.37
		Valine (%)	1.45

[1] Warranty levels per kilogram of product (Nutron Alimentos): vit. A – 100,000UI; vit. D3 – 500,000UI; vit. E – 20,000UI; vit. K3 - 500mg; vit. B1 – 1,250mg; vit. B2 – 2,500mg; vit. B6 – 2,485mg; vit. B12 – 3,750mg; folic acid - 250mg; pantothenic acid – 5.000mg; vit. C – 28.000mg; biotin – 125mg; Co – 25mg; Cu – 2.000mg; Fe – 13,820mg; I – 100mg; Mn – 3,750mg; Se – 75mg; Zn – 17,500mg; antioxidant – 0.60g; niacin – 5,000mg.

At the end of the experimental period, fish were submitted to fasting for 24 hours. Then the animals were anesthetized in water and ice, and taken to the Fish Technology Laboratory of Unioeste - *Campus* Toledo-PR, and individual measurements of weight (g) and length (cm) were taken, to calculate weight gain (g), feed conversion, feed efficiency and survival (%) of fish per unit. The fish were frozen for subsequent chemical analyzes of moisture, crude protein, mineral matter and lipids, according to the methodology proposed by AOAC (2000).

We submitted the data to analysis of variance at 5% probability ($p < 0.05$) and in case of difference, we applied Tukey test through SAEG statistical program (Statistical Analysis System and Genetics) (UFV, 1997).

RESULTS AND DISCUSSION

There were no significant differences ($p > 0.05$) among treatments regarding the averages of the physicochemical parameters of water in the net cages of this experiment (Table 2).

The low dissolved oxygen (3.73 ± 0.37 mg O_2D L^{-1}) observed may be explained by the type of experimental net cages, made of shade net, which possibly reduces the passage of water through clogging. For *R. quelen* fingerlings submitted to different dissolved oxygen concentrations (1.3; 2.4; 3.7; 5.4 and 7.5 mg O_2D L^{-1}), the increase of dissolved oxygen concentration in water provided greater growth in weight and length (MAFFEZZOLLI & NUÑER, 2006). In the present experiment, although no statistical difference ($p > 0.05$) among treatments for this parameter was found, the value of 5.4 mg O_2D L^{-1} is recommended for better growth of *R. voulezi* (MAFFEZZOLLI & NUÑER, 2006).

Table 2 - Physicochemical parameters of water in the experimental nursery

	Processing of the diet			
Parameters	Mash	Pelleted	Extruded	CV%
Dissolved Oxygen (mg O_2D L^{-1})	3.52±0.33	3.69±0.55	3.98±0.23	2.04 ^{ns}
pH	6.85±0.06	6.86±0.04	6.91±0.03	1.93 ^{ns}
Electric conductivity (µS cm^{-1})	48.26±0.32	45.45±4.14	47.91±0.32	6.08 ^{ns}

^{ns} no significant differences by Tukey test ($p > 0.05$)

The pH close to 7.0, obtained in this experiment, is within the recommended range for *R. voulezi* juveniles, which is 4.0 to 9.0 in soft water, according to BALDISSEROTTO & RADÜNZ-NETO (2005).

Water temperature ranged between 25 and 27.9°C. PIEDRAS et al. (2004) evaluated the growth of *R. quelen* juveniles (mean weight 24.6 g) in different water temperatures (20, 23 and 26°C) and found that the species had higher weight gain (41.4 g) at a temperature of 23.7°C. The temperature rise may increase the growth of *R. voulezi*, but it also increases the metabolism, which leads to higher energy expenditure to maintain their functional activities and may lead to higher feed conversion (BALDISSEROTO & RADÜNZ-NETO, 2005). The water temperature in this experiment remained around 26°C, higher than the recommendation by PIEDRAS et al. (2004). This fact may have influenced the weight gain of fish, which could have been larger if the temperature was lower. This shows the rearing potential of this species in cooler regions. Moreover, temperature of 26°C may have influenced feed conversion (Table 3), which presented values between 4.24 and 7.26, higher than the ideal. For *R. voulezi* juveniles, reared in 1000L polyurethane boxes at a temperature of 26°C, PIEDRAS et al. (2004) obtained feed conversion of 1.92. In an experiment assessing levels of energy and protein in the diet for *R. quelen* juveniles (initial weight of 47.39 g), feed conversion was 2.48 for fish fed diet containing 30% CP and 3250 kcal / kg of digestible energy at the mean temperature of 23.6 ºC (REIDEL, 2007).

Although the diets had the same formulation, there was significant ($p < 0.05$) effect of the processing on the final weight, weight gain and total length (Table 3). Final weight of fish fed pelleted diet was 70.44% and 59.35% higher than that of fish fed mash and extruded diet, respectively, because *R. voulezi* lives in deeper regions in the water column. *R. voulezi* lives in lakes and deep wells of rivers, preferring calmer environments (GOMES et al., 2000); therefore, the pelleted diet, due to its high density, sinks in water and may be more available for the fish. In experiments with *R. quelen* larvae and fingerlings in captivity, there was a marked

aversion to light and search for dark places (PIAIA et al., 1999).

Table 3 - Mean values of performance of *R. voulezi* grown in net cages, fed mash, pelleted and extruded diets

	Processing of the diet			
Parameters *	Mash	Pelleted	Extruded	CV %
Initial weight (g)	7.69±0.26	7.43±0.18	7.68±0.17	4.62^{ns}
Final weight (g)	26.16±0.84b	44.08±8.37a	31.05±2.68b	15.10*
Weight gain (g)	18.47±0.49b	36.65±8.32a	23.37±2.47b	19.17*
Total length (cm)	13.64±0.19b	16.51±0.99a	14.28±0.25b	4.06*
Feed intake (g)	134.31±7.83b	149.94±7.29a	98.34±5.73c	5.50*
Feed	7.27±0.30a	4.09±0.84b	4.21±0.43b	10.89*
Feed efficiency	0.14±0.01b	0.24±0.06a	0.24±0.03a	17.38*
Survival (%)	96±5.48	98±4.47	96±5.48	5.34^{ns}

* Means in the same line followed by different letters differ by Tukey test ($p < 0.05$). ns = non-significant

The worst averages (final weight, weight gain, total length, feed conversion, feed efficiency) were obtained with fish fed mash diet (Table 3), confirming the conclusions of DUPREE (1985), because mash diets provide high nutrient losses to the environment and worsen the performance of the fish, which can select more palatable ingredients.

Assessing the influence of feeding frequency on the performance of *R. quelen* juveniles (initial weight 7.47 g) fed extruded diets for 120 days, CANTON et al. (2007) observed maximum gain for the fish fed four times a day (41.10 g). In this experiment, at 60 days, the *R. voulezi* fed pelleted diet had weight gain of 36.65 g, higher ($p < 0.05$) than the weight gain of fish treated with extruded diet (23.37 g). The comparison of the weight gain of the fish treated with extruded ration in the experiment carried out by CANTON et al. (2007) with the fish in this experiment demonstrates the potential of pelleted diets in growing *R. voulezi*.

During sex reversion of Nile tilapia, mash diet promotes better final biomass compared with larvae fed paste or micro-pelleted diet (MEURER et al., 2003). However, it is noteworthy that the fish were in the larval stage, time when the mash diet is recommended. In this current research, the fish were juveniles and diet processing facilitates food ingestion.

Feed intake differed ($p < 0.05$) among types of diet, with the lowest mean value for extruded diet. As *R. voulezi* characteristically inhabit the bottom of lakes and rivers (GOMES et al., 2000), rarely going to the surface, the consumption was much lower compared to pelleted diet. Although the mash diet presented similar intake to the pelleted diet, it did not reflect on better final weight, because of the particle sizes of diet (RODRIGUES & FERNANDES, 2006).

The high feed conversion observed for the treatment with mash diet (7.27) is explained by the fact that the mash diet has little stability in the water, suffering high losses by leaching and solubilization of nutrients due to the degradation of food particles (TOYAMA et al., 2000). In Nile tilapia juveniles, mash diets feeding also increases feed conversion, as verified by SIGNOR et al. (2011).

Weight gain of Nile tilapia juveniles fed extruded diets was 50% higher than of those fed pelleted diet (KLEEMANN, 2006). This author reports that this was due to greater exposure of nutrients within the vegetable cells to the digestive action, thus improving feed efficiency of fish. However, for *R. voulezi* juveniles, this was not observed, since feed efficiency did not differ between extrusion and pelletisation processes, showing worst average (0.14) for the mash diets. This result can be explained by the different habitats of two species, tilapia is a half-water and surface fish, thus extruded diet is more available.

Fish survival did not differ ($p > 0.05$) among treatments, showing that the type of processing interferes with the performance, but not on survival. FURUYA et al. (1998) performed experiments with pelleted and extruded diets for

reversed males of Nile tilapia (188.9 to 362.4 g) and verified 100% survival for both treatments, demonstrating that survival was not influenced by different diets, and any diet caused mortality. For *R. quelen* juveniles (initial weight 7.47 g), CANTON et al. (2007) observed 86.90% survival of fish fed extruded feed three times a day.

Regarding the composition of fish carcass, moisture and lipid parameters differed significantly ($p < 0.05$), showing higher lipid content (8.59%) for fish fed pelleted diet (Table 4). For *R. quelen* carcass, the following values were observed: from 12.38 to 15.09% for crude protein, 2.76 to 10.39% for lipids, 2.13 to 2.24% for mineral matter and 70.1 to 73.16% for humidity (MELO et al., 2003). Such results are similar to the ones found in this study.

Table 4 - Centesimal composition of the carcass of *R. voulezi* juveniles grown in cages, fed mash, pelleted and extruded diets

	Processing of the diet			
Parameters (%)	Mash	Pelleted	Extruded	CV %
Humidity	75.98±0.58a	71.83±1.62b	72.99±1.26b	1.67*
Crude protein	14.36±0.87	15.52±0.85	14.67±0.73	5.53^{ns}
Lipids	5.45±0.43b	8.59±1.25a	8.10±1.07a	13.14*
Mineral Matter	3.33±0.80	3.60±0.81	3.57±1.01	25.00^{ns}

* Means in the same line followed by different letters differ by Tukey test ($p < 0.05$). ns = non-significant.

The greater fat deposition in the carcass of fish fed pelleted and extruded diets possibly occurred because these diets provide more digestible carbohydrates, and the surplus was transformed into fatty acids and deposited as fat in the carcass. The same observation was made for Nile tilapia fed mash, pelleted and extruded diets (SIGNOR et al., 2011). Although lipids are essential for the metabolism of fish (FUJIMOTO et al., 2007), the excess of fat in the carcass is an undesirable characteristic, which should be maintained at a level that does not affect the organoleptic characteristics of meat and assist in maintaining their quality during freezing (MEURER et al., 2002). ROCHA et al. (2007) evaluated the supplementation of microbial phytase to the diet of *R. quelen* fingerlings (final weight from 15.62 to 16.63 g) and observed lipid values ranging from 10.59 to 13.54%, much higher than the values found in this experiment.

A study by KUBOTA & EMANUELLI (2004) showed that the protein content for juvenile catfish (body weight about 50g) ranged from 12.5 to 14.5%. However, the meat of the fish with 200 to 450g of body weight had higher protein content, around 17%, close to the content of muscle protein around 18%, found in other adult catfish.

The ash contents observed for freshwater fish are between 0.90 and 3.39% (CONTRERAS-GUZMÁN, 1994). These values are similar to those found in this study, 3.33 to 3.60%. However, REIDEL et al. (2010) verified ash values ranging from 1.9 to 2.5% for *R. quelen* juveniles with final weight from 334.0 to 482.5g when fed diets containing different levels of crude protein and digestible energy.

Pelleted diet promoted better performance in weight gain, being 18.18 g and 13.28 g higher than mash and extruded diets, respectively, and greater overall length (16.51 cm) for *R. voulezi* juveniles. Diet processing did not affect fish survival, but it influenced productive performance. Mash diet provided 36.55% less lipid content in fish carcass and 5.46% more humidity than pelleted diet.

CONCLUSION

Pelleted diet is the best for *R. voulezi* juveniles grown in net cages.

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Submitted on August 22, 2011. Accepted on May 04, 2012.