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Original Research Article

Assessment of the Constituent Minerals of Fish Species Captured in the Lower Stretch of the Itapecuru River, Maranhão, Brazil

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The concentrations of the constituent minerals calcium, iron, potassium, magnesium, phosphorus, zinc, copper, iodine, selenium and nickel were determined in the muscle tissue of the following seven species of fish collected in the lower stretch of the Itapecuru River, northeastern Maranhão, Brazil: *Plagioscion squamosissimus*, *Geophagus surinamensis*, *Curimata sp.*, Schizodon dissimilis, *Ageneiosus ucayalensis*, *Hypostomus plecostomus* and *Prochilodus lacustris*. Samples of muscle were digested in a nitric-perchloric solution and then analyzed using an inductively coupled plasma (ICP) atomic emission spectrometer (Model 720-ES, VARIAN brand) and specific calibration curves for each element. Analyses were performed in triplicate. The analyzed individuals were small in size. The shortest total length of 6.7 cm was observed in *G. surinamensis*, and the longest total length of 38.7 cm was observed in *P. lacustris*. With regard to total weight, the minimum and maximum values were 11.0 g and 465.3 g for the species *P. squamosissimus* and *H. plecostomus*, respectively. The concentrations of all minerals can be considered low and are present in concentrations below the maximum limits established by the Brazilian legislation for human ingestion of fish. A comparison of the seven investigated species of fish revealed no statistically significant differences between the concentrations of minerals, suggesting that the size and dietary habit differences did not exert an influence on absorption.

Keywords: Fish, Soft tissue, Minerals, Spectrophotometry, Itapecuru River, Brazil.

INTRODUCTION

Currently, many human populations depend on fish as a part of their main daily diet, especially in developing countries, where this aquatic resource contributed 19.6% of the animal protein consumed in 2010 (FAO, 2014). There is a pressing need for basic food in these countries, making fish an essential nutritional item for maintaining the health of their inhabitants.

The expansion of nutrition as an area of knowledge has enabled researchers to emphasize the advantages of fish as food, due to its high nutritional value, especially in regard to the ingestion of numerous minerals that are present in the organs and tissues in considerable quantities (Lederer, 1991; Menezes, 2006; Stansby, 1976). Fish flesh is generally considered a particularly valuable source of calcium and phosphorus, but it also contains reasonable quantities of sodium, magnesium, manganese, chlorine, sulfur, selenium, chromium, nickel, aluminum, cobalt, zinc, potassium, iron, copper and iodine (Connell, 2005). Some of these elements represent the so-called macroelements, of which an adult human being requires 100 mg/day or more, whereas others represent microelements, or trace elements, of which a human being requires only minimal quantities (Mahan and Escott-Stump, 2005). The sustainability and improved quality of life for low-income populations has been a concern of many governments around the world, and the global demand for high nutritional value in food makes fish one of the most consumed meats.

Despite the consensus that fish intake is beneficial for humans, scientific studies on the mineral constituents in fish in Brazil are still insufficient. Thus, studies in Brazil that include data on the quality of fish from artisanal fisheries are of great importance to ensuring adequate food and nutrition security in low-income populations living in tropical river basins.

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MATERIAL AND METHODS

This study is based on data from quarterly collections performed between the months of June 2012 and May 2013 at three sampling sites located in the lower stretch of the Itapecuru River between the ITALUÍS water catchment system and the mouth in the city of Rosario. The spatial distribution is shown in Figure 1.

The identification of fish species was made based on the works of Britski (1972), Mees (1974), Isbrücker (1979), Britski et al. (1988), Vari (1988), dos Santos, Jégu, and de Mérona (1984), dos Santos, de Mérona, Juras, and Jégu (2004), Piorski, Castro, Pereira, and Musiz (1998), Piorski, Castro, and Sousa-Neto (2007) and de Mérona, Juras, dos Santos, and Cintra (2010). A taxonomic update was performed through access to Fishbase (Froese and Pauly, 2015).

Among the specimens captured, individuals of seven species were selected for muscle tissue removal based on the capture volume and marketing potential. The samples considered had the best organoleptic conditions, independent of the size of the species and sex. The following taxa were selected: *Plagioscion squamosissimus*, *Geophagus surinamensis*, *Curimata sp*., *Schizodon dissimilis*, *Ageneiosus ucayalensis*, *Hypostomus plecostomus* and *Prochilodus lacustris,* and morphometric measurements of total length (cm), total weight (g) and sex were taken. Some individuals of each species were filleted, regardless of sex, anatomical differences and physiological characteristics. Then, a portion of the lateral-medial region (abdominal muscle filet) was sampled. The samples were skinless, boneless, representative of the edible part of each individual, and equivalent to approximately 200 g.

Subsequently, the samples were placed in labeled plastic bags and frozen at -17° C and transported to the Quality Control Laboratory of Food and Water, Department of Chemical Technology, Federal University of Maranhão (UFMA), where ash content analyses were performed. They were then processed at the Soil Chemistry Laboratory of the Technological Center of Rural Engineering, Maranhão State University (UEMA) for mineral analyses of the chemical elements calcium, iron, potassium, magnesium, phosphorus, zinc, copper, iodine, selenium and nickel.

The determination of the elemental concentrations was performed via the analyses of ash, obtained by dry digestion after complete decomposition of the fish muscle tissue, as adapted from Jones and Case (1990) and Perkin-Elmer (1973). The solutions were analyzed in an inductively coupled plasma atomic emission spectrophotometer (model 720-ES, VARIAN brand) and specific calibration curves were used for each element. The analyses were conducted in triplicate. To compare the chemical and nutritional compositions between species, we used a one-factor analysis of variance, after attaining the homogeneity of assumptions and normality of the data with the use of the Levene test. When the results of the analysis of variance (ANOVA) indicated the presence of significant differences ($p < 0.05$), the posteriori Tukey test was used to identify the differences between the means, adopting a significance level of $\alpha = 0.05$. In cases where the ANOVA assumptions were not met, we used the non-parametric method of Kruskal-Wallis (Conover, 1990) and the nonparametric Mann-Whiney U test to compare possible differences between means. A multivariate analysis employing the ordination technique of principal components (PCA) was used to verify the association between the sampled species and the element concentrations based on the matrix of variance-covariance. The evaluations were conducted using the statistical package Palaeontological Computational Statistics (PAST), version 2.17 (Hammer et al., 2001).

RESULTS AND DISCUSSION

Studies on minerals are essential for understanding the effects associated with the consumption of fish by humans. Though the physiological importance is well documented for some animals, many aspects of ingestion, function and bioavailability need to be better understood (Watanabe *et al*., 1997). Information on the nutritional micronutrient requirements of the fish is also fragmentary, especially because many micronutrients are needed only in very small quantities.

Table 1 presents the morphometric variables and the feeding habits of the analyzed species. These parameters may influence the levels of minerals in the fish. The values of total length and total weight, as well as the standard deviation and amplitude of variation, are also presented.

The individuals analyzed were small in size. The lowest value of total length was 6.7 cm, recorded for the species *G. surinamensis*, and highest value was 38.7 cm, recorded for *P. lacustris*. With regard to the total weight, the minimum and maximum values were 11.3 g and 465.3 g, recorded for the species *G. surinamensis* and *H. plecostomus*, respectively. The mineral concentrations observed in the muscles of fish from the examined species (*P. squamosissimus, G. surinamensis, Curimata sp., P. lacustris, S. dissimilis, A. ucayalensis and H. plecostomus*), are shown in Table 2.

Some metals are considered to be nutritionally essential and play important roles in biological processes but can become harmful when ingested in greater than normal quantities (Amundsen *et al*., 1997; Ashraf *et al*., 2006).

The following results are presented to show the variability in concentrations of the mineral constituents of the fish species investigated in this study.

Calcium (Ca)

Fish absorb calcium directly from the water and do not require additional food-based sources of this element. The level of dissolved Ca in the environment also acts as a stimulus for hormone synthesis and maintenance of cell membrane integrity. The concentration of Ca in the fish is mediated by its diffusion through the gills and skin as well as by absorption through the intestine. Considering the seven species analyzed during the study, the mean Ca concentration values were higher in the species *G. surinamensis* (63.34 mg 100 g^{-1}), *Curimata sp.* (62.81 mg 100 g^{-1}) and *P. lacustris* (60.81 mg 100 g^{-1}).

The lowest values of this metal were detected in the species *A. ucayalensis* (21:42 mg 100 g^{-1}) and *H. plecostomus* (22.68 mg 100 g^{-1}). The average concentrations and the standard deviation ranged from 21.42 ± 11.73 mg 100 g^{-1} to 63.34 ± 1:40 mg 100 g^{-1}. Because only one individual of the species *P. lacustris* was analyzed, no mean or standard deviation is presented.

Iron (Fe)

The iron content in fish is very low compared with mammals. Information on the absorption and metabolism of this mineral in fish are very limited, but the available records indicate that the process is usually the same as in other vertebrates. Although the gill membranes absorb a certain amount of iron, the intestinal mucosa is considered to be the main absorption pathway.

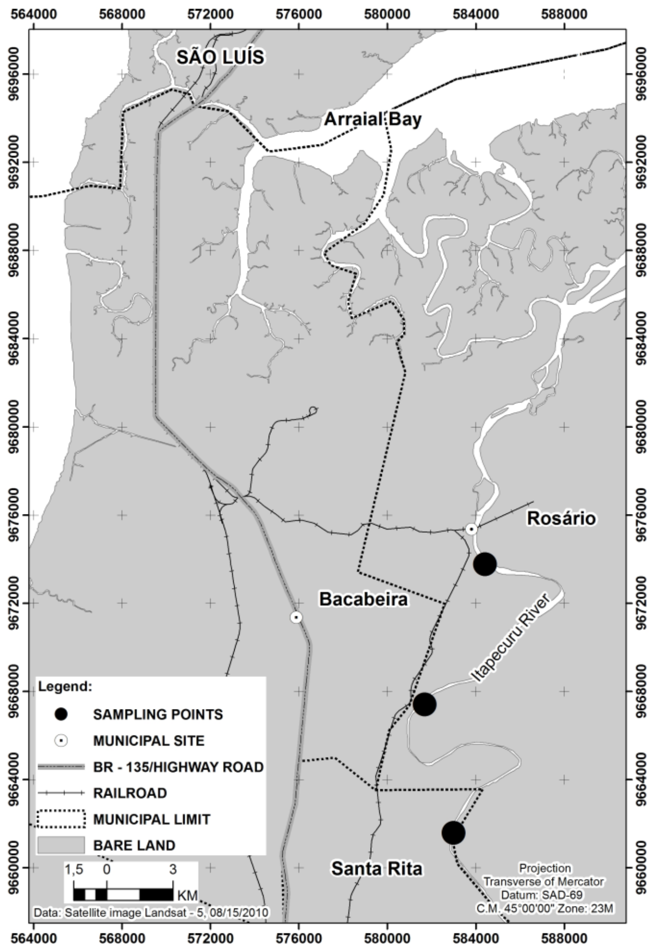

Figure 1. Location map of the points of fish sampling in the lower stretch of the Itapecuru river.

Table 1. Taxonomy, morphometric variables and feeding habit of the species analyzed.

Order	Family	Species	N	Wt (g)	Lt (cm)	Feeding habit
Perciformes	Sciaenidae	*P. squamosissimus*	25	102.5 ± 80.63 months (313.7-21.7)	16.2 ± 3.8 (24.6 - 10.5)	Carnivore
Characiformes	The Curimatidae	*Curimata* sp.	12	69.7 ± 21.0 (93.7 - 35.3)	13.1 ± 1.4 (15.0 - 10.5)	Dentritívore
Perciformes	Cichlidae	*G. surinamensis*	19	34.6 ± 12.4 (61.4 - 11.3)	9.6 ± 1.1 (11.6 - 6.7)	Dentritívore
Characiformes	Anostomidae	*S. dissimilis*	5	(218.7 140.8 ± 78.2 - 55.4)	18.9 ± 3.9 (22.5 - 14.4)	Herbivore
Siluriformes	Auchenipterida e	*A. ucayalensis*	7	47.5 ± 12.2 (61.3 - 28.6)	16.5 ± 1.5 (18.5 - 14.2)	Carnivore
Siluriformes	Loricariidae	*H. plecostomus strain*	7	203.3±155.8 (465.3- 32.5)	18.0 ± 5.2 (25.6 - 10.5)	Dentritívore
Characiformes	Prochilodontida e	*P. lacustris*	4	107.9 ± 11.5 (123.2 - 96.5)	33.2 ± 4.12 (38.7 - 29.6)	Dentritívore

Table 2. Mean values and standard deviation of the concentrations of the mineral constituents of seven species in the lower stretch of the Itapecuru River

Minerals mg.100g $^{-1}$	Species						
	P. squamosissimus	***Curimata sp.***	***P. lacustris***	***G. surinamensis***	***S. dissimilis***	***A. ucayalensis***	***H. plecostomus strain***
Ca	44, 56 ± 12.74	62.81 ± 51.78	60.81*	63.34 ± 1.40	23.32 ± 10.31	21.42 ± 11.73	To 22.68 ± 13.89
Fe	1.31 ± 0.95	1.34 ± 0.79	1.17*	1.40 ± 0.87	1.73 ± 1.16	1.05 ± 0.07	1.57 ± 0.05
K	85.96 ± 17.29	115.94 ± 89.87	144.6*	85.84 ± 17.88	97.84 ± 5.75	61.09 ± 12.33	75.61 ± 12.97
Mg	22.08 ± 2.41	29.49 ± 14.69	20.46*	25.84 ± 7,92	25.43 ± 1.62	20.55 ± 1.60	21.59 ± 1.51
P	238.76 ± 49.69	298.69 ± 210.92	269.52*	399.83 ± 255.58	220.50 ± 0.01	142.7 ± 12.26	194.75 ± products 23.41
Zn	0.58 ± 0.29	1.48 ± 1.99	0.77*	1.39 ± 0.55	0.51 ± 0.04	0.52 ± 0.02	0.62 ± 0.11
Cu	0.47 ± 0.69	0.12 ± 0.15	0.13*	0.28 ± 0.54	-	0.76 ± 0.89	0.18 ± 0.29
I	3.22 ± 0.44	3.17 ± 0.71	-	4.75 ± 1.39	3.98 ± 0.88	4.12 ± 3.81	2.52 ± 2.13
If	8.31 ± 3.72	10.11 ± 3.69	-	9.88 ± 12.01	12.25 ± 0.03	-	0.061*
Ni	61.97 ± 13.03	90.2*	48.24*	No 38.01 ± 18.66	-	-	63.46*

* = analysis based on only one measurement.

The analyzed values of Fe showed little variation in their concentrations between the studied species. The average and standard deviation of Fe varied between 1.05 ± 0.07 and 1.73 ± 1.16 mg 100 g^{-1}. The greatest average value for this metal was found in *S. dissimilis* (1.73 mg 100 g^{-1}).

The species *A. ucayalensis* and *P. lacustris* were found to have the lowest Fe values, with concentrations of 1.05 and 1.17 mg 100 g^{-1}, respectively. The averages for the seven studied species showed the following pattern: *N. dissimilis* (1.73 mg 100 g^{-1}) > *H. plecostomus* (1.57 mg 100 g^{-1}) > *G. surinamensis* (1.40 mg 100 g^{-1}) > *Curimata* sp. (1.34 mg 100 g^{-1}) > *P. squamosissimus* (1.31 mg 100 g^{-1}) > *P. lacustris* (1.17 mg 100 g^{-1}) > *A. ucayalensis* (1.05 mg 100 g^{-1}).

Potassium (K)

Potassium is an important mineral for muscle contractions, transmission of nerve impulses and metabolism of sugar. The potassium concentrations among the species of fish ranged from 47.65 - 247.90 mg 100 g^{-1}. These concentrations fell within the FAO-defined range of 19 - 502 mg /100 g (FAO/WHO, 2001). The mean concentrations of this metal varied significantly among the studied species. *A. ucayalensis* presented the lowest average value (61.09 mg 100 g $^{-1}$), whereas *P. lacustris* exhibited the highest value (144.6 mg 100 g $^{-1}$). The average concentrations and deviations of K for the studied species varied between 61.09 ± 12.33 mg 100 g $^{-1}$ to 144.6* mg 100 g^{-1} (the latter figure does not have a standard deviation due to the sampling of only one individual).

Mogobe, Mosepele, K., and Masamba (2015), Alas, Özcan and Harmankaya (2014) and Tao, Wang, Gong, and Liu (2012) recorded ranges of 245-443 mg 100 g $^{-1}$ in the Okavango Delta (Africa), 321-441 mg / 100 g in Turkey, and 301 - 402 mg 100 g $^{-1}$ in China, respectively. In this context, relatively low K values are present in the fish caught in the lower stretch of Itapecuru River. However, in the study area, a species of the genus *Curimata sp.* was observed to have the highest concentration of this element (247.90 mg 100 g $^{-1}$, including an average of 115.94 mg 100 g $^{-1}$), because the analysis of *P. lacustris* was based on a sample that limited the use of descriptive statistics.

Magnesium (Mg)

Magnesium is present in muscles and plays a crucial role in the metabolisms of aquatic organisms, particularly in cases involving enzymatic compounds of the electron donor/acceptor system (Gao *et al*., 2003). It is a macroelement and an activator of enzymatic systems that control the metabolism of carbohydrates, fats, proteins and electrolytes, acting as a cofactor of oxidative phosphorylation (Oliveira *et al.*, 2014).

This metal also has an influence on the integrity of and transport within the cell membrane and in the transmission of nerve impulses, aiding in muscle contraction and in energy metabolism (Pinheiro, Porto, & Menezes, 2005). Mg was present in very similar concentrations in all species sampled. The highest values recorded were 29.49 mg 100 g^{-1} for the species *Curimata* sp., followed by 25.84 mg 100 g^{-1} for the species *G. surinamensis.* The lowest values were 20.46 mg 100 g^{-1} and 20.55 mg 100 g^{-1} for the species *P. lacustris* and *A. ucayalensis*, respectively.

The average concentrations of Mg in the seven species studied ranged from 20.46 to 29.49 mg 100 g^{-1}. The studied species exhibited the following order in terms of increasing concentration: *P. lacustris* (20.46 mg 100 g^{-1}) < *A. ucayalensis* (20.55 mg 100 g^{-1}) < *H. plecostomus* (21.59 mg 100 g^{-1}) < *P. squamosissimus* (22.08 mg 100 g^{-1}) < *S. dissimilis* (25.43 mg 100 g^{-1}) < *G. surinamensis* (25.84 mg 100 g^{-1}) < *Curimata* sp. (29.49 mg 100 g^{-1}).

Phosphorus (P)

Together with calcium and magnesium, phosphorus is one of the main constituents of bones. The concentrations of this mineral showed no significant differences between the species sampled in the lower course of the Itapecuru River, with a range of 128.27-809.82 mg/100 g among all the analyzed samples. The highest P content (mg/100 g 809.82) was registered for *G. surinamensis*, a dentritívorous species that is small in comparison to the other taxa. Mogobe *et al*., 2015 also observed the highest concentrations of P in a small species, *Barbus poechii*, in comparison to the other samples.

The range of P concentrations obtained in the present study is higher than the values established by the FAO/WHO (2001) (68-550 mg/100) and is also higher than those of other freshwater fish recorded around the world by Alas, Özcan and Harmankaya (2014), (232-426 mg 100 g^{-1}) and Tao *et al.* (2012), (198-240 mg 100 g^{-1}). However, the range is lower than that obtained by Luczynska, Tonska, and Luczynska (2009), who observed a range of 1047-1261 mg 100 g^{-1}.

The recommended daily intake for adults is 700 mg P. Therefore, a serving of only 100 g of fish from the lower course of the Itapecuru River could contribute, on average, at least 40% of the daily requirement, which highlights the high phosphorous content found in this watercourse in northeastern Brazil. The average P concentration observed in the studied species remained between 142.7 mg 100 g^{-1} and 399.86 mg 100 g^{-1}, with the lowest value in the species *A. ucayalensis* and the highest value in *G. surinamensis.*

The studied species exhibited the following order in terms of decreasing concentration: *G. surinamensis* (399.83 mg 100 g^{-1}) > *Curimata* sp. (298.69 mg 100 g^{-1}) > *P. lacustris* (269.52 mg 100 g^{-1}) > *P. squamosissimus* (238.76 mg 100 g^{-1}) > *S. dissimilis* (220.50 mg 100 g^{-1}) > *H. plecostomus* (194.75 mg 100 g^{-1}) > *A. ucayalensis* (142.7 mg 100 g^{-1}).

Zinc (Zn)

When accumulated in large quantities in fish, this metal causes histopathological alterations in the gills, such as hyperplasia, lamellar fusion, destruction of epithelium and excessive production of mucus (Hogstrand, Wilson, Polgar, & Wood, 1994; Marques, Matta, Oliveria, & Dergam, 2009). Additionally, this metal causes disturbances in the acid-base balance (Hogstrand *et al*, 1994) and immunotoxic effects (Mottin *et al*, 2010). Kuz'mina (2011) evaluated the effect of Zn on the behavior of fish (larvae of *Chironomus* sp.) and observed that exposure to this element causes a reduction in the consumption of food.

In addition, it can clog the interlamellar spaces, blocking the movement of respiration, while also promoting the delay of growth and maturation (Atli & Canli, 2010). The results of the analysis of the mean concentrations of this metal in all the studied species varied little among the study sites. The species *Curimata* sp. presented the highest value (1.48 mg 100 g^{-1}), and the species *S. dissimilis* presented the lowest value (0.51 mg 100 g^{-1}). The average concentrations and standard deviation values of Zn for the studied species ranged from 0.51 ± 0.04 to 1.48 ± 1.99 mg 100 g^{-1}.

Copper (Cu)

Numerous studies have examined fish that have been exposed to copper (dos Santos Carvalho, Bernusso, Araújo, Espíndola, & Fernandes, 2012; Mottahari *et al*, 2013; Ransberry, Morash, Blewett, Wood, & McClelland, 2015) and have found that its toxicity can be fostered by multiple stressors that alter the behavior of fish through synergistic effects associated with other metals (dos Santos Carvalho, Bernusso, & Fernandes, 2015). In general, the toxicity of copper is highly influenced by the physical and chemical characteristics of the water, such as hardness, alkalinity, pH, temperature and dissolved oxygen concentration (Carvalho *et al*, 2015).

Therefore, to determine whether a species of fish is more sensitive than another in relation to the toxicity of copper, certain physico-chemical characteristics of the water should be taken into consideration. The values of Cu showed little variation among the studied species. This metal was not detected in *S. dissimilis*. The largest value detected was 0.76 mg 100 g^{-1} for the species *A. ucayalensis* and the lowest value for this metal was 0.12 mg 100 g^{-1} for the species *Curimata* sp.

Iodine (I)

Iodine is involved in thyroid hormones, which regulate the level of metabolic activity in fish. The hormones have great influence on the cellular oxidation, neuromuscular control, circulatory dynamics, nutrient metabolism and growth. This mineral can be ingested from the surrounding water through the gills, and the absorption rate is inversely dependent on the calcium content of the water (Hunn & Fromm, 1966). As sea water contains more iodine than freshwater, signs of deficiency of this mineral are larger in freshwater fish (Freshwater Working Group).

The studied species exhibited the following order in terms of decreasing concentration: *G. surinamensis* (4.75 mg 100 g^{-1}) > *A. ucayalensis* (4.12 mg 100 g^{-1}) > *S. dissimilis* (3.98 mg 100 g^{-1}) > *Curimata sp.* (3.17 mg 100 g^{-1}) > *P. squamosissimus* (3.22 mg 100 g^{-1}) > *H. plecostomus strain* (2.52 mg 100 g^{-1}). The average concentrations and the standard deviation values of I for the studied species ranged from 2.52 ± 2.13 to 4.75 ± 1.39 mg 100 g^{-1} (no I was detected in the species *P. lacustris*).

Selenium (Se)

Selenium is essential for animals, including fish, and is used to avoid nutritional muscular dystrophy processes when combined with vitamin E. It is an integral component of glutathione peroxidase. The level of this enzyme in the liver or plasma is indicative of the feeding activity of the organism. Selenium deficiency is usually associated with reduced growth.

Moreover, Se is also able to protect fish from spread the toxicity of heavy metals, such as cadmium and mercury. The analyses in the study area indicated the absence of this element in the species *P. lacustris* and *A. ucayalensis*. The lowest value identified for this mineral constituent occurred in *H. plecostomus strain*, with a concentration of 0.061 mg 100 g^{-1}, and the highest value detected was 10.11 mg 100 g^{-1} in *Curimata* sp.

Nickel (Ni)

Nickel is a transition metal that is relatively abundant in the crust, and Brazil has the third largest reserve in the world (Palermo, Risso, Simonato, & Martinez, 2015). Several anthropogenic processes, including mining, smelting, refining, manufacturing of stainless steel and Ni-CD batteries have resulted in Ni contamination in many aquatic environments (Bielmyer, DeCarlo, Morris, & Carrigan, 2013). The Brazilian law stipulated a maximum permissible limit of 25 µg L-1 in continental waters, although levels greater than 100 µg L^{-1} have been detected in the muscle tissue of several species of fish collected in Brazilian basins with high levels of heavy metals (Meche *et al,* 2010). The results of the analysis of the mean concentrations of this metal in all species used in this study ranged between 38.01 to 90.2 mg 100 g^{-1}.

The species *Curimata* sp. exhibited the highest value (90.2 mg 100 g^{-1}), and the species *G. surinamensis* exhibited the lowest value (38.01 mg 100 g^{-1}). This metal was not detected in the species *S. dissimilis* and *A. ucayalensis* during the study period. The average element concentration values showed no significant differences ($p > 0.05$) when submitted to analysis of variance, demonstrating the similarity among the species of different sizes and eating habits.

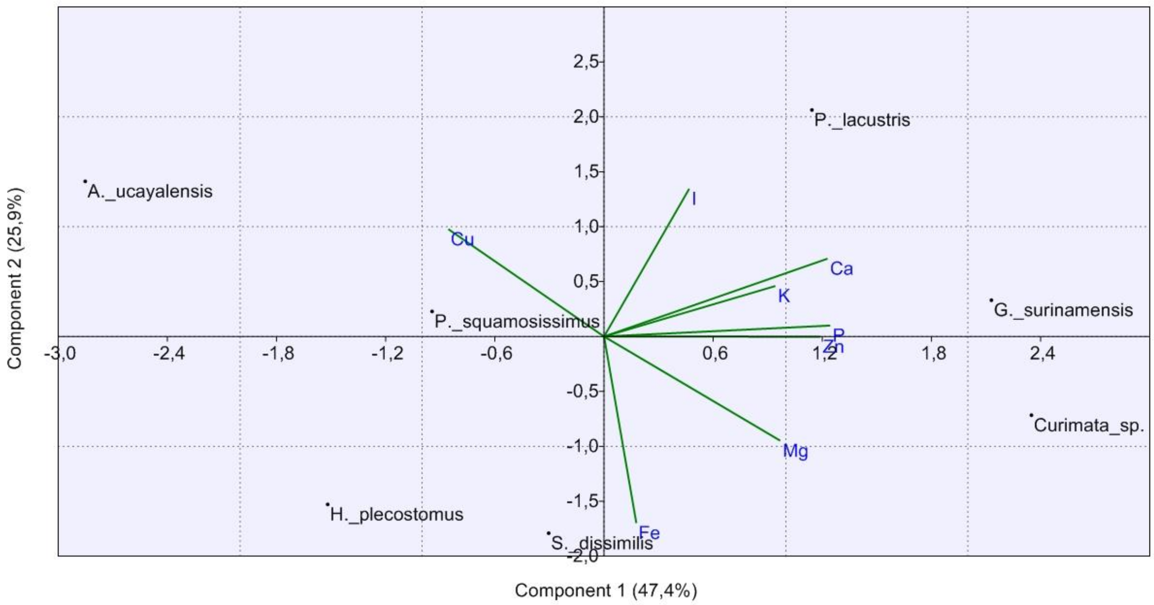

Figure 2 Factorial Plan resulting from the analysis of the main components in the mineral concentration of species caught in the lower stretch of the river Itapecuru.

The principal component analysis showed that the first two components explain 73.3% of the variability in the data (Figure 2). The species *P. lacustris* and *G. surinamensis* correlate positively with Component 1, associated with the concentrations of phosphorus, potassium, calcium and iodine, whereas the species *Curimata* sp. and *S. dissimilis* correlate negatively with Component 2, associated with the concentrations of zinc, magnesium and iron.

CONCLUSION

The concentrations of all minerals can be considered low and are below the maximum limit established by Brazilian legislation for the human intake of fish. The comparison between the seven species of fish investigated showed no statistically significant differences between the concentrations of minerals, suggesting that the size and dietary habit differences did not influence the mineral composition of the fish.

Low concentrations of minerals can be related to the environmental conditions of the mouth of the Itapecuru River, which experiences marine influence. During some tidal cycles, this marine influence expands, reducing the residence time in the water column and reducing the availability of these minerals for fish. The data obtained may be important for the development of tables of nutritional balance, with calculation of nutrient intake, and may contribute a value-added incentive to the fishing sector in the region.

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