PERFORMANCE OF HYBRID CATFISH SUBJECTED TO DIFFERENT PROTEIN LEVELS

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ABSTRACT

In this study, we investigated the performance of hybrid catfish (*Pseudoplatystoma reticulatum* x *Leiarius marmoratus*) fed with feeds containing 32% or 40% crude protein (CP). We analyzed the performance, yield in whole gutted fish, fillet yield and visceral fat index. The experimental units comprised 108 fish with average initial weights of 272.12 ± 74.71 g (32% CP) and 231.97 ± 87.70 g (40% CP). The experimental period was 182 days. Final weight, body height, body width, yield of whole gutted fish and visceral fat content differed (P<0.05) between treatments, with respective values of 1,016.63 g, 7.17 cm, 6.88 cm, 86.06% and 3.28% for the lower protein level; and 1,152.22 g, 7.67 cm, 7.27 cm, 84.44% and 4.81% for the higher protein level. The treatment with 40% CP promotes better performance of hybrid catfish. However, this treatment reduces the yield of whole gutted fish and increases the visceral fat index.

Keywords: fish feeding; *Leiarius marmoratus*; *Pseudoplatystoma reticulatum*

DESEMPENHO DO PINTADO HÍBRIDO SUBMETIDO A DIFERENTES NÍVEIS DE PROTEÍNA

RESUMO

Este estudo teve como objetivo avaliar o desempenho do pintado híbrido (*Pseudoplatystoma reticulatum* x *Leiarius marmoratus*) submetido à alimentação com 32% ou 40% de proteína bruta (PB) na ração, analisando-se o desempenho, rendimento do peixe inteiro eviscerado, rendimento do filé e o índice gordura visceral. Foram estocados 108 peixes nas unidades experimentais, com peso inicial médio de 272,12 ± 74,71 g (32% de PB) e 231,97 ± 87,70 g (40% de PB). O período experimental foi de 182 dias. O peso final, altura do corpo, largura do corpo, rendimento em peixe inteiro eviscerado e índice de gordura visceral diferiram (P<0,05) entre os tratamentos, apresentando valores de 1.016,63 g, 7,17 cm, 6,88 cm, 86,06% e 3,28% para o menor nível de proteína, e 1.152,22 g, 7,67 cm, 7,27 cm, 84,44% e 4,81% para o maior nível de proteína, respectivamente. O tratamento com 40% PB proporciona maior desempenho para o pintado híbrido. Todavia, este tratamento diminui o rendimento do peixe inteiro eviscerado e aumenta o acúmulo de gordura visceral.

Palavras-chave: alimentação de peixes; *Leiarius marmoratus*; *Pseudoplatystoma reticulatum*

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INTRODUCTION

The genus *Pseudoplatystoma* has three known species, namely *Pseudoplatystoma fasciatum* (Essequibo and Suriname Rivers), *P. tigrinum* (Amazon River) and *P. corruscans* (Paraná and São Francisco Rivers), and five species have been recently described, namely *P. punctifer* (Amazon River), *P. orinocoense* (Orinoco River), *P. reticulatum* (Central Amazon and Paraná Rivers), *P. metaense* (Orinoco River) and *P. magdaleniatum* (Magdalena River) (BUITRAGO–SUÁREZ and BURR, 2007). Although species of the genus *Pseudoplatystoma* show great potential for fish farming, the rearing of purebred species is extremely restricted to some regions, and factors such as high cannibalism rate in the initial stage and carnivorous feeding habits hinder the rearing of these fish, which leads to interest in hybridization (MATEO *et al.*, 2008).

In the list of classical methods of crossbreeding, interspecific hybridization is one of the most widely used in fish farming and, for many years, the main catfish reared in Brazil was the cachapinta (female of *P. reticulatum* x male *P. corruscans*) (LOPERA-BARRERO *et al.*, 2011). To reduce production costs and increase productivity, many fish farmers have used hybrid species obtained from cross-species of the genus *Pseudoplatystoma* with other Siluriformes with omnivorous feeding habit (CAMPOS, 2010). Among these, the species *Leiarius marmoratus* stands out for having an omnivorous feeding habit and being one of the largest fish in the South American drainage basins (FORTES-SILVA *et al.*, 2016). It is a South American catfish that inhabits the basins of the Amazon, Essequibo and Orinoco rivers (LOPERA-BARRERO *et al.*, 2011).

The use of hybrids of carnivorous species of high commercial value, such as *P. reticulatum*, with omnivorous species, such as *L. marmoratus*, can minimize cannibalism problems (MATEO *et al.*, 2008). This hybrid is commonly known as the hybrid catfish. The increase in production of this hybrid compared with other catfish is attributed to the easiness of food training and omnivorous feeding habit (LOPERA-BARRERO *et al.*, 2011). Therefore, this hybrid has been increasingly produced on a commercial scale in fish farms, mainly in the central-western region of Brazil. The farming of sorubim (pure species of the genus *Pseudoplatystoma* and their hybrids) has considerably increased after the use of the hybrid originating from the cross between *Pseudoplatystoma* spp. and *L. marmoratus*. Its production rose from 2,486.5 t in the year 2010 (BRASIL, 2012) to 8,824.3 t in 2011 (BRASIL, 2013) and 18,354.6 t in 2015, which made this the fifth most largely produced fish in Brazil (IBGE, 2016).

Establishing the protein requirements is essential in the formulation of adequate diets to improve fish performance (HONORATO *et al.*, 2014) and to reduce nitrogen excretion, one of the most polluting nutrients in the aquatic medium (BOTARO *et al.*, 2007). In this regard, it is very important to determine the right concentration of protein for the production of hybrid catfish.

Currently, there is little scientific information about the nutritional aspect of the hybrid catfish. Only a few studies exist evaluating protein levels in the initial production stage (fish with 20 to 400 g), adopting protein levels of 20.8 to 39.5% (SOUZA *et al.*, 2014), 42.0% (PRIETO-GUEVARA *et al.*, 2015), 42.9 to 43.3% (BERNARDES *et al.*, 2016) and 45% (FARIA *et al.*, 2011), and in the final production stage (fish with 900 to 1,287 g) the level of 40% (FARIA *et al.*, 2011). There is also a large divergence about the protein level required for this fish. It is known that inadequate protein levels in fish feeding can influence performance, carcass yield and accumulation of visceral fat. For that reasons this study evaluated the performance, yield of whole gutted fish, fillet yield and visceral fat index of hybrid catfish (*P. reticulatum* x *L. marmoratus*) consuming feed containing 32% and 40% crude protein.

MATERIAL AND METHODS

The experiment was carried out at the Experimental Station of Fish Farming at the Federal University of Mato Grosso (UFMT), located in the municipality of Santo Antônio do Leverger, Mato Grosso State, 34 km from the capital city Cuiabá – MT, Brazil. The experiment was conducted with the approval by the Ethics Committee on Animal Use (CEUA) of UFMT (Case No. 23108.009009/14-8).

The experimental design used was completely randomized, with the protein level as the

analyzed factor and the levels 32% and 40% of crude protein (CP) as treatments, which were conducted in three replicates. The fingerlings of hybrid catfish (female *P. reticulatum* x male *L. marmoratus*) used in the experiment were reared in January 2015, according to the breeding protocol recommended by ZANIBONI-FILHO and WEINGARTNER (2007). These fish were stocked in six experimental units of 133 m^2 (1.0-m-deep ponds) with a water renewal rate of 5.0% per day. In each experimental unit, 18 fish were distributed randomly, estimated density to obtain a final biomass of 0.1 to 0.5 kg m^{-2} - adequate for production under low water renewal, totaling 108 fish.

Prior to the experiment, the fish were subjected to an acclimatization period of 15 days, allocated in the experimental units and receiving a similar management. Afterwards, the fish allocated in the experimental units were fed twice daily (9:00 h and 16:00 h) with commercial extruded feed (VB Alimentos) containing (according to the manufacturer) 32% crude protein (4,099.0 kcal kg^{-1} gross energy, 6.0% ether extract, 3.0% crude fiber, 10% mineral matter, 90% dry matter) or 40% crude protein (4,317.5 kcal kg^{-1} gross energy, 7.0% ether extract, 3.0% crude fiber, 10% mineral matter, 90% dry matter) up to satiety, during 182 days. The two feed contained 3.0% calcium, 0.8% phosphorus and a premix (2.0 mg kg^{-1} folic acid; 40 mg kg^{-1} pantothenic acid; 1,000 mcg kg^{-1} biotin; 16 mg kg^{-1} copper; 0.60 mg kg^{-1} choline; 110.56 mg kg^{-1} iron; 0.80 mg kg^{-1} iodine; 30 mg kg^{-1} manganese; 0.20 mg kg^{-1} cobalt; 40 mg kg^{-1} niacin; 0.60 mg kg^{-1} selenium; 8,000 IU kg^{-1} vitamin A; 15 mg kg^{-1} pyridoxine; 30 mcg kg^{-1} vitamin B12; 20 mg kg^{-1} riboflavin; 10 mg kg^{-1} thiamine; 336 mg kg^{-1} vitamin C; 4,000 IU kg^{-1} vitamin D3; 160 IU kg^{-1} vitamin E; 4.0 mg kg^{-1} vitamin K3; and 140 mg kg^{-1} zinc).

The initial average fish weight was 272.12 ± 74.71 g for the treatment with 32% CP in the feed and 231.97 ± 87.70 g for treatment with 40% CP in the feed. During the experimental period, biometric measurements were performed at the onset and at 42, 77, 114, 147 and 182 days of experiment to determine the following variables: weight, total length (measurement from the anterior end of the mouth to the end of the caudal fin), standard length (measurement from the anterior end of the mouth to the start of the caudal fin), body width (measured at the beginning of the dorsal fin) and body height (measured at the beginning of the dorsal fin).

Before the biometric measurements, the fish were subjected to a 24-h fasting period. The biometrics procedure included the capture of the fish with a trawl and their transfer to a plastic box containing 100 L of water for anesthesia in eugenol (50 mg L^{-1}) for 5 min. The fish were then removed from the box to obtain the weight (Toledo 9094 scale) and for morphometric measurements.

At the end of the 182-d experimental period, the survival was determined and the following performance parameters were calculated: daily weight gain [(final average weight – initial average weight)/experimental period], biomass gain (final biomass – initial biomass) and apparent feed conversion (feed intake/biomass gain).

At the end of the experiment, all fish were slaughtered and cut to removal and weigh the viscera, head, skin and fillet. The yield of whole gutted fish [(whole fish weight without viscera x 100)/whole fish weight] and fillet yield [(fillet weight x 100)/whole fish weight] were evaluated from whole fish. To assess the visceral fat deposition, fat was separated from the viscera and weighed individually to obtain the visceral fat index [(fat weight × 100)/whole fish weight].

During the experiment, the following water quality variables were monitored biweekly in all experimental units: transparency (Secchi disk), temperature, dissolved oxygen (Oximeter YSI 55), pH, total ammonia, nitrite, alkalinity and hardness (colorimetric tests - Alphakit®).

The results were subjected to analysis of variance (ANOVA) using SAS software version 9.0 (SAS Institute Inc., Cary, NC, USA), and expressed by the mean and standard deviation. When necessary the means were tested by Tukey's test, at a significance level of 5.0%.

RESULTS

The water characteristics during the 182 days of experiment did not present critical levels to the tropical fish production (Table 1). Additionally, there was no variation in water characteristics between treatments.

Table 1. Water quality variables analyzed in tanks used for rearing hybrid catfish (*P. reticulatum* x *L. marmoratus*) consuming feed containing 32% or 40% crude protein for 182 days of experiment.

Variables	Mean ± standard deviation
Temperature (°C)	27.85 ± 1.69
Dissolved oxygen (mg L^{-1})	5.43 ± 0.60
pH	6.72 ± 0.76
Total ammonia (mg L^{-1})	0.11 ± 0.13
Nitrite (mg L^{-1})	0.01 ± 0.03
Alkalinity (mg $CaCO_3$ L^{-1})	42.34 ± 16.88
Hardness (mg $CaCO_3$ L^{-1})	35.63 ± 11.67
Transparency (cm)	44.61 ± 10.32

Initially, weight and morphometric traits of the hybrid catfish were similar between treatments, but at the end of the experimental period, weight, body width and body height were higher (P<0.05) for the higher-protein treatment (Table 2).

Daily weight gain, biomass gain, apparent feed conversion and survival of hybrid catfish were similar between the treatments with higher and lower levels of crude protein in the feed (Table 3).

Results for yield of whole gutted fish were higher (P<0.05) in the treatment with 32% CP in comparison with that with 40% CP (Table 4). However, for fillet yield, there was no significant difference between the tested treatments. Visceral fat index was lower (P<0.05) in the fish fed 32% CP than in those fed 40% CP.

Table 2. Weight, total length (TL), standard length (SL), body width (BW) and body height (BH) of hybrid catfish (*P. reticulatum* x *L. marmoratus*) consuming feed containing 32% or 40% crude protein (CP) for 182 days of experiment.

Variable	Initial*		Final*	
	32% CP	40% CP	32% CP	40% CP
Weight (g)	272.12 ± 74.71[a]	231.97 ± 87.70[a]	1,016.63 ± 250.59[b]	1,152.22 ± 338.50[a]
TL (cm)	32.77 ± 2.85[a]	31.35 ± 3.85[a]	48.83 ± 3.85[a]	49.66 ± 4.97[a]
SL (cm)	27.27 ± 2.43[a]	25.51 ± 3.63[a]	39.02 ± 3.77[a]	38.87 ± 3.66[a]
BW (cm)	4.65 ± 0.70[a]	4.15 ± 0.73[a]	7.17 ± 0.89[b]	7.67 ± 1.08[a]
BH (cm)	4.25 ± 0.60[a]	4.04 ± 0.68[a]	6.88 ± 0.81[b]	7.27 ± 1.01[a]

**Mean ± standard deviation. Means followed by the same letter in the rows in the stages (initial and final) indicate that the treatments do not differ by Tukey's test (a=0.05).*

Table 3. Daily weight gain, biomass gain, apparent feed conversion and survival of hybrid catfish (*P. reticulatum* x *L. marmoratus*) consuming feed containing 32% or 40% crude protein (CP) for 182 days of experiment.

Variable	Crude protein (CP) level in the feed (%)*	
	32% CP	40% CP
Daily weight gain (g day^{-1})	3.75 ± 0.25	5.4 1± 1.51
Biomass gain (kg)	10.04 ± 0.67	14.61 ± 4.08
Apparent feed conversion	2.82 ± 0.05	2.72 ± 0.23
Survival (%)	100.0	100.0

**Mean ± standard deviation.*

Table 4. Yield of whole gutted fish, fillet yield and visceral fat index of hybrid catfish (*P. reticulatum* x *L. marmoratus*) consuming feed containing 32% or 40% crude protein (CP) for 182 days of experiment.

Variable	Crude protein (CP) level in the feed (%)*	
	32% CP	40% CP
Yield of whole gutted fish (%)	86.06 ± 0.94[a]	84.44 ± 0.65[b]
Fillet yield (%)	46,27 ± 0.86[a]	47.12 ± 0.76[a]
Visceral fat index (%)	3.28 ± 1.49[a]	4.81 ± 1.76[a]

**Mean ± standard deviation. Means followed by the same letter in the rows indicate that treatments do not differ by Tukey's test (a= 0.05).*

DISCUSSION

The water quality variables analyzed during the experimental period are in accordance with recommendations of CAMPOS (2010) for rearing tropical fish. Additionally, there was no variation between treatments that could interfere with the treatments.

The fish fed the higher level of protein exhibited a higher final weight (19.1% higher) than those receiving the lower protein level. There is lack of studies on hybrid catfish evaluating production in a similar period. Nevertheless, the obtained final weight can be considered significant enough for a rearing period of 182 days, mainly for the treatment with a higher protein level.

TEIXEIRA *et al.* (2013) evaluated the hybrid cachapinta (*P. reticulatum* x *P. corruscans*), and observed a higher final weight in the treatment with 36% CP in relation to that with 40% CP. For *L. marmortus*, MURILLO-PACHECO *et al.* (2012) observed that 34% CP was better than the other levels, indicating a reduced need for protein for this omnivorous species. The results obtained by those authors for carnivorous (TEIXEIRA *et al.*, 2013) and omnivorous fish (MURILLO-PACHECO *et al.*, 2012) suggest that the CP level for weight gain may be lower than 40%, especially considering that the results were obtained in the initial production phase, in which the protein requirement is greater. This was demonstrated in a study with hybrid catfish by SOUZA *et al.* (2014), who found similar final weights in treatments with 34.06 and 39.52% CP (initial production stage). However, results of our study indicate better performance obtained with the feed containing a higher protein level.

The total and standard lengths were similar at the beginning and end of the experiment, indicating that the protein level did not influence these features. However, the fish width and height after 182 days of experiment were better in the treatment with a higher protein level, conditions that confirm the better weight gain of fish fed feed with a higher protein level. These data reveal that the treatment with 40% CP promoted greater growth in the fish circumference than in their length.

The daily weight gain obtained in this experiment (32% CP: 3.75 g day^{-1}; 40% CP: 5.41 g day^{-1}) was greater than the 2.34 and 3.01 g day^{-1} observed by CRUZ-CASALLAS *et al.* (2010) and the 1.64 and 3.20 g day^{-1} reported by MURILLO-PACHECO *et al.* (2012), both of whom evaluating *L. marmoratus* fed 30% CP and 24 to 34% CP, respectively. On the other hand, SCORVO FILHO *et al.* (2008) found values similar to those in this work for *P. corruscans* fed 40% CP, for which a daily weight gain of 4.05 g day^{-1} was observed. TEIXEIRA *et al.* (2013) observed, in the cachapinta hybrid, a daily weight gain of 4.24, 3.79, 2.74, 1.84 and 1.05 g day^{-1}, for the dietary CP levels of 36, 40, 44, 48, 52%, respectively, indicating that very high levels affected the daily weight gain. Regardless of the CP level in the feed, the daily weight gain observed for the hybrid catfish in this experiment can be considered high in relation to that obtained for other Siluriform fish.

In the initial production stage of hybrid catfish, PRIETO-GUEVARA *et al.* (2015) and BERNARDES *et al.* (2016) found daily weight gain values from 1.1 to 1.7 (42.1% CP) and 2.7 to 2.9 (42.9 to 43.5% CP), respectively. In an experiment with hybrid catfish using feed with 40% CP, FARIA *et al.* (2011) observed a higher daily

weight gain as the fish weight increased, obtaining 0.7 to 1.0 g day^{-1} in the initial stage (weight from 30.8 to 58.3 g) and 5.0 to 8.9 g day^{-1} in the final stage (weight from 399.5 to 1,287.1 g). These authors observed a decrease in daily weight gain as rearing density was elevated. These results indicate that daily weight gain is highly influenced by the production stage and density, which makes it difficult to compare studies for these variables. Furthermore, factors like feeding management and water quality conditions can also affect this variable. In this regard, comparisons between studies must be carefully analyzed. However, the values obtained in the above-mentioned works suggest great potential for daily weight gain in hybrid catfish.

Similar to the daily weight gain, the biomass gain did not increase significantly with the increased protein level in the feed. There is a dearth of scientific information on biomass gain in different rearing systems for hybrid catfish. FARIA *et al.* (2011) observed that the biomass in the final rearing stage (final weight between 901.2 and 1,287.1 g) ranged from 5,148.5 to 14,419.5 kg at densities of 10-40 fish m^{-3}, respectively. The biomass gain is relative to the production system and is greater in more-intensive systems. The rearing density used in the present study was low, because the water renewal rate was not high (around 5% per day). The recommended density for a low water flow is between 0.1 and 0.5 kg m^{-2} (LOPERA-BARRERO *et al.*, 2011). Larger biomasses in both treatments could be obtained with an increase in water flow.

The apparent feed conversion was similar between fish treated with 32% CP (2.82) or 40% CP (2.72). Although the values were relatively high compared with those achieved for omnivorous (around 1.5) and carnivorous (2.0) fish, it may have been caused by the feeding method, which used satiety to maximize weight gain for both protein levels. Lower apparent feed conversion values (between 1.49 and 1.60) were obtained by TURRA *et al.* (2009) and HONORATO *et al.* (2014) for cachapinta (between 1.38 and 1.52) in the early rearing stage. However, SCORVO-FILHO *et al.* (2008) and LIRANÇO *et al.* (2011) found, in *P. corruscans*, apparent feed conversion ranging from 4.6 to 5.2 and 3.09 to 4.15, respectively, in different production systems (semi-intensive: 0.25 to 0.75 fish m^{-3}; intensive 22 to 133 fish m^{-3}). These results indicate that apparent feed conversion can vary depending on the fish species, stage, rearing density and feeding procedures. In the experimental conditions of this work, CP levels did not influence apparent feed conversion.

The higher yield of whole gutted fish obtained in the 32% CP treatment indicates that the higher final weight of the 40% CP treatment was not fully related to a greater flesh increase. This was demonstrated by the analysis of fillet yield, which did not differ across the treatments, indicating an increase in the viscera of the fish receiving a higher protein level.

In fact, the visceral fat index of hybrid catfish was 1.53% higher in fish treated with 40% CP (4.81%) in relation to those treated with 32% CP (3.28%). This result indicates greater accumulation of visceral fat in the fish fed a higher protein level, confirming that the higher final weight of the treatment with 40% CP was not fully converted to a greater meat increase. Therefore, higher protein level contributed to lower yield in whole gutted fish, resulting in market loss, since slaughterhouses have currently penalized the excess of visceral fat (above 3%) due to lower income for the processing unit.

Feeds with a low protein/energy ratio promote the intake of a suboptimal quantity of protein upon satiation, compromising weight gain and promoting body fat accumulation (MEYER and FRACALOSSI, 2004). However, the largest amount of viscera and visceral fat was observed in the treatment with 40% CP, which had a higher protein/energy ratio (92.6 mg protein kcal^{-1}) in relation to the treatment with 32% CP (78.1 mg protein kcal^{-1}). This result may be related to a lack of nutritional balancing of the feeds, which reflects the need for determining the nutritional requirements of hybrid catfish, which is inexistent today. This was demonstrated in the study of PRIETO-GUEVARA *et al.* (2015), who observed a higher yield of whole gutted fish (92.4 to 93.5%) in hybrid catfish using 103.5 mg protein kcal^{-1} (42% CP and 4,058.3 kcal); and BERNARDES *et al.* (2016), who did not find differences in the yield of whole gutted fish (90.9 to 91.5%) in hybrid catfish for the energy ratios of 80.5 mg CP kcal^{-1} (42.9% CP and 5,329.8 kcal), 79.4 mg CP kcal^{-1} (43.1% CP

and 5,425.4 kcal), 78.1 mg CP kcal^{-1} (43.5% CP and 5,568.8 kcal) and 76.8 mg CP kcal^{-1} (43.3% CP and 5,640.5 kcal).

Although the performance was superior in the hybrid catfish consuming a higher protein level, the lower yield of whole gutted fish and greater accumulation of visceral fat in this treatment can characterize lower financial return. In this regard, other protein levels and other nutrients should be tested for hybrid catfish to produce better performance and yield of whole gutted fish.

CONCLUSIONS

Feeding hybrid catfish diets with 40% crude protein promotes greater growth in 182 days of rearing. However, this feeding strategy also promotes greater accumulation of visceral fat and lower yield of gutted fish, indicating that further studies are required for a better adjustment of the levels and quality of protein and other nutrients.

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