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Effect of dietary supplement (*cevas*) on the chemical composition of wild fish *Brycon falcatus* Müller & Troschel, 1844 in the Teles Pires river basin

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ABSTRACT. In the Teles Pires River watershed, one of the most common techniques currently used by fishermen to catch fish is to provide a food supplement commonly known as "*cevas*". The purpose of this study was to compare the chemical composition of fillets from *Brycon falcatus* that were caught in both the presence and absence of *cevas*. The fish were sampled monthly and captured in the following conditions: the Tapaiúna River without *cevas*, the Teles Pires River with one *ceva*/100 m, the Celeste River with one *ceva*/500 m, the Verde River with one *ceva*/1000 m and the Cristalino River (control area). Subsequent to capture, the fish were euthanized and preserved on ice to determine their water, ash, crude protein and fat contents. Fillets of fish from the control area exhibited a lower level of crude protein (17.81%) compared with that of fish from the other rivers, which did not differ amongst one other. The fillets of fish from the river with the greatest density of *cevas* (1/100 m) exhibited a higher fat content (3.63%) than that of fish from the control area (1.51%). Thus, the *cevas* changed the chemical composition of *B. falcatus* fillets.

Keywords: Amazon basin, fresh soybean, feeding, lipids, matrinxã, protein.

Efeito do suplemento alimentar (cevas) na composição química do peixe selvagem *Brycon falcatus* Müller & Troschel, 1844 na bacia do rio Teles Pires

RESUMO. Atualmente, na bacia do rio Teles Pires, uma das técnicas mais utilizadas pelos pescadores para captura de peixes é a oferta de suplemento alimentar, popularmente conhecida como ceva. Objetivou-se comparar a composição química do filé de *Brycon falcatus* de locais com oferta de suplemento alimentar (cevas) e sem cevas. As coletas dos peixes foram mensais e as capturas foram em rio Tapaiúna sem cevas, rio Teles Pires com uma ceva/100 m, rio Celeste com uma ceva/500 m, rio Verde com uma ceva/1.000 m e rio Cristalino em Unidade de Conservação (controle). Após as capturas, os peixes foram eutanasiados e acondicionados em gelo, para determinação dos teores de umidade, cinzas, proteína bruta e gordura. Os filés dos peixes oriundos da área controle apresentaram o menor teor de proteína bruta (17,81%) que dos outros rios, que não diferiam entre si. Os filés dos peixes do rio com maior densidade de cevas (1/100 m) apresentaram maior teor de gordura (3,63%) que do rio em Unidade de Conservação (1,51%), mas não diferiram dos outros rios. As cevas de soja *in natura* alteraram a composição química dos filés de *Brycon falcatus*.

Palavras-chave: bacia Amazônica, soja *in natura*, alimentação, gordura, matrinxã, proteína.

Introduction

One technique currently used by fishermen to catch fish in the Teles Pires River watershed is to provide food supplements that are popularly known as "*ceva*" (Matos & Carvalho, 2016). *Ceva* is defined as a food source used to attract omnivorous fish (Matos, Silva, Tesk, & Carvalho, 2015). However, *ceva* can also provide a method of observing fish and is common with tourists at the Bonito, MS beach resort, where public visitors supply an artificial food source (snack food and bread crumbs) to attract fish. Thus, supplying food supplements can produce physiological and behavioral changes in animals.

Among the food supplements offered in the Teles Pires River, fresh soybean (*Glycine max*) is the most common due to its high protein content (40%) and high availability in the region. However, soybeans possess numerous anti-nutritional factors (Francis, Makkar, & Becker, 2001), which refers to a substance that can affect the uptake of nutrients from food, reduce digestibility or metabolism and potentially change the physiology of fish, rendering them susceptible to parasites, negatively impacting growth and productive performance and even causing death if used for extended periods (Makkar & Becker, 1997). Fresh soybean can be used in fish diets at levels of up to 11.1% of the dietary total over a period of up to 90 days (Del Carratore, Pezzato, Pezzato, Barros, & Ribeiro, 1996) without affecting digestion, nutrient uptake, or changing the chemical composition of fish.

The chemical composition of fish ranges from 60 to 85% water, 15 to 24% protein, 0.6 to 36% fat and 1 to 2% minerals depending on the species, time of year, food availability, quality of diet, stage of gonadal maturation and the part of the body analyzed (Ogawa & Maia, 1999). Because there is a relationship between fish chemical composition and diet consumed, fish that consume foods with higher energy content possess a higher amount of lipids (Roubach & Saint-Paul, 1994). In the wild, traditional fish diets meet their nutritional needs (Pezzato, Barros, Fracalossi, & Cyrino, 2004) and provide an optimal balance between energy and protein. An unbalanced diet can reduce growth rates, worsen feed conversion and favor an increased accumulation of body fat (Lovell, 1991). Therefore, providing fresh soybean to matrinxã (*Brycon falcatus*, Müller & Troschel, 1844) may lead to high fat deposition in muscle tissue. The aim of this study was to compare the chemical composition of *B. falcatus* fillets from sites within the Teles Pires River watershed with, and without food supplements (*cevas*).

Material and methods

Study site

Collections were conducted in the Teles Pires River watershed, which is located in the northern region of Mato Grosso (MT) State in an area known as the Legal Amazon. This watershed is one of the main sources of the Tapajós River. The Teles Pires River is a clear-water river, with its surrounding watershed being host to major economic activities such as logging, gold extraction, fishing and agriculture (mainly soybean and corn). These activities have led to widespread negative impacts on water resources (Barthem & Goulding, 1997).

The experimental design of this study considers the density of *cevas* in the Teles Pires River watershed (Figure 1)

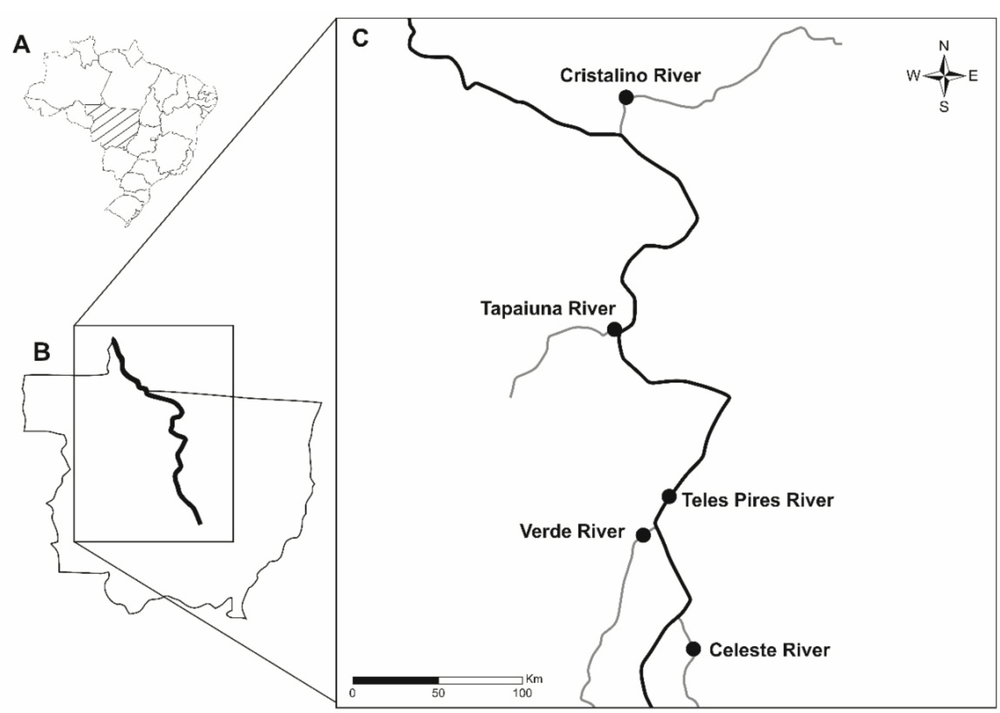

Figure 1. Study area showing the rivers where fish were collected, namely the Celeste River (12°24'56,00"S and 55°31'28,00"W), Verde River (11°4'1,99"S and 55°34'17,00"W), TelesPires River (11°34'48,00"S and 55°39'5,00"W), Tapaiuna River (10°41'29,28"S and 55°56'51,11"W) and Cristalino River (9°32'47,00"S and 55°47'38,00"W), State of Mato Grosso, Brazil.

Collections were performed in the following areas: the Verde River (municipality of Sorriso), which is categorized as having a low density of *cevas* with approximately one *ceva* for each 1000 m stretch of river; the Celeste River (municipality of Vera), categorized as having a medium density of *cevas* with approximately one *ceva* for every 500 m stretch of river; the Teles Pires River (municipality of Sinop), classified as having a high density of *cevas*, with approximately one *ceva* for every 100 m stretch of river; the Tapaiúna River (municipality of Nova Canaã do Norte), which does not currently have *cevas*, although it is close to the *cevas* system; and the Cristalino River (municipality of Novo Mundo), which is the control treatment as it lies within a conservation unit.

The Cristalino River is primarily located within the Cristalino State Park (*Parque Estadual do Cristalino - PEC*) in MT, with the land surrounding the Cristalino River watershed legally protected against deforestation and human settlement. The Cristalino River is a typical black-water headwater river. Fish collected from the PEC conservation unit in this study were treated as the control group.

Fish collection and biometrics

Fish were collected monthly from April to June of 2013. Various collection instruments were used in the capture of fish such as gillnets with a mesh size of 12 mm between knots, 60 meter longlines with 30 #7 hooks, artisanal hook and longline traps set up along riverbanks, and fishing rods with artificial bait. After capture, the collected fish were euthanized with 300 mg L^{-1} of Eugenol® anesthetic (American Veterinary Medical Association [AVMA], 2001; Vidal et al., 2008) then preserved on ice in plastic bags for further analysis in the laboratory at the *Universidade Federal de Mato Grosso,* UFMT; Biological Collection Southern Amazon, ABAM. For each specimen, the following data were collected: total length (TL), standard length (SL) and total weight (TW). Fillets were collected and stored at -20°C for subsequent chemical composition analysis. Voucher specimens were deposited at the *Instituto Nacional de Pesquisas da Amazônia* (INPA) and the *Universidade Estadual de Campinas* (UNICAMP) n° ZUEC 9190.

Analysis of chemical composition

Forty-two *B. falcatus* individuals were analyzed for chemical composition (Table 1). The Matrinxã fillet samples were ground and homogenized in an oven at 105°C until reaching a constant weight to determine their water content, crude protein (Kjeldahl method), fat or ether extract (Bligh & Dyer, 1959), with the ashes dried in a muffle furnace at 550°C until reaching a constant weight. All measurements were performed according to the Association of Official Analytical Chemist [AOAC] (2000), and the results represent the mean of three measurements per sample.

After determining the chemical composition of the samples, a comparison of the results was performed among the rivers (Cristalino, Tapaiúna, Verde, Celeste and Teles Pires) to determine any differences in chemical composition, with the concentration of ether extract (fat) in the fillet considered the main indicator of change. Data from the literature on the chemical composition of *Brycon* were compared with the results of chemical composition tests.

Statistical analyses

The water, protein, fat and ash contents (expressed as the mean and standard deviation) of *B. falcatus* among the rivers of the Teles Pires basin watershed were subjected to an analysis of variance (ANOVA) followed by a post-hoc Tukey's test (R version 3.0.2 Statistical Software - R Core Team, R. (2014)) at a 95% ($p < 0.05$) significance level.

Results and discussion

The river with the greatest density of *ceva* (1/100 m) produced fish fillets that exhibited lower ($p < 0.05$) water content and greater ($p < 0.05$) fat content than those from the river in the conservation unit. In addition, the crude protein content of fillets from the river in the conservation unit was lower ($p < 0.05$) than in the fillets from the remaining rivers, which did not differ from one another. Fillets of *B. falcatus* from the river with a density of one *ceva*/1000 m exhibited the greatest ($p < 0.05$) ash content (2.08%) compared with all other fillets, except those from the river with the highest density of *ceva*. There was no difference in the ash content of fillets between the rivers in the conservation unit and those from rivers with *cevas* densities of 1/100 m and 1/500 m, and without *ceva* (Table 2).

Table 1. Total length (TL), standard length (SL) and weight (mean and ranges) of *Brycon falcatus* specimens collected in rivers of the Teles Pires watershed to determine chemical composition.

River	N	TL (cm)	SL (cm)	Weight (kg)
Cristalino[1]	10	45.31 (32.00 - 54.00)	34.55 (15.50 - 42.00)	1.65 (0.54 - 2.92)
Tapaiúna[2]	9	34.45 (28.50 - 39.50)	27.45 (22.50 - 31.00)	0.67 (0.35 - 0.95)
Verde[3]	6	40.64 (23.50 - 51.00)	30.87 (19.00 - 41.00)	1.20 (0.21 - 2.83)
Celeste[4]	7	40.30 (37.00 - 45.50)	30.14 (20.50 - 37.50)	1.07 (0.25 - 2.09)
Teles Pires[5]	10	39.34 (29.5 - 51.00)	31.01 (23.50 - 41.00)	1.24 (0.43 - 2.83)

[1]Conservation unit, [2]without *ceva*, [3]one *ceva*/1000 m of river, [4]one *ceva*/500 m of river and [5]one *ceva*/100 m of river.

Table 2. Chemical composition of *Brycon falcatus* fillets collected in rivers of the Teles Pires watershed.

Rivers	Chemical composition (%)			
	Water	Crude Protein	Ash	Fat
Cristalino	74.87 [a] ± 2.36	17.81 [b] ± 1.11	1.41 [b] ± 0.25	1.51 [b] ± 0.84
Tapaiúna	73.89 [ab] ± 1.04	19.60 [a] ± 0.66	1.48 [b] ± 0.25	3.13 [ab] ± 0.94
Verde	74.08 [ab] ± 3.97	20.77 [a] ± 2.29	2.08 [a] ± 0.39	2.29 [ab] ± 1.37
Celeste	72.59 [ab] ± 3.64	19.76 [a] ± 1.23	1.41 [b] ± 0.23	3.40 [ab] ± 2.16
Teles Pires	71.31 [b] ± 2.15	20.91 [a] ± 0.88	1.73 [ab] ± 0.31	3.63 [a] ± 1.59
CV	3.89	8.48	22.72	56.68
Value-P	0.0465	< 0.001	< 0.001	0.0381

Mean values ± standard deviation. Means followed by the same letter in each column were not significantly different ($p \geq 0.05$) by ANOVA. CV=Coefficient of Variance.

Providing fresh soybean as a food supplement in the rivers of the Teles Pires watershed has caused a significant change in the chemical composition of *B. falcatus*. The crude protein content of *B. falcatus* fillets from the conservation unit site was lower than that from the other sites. The greatest difference occurred between *B. falcatus* fillets collected from the conservation unit site and those collected from the site with the greatest density of *cevas*. In the conservation river unit, collections were performed during the dry period when the diet was based mainly on leaves, crustaceans, fish and native seeds. Pizango-Paima, Pereira-Filho, and Pereira (2001) analyzed the chemical composition of matrinxã (*B. cephalus*) stomach contents in Amazonian rivers during the wet and dry seasons. This species is also omnivorous in its natural environment and has a tendency toward frugivory in the wet season and insectivory in the dry season. In the dry season, the stomach content of *B. cephalus* contained 24.9% crude protein, which was similar to the diet of *B. falcatus* in the river located in the conservation unit. The diet of *B. falcatus* in the river with the greatest density of *cevas* during all collection periods was based primarily on fresh soybean, which contains 17 to 18% oil and 35 to 37% crude protein (Bellaver, Cotrefal, & Grecco, 2002). Thus, considering the relationship between fish chemical composition and diet consumed (Roubach & Saint-Paul, 1994), the chemical composition of the *B. falcatus* diet reflected the percentage of crude protein in the fillets from the sampled rivers.

One study with wild and cultivated *Brycon orbignyanus* in southern Brazil found crude protein percentages of 18.94% in wild fish fillets and 19.74 in cultivated fish fillets (Moreira, Visentainer, Souza, & Matsushita, 2001). Macedo-Viegas, Scorvo, Vidotti, & Secco (2000) obtained crude protein values of 19.05% in fillets of cultivated *B. cephalus* in southeast Brazil. Compared with our data, only the crude protein content of specimens collected from the river within the conservation unit (17.81%) presented values close to the crude protein percentage found in wild specimens of *B. orbignyanus* (Moreira *et al*., 2001). The specimens collected from other sites in the Teles Pires River watershed contained crude protein percentages similar to those of cultivated *B. orbignyanus* and *B. cephalus* specimens. Under cultivation, the growth of *Brycon* is conducted with a balanced ratio of 27 to 28% crude protein (Izel, Pereira-Filho, Melo, & Macedo, 2004). In a growth study of *B. orbignyanus* that had been fed a diet with crude protein levels between 24% to 42%, it was observed that the highest growth rate occurred with a crude protein level of 29%, while the lowest growth rate occurred with a crude protein rate of 42% (Carmo e Sá & Fracalossi, 2002). Nevertheless, the diets of *B. falcatus* in the rivers with medium and high densities of *cevas* are based on fresh soybean, which provides an unbalanced ratio of nutrients and approximately 40% crude protein, thus confirming the excess of dietary protein.

The ash percentage of *B. falcatus* fillets in this study ranged from 1.41% (river with medium density) to 2.08% (river with low density of *cevas*) and is similar to values found by Moreira *et al.* (2001) in wild *B. orbignyanus* (1.19%) as well as in cultivated specimens (1.32%). These values are within the normal range (1 to 2% of the chemical composition of fish) for freshwater fish (Ogawa & Maia, 1999).

The percentage of water content in *B. falcatus* fillets ranged from 71.31% for the river with a high density of *cevas,* to 74.87% for the river in the conservation unit. These values are close to the percentages observed by Moreira *et al.* (2001) for wild and cultivated *B. orbignyanus* specimens (Table 3). However, our values differ from those observed by Macedo-Viegas *et al*. (2000) for cultivated *B. cephalus* and Rocha, Aguiar, Marinho & Shrimpton (1982) for wild *Brycon* sp. (Table 3). We observed an inverse relationship, with greater fat percentages leading to lower water content, with this same chemical composition of fish described by Ogawa & Maia (1999).

The percentage of fat found in this study for *B. falcatus* ranged between 1.51% in specimens collected from the river within the conservation unit, and 3.63% for specimens collected from the river with the greatest density of *cevas*. In a study of wild matrinxãs, Moreira *et al*. (2001) found a fat percent of 3.56% for *B. orbignyanus* and 2.49% for *B. microlepis*. Almeida and Franco (2007) reported fat percentages of 9.6% for wild *B. cephalus* during the wet season and 4.5% during the dry season (Table 3). These differences may have resulted from different habitats, seasons, food availability and migration (Ogawa & Maia, 1999). Differences in percent fat can be explained by the large availability of food sources in the wet season, and large energy expenditures related to the searching and capturing of food in the dry season (Dabrowski & Portella, 2006). The low fat percent in matrinxã from the river within the conservation unit most likely reflects dry season conditions, which presents low food availability and low energy allocation for gonadal maturation. However, matrinxã collected in this study from the river with the greatest density of *cevas* in all of the collection periods exhibited a fat concentration in the fillet and abdomen that was significantly greater than that of fish collected from the river within the conservation unit due to the constant availability of food provided by the *cevas* (fresh soybean).

Table 3. Data for the water and fat (ether extract) content of *Brycon* species.

Specie	Water (%)	Fat (%)	Reference
Brycon falcatus (CR)	74.87	1.51	Presente study
Brycon falcatus (TPR)	71.31	3.63	Presente study
Brycon sp. (W)	66.80	11.80	Rocha et al., 1982
Brycon cephalus(C)	60.62	18.43	Macedo-Viegas *et al*. 2000
Brycon cephalus(C)	71.77	6.83	Moreira et al., 2001
Brycon orbignyanus(C)	73.98	3.74	Moreira et al., 2001
Brycon orbignyanus(W)	73.15	3.56	Moreira et al., 2001
Brycon microlepsis(W)	74.06	2.49	Moreira et al., 2001
Brycon cephalus(W)	-	21.60**	Pizango-Paima et al., 2001
Brycon cephalus(W)	-	7.05*	Almeida & Franco 2007
Brycon cephalus(C)	-	9.40	Almeida & Franco 2007

*Mean percentage of fat between wet and dry seasons. **Mean annual percentage of fat. CR = Cristalino River, TPR = Teles Pires River, W = Wild and C = Cultivated

Conclusion

The present study showed that offering a food supplement, soybean *in natura*, induced modification of the chemical composition in the flesh of *Brycon falcatus*. The most significant difference concerned fat content, which was significantly increased. Provisioning food is a commonly used strategy, by both fishermen and tourism managers, to increase the probability of encounters with fish. Our results improve our understanding of the impact of food supply on fish dietary habits and consequently, the dynamics of fat deposition. Overall, this study underlines the necessity to take into account the consequences of such practices, and that efficient public policy should be created and applied.

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