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Probiotic in feeding of juvenile matrinxã (*Brycon amazonicus*): economic viability

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ABSTRACT. This study aimed to analyze the economic feasibility of supplement probiotics *Bacillus subtilis* to "matrinxã" *Brycon amazonicus,* raised in cages. The experiment was conducted at the Polo Regional Vale do Ribeira, in Pariquera-açu municipality, São Paulo State, Brazil, from February to July 2009. A total of 960 juvenile matrinxã were stocked in twelve 2.7 m^3-net cages (1.5 x 1.5 x 1.2 m), in ponds with a total area of 600 m^2 and an average depth of 1.50 m. The tests were conducted with a control treatment (T_1) and two probiotic doses (T_2 = 5 g and T_3 = 10 g kg^{-1} of diet) with four replicates. Results showed that T_2 produced better economic performance for matrinxã at the juvenile stage in intensive rearing system.

Keywords: fish farming, growth promoter, production cost, economic indicator.

Probiótico na alimentação de juvenis de matrinxã, *Brycon amazonicus*: viabilidade econômica

RESUMO. Objetivou-se analisar a viabilidade econômica do uso do probiótico *Bacillus subtilis* na alimentação de matrinxã *Brycon amazonicus*, em tanques-rede. O experimento foi conduzido no Polo Regional do Vale do Ribeira, no município de Pariquera-Açu, São Paulo, Brasil, entre fevereiro e julho de 2009. Foram avaliados 960 peixes juvenis, divididos em 12 tanques-rede de 2,7 m^3 (1,5 x 1,5 x 1,2 m) em uma área total de 600 m^2, com profundidade média de 1,50 m. Os testes foram conduzidos com um tratamento testemunha (T_1), duas doses de probiótico (T_2 = 5 g e T_3 = 10 g kg^{-1} de ração) e quatro repetições. Os resultados mostraram que o T_2 proporcionou melhor desempenho zootécnico e econômico da matrinxã na fase de engorda no sistema intensivo de criação.

Palavras-chave: piscicultura, promotor de crescimento, custo de produção, indicador econômico.

Introduction

In recent years, fish farming in Brazil has grown rapidly, following the global trend of professionalization of this activity, similar to cattle, poultry and swine (GOMES et al., 2004). The culture of tilapia *Oreochromis niloticus*, carp *Cyprinus carpio*, tambaqui *Colossoma macropomum* and trout *Oncorhynchus mykiss* is prominent, especially in the South, Southeast and Northeast Brazilian regions (ROUTLEDGE; CASTRO, 2001). Gomiero et al. (2003) stated that, in recent years, "matrinxã" *Brycon amazonicus* has been successfully cultivated in the southeast region of Brazil mainly for its good market acceptance and easy adaptation to captive breeding. The knowledge on artificial propagation technology and the established supply chain favors the consolidation of this activity. Currently, "matrinxã" is considered one of the most used fish by sport fishermen in Brazilian continental waters (FRASCÁ-SCORVO et al., 2007).

"Matrinxã", *Brycon amazonicus* (= *Brycon cephalus*), has an enormous growth potential in captivity (700 to 1,000 g in the first year) as well as prime meat (BRANDÃO et al., 2005). According to Eler and Millani (2007) fish farming is an agribusiness that needs to be conducted by social, environmental, economic and technological criteria. In this sense, the use of probiotics in fish farming meets the requirements of sustainable development because it benefits the aquatic ecosystem (VERSCHUERE et al., 2000). On the other hand the probiotics allows for cost reduction, since food represent approximately 50% of the operational costs of intensive and semi-intensive fish cultures (FURLANETO; ESPERANCINI, 2009).

Probiotics are non-digestible ingredients incorporated into foods in order to select certain intestinal bacteria, by acting as a selective substrates in the colon (COPPOLA; TURNES, 2004). According to Balcazar et al. (2006), probiotics have multiple beneficial actions such as aiding in digestion, inhibition of pathogenic bacteria growth, lactate and acetate production that reduce the pH of the medium, antibacterial effects, complex-B vitamin production, immune system stimulation by macrophage activation and restoration of intestinal microbiota after antibiotic treatment and operate as growth promoters.

Li et al. (2001) reported that probiotics in aquaculture has been promising as studies performed by Ghosh et al. (2007) working with *Bacillus subtilis*, in *Poecilia reticulate*, *Poecilia sphenops*, *Xiphophorus helleri* and *Xiphophorus maculates*, by Dias et al. (2007) and França et al. (2008) about the effect of probiotic *Bacillus subtilis* on growth, survival and physiology of bullfrogs (*Rana catesbeiana*) and by Ghazalah et al. (2010) that evaluated the effect of probiotics on performance and nutrients digestibility of Nile tilapia (*Oreochromis niloticus*).

The intensive system of rearing fish in net cages has grown rapidly over the last years because it is an excellent alternative for water bodies that are unexplored by conventional aquaculture (WAGNER et al., 2004). Additionally, they avoid large areas of deforestation, which prevents erosion and siltation problems (BRIONES et al., 2008). Among the Neotropical species that can be reared in cages, the genus Brycon has gained special attention (MARQUES et al., 2004).

The aim of this study was to evaluate the economic viability of the use of probiotics *Bacillus subtilis* added to the feed for “matrinxã” *Brycon amazonicus* during the juvenile stage, using fish cages.

Material and methods

The experiment was carried out at the Polo Regional Vale do Ribeira in Pariquera-açu, São Paulo State, Brazil, between February and July 2009. A total of 960 juvenile “matrinxã”, *B. amazonicus*, with an initial weight and length of 39.83 ± 8.18 g and 14.60 ± 1.00 cm, respectively, were distributed into twelve 2.7 m^3 (1.5 x 1.5 x 1.2 m) fish cages installed in ponds with area of 600 m^2, average depth of 1.50 m and a flow rate of 15 L min^{-1}.

The experimental design was completely randomized with three treatments (T_1 = 0% of probiotic, T_2 = 5 g of probiotic, and T_3 = 10 g of probiotic kg^{-1} food) and four replicates. Fish were fed twice daily (1% of the total biomass). The initial biometry (weight and total length) was taken from all animals and repeated every 21 days, by collecting 20% of the fish from each cage. The experiment lasted 84 days.

The probiotic *Bacillus subtilis* was added directly to commercial extruded ration containing 32% crude protein (minimum), 6.5% ether extract (minimum), 7% crude fiber (maximum), 10% mineral material (maximum), 1.2% calcium (maximum) and 0.6% phosphorous (minimum).

Initial weight (Wi), final weight (Wf), weight gain (WG), specific growth rate (SGR) and feed conversion rate (FCR) were evaluated for each experimental unit. Specific growth rate (SGR) was calculated at sampling intervals, according to the formula: SGR = 100 [(ln Wf – ln Wi) days-1]. Apparent feed conversion rate (AFC) was estimated using the equation: AFC = feed offered/weight gain (WG), as described in Senhorini et al. (1998).

Data were subjected to analysis of variance (ANOVA) and means were compared by Tukey’s test. Data expressed in percentages were previously transformed according to the formula y = arccosine √x (ZAR, 1999) for further evaluation.

Production cost analysis took into account the feed offered and the production per experiment. The diet and probiotic prices per kg were R$ 1.83 (US$ 0.77) and R$ 12.60 (US$ 7.00). The dollar was equivalent to R$ 1.80, which was the exchange rate in March 2010. The selling price of “matrinxã” was R$ 4.50 (US$ 2.50).

The total cost of production (TCP) estimated per kilo of live “matrinxã” was determined by the equation (MATSUNAGA et al., 1976):

$$TCP = CFT / Pr$$

where:

CFT = cost of feeding per treatment (R$/treatment); and

Pr = production per area unit (kg of live “matrinxã”/treatment).

Economic analysis indicators of the results were based on Martin et al. (1998):

gross income (GI): the expected revenue for a given production per unit area for a pre-determined sale price or actually received:

$$GI = Pr \times Pu$$

where:

Pu = unit price of the product (R$ kg^{-1} live “matrinxã”).

The operating profit (OP) is the difference between the gross income and total operational cost (TOC) per unit area:

$$OP = GI - TOC$$

The profitability rate (PR) shows the relationship between operating profit (OP) and gross income as a percentage:

$$PR = (OP / GI) \times 100$$

Results and discussion

The individual final weight of the fish submitted to the different treatments was significantly different ($p < 0.05$), showing that "matrinxãs" fed with probiotics (T_2 and T_3) had a higher average weight compared to the control. Regarding the weight gain, the fish from the T_1 was similar to the T_2 and different from those observed for T_3. The specific growth rate showed the same results in the weight gain. The apparent feed conversion (AFC) was similar in T_2 and T_3 but both differed from T_1 (Table 1 and 2).

This difference may be due to the greater amount of probiotic that induce the production of digestive enzymes, and consequently better digestibility of food. Ghazalah et al. (2010) showed better food conversion rate for Nile tilapia fed with ration containing commercial probiotic Biongen (*Bacillus subtilis*, allicin, hydrolytic enzymes and ginseng extract). However, due to the scarcity of studies in this area, it was not possible to compare this data with other studies involving "matrinxã" fed with probiotics, reared in cages.

Table 1. Mean and standard deviation of individual initial weight (Wii), individual final weight (Wfi), weight gain (WG), specific growth rate (SGR) and apparent feed conversion (AFC) of "matrinxã", *B. amazonicus*, after 84 days on a diet containing the probiotic *Bacillus subtilis*.

Trat.	Un.	T_1		T_2		T_3	
Wii	(g)	42.24	± 5.89	43.40	± 2.27	40.80	± 1.24
Wfi	(g)	235.29^{b}	± 5.89	253.11^{a}	± 10.63	256.21^{a}	± 10.67
WG	(g)	193.04^{b}	± 4.62	209.71^{ab}	± 13.92	215.41^{a}	± 10.62
SGR	(%)	2.02^{b}	± 0.03	2.08^{ab}	± 0.06	2.13^{a}	± 0.06
AFC	(kg)	2.38^{b}	± 0.11	2.09^{a}	± 0.13	2.21^{ab}	± 0.07

T_1 = control, T_2 = 5 g kg^{-1}, T_3 = 10 g kg^{-1}.

Different letters in different columns are significantly different by Tukey's test ($p < 0.05$).

Oliveira et al. (2002) reported that some ingredients (functional foods) have beneficial effects for the host, because they provide basic nutrition and improve the animal productivity, through mechanisms not promoted by conventional nutrition (IRIANTO; AUSTIN, 2002). This group of ingredients includes probiotics that, when incorporated into the diet, become food supplements that benefit the individual's general condition by balancing the intestinal flora. Therefore, the results of this study confirm the observation described above.

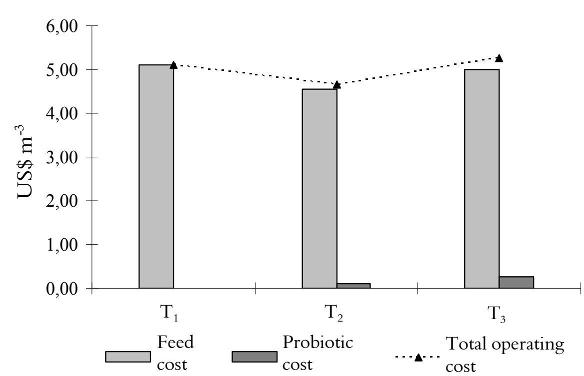
The mean values of AFC were statistically different between treated and control fish, and similar to values found by Romagosa et al. (1998) (2.40 to 2.00:1), Izel et al. (2004) (2.17 to 2.04:1) and Frascá-Scorvo et al. (2007) (2.48 to 2.11:1) for *B. amazonicus*, demonstrating that utilization of probiotic in feed can promote better values of AFC and data were according to specialized literature.

Table 2. Zootechnical parameters for "matrinxã", *B. amazonicus*, for each treatment obtained in the experiment using the probiotics *B. subtilis*.

Parameters	Un.	T_1	T_2	T_3
Initial total biomass	(kg m^{-3})	0.56 ± 0.04	0.52 ± 0.02	0.47 ± 0.05
Final total biomass	(kg m^{-3})	2.80 ± 0.23	2.84 ± 0. 5	2.95 ± 0.35
Total feed offered	(kg m^{-3})	6.66	5.94	6.52
Probiotics offered	(g m^{-3})	-	29.7	65.2

T_1 = control, T_2 = 5 g kg^{-1}, T_3 = 10 g kg^{-1}.

The final total biomass of T_3 (higher productivity) was 5.08% greater than T_1 (lower productivity). The difference between T_1 and T_2 was 1.41%. "Matrinxã", *B. amazonicus*, feeding costs ranged from US$ 4.67 to US$ 5.25 per m^3 (Figure 1). The cost per kilo of live "matrinxã" corresponded to US$ 1.82, 1.62 and 1.78 in T_1, T_2 and T_3, respectively. The cost per kilo of "matrinxã" in T_2 was smaller than T_1 and T_3 due to the better conversion rate caused by the effect of the probiotics on the fingerlings diet.



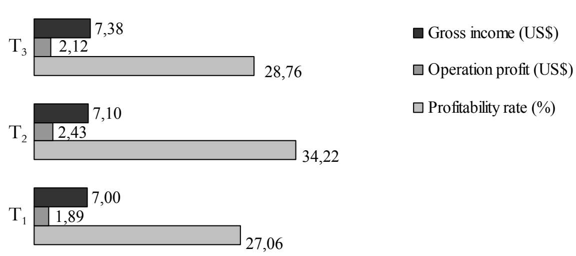
T_1 = control group; T_2 = probiotic 5 g kg^{-1} of feed; T_3 = probiotic 10 g kg^{-1} of feed.

Figure 1. Cost of feed, probiotic, and total production (in dollar) per m^3 of cage of live "matrinxã", *B. amazonicus*, in the fattening period using *B. subtilis* as probiotic.

The gross income, per m^3, was greater in T_1 (US$ 7.38). However, the operating profit was greater in the T_2 due to the higher biomass production per unit area observed in this treatment.

The profitability rate was equivalent to 28.76% (T_1), 34.22% (T_2) and 27.06% (T_3) as shown in Figure 2. The results pointed out that the use of probiotics as growth promoters for "matrinxã" reared in cages is economically viable.

The total operational cost of "matrinxã" reared in dams in the State of Amazonas, Brazil, identified by Izel et al. (2004) was US$ 1.25 per kg, resulting in net incomes ranging from US$ 0.14 to 0.69 per kg, depending on the price variation. The results obtained in this study showed a profitability varying from 10 to 36%, indicating that the cultivation of "matrinxã" in net cages is an economically viable option. Therefore, the results indicate that the use of the probiotic is economically viable for "matrinxã" reared in cages.



T_1 = control group; T_2 = probiotic 5 g kg^{-1} of feed; T_3 = probiotic 10 g kg^{-1} of feed.

Figure 2. Gross income (US$), operating profit (US$) and profitability rate (%), per m^3 of cage, of live "matrinxã" *B. amazonicus*, in the fattening period using *B. subtilis* as probiotic.

The utilization of 5 g kg^{-1} of probiotic promotes the same zootechnical performance of 10 g kg^{-1}, therefore, is recommended to utilize the lower dosage, hence leading to a low cost of product inclusion.

Conclusion

The probiotic, *Bacillus subtilis* at levels of 5 and 10 g kg^{-1} of feed improves the zootechnical performance of fish. The dosage of 5 g kg^{-1} of feed is recommended for better economic performance of juvenile "matrinxã" *Brycon amazonicus*, reared in cages.

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