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Trophic ecology of *Loricariichthys melanocheilus* Reis & Pereira, 2000 (Siluriformes: Loricariidae) in Ibicuí river, southern Brazil

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ABSTRACT. Aiming to characterize aspects of the trophic ecology of *Loricariichthys melanocheilus* in the Ibicuí river, bimonthly samples were taken in lotic and lentic ecosystems. Fish were caught and fixed in 10% formalin and dissected for stomach content analysis. Items were identified to the lowest taxonomic level possible. Stomach fullness (SF), repletion index (RI) and intestinal quotient (IQ) were estimated. Diet was assessed by the frequency of occurrence and the volumetric method, combined to obtain a Alimentary index. Feeding activity was analyzed with mean values of SF, RI and vacuity index (VI), which represents the percentage of empty stomachs. These parameters were compared seasonally, spatially, and according to the circadian rhythm. The main items in the trophic spectrum of *L. melanocheilus* were detritus, sediment, plant organic matter, nematodes, micro crustaceans (Copepoda, Cladocera) and insects (Diptera, Trichoptera, Ephemeroptera and Odonata). No environmental or seasonal variations were found for the consumed items. Feeding activity showed seasonal and environmental variations according to RI but did not significantly change according to SF. The IQ was 1.51, and showed seasonal variations, indicating changes in the diet.

Keywords: feeding activity, feeding habits, intestinal quotient, stomach fullness, trophic spectrum.

Ecologia trófica de *Loricariichthys melanocheilus* Reis & Pereira, 2000 (Siluriformes: Loricariidae) no rio Ibicuí, sul do Brasil

RESUMO. Com o objetivo de caracterizar aspectos da ecologia trófica de *Loricariichthys melanocheilus* no rio Ibicuí, amostras bimestrais foram realizadas em ecossistemas lóticos e lênticos. Os peixes foram capturados, fixados em solução formalina 10% e dissecados para a avaliação do conteúdo estomacal, sendo os itens identificados até a menor categoria taxonômica possível. Foram obtidos o grau de repleção (GR), índice de repleção (IR) e quociente intestinal (QI). A dieta foi avaliada por meio da frequência de ocorrência e pelo método volumétrico, sendo ambos combinados para se obter o índice alimentar (IAi). A atividade alimentar foi analisada a partir das médias de GR, IR e índice de vacuidade, representado pela porcentagem de estômagos vazios. Estes parâmetros foram comparados sazonalmente, ambientalmente e de acordo com o ritmo circadiano. Os principais itens presentes no espectro trófico de *L. melanocheilus* foram: detritos, sedimento, matéria orgânica vegetal, nematoides, microcrustáceos (Copepoda, Cladocera) e insetos (Diptera, Trichoptera, Ephemeroptera e Odonata). Não foram observadas variações ambientais ou sazonais nos itens consumidos. A atividade alimentar mostrou variações sazonais e ambientais de acordo com o IR e não variou significativamente conforme o GR. O QI obtido foi de 1,51, e mostrou variações sazonais, refletindo mudanças na dieta.

Palavras-chave: atividade alimentar, habito alimentar, quociente intestinal, grau de repleção, espectro trófico.

Introduction

Studies on feeding are of fundamental importance to all organisms, under any conditions. In ecology, a full understanding of the behavior of a species, regarding reproduction, growth, mortality, birth rate and migration, among other aspects, requires knowledge about its food needs (Andrian & Barbieri, 1996). In addition, information on the food resources consumed by fish allow a better understanding of their relationships with other components of the aquatic community and the ecological role they play (Hahn, Andrian, Fugi, & Almeida, 1997).

Loricariichthys melanocheilus, also known as “cascudo-viola”, or armored catfish, was recently described by Reis and Pereira (2000) for the Uruguay river and Paraná river basins, Rio Grande do Sul State. It is distinguished from other species mainly because of the caudal peduncle not greatly compressed and straight in the lateral view, and the presence of pre-maxillary teeth and a relatively short rostral edge (Reis & Pereira, 2000). According to the same authors, it is a species very common in the lower and middle Uruguay river and in the lower Paraná river, either in streams or large rivers, usually associated with sandy and muddy bottom.

Studies on the trophic ecology of fish of this family have been conducted in various Brazilian regions, with diverse species, including *R. aspera* (Soares, Hayashi, Furuya, Furuya, & Maranhão, 1997), *H. strigaticeps* (Cardone, Lima-Junior & Goitein, 2008), *N. microps* (Braga, Gomiero, & Souza, 2008), *H. punctatus* (Mazzoni, Rezende, & Manna, 2010), *E. pantherinus* and *P. hystrix* (Dias & Fialho, 2011), among others. Regarding the genus *Loricariichthys*, studies are primarily concentrated on *L. anus* (Albrecht & Silveira, 2001; Petry & Schulz, 2000) and *L. platymetopon* (Agostinho, Hahn, Gomes & Bini, 1997), but research on *L. melanocheilus* is lacking. In general, these studies show a variety of foods consumed by the species, such as algae, microcrustaceans, fungi, plant remains, larval insects, besides a great amount of detritus and sediments, these items being considered by some authors as the most important for the diet of Loricariidae (Almeida & Resende, 2012; Agostinho et al., 1997; Fugi, Agostinho, & Hahn, 2001).

Due to the lack of studies addressing the biological and ecological aspects of *L. melanocheilus*, this study described the feeding habits and assessed the seasonal and environmental variations, as well as the circadian rhythm of food intake.

Material and methods

The Ibicui river is one of the main tributaries of the Uruguay river, formed by the Ibicui-Mirim and Santa Maria rivers in the State of Rio Grande do Sul, Brazil. The river has a sandy substrate, and despite its narrowness, it has numerous marshes along the banks and a large floodplain (Rambo, 1994).

Sampling sites were set between the municipalities of São Vicente do Sul and Itaqui. Site 1 is located downstream of the mouth of Santa Maria river, between São Vicente do Sul and Cacequi (29°48'S; 54°58'W); site 2 is located in the middle Ibicui River, between the municipalities of Manoel Viana and Alegrete (29°29'S; 55°45'W); and site 3 is located upstream of the mouth of Ibirocai River, between Itaqui and Alegrete (29°25'S; 56°37'W) (Figure 1).

At each site, samples were collected in lotic and lentic environments, represented, respectively, by the main axis of the river and ponds that are connected with the river during most of the year. The samples sites are the same of Fagundes, Behr and Kotzian (2007; 2008), Behr and Signor (2008), Lima and Behr (2010) and Zardo and Behr (2015).

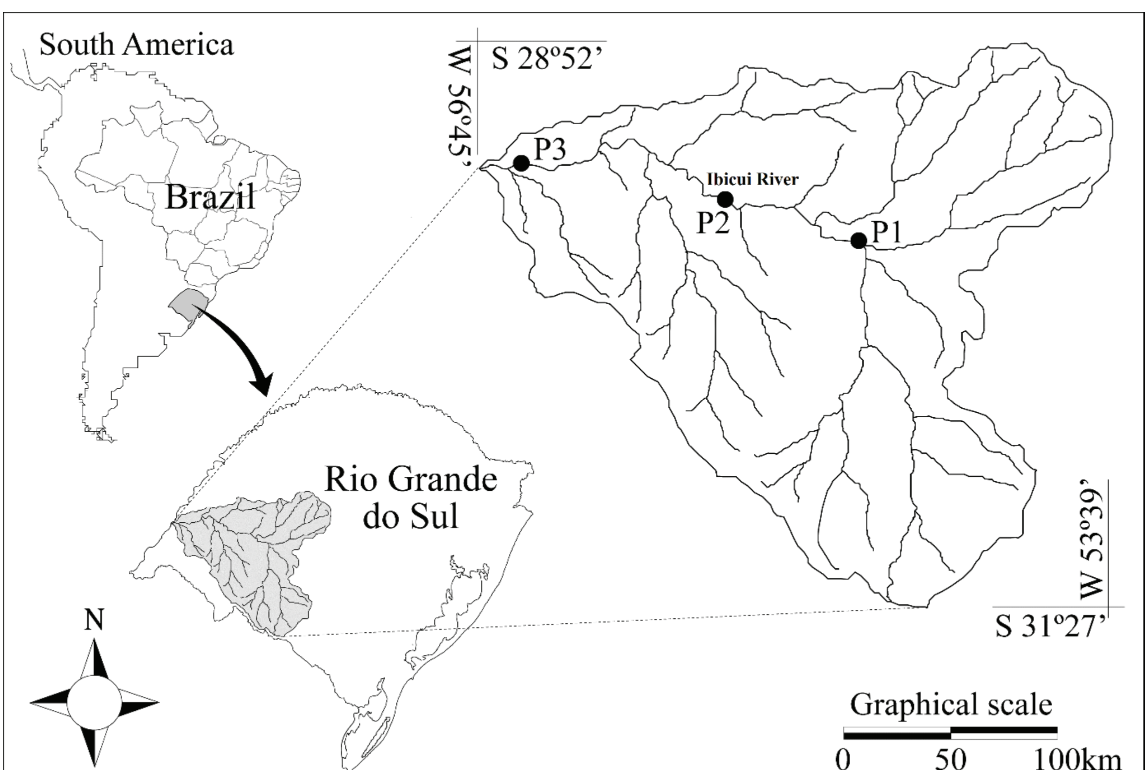

Figure 1. Location of the three sites (P1, P2 and P3) in the Ibicui river, Rio Grande do Sul State, Brazil.

Samplings were conducted every two months from January 2000 to December 2001, totaling 36 campaigns and 12 samplings at each site. For each environment, 10 m of gillnets with mesh sizes of 1.5, 2.0, 2.5 and 3 cm; 20 m of gillnets with mesh sizes of 4.0, 5.0, 6.0, 8.0 and 10.0 cm; trammel nets with mesh sizes of 4.0/20.0, 5.0/20.0 and 6.0/20.0 cm (all meshes measured between adjacent nodes). The nets remained in the water for 24 hours, and were checked every six hours (at 6:00, 12:00 18:00 and 24:00).

Fish were numbered, fixed in a 10% formalin solution and then preserved in alcohol 70%, as per Malabarba and Reis (1987), for further analyses. In laboratory, fish were measured for total length (L_t) and standard length (L_s), in centimeters, and total weight (W_t) in grams. Samples were collected under Ibama (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis) permit (135/99). Voucher specimens were deposited in the Museum of Science and Technology of PUC (MCP 44055 and MCP 28915).

Stomachs were removed and weighed, and the Stomach Fullness (SF) was rated for each stomach, according to the following scale: 0 = completely empty; 1 = up to 25% of the stomach with content; 2 = from 25% to 75% of the stomach with content; 3 = over 75% of the stomach with content. The Repletion Index was calculated as the ratio between the weight of the stomach and total weight (W_t) (Santos, 1978). Food items were identified under a stereomicroscope and optical microscope to the lowest possible taxonomic level. Such identification was performed as described in the literature (Bicudo & Menezes, 2006; Needham & Needham, 1982) and in consultation with specialists.

The items found in the food spectrum were grouped into 14 food categories, namely: detritus, sediment, nematode, larval Diptera (LD), other invertebrates (OI), larval Trichoptera (LT), Copepoda, Cladocera, other microcrustaceans, plant organic matter (POM), protozoa, algae, rotifers and fungi. In the detritus category, all fine particulate organic matter, in advanced stage of digestion, was considered, and it was not possible to determine whether they were of animal or plant origin. In the sediment category, sand particles and inorganic matter were included (Simabuku & Peret, 2002; Dias & Fialho, 2011). The POM category included organic matter with characteristics that enabled to affirm it derived from plant, such as leaves and stems in advanced stage of digestion, fibers and cell walls. The other invertebrates (OI) category included insects belonging to the orders Odonata, Coleoptera, Ephemeroptera and others in advanced stage of digestion, besides mites and gastropods. The other microcrustaceans category included organisms of the order Amphipoda and others in advanced stage of digestion, which prevented identification. Among algae, the groups Diatomacea, Clorophyta, Cianophyta and Euglenophyta are included.

Each food item was analyzed according to the frequency of occurrence (Hynes, 1950) and the volumetric method (Hyslop, 1980). Frequency of occurrence was calculated considering the number of stomachs that contained a given food in relation to the total number of stomachs with content, according to the following formula: $Fi = (Ni \times 100)/N$, where: Fi=Frequency of occurrence of the food item i; Ni = Number of stomachs containing the food item i; N=Total number of stomachs with content.

The volumetric proportion of each food item was estimated according to the percent contribution of food in relation to the total volume contained in the stomach, using graduated test tubes, graph paper and glass counting plate (Hellawell & Abel, 1971). Both methods were combined to obtain the Alimentary index (IAi) (Kawakami & Vazzoler, 1980), according to the following formula:

$$IAi = \frac{Fi \times Vi}{\sum_{j=1}^{n}(Fi \times Vi)} \times 100$$

where:

IAi =Alimentary Index; Fi= Relative frequency of item i; Vi= Volumetric share of item i.

The relationship between the percentages of frequency of occurrence and the volume of each food item was represented according to Costello's graphical index (Costello, 1990). The method consists of plotting the values of volume on the y-axis y and the occurrence on the x-axis. The item with higher frequency of occurrence and volume were used to determine the dominant food item.

Dietary variations of the major items consumed in relation to the frequency of occurrence were analyzed seasonally and according to environments using the Chi-squared test (χ^2) (expected equal ratios). To this end, the frequency of the occurrence of detritus, sediment, nematode and particulate organic matter (POM) were considered as variables and the bimesters and environments were considered as factors.

The feeding activity was assessed by means of the following parameters: mean Stomach Fullness (SF); Repletion Index (RI) (Santos, 1978); Vacuity Index (VI) (Albertini-Behaut, 1974) and intestinal quotient (IQ), represented by the intestine length/total length ratio (Zavala-Camin, 1996). The homogeneity of variances of these parameters was tested (Shapiro-Wilk; $p < 0.05$), and when not met, nonparametric statistics was applied. The SF and RI means were compared according to seasonality and circadian rhythm through the nonparametric Kruskal-Wallis test. The Mann-Whitney test was used to compare the same means regarding the environments (lotic and lentic environments). The IQ means were compared every two months by Anova, followed by tukey's test. All analyses considered 5% as a significance level.

Results and discussion

Individuals of *L. melanocheilus* (n = 373) used for the diet analysis presented an average standard length (Ls) of 18.44 cm (SD = 2.29) and average total weight (Wt) of 51.17 g (SD = 24.40).

According to the Alimentary index, detritus was the main food item in the diet (IAi = 56.38%), followed by plant organic matter (IAi = 29.57%), sediment (IAi = 8.27%) and nematode (IAi = 3.35%) (Table 1), considering all the samples. Only detritus, sediment, POM and nematode had a frequency of occurrence higher than 50%, and these were considered the most important food items in the *L. melanocheilus* diet, due to the higher frequency recorded and for having the highest volumetric percentages (Figure 2).

Some items were consumed only in certain periods of the year, and only detritus, sediment, OI, Copepoda, Cladocera, POM and algae were ingested throughout the year (Table 2). Major seasonal variations were not observed in the Alimentary index, and except for December/January, when POM was the most important item, detritus was the most consumed item during the two-month period. In April/May, POM showed a very low importance, and was less consumed than Copepoda, Nematode, LD, LT, Cladocera, sediment and OI (Table 3).

Regarding the environments, significant changes were not detected in the *L. melanocheilus* diet, and detritus was the main food item in both lentic and lotic environments. POM was less important (according to IAi) than sediment in lotic environments, although both items had presented the same frequency of occurrence (Table 4). All food items were recorded for lentic and lotic environments.

Sediment and POM had significant seasonal variations regarding the frequency of occurrence ($\chi^2 = 23.22; p < 0.001$) and ($\chi^2 = 83.11; p < 0.001$), with the highest frequencies recorded in December/January, respectively (Table 2). No significant differences between lentic and lotic environments were registered for the frequency of occurrence of the major items consumed, and the frequency of these items was similar in both environments.

The mean SF did not show significant variations bimonthly, environmental and according to circadian rhythm ($p > 0.05$), and the stomach repletion index (RI) showed significant seasonal ($H = 29.93; p < 0.001$) and environmental variation ($U = 11510.5; p < 0.001$), no significant variation was observed for the circadian rhythm ($H = 6.07; p = 0.108$) (Figures 3 and 4).

Table 1. Frequency of occurrence (*Fi*), volumetric percentage (*Vi*) and Alimentary index (*IAi*) of items consumed by *Loricariichthys melanocheilus* in the Ibicui River, RS, Brazil, considering all sampling periods.

Food items	*Fi*%	*Vi*%	*IAi*%
Detritus	94.59	45.49	56.38
POM	65.54	34.45	29.57
Sediment	65.54	9.63	8.27
Nematode	59.45	4.30	3.35
Copepoda	48.64	1.89	1.20
Other invertebrates	21.62	2.04	0.57
Cladocera	29.72	0.67	0.26
Larval Diptera	18.91	0.75	0.18
Algae	41.89	0.17	0.09
Larval Trichoptera	11.48	0.45	0.06
Protozoa	14.86	0.07	0.01
Other micro crustaceans	3.37	0.01	*
Rotifers	6.08	0.02	*
Fungi	3.37	-	-

*Values below 0.01.

The IQ was 1.51 (SD = 0.2) and showed significant seasonal variations, with higher values in June/July and October/November ($F = 13.82; p = 0.001$) (Table 5). The Vacuity Index was higher in June/July ($p < 0.05$) (Table 5). Fish caught at noon showed a greater number of empty stomachs and 53.50% fish caught at 18:00 had empty stomachs.

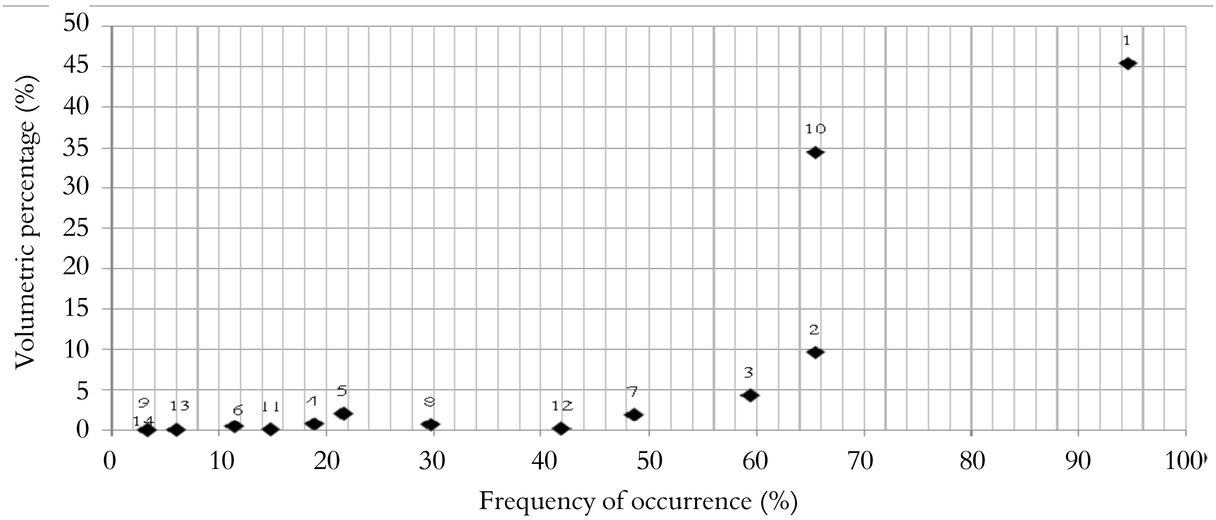

Figure 2. Costello plot with the frequency of occurrence (%) and volumetric percentage (%) of each food item consumed by *L. melanocheilus* in the Ibicui river, Rio Grande do Sul State, Brazil. 1 = Detritus; 2 = Sediment; 3 = Nematode; 4 = Larval Diptera; 5 = Other invertebrates; 6 = Larval Trichoptera; 7 = Copepoda; 8 = Cladocera; 9 = Other microcrustaceans; 10 = POM; 11 = Protozoa; 12 = Algae; 13 = Rotifer; 14 = Fungi.

Table 2. Bimonthly variation in the Frequency of Occurrence (%) and Volumetric Percentage (%) of the items eaten by *L. melanocheilus* in the Ibicui river, Rio Grande do Sul, Brazil.

	Dec-Jan (n=122)		Feb-Mar (n=91)		Apr-May (n=17)		June-July (n = 21)		Aug-Sept (n = 39)		Oct-Nov (n = 83)	
Food items	*Fi*	*Vi*	*Fi*	*Vi*	*Fi*	*Vi*	*Fi*	*Vi*	*Fi*	*Vi*	*Fi*	*Vi*
Detritus	95.55	35.67	90.69	52.03	100	56.13	100	88.29	94.11	69.10	96.55	70.78
Sediment	80.00	9.57	69.76	10.58	50.00	1.63	33.33	1.37	52.94	6.28	55.17	12.29
Nematode	66.66	3.89	69.76	6.91	62.50	10.81	-	-	47.05	1.82	51.72	2.84
LD	26.66	0.48	25.58	1.53	37.50	7.05	-	-	-	-	6.89	0.19
OI	22.22	2.89	18.60	0.64	37.50	1.37	33.33	0.48	17.64	1.61	20.68	0.12
LT	8.88	0.13	18.60	0.92	25.00	6.91	-	-	11.76	1.16	3.44	0.01
Copepoda	35.55	0.71	41.86	1.99	62.50	11.11	33.33	4.78	82.35	7.93	58.62	3.48
Cladocera	28.88	0.30	18.6	0.52	37.50	2.37	33.33	1.98	47.05	3.00	34.48	1.47
OM	4.44	0.01	-	-	-	-	-	-	5.88	0.03	6.89	0.03
POM	77.77	45.93	58.13	24.82	2.50	2.59	33.33	3.07	58.82	8.62	79.31	8.60
Protozoa	22.22	0.07	2.32	0.01	-	-	-	-	35.29	0.41	17.24	0.02
Algae	64.44	0.25	41.86	-	12.50	-	33.33	-	11.76	-	34.48	0.08
Rotifer	2.22	0.04	2.32	-	-	-	-	-	11.76	-	17.24	0.01
Fungi	6.66	-	2.32	-	-	-	-	-	-	-	6.89	-

LD=Larval Diptera; OI=Other Invertebrates; LT=Larval Trichoptera; OM=Other microcrustaceans; POM = Plant Organic Matter.

Table 3. Bimonthly variation and Food Index (%) of the items consumed by *Loricariichthys melanocheilus* in Ibicuí river, Rio Grande do Sul State, Brazil.

	Food Index (%)					
Food items	Dec-Jan (n = 122)	Feb-Mar (n = 91)	Apr-May (n = 17)	Jun-Jul (n = 21)	Aug-Sept (n = 39)	Oct-Nov (n = 83)
Detritus	41.88	62.55	73.37	95.76	78.54	79.41
POM	43.89	19.12	0.08	1.11	6.12	7.93
Sediment	9.40	9.78	1.07	0.49	4.01	7.88
Nematode	3.19	6.39	8.83	-	1.03	1.70
Copepoda	0.31	1.10	9.08	1.73	7.88	2.37
OI	0.79	0.15	0.67	0.17	0.34	0.03
Cladocera	0.10	0.12	1.16	0.71	1.70	0.59
LD	0.15	0.52	3.45	-	-	0.01
Algae	0.20	*	-	-	-	0.03
LT	0.01	0.22	2.25	-	0.16	*
Protozoa	0.02	*	-	-	0.17	*
OM	*	-	-	-	*	*
Rotifer	*	*	-	-	-	*
Fungi	*	*	-	-	-	-

*Values below 0.01. LD=Larval Diptera; OI=Other Invertebrates; LT=Larval Trichoptera; OM=Other microcrustaceans; POM =Plant Organic Matter.

Table 4. Frequency of Occurrence (%), Volumetric Percentage (%) and Alimentary Index (%), in lentic and lotic environments, of items consumed by *Loricariichthys melanocheilus* in Ibicui river, Rio Grande do Sul State, Brazil.

	Lentic (N=251)			Lotic (N=122)		
Food items	*Fi*	*Vi*	*IAi*	*Fi*	*Vi*	*IAi*
Detritus	93.00	40.54	50.89	95.91	61.66	72.43
Sediment	63.00	7.16	6.08	69.38	17.72	15.06
POM	65.00	43.14	37.84	65.30	6.07	4.86
Nematode	58.00	3.78	2.96	61.22	5.99	4.49
Copepoda	49.00	1.79	1.18	46.93	2.19	1.26
Algae	41.00	0.18	0.09	42.85	0.13	0.07
Cladocera	28.00	0.45	0.17	32.65	1.41	0.56
OI	24.00	1.80	0.58	16.32	2.82	0.56
Protozoa	15.00	0.05	0.01	14.28	0.12	0.02
LD	13.00	0.56	0.09	32.65	1.35	0.54
LT	8.00	0.45	0.04	18.36	0.46	0.10
Rotifer	8.00	0.03	*	2.04	0.40	0.01
Fungi	5.00	0	0	2.04	0	0
OM	4.00	0.01	*	2.04	0.01	*

*Values below 0.01. LD = Larval Diptera; OI = Other Invertebrates; LT = Larval Trichoptera; OM = Other microcrustaceans; POM = Plant Organic Matter.

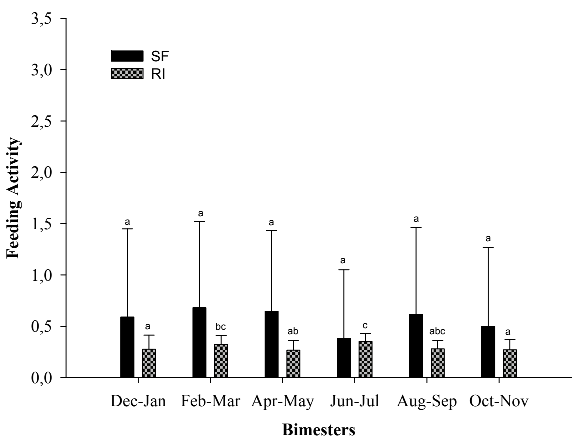

Figure 3. Bimonthly food activity of *Loricariichthys melanocheilus* according to the Stomach Fullnes (SF) and Repletion Index (RI) in the Ibicui river, Rio Grande do Sul State, Brazil.

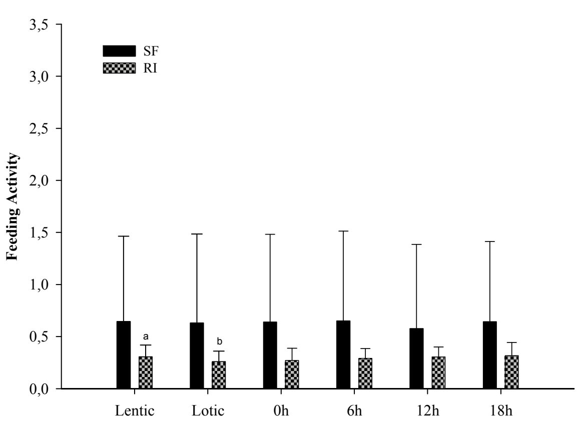

Figure 4. Environmental and daily variations in feeding activities, according to the repletion degree (RD) and repletion index (RI) of *Loricariichthys melanocheilus* in the Ibicui river, Rio Grande do Sul State, Brazil.

According to the Alimentary index, *L. melanocheilus* can be classified as a detritivorous species. This is primarily due to the frequency occurrence and high volumetric percentage of detritus, the most important food item found in all periods, except for December/January, and in both lentic and lotic environments.

Table 5. Variations in the intestinal quotient and respective standard deviations and Vacuity Index according to the studied environments and periods for *Loricariichthys melanocheilus* in the Ibicuí river, Rio Grande do Sul State, Brazil.

	N	Intestinal quotient	Vacuity Index
Lentic	251	1.52 ±0.21^{a}	60.59%
Lotic	122	1.48 ±0.17^{a}	59.83%
Dec-Jan	122	1.41 ±0.21^{a}	63.11%
Feb-Mar	91	1.54 ±0.17^{b}	53.74%
Apr-May	17	1.45 ±0.16^{ab}	52.94%
June-July	21	1.68 ±0.17^{c}	71.42%
Aug-Sep	39	1.52 ±0.15^{bd}	56.41%
Oct-Nov	83	1.55 ±0.25^{bcd}	65.06%

*Different letters in the same column indicate significant difference ($p < 0,05$).

Detritivorous feeding habits are commonly found in fish of the family Loricariidae, such as *Hypostomus* sp., *Loricaria* sp.,*L. prolixa*, *Loricariichthys sp.*, *L. platymetopon*, *R. aspera*, *L. labialis*, *S. robustum* and *R. parva* (Almeida & Resende, 2012; Agostinho et al., 1997). However, although numerous studies have classified these catfishes as detritivorous, some variations in the classification of the feeding habits of several species of this family have been observed, among them *E. pantherinus* classified as insectivorous (Dias & Fialho, 2011), *N. paranensis* classified as omnivorous (Rolla, Esteves & Ávila-da-Silva, 2009), *L. anus* as iliophagus-omnivorous (Albrecht & Silveira, 2001). Furthermore, Cardone et al. (2008) classified six species of the genus *Hypostomus* as iliophagus-detritivorous. Such classifications are often accompanied by some level of subjectivity because the methods for analysis of consumed foods sometimes disregard differences between microhabitats, behavior and even differences in food availability, and do not often consider ontogenetic variations (Albrecht & Silveira, 2001; Matthews, 1998). Another key aspect is that there is some controversy in the classification of the food items consumed, particularly items that are difficult to be analyzed, such as detritus and sediments, sometimes classifying the same species as iliophagus, phytoplanktivorous, detritivorous or benthivorous by different authors (Fugi, Hahn, & Agostinho, 1996).Araújo-Lima, Forsberg, Victoria and Martinelli (1986) reported that the stomach contents of detritivorous fish resemble a complex mosaic of food items, which include microinvertebrates, algae and bacteria, always surrounded by a great amount of detritus. Little is known about the actual nutritional value of detritus for fish and which items consumed with detritus are in fact digested and assimilated by them (Araújo-Lima et al., 1986).

POM and sediment items are also of great importance for the diet of *L. melanocheilus*, present in 65.54% of the stomach contents examined, with a Alimentary index of 29.57 and 8.27%, respectively. Plant remains represented an important food index of up to 67% of the diet of *L. anus* in two lakes of the coastal plain in Rio Grande do Sul State (Albrecht & Silveira, 2001), but the authors do not consider this species as an herbivore because, as described by Zavala-Camin (1996), herbivorous fish feed on live plant material such as higher plants, benthic macro- and microalgae and plankton. As described for *L. anus*, the plant material found in the stomach of *L. melanocheilus* was in advanced stage of decomposition, and probably was consumed with detritus and other organisms directly from the bottom of the environments. Sediment has also been cited as an important food item in the diet of Loricariidae (Albrecht & Silveira, 2001; Almeida & Resende, 2012; Agostinho et al., 1997), but, in many cases, the authors consider this item within the detritus category, which does not enable to distinguish the actual contribution of this item in the diet. Moraes, Barbola and Guedes (1997) affirm that the presence of sediment in the digestive tract of *P. lineatus* is because the fish search for other foods in the sediment or mud, once this item has low nutritional value and in some cases may help break the algae cell wall (Payne, 1978).

Consumption of algae is well documented for species of this family, once they are the major organisms in the formation of periphyton. However, in our study their volumetric contribution was low, and thus the Alimentary index is not representative. The major item found in the stomach of *L. melanocheilus* is the group of diatoms, because they are the most common organism of the microflora in several environments, also having greater resistance to digestion when compared to the other groups, and is always present in stomach content analyses (Moraes et al., 1997; Teixeira & Tundisi, 1967).

Detritus was always present as the major item in all periods, except for December/January, where the main item was POM. The frequency of occurrence of detritus in the stomach content of *L. melanocheilus* did not present significant variations over the year. The minor variations of this item in the Alimentary index are primarily related to the volume consumed, which increased in June/July, mainly due to the rise of the water level, which carries a great amount of organic matter from the terrestrial vegetation that is used as a food resource by fish. The high value of POM in the Alimentary index in December/January is primarily a response to an increase in the consumed volume, although the frequency of occurrence has also changed significantly during the year. Albrecht and Silveira (2001) found no large variations in the food importance index of the main items consumed by *L. anus* between winter and summer, but a small increase in the consumption of detritus/sediment was also verified in the winter. In studies on armored catfish and other scavenging fish, major seasonal variations in the items consumed were not registered either (Dias & Fialho, 2011; Giora & Fialho, 2003; Mazzoni et al., 2010).

Moreover, the main items consumed by *L. melanocheilus* showed minor variations in the Alimentary index in lentic and lotic environments, and such variations are related to the volume ingested rather than to the frequency of occurrence, which did not vary significantly between the environments. POM showed a significant increase in the volume consumed in lentic environments, which caused a considerable increase in the Alimentary index of this item in the ponds. As the consumption of the other items showed no major variations and all items were consumed in both types of environment, it can be affirmed that the diet of *L. melanocheilus* was practically the same in both lentic and lotic environments. Large seasonal and spatial variations in fish diets seem to occur mostly in omnivorous species with generalist and opportunistic strategies, once they do not have significant trophic specialization, thus adapting their diets according to the availability of resources (Abilhoa, Bornatowski & Otto, 2009; Da Silva, Fugi & Hahn, 2007; Fagundes, Behr & Kotzian, 2008; Lima & Behr, 2010). On the other hand, fish with marked morphological adaptations exhibited no large dietary variation, once the morphological characteristics, such as the position and shape of the mouth, the structure of the gill rakers, the teeth shape, intestine length, among others, allow the consumption of only certain types of food, and the diet is restricted to a relatively small number of items (Abelha, Agostinho & Goulart, 2001; Delariva & Agostinho, 2001).

The low SF and RI values, when compared to other species, and the presence of at least 50% of empty stomachs in all periods and environments indicate that *L. melanocheilus* does not have an intense feeding activity, and the food content remains for a short time in the stomach. According to the RI, there was an increased feeding activity in February/March, June/July and August/September. However, the low SF value and high VI value in June/July are in disagreement with the highest RI values in this period and indicate that the feeding activity in this period was reduced, mainly due to the higher percentage of empty stomachs, which contribute to the lower mean of SF. Stomachs of *L. melanocheilus* are tiny and have low weight or volume, and then RI becomes very dependent on the stomach weight, and not so much on the content weight. Thus, the low number of samples in June/July may has contributed to the high RI, due to the greater weight of few stomachs found in this period.

Though not significant, higher SF values found in February/March, April/May and August/September indicate a tendency of increase of the feeding activity during these months, also as a function of the lower percentage of empty stomachs (VI). These changes coincide with the periods before and after the peak of the reproductive period, which is in October/November and December/January (Zardo & Behr, 2015). Reductions in the feeding activity, mainly in females in the reproductive period, are expected because of a considerable increase in gonadal size, leading to a reduction of the coelomic cavity (Barbieri & Barbieri, 1984).

The feeding activity, according to the higher RI in lentic environments, is explained by the better adaptation of this species to the ponds, where the number of fish caught was greater, a characteristic also observed by Hahn et al. (1997) for *L. platymetopon*. The feeding activity of fish is usually higher in lentic environments when compared to channels and rivers, due to the higher trophic specialization in lakes, once, in rivers, food resources vary considerably according to the season (Hahn, Fugi, Almeida, Russo & Loureiro, 1997; Lowe-Mcconnell, 1999). Although no significant difference was recorded for the feeding activity according to the circadian rhythm, there was a slight tendency to increase at dusk. This pattern is found in numerous species, especially in Siluriformes, such as *P. maculatus* (Lolis & Andrian, 1996), *R. dorbignyi* and *I. labrosus* (Fagundes et al., 2007; 2008), *P. granulosus*, *A. nuchalis*, *P. galeatus* (=*T. galeatus*), *P. corruscans*, *S. lima*, *H. littorale*, among others (Hahn et al., 1997).

The IQ observed for *L. melanocheilus* is below that registered for *L. anus* (Petry & Schulz, 2000; Albrecht & Silveira, 2001), for other species of the family Loricariidae (Delariva & Agostinho, 2001) and other species considered detritivorous, such as *P. lineatus* and *S. brevipinna* (Moraes et al., 1997; Giora & Fialho, 2003). Although *L. melanocheilus* is classified as detritivorous, the IQ found is similar to the omnivorous (Ward-Campbell, Beamish & Kongchaiya, 2005). However, only single analyses of IQ values are not sufficient to determine the feeding habits of a species, and other morphological aspects and especially the items found in the stomach content should be considered. Furthermore, IQ variations are expected, according to the fish ontogenetic development, in response to dietary variations, and according to the feeding activity, higher in peak periods (Zavala-Camin, 1996). The highest IQ found in June/July, when compared to the other months, except for October/November, can be explained by a more detritivorous diet in this period, of difficult digestion, which requires a larger area for intestinal absorption and contact with digestive enzymes to optimize digestion (Baldisserotto, 2009).

Conclusion

It is concluded that *L. melanocheilus* has a detritivorous feeding. The feeding habit had no significant variations between seasons and environments, and the minor variations found were more related to the amount of each item consumed, because of individual or, possibly, environmental variations. The feeding activity was not intense, which is often found in bottom fish. There was a tendency for an increased feeding activity in the periods before and after the breeding period, and at dusk. The feeding activity in lentic environments was higher than lotic environments, which indicates a preference of the species for still waters.

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References

Abelha, M. C. F., Agostinho, A. A., & Goulart, E. (2001). Plasticidade trófica em peixes de água doce. *Acta Scientiarum. Biological Sciences, 23*(2), 425-434.

Abilhoa, V., Bornatowski, H., & Otto, G. (2009). Temporal and ontogenetic variations in feeding habits of *Hollandichthys multifasciatus* (Teleostei: Characidae) in coastal Atlantic rainforest streams, southern Brazil. *Neotropical Ichthyology,* 7(3), 415-420.

Agostinho, A. A., Hahn, N. S., Gomes, L. C., & Bini, L. M. (1997). Estrutura Trófica. In A. E. A. M. Vazzoler, A. A. Agostinho, & N. S. Hahn (Eds.), *A planície de inundação do alto rio Paraná: aspectos físicos, biológicos e sócio-econômicos* (p. 229-248). Maringá, PR: Eduem.

Albertini-Behaut, J. (1974). Biologie dês stades juveniles de teleosteens Mugilidae *Mugil auratus* Risso 1810, *Mugil capito* Cuvier 1829 et *Mugil saliens* Risso 1810. II. Modifications du regime alimentaraire em relation avec La taille. *Aquaculture, 4*(2), 13-27.

Albrecht, M. P., & Silveira, P. M. (2001). Alimentação de *Loricariichthys anus* (Teleostei, Loricariidae) nas lagoas Marcelino e Peixoto, planície costeira do Rio Grande do Sul. *Acta Limnologica Brasiliensia, 13*(2), 79-85.

Almeida, I. M., & Resende, E. K. (2012). Alimentação dos peixes detritívoros da Baía Tuiuiú, Rio Paraguai, Pantanal de Mato Grosso do Sul, Brasil. *Boletim de Pesquisa e Desenvolvimento.* Corumbá, MT: Embrapa Pantanal.

Andrian, I. F., & Barbieri, G. (1996). Espectro alimentar e variação sazonal e espacial na composição da dieta de *Parauchenipterus galeatus* Linnaeus, 1766 (Siluriformes, Auchenipteridae) na região do reservatório de Itaipu, PR. *Revista Brasileira de Biologia, 56*(2), 409-422.

Araújo-Lima, C. A. R. M., Forsberg, B. R., Victoria, R., & Martinelli, L. (1986). Energy sources for detritivorous fishes in the Amazon. *Science, 234*(4781), 1256-1258.

Baldisserotto, B. (2009). *Fisiologia de peixes aplicada à piscicultura*. Santa Maria, RS: Editora da Ufsm.

Barbieri, G., & Barbieri, M. C. (1984). Note on nutritional dynamics of *Gymnotus carapo* (L.) from the Lobo Reservoir, São Paulo State, Brazil. *Journal of Fish Biology, 24*(4), 351-355.

Behr, E. R., & Signor, C. A. (2008). Distribuição e alimentação de duas espécies simpátricas de piranhas *Serrasalmus maculatus* e *Pygocentrus nattereri* (Characidae, Serrasalminae) do rio Ibicuí, Rio Grande do Sul, Brasil. *Iheringia, Série Zoologia, 98*(4), 501-507.

Bicudo, C. E. M., & Menezes, M. (2006). *Gêneros de Algas de Águas Continentais do Brasil - Chave para Identificação e Descrições*. São Carlos, SP: Rima.

Braga, F. M. S., Gomiero, L. M., & Souza, U. P. (2008). Aspectos da reprodução e alimentação de *Neoplecostomus microps* (Loricariidae, Neoplecostominae) na microbacia do Ribeirão Grande, serra da Mantiqueira oriental (Estado de São Paulo). *Acta Scientiarum. Biological Sciences, 30*(4), 455-463.

Cardone, I. B., Lima-Junior, S. E., & Goitein, R. (2008). Diet and capture of *hypostomus strigaticeps* (Siluriformes, Loricariidae) in a small Brazilian stream: relationship with limnological aspects. *Brazilian Journal of Biology, 1* (66), 25-33.

Costello, M. J. (1990). Predator feeding strategy and prey importance: a new graphical analysis. *Journal of Fish Biology, 36*, 261-263.

Da Silva, E. L., Fugi, R., & Hahn, N. S. (2007). Variações temporais e ontogenéticas na dieta de um peixe onívoro em ambiente impactado (reservatório) e em ambiente natural (baía) da bacia do rio Cuiabá. *Acta Scientiarum. Biological Sciences, 29*(4), 387-394.

Delariva, R. L., & Agostinho, A. A. (2001). Relationship between morphology and diets of six neotropical Loricariids. *Journal of Fish Biology, 58*(3), 832-847.

Dias, T. S., & Fialho, C. B. (2011). Comparative dietary analysis of *Eurycheilichthys pantherinus* and *Pareiorhaphis hystrix*: two Loricariidae species (Ostariophysi, Siluriformes) from Campos Sulinos biome, Southern Brazil. *Iheringia. Série Zoologia, 101*(1-2), 49-55.

Fagundes, C. K., Behr, E. R., & Kotzian, C. B. (2007). Alimentação de *Rhinodoras dorbigny* (Kröyer, 1855) (Siluriformes: Doradidae) no rio Ibicuí, Rio Grande do Sul, Brasil. *Acta Scientiarum. Biological Sciences, 29*(2), 137-143.

Fagundes, C. K., Behr, E. R., & Kotzian, C. B. (2008). Diet of *Iheringichthys labrosus* (Siluriformes, Pimelodidae) in the Ibicui river, Southern Brazil. *Iheringia. Série Zoologia, 98*(1), 60-65.

Fugi, R., Agostinho, A. A., & Hahn, N. S. (2001). Trophic morphology of five benthic-feeding fish species of a tropical floodplain. *Revista Brasileira de Biologia, 61*(1), 27-33.

Fugi, R., Hahn, N. S., & Agostinho, A. A. (1996). Feeding styles of five species of bottom-feeding fishes of the high Paraná river. *Environmental Biology of Fishes, 46*(3), 297-307.

Giora, J., & Fialho, C. B. (2003). Biologia alimentar de *Steindachnerina brevipinna* (Characiformes, Curimatidae) do rio Ibicuí-mirim, Rio Grande do Sul, Brasil. *Iheringia. Série Zoologia, 93*(3), 277-281.

Hahn, N. S., Andrian, I. F., Fugi, R., & Almeida, V. L. L. (1997). Ecologia trófica. In A. E. A. M. Vazzoler, A. A. Agostinho, & N. S. Hahn (Eds.), *A planície de inundação do alto rio Paraná: aspectos físicos, biológicos e sócio-econômicos* (p. 209-228). Maringá, PR: Eduem.

Hahn, N. S., Fugi, R., Almeida, V. L. L., Russo, M. R., & Loureiro, V. E. (1997). Dieta e atividade alimentar de peixes do reservatório de Segredo. In A. A. Agostinho, & L. C. Gomes (Eds.), *Reservatório de Segredo - bases ecológicas para o manejo* (p. 141-162). Maringá, PR: Eduem.

Hellawell, J. M., & Abel, R. A. (1971). Rapid volumetric method for the analysis of the food of fishes. *Journal of Fish Biology, 3*(1), 29-37.

Hynes, H. B. N. (1950). The food of fresh-water sticklebacks (*Gasterosteus aculeatus* e *Pygosteus pungitius*), with a rewiew of methods used in studies of the food fishes. *Journal of Animal Ecology, 19*(1), 36-57.

Hyslop, E. J. (1980). Stomach contents analysis: a review of methods and their application. *Journal of Fish Biology, 17*(4), 411-429.

Kawakami, E., & Vazzoler, G. (1980). Método gráfico e estimativa de índice alimentar aplicado ao estudo de alimentação de peixes. *Boletim do Instituto de Oceanografia, 29*(2), 205-207.

Lima, D. O., & Behr, E. R. (2010). Feeding ecology of *Pachyurus bonariensis* Steindachner, 1879 (Sciaenidae: Perciformes) in the Ibicui river, Southern Brazil: Ontogenetic, seasonal and spatial variations. *Brazilian Journal of Biology, 70*(3), 503-509.

Lowe-Mcconnell, R. H. (1999). *Estudos ecológicos de comunidades de peixes tropicais.* São Paulo, SP: Edusp.

Lolis, A. A., & Andrian, I. F. (1996). Alimentação de *Pimelodus maculatus* Lacépède, 1803 (Siluriformes, Pimelodidae), na planície de inundação do alto rio Paraná, Brasil. *Boletim do Instituto de Pesca, 23*, 182-202.

Malabarba, L. R., & Reis, R. E. (1987). Manual de técnicas para a preparação de coleções zoológicas. *Campinas, Sociedade Brasileira de Zoologia, 36*, 1-14.

Matthews, W. J. (1998). *Patterns in freshwater fish ecology.* New York, USA: Chapman & Hall.

Mazzoni, R., Rezende, C. F., & Manna, L. R. (2010). Feeding ecology of *Hypostomus punctatus* Valenciennes, 1840 (Osteichthyes, Loricariidae) in a costal stream from Southeast Brazil. *Brazilian Journal of Biology, 70*(3), 569-574.

Moraes, M. F. P. G., Barbola, I. F., & Guedes, É. A. C. (1997). Alimentação e relações morfológicas com o aparelho digestivo do "curimbatá", *Prochilodus lineatus* (Valenciennes) (Osteichthyes, Prochilodontidae), de uma lagoa do sul do Brasil. *Revista Brasileira de Zoologia, 14*(1), 169-180.

Needham, J. G., & Needham, P. R. (1982). *Guia para El estúdio de los seres vivos de lãs aguas dulces*. Barcelona, ES: Editorial Reverte.

Payne, A. I. (1978). Gut pH and digestive strategies in estuarine grey mullet (Mugilidae) and tilapia (Cichlidae). *Journal of Fish Biology, 13*(5), 627-629.

Petry, A. C., & Schulz, U. H. (2000). Ritmo de alimentação de juvenis de *Loricariichthys anus* (Siluriformes, Loricariidae) da lagoa dos Quadros, RS. *Iheringia. Série Zoologia, 89*, 171-176.

Rambo, B. (1994). *A fisionomia do Rio Grande do Sul.* São Leopoldo, RS: Unisinos.

Reis, R. E., & Pereira, E. H. L. (2000). Three new species of the loricariid catfish genus *Loricariichthys* (Teleostei: Siluriformes) from Southern South America. *Copeia, 2000*(4), 1029-1047.

Rolla, A. P. P. R., Esteves, K. E., & Ávila-Da-Silva, A. O. (2009). Feeding ecology of a stream fish assemblage in an Atlantic Forest remnant (Serra do Japi, SP, Brazil). *Neotropical Ichthyology, 7*(1), 65-76.

Santos, E. P. (1978). *Dinâmica de populações aplicada à pesca e piscicultura*. São Paulo, SP: Hucitec/Edusp.

Soares, C. M., Hayashi, C., Furuya, W. M., Furuya, V. R. B., & Maranhão, T. C. F. (1997). Alimentação natural de larvas do cascudo-preto *Rhinelepis aspera* Agassiz, 1829 (Osteichthyes-Loricariidae) em tanques de cultivo. *Boletim do Instituto de Pesca, 24*, 109-117.

Simabuku, M. A. M., Peret, A. C. (2002). Alimentação de peixes (Osteichthyes, Characiformes) em duas lagoas de uma planície de inundação brasileira da bacia do rio Paraná. *Interciência, 27*(6), 299-230.

Teixeira, C. I., & Tundisi, J. (1967). Primary production and phytoplankton in equatorial waters. *Bulletin of Marine Science, 17*(4), 991-994.

Ward-Campbell, B. M. S., Beamish, F. W. H., & Kongchaiya, C. (2005). Morphological characteristics in relation to diet in five coexisting Thai fish species. *Journal of Fish Biology, 67*(5), 1266-1279.

Zardo, É. L., & Behr, E. R. (2015). Population structure and reproductive biology of *Loricariichthys melanocheilus* Reis & Pereira, 2000 (Siluriformes: Loricariidae) in the rio Ibicuí, Brazil. *Neotropical Ichthyology, 13*(2), 371-382.

Zavala-Camin, L. A. (1996). *Introdução aos estudos sobre alimentação natural em peixes*. Maringá, PR: Eduem.

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