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Original Article

The consumption of fish by the riverine population of the lower Solimões River, Amazonas, Brazil

O consumo de pescado de uma população ribeirinha do baixo rio Solimões, Amazonas, Brasil

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Abstract

The riverine population of the Amazon Basin are among the largest consumers of fish in the world, but the consumption patterns could be regionally distinct. Moreover, their total fish catches are not fully known. The objective of this work was to estimate the *per capita* fish consumption of the riverine people that inhabit the Paciência Island (Iranduba, Amazonas), where there is a fishing agreement in force. A total of 273 questionnaires were applied during the first two weeks of each month between April 2021 and March 2022. The sample unit was the residences. The questionnaire contained questions about the species captured and their quantities. Consumption was calculated by dividing the average monthly capture with the average number of residents per household interviewed, which was multiplied by the number of questionnaires applied. Thirty groups of consumed fish species belonging to 17 families and 5 orders were recorded. The total catch was 3,388.35 kg and the highest monthly catch was 602.60 kg during the falling-water season in October. Daily *per capita* fish consumption averaged 66.13 ± 29.21 g/day, with a peak of 116.45 g/day during the falling-water season in August. The high fish consumption rate highlighted the importance of fisheries management to food security and the maintenance of the community's lifestyle.

Keywords: riverine population, fishery production, artisanal fisheries, floodplain lakes, fishery management.

Resumo

As populações amazônicas são uma das maiores consumidoras de pescado do mundo, contudo os padrões de consumo podem ser regionalmente distintos. Além disso, as capturas totais não são totalmente conhecidas. O objetivo do trabalho foi estimar o consumo *per capita* e as capturas de pescado por ribeirinhos residentes na Ilha da Paciência (Iranduba, Amazonas), onde há um acordo de pesca vigente. Foram aplicados no total 273 questionários durante as duas primeiras semanas de cada mês entre abril de 2021 e março de 2022. A unidade amostral foram as residências. O questionário continha perguntas sobre as espécies capturadas e respectivas quantidades. O consumo foi calculado pela divisão entre a média de captura mensal com a média de moradores por residência entrevistada que foi multiplicada pelo número de questionários aplicados. Foram registrados 30 grupos de espécies de peixes consumidos pertencentes a 17 famílias e 5 ordens. A captura total foi de 3.388,35 kg e a maior captura mensal foi de 602,60 kg durante a vazante no mês de outubro. O consumo de pescado *per capita* diário foi em média 66,13 ± 29,21 g/dia, com pico de 116,45 g/dia durante a vazante no mês de agosto. A alta taxa de consumo de pescado mostra a importância do manejo pesqueiro para a segurança alimentar e a manutenção do estilo de vida da comunidade.

Palavras-chaves: ribeirinhos, produção pesqueira, pesca artesanal, lagos de várzea, manejo pesqueiro.

1. Introduction

The Amazon region has a vast area of aquatic environments that are home to a great diversity of fish. Some stocks are very abundant and support important fisheries that stand out for the amount of fish caught when compared to those carried out in other regions of the country (Barthem and Fabré, 2004). Among the different habitats in the Amazon region are the plains adjacent to the great whitewater rivers that begin in the pre-Andean and Andean zone (Junk et al., 2012). Known as floodplains, these plains are complex aquatic environments that are formed by lakes and channels. The water in these environments has a pH close to neutral, high electrical

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conductivity due to the high concentration of sediments and minerals, and high fishery productivity (Junk, 1984), the seasonal flood assure the annual nutrient input to the floodplains (Junk et al., 2012).

Fishing is a traditional activity that provides the main food item in the diet of Amazonian populations, which makes them dependent on fishery resources (Fraxe et al., 2007; Alho et al., 2015). The variation in river level influences the patterns of connectivity between Amazonian environments, which also affects the vulnerability of fish to fishing (Bittencourt and Amadio, 2007; Hurd et al., 2016), which is the main source of animal protein to the riverine people (Batista et al., 1998; Cerdeira et al., 2000). Thus, seasonality directly influences the way of life of riverine populations, who use natural resources to obtain food and income through fishing, agriculture, and plant extractivism, among other productive activities (Fraxe et al., 2007; Porto Braga and Rabêlo, 2015; Venticinque et al., 2016).

Subsistence fishing is carried out by riverine families using simple equipment, such as canoes and diverse fishing tackle (Cerdeira et al., 2000; Santos et al., 2010; Hallwass and Silvano, 2016). According to Silva et al. (2017), riverine populations who fish for subsistence may occasionally sell surplus fish as a way to increase their income. Ruffino (2004) reported that, despite the importance of the region's fishing sector, much of the fishing production of rural areas in the Amazon remains unknown. This scarcity of fishing data is a common problem in regions with great biodiversity, such as the Amazon basin (Doria et al., 2018). Inland fisheries receive less attention when compared to other sectors such as agriculture, which have more information available, with this, threats to fishery resources can be seen as less urgent issues to be resolved and puts the sustainability of fisheries at risk (Lynch et al., 2020).

The diffuse nature and informality of subsistence fishing make it difficult to estimate its production (Silva et al., 2017; Funge-Smith and Bennett, 2019). The lack of data contributes to lower visibility of subsistence fishing, despite its importance, especially for the most vulnerable and resource-dependent populations (Funge-Smith and Bennett, 2019). The available data on fish consumption are mostly inaccurate mainly in remote areas and, by elucidating the importance of inland fishing from catch data, it is possible to manage the fishery resource in order to ensure the food security of these populations (Fluet-Chouinard et al., 2018).

From the fish consumption information, it is possible to discover the eating habits and nutritional level of a population, in addition to estimating fishery production (Isaac and Almeida, 2011). The objective of this study was to estimate the per capita consumption and fishery catches of riverine populations who exploit the resources of floodplain lakes located on Paciência Island (Solimões River).

2. Materials and Methods

2.1. Study area

Fish consumption data were collected from families living on Paciência Island (3° 19' 16" S, 60° 13' 29.5" W), which is located in the lower stretches of the Solimões River (Figure 1). The variation in the level of the Amazon River and its tributaries is of the monomodal type, presenting

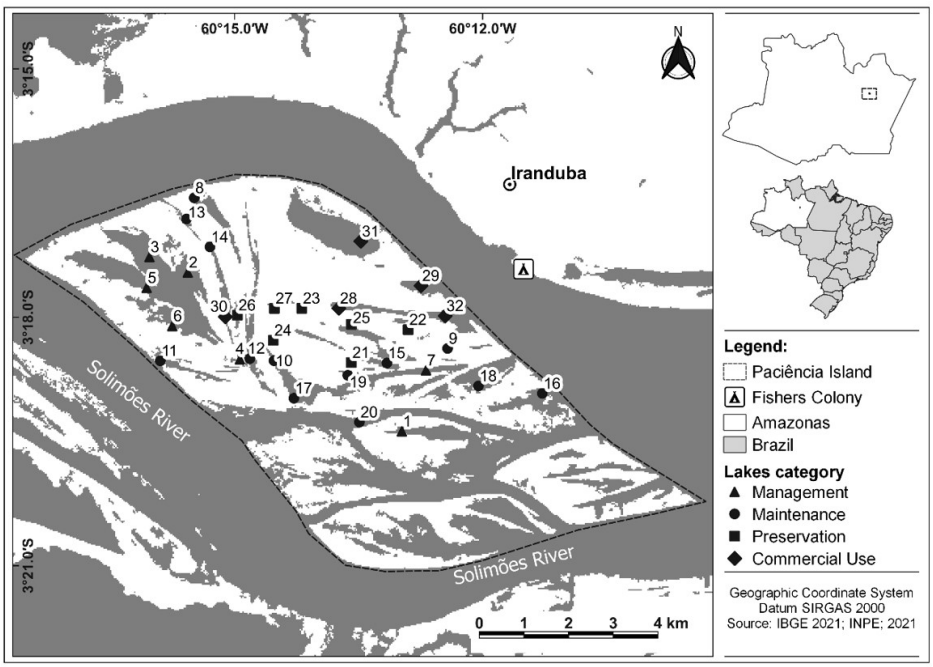

Figure 1. Paciência Island (Solimões River, Amazon basin) with the identification of the lakes exploited for commercial and subsistence fishing (Appendix 1). Sources: IBGE (2021) and INPE (2021).

annually alternating seasons of high water and low water; this being the main force that governs the system and keeps it in balance (Junk et al., 2012). For the areas of the Solimões-Amazon River near Manaus, where this island is located, the peak of the high water occurs between May and June (Marengo, 2006; Venticinque et al., 2016). In this area, when flooding occurs, isolated lakes can connect with each other and to the main river depending on the distance and degree of flooding that varies between years (Freitas et al., 2010).

The island is 62.9 km^2 and is home to 32 lakes (Appendix 1) that vary in size during the year according to the flood pulse of the river. The use of the fishery resources of these lakes is governed by normative instruction N° 02/11 (Manaus, 2011). Currently, the total population of Paciência Island is 198 people, and families are engaged in fishing, animal husbandry and agriculture.

2.2 Data collection

A total of 273 interviews (Appendix 2) were conducted by a trained interviewer during the first two weeks of each month between April 2021 and March 2022. On average, 23 questionnaires were administered per month. Each residence comprised a sampling unit, where one fisher per family was interviewed. The questionnaire addressed questions related to the species caught and its quantity, according to the fisher's recall (Isaac and Almeida, 2011). The data were organized in electronic spreadsheets. Due to the proximity of Paciência Island to the state capital, we used the data of the height (m) of the Negro River, which is measured daily in the port of the state capital, Manaus (Porto de Manaus, 2022), to represent the river level.

2.3. Per capita consumption

Per capita consumption was obtained according to the Equation 1:

$$PCC = \frac{C}{R \times Q} \quad (1)$$

Where C is the average monthly catch, R is the average number of residents per household interviewed and Q is the number of questionnaires applied.

2.4. Species identification

The species were registered in the questionnaires according to their vernacular name and identified up to the level of species, genus and/or family via the literature (Santos et al., 2009, Dagosta and Pinna, 2019), the Fishbase database (Fishbase, 2022) and the Global Biodiversity Information Facility (GBIF, 2022).

3. Results

A total of 30 groups of fish species were recorded being consumed by residents in the riverine communities of Paciência Island. These species are distributed in 17 families and 5 orders (Table 1). The most captured species were pacu (Serrasalmidae) (32.22%), curimatã (*Prochilodus nigricans* Spix & Agassiz, 1829) (25.90%) and bodó (*Pterygoplichthys pardalis* Castelnau, 1855) (14.31%). The pacu was captured throughout the year and its capture was greater than 50% during the high-water period (Figure 2). The total catch was 3,388.35 kg and the largest catch occurred in October, during the falling-water period. In this period, there was also a greater variation in production (Figure 3). The daily *per capita* consumption of fish was, on average, 66.13 ± 29.21 g/day, with a peak of 116.45 g/day during the falling-water period (Figure 4).

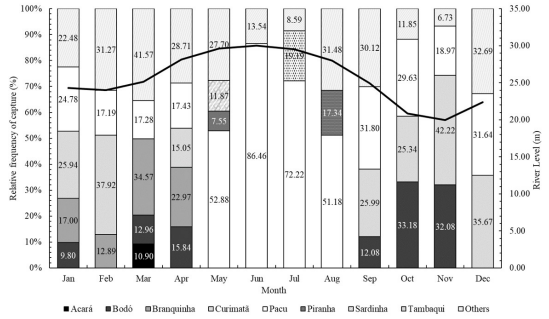

Figure 2. Temporal variation of the relative frequency of capture by species group on Paciência Island, Iranduba, AM.

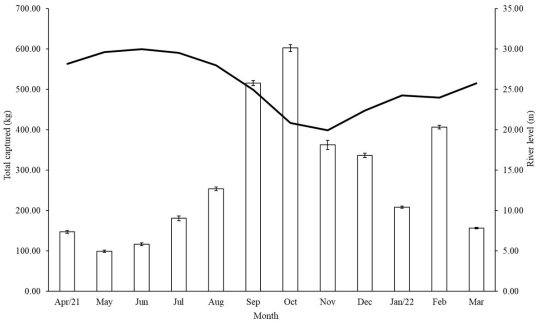

Figure 3. Temporal variation of fish catches by subsistence fishers of Paciência Island, Iranduba, AM.

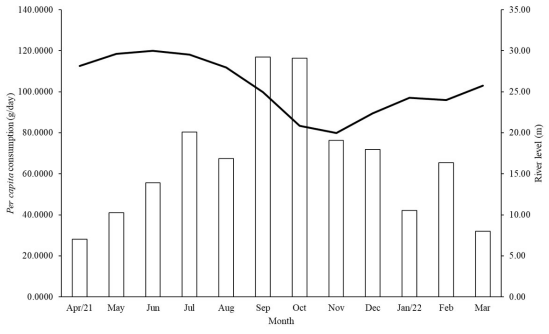

Figure 4. Temporal variation of daily *per capita* consumption (g/day) of the population of Paciência Island, AM.

Table 1. List of fish caught, with scientific and vernacular name and total weight.

Order/Family	Vernacular name	Genus/Species	Total (kg)
CHARACIFORMES			2,171.75
Anostomidae	Aracu	*Leporinus* spp.; *Schizodon fasciatus* (Spix & Agassiz, 1829); *Rhytiodus argenteofuscus* (Kner, 1858); *Anostomoides laticeps* (Eigenmann, 1912)	21.80
Bryconidae	Matrinxã	*Brycon* spp.	31.95
Curimatidae	Branquinha	*Potamorhina* spp.; *Psectrogaster* spp.	50.00
Cynodontidae	Peixe-cachorro	*Cynodon gibbus* (Agassiz, 1829); *Rhaphiodon vulpinus* (Spix & Agassiz, 1829); *Hydrolycus scomberoides* (Cuvier, 1819)	4.00
Erythrinidae	Traíra	*Hoplias* spp.	16.50
Prochilodontidae	Curimatã	*Prochilodus nigricans*	795.40
	Jaraqui	*Semaprochilodus insignis* (Jardine, 1841); *S. taeniurus* (Valenciennes, 1821)	2.00
Serrasalmidae	Pacu	*Mylossoma* spp.; *Myleus* spp.; *Metynnis* spp.	410.00
	Piranha	*Serrasalmus* spp.; *Pristobrycon striolatus* (Steindachner, 1908); *Pygocentrus nattereri* (Kner, 1858)	28.00
	Pirapitinga	*Piaractus brachypomus* (Cuvier, 1818)	190.00
	Tambaqui	*Colossoma macropomum*	614.00
Triportheidae	Sardinha	*Triportheus* spp.	8.10
CLUPEIFORMES			
Pristigasteridae	Apapá	*Pellona castelnaeana* (Valenciennes, 1847); *P. flavipinnis* (Valenciennes, 1837)	76.50
OSTEOGLOSSIFORMES			290.50
Arapaimidae	Pirarucu	*Arapaima gigas*	70.00
Osteoglossidae	Aruanã	*Osteoglossum bicirrhosum*	220.50
PERCIFORMES			257.80
Cichlidae	Acará-açu	*Astronotus* spp.	20.50
	Acará	*Aequidens* spp.; *Geophagus* spp.; *Heros* spp.; *Satanoperca* spp.	15.90
	Tucunaré	*Cichla* spp.	202.40
Sciaenidae	Pescada	*Plagioscion* spp.	19.00
SILURIFORMES			681.30
Auchenipteridae	Mandubé	*Ageneiosus* spp.	1.00
	Cangati	*Trachelyopterus* spp.	3.00
Doradidae	Bacu	*Acanthodoras* spp.; *Lithodoras* spp.; *Megalodoras* spp.; *Platydoras* spp.; *Pterodoras* spp.	2.00
	Cuiú-cuiú	*Oxydoras niger* (Valenciennes, 1821)	8.00
Loricariidae	Bodó	*Pterygoplichthys pardalis*	334.80
Pimelodidae	Caparari	*Pseudoplatystoma tigrinum* (Valenciennes, 1840)	113.00
	Dourada	*Brachyplatystoma rousseauxii* (Castelnau, 1855)	31.00
	Jaú	*Zungaro zungaro* (Humboldt, 1821)	7.00
	Mapará	*Hypophthalmus* spp.	16.50
	Pirarara	*Phractocephalus hemioliopterus* (Bloch & Schneider, 1801)	21.00
	Surubim	*Pseudoplatystoma* spp.	144.00

4. Discussion

In South America, Characiformes dominate the ichthyofauna, and species of this order make up a good part of the fish assemblages in floodplain lakes (Siqueira-Souza and Freitas, 2004; Granado-Lorencio et al., 2012; Borie et al., 2019; Dagosta and Pinna, 2019; Virgilio et al., 2020). The preference of riverine communities for consumption of species of this order has already been observed in other studies (Garcez et al., 2009; Silva et al., 2017; Begossi et al., 2019). Characiformes are also the most exploited species by commercial fishing and the most consumed in regional urban centers such as Manaus (Freitas and Rivas, 2006; Corrêa et al., 2014; Faria Junior and Batista, 2019).

During a research in the same study area, Batista et al. (1998) identified pacu (Serrasalmidae), curimatã (*P. nigricans*), and bodó (*P. pardalis*) as the most consumed species, as was also observed in our work. Among the Siluriformes, the bodó is one of the species that is most appreciated by riverine populations (Batista et al., 1998), unlike others of the same order, the so-called flatfish, which are generally not consumed due to "food taboos"

(Begossi and Braga, 1992; Garcez et al., 2009; Costa et al., 2013). Subsistence fishing is less selective when compared to other modalities such as commercial fishing, which seeks to meet the demands of the urban market (Hallwass and Silvano, 2016). Tregidgo et al. (2021) analyzed the composition of catches from communities near and far from urban areas and the target species depended on the type of fishing, whether for consumption or sale, or both, as well as the distance of the community to the urban center. Most of the catches were made up of only four species (*Mylosoma albiscopum* Cope 1872, *Osteoglossum bicirrhosum* Cuvier 1829, *Colossoma macropomum* Cuvier 1816 and *Arapaima gigas* Schinz 1822). For these authors, fishing in the Amazon is quite selective, especially when it is intended for sale. In the estuary of Babitonga Bay, in southern Brazil, Cunha et al. (2023) observed that fishers preferentially consumed those species with lower trophic level and lower commercial value. Batista et al. (2000) also observed differences in the composition of catches according to the purpose of fishing; sardines (*Triportheus* spp.) were the most frequent when the fish was intended only for consumption or for consumption and sale, while *P. nigricans* was the most frequent species in commercial fisheries, in which 100% of the production is sold.

As observed in this study, fisheries also depend on the seasons, which determine the availability of habitats, behavior and phase of the fishes' life cycle (Welcomme, 2001; Isaac et al., 2016). Silva et al. (2021) observed that the river level and variables related to spatial and temporal variation of the aquatic environment were responsible for 10% of the variation of the fish assemblage in a floodplain area. During the high-water period, herbivorous species, such as the pacu, enter the flooded forest to feed and fishers take advantage of this moment to fish in those areas that are accessible (Batista et al., 2000; Silva et al., 2021). Batista et al. (1998) obtained similar results to this study noting the predominance of pacu during the high-water period with bodó and curimatã during the low-water period. Tregidgo et al. (2021) also observed that pacu made up a good part of the catch during the high-water period and aruanã (*O. bicirrhosum*) stood out during the low-water period; during this period, there was also a greater diversity of species caught. Siqueira-Souza and Freitas (2004) analyzed the diversity and frequency of fish in floodplain areas and observed that groups of species, such as branquinha, aracu and piranha, were predominant during the periods of falling-water and low-water.

Estimated at 55.62 g/day, *per capita* fish consumption on Paciência Island is higher than the global average (FAO, 2020). The average *per capita* fish consumption of this community also exceeds rates observed in continents such as Asia, which has a consumption of 66.02 g/day (FAO, 2020), and Africa that consumes 3.1 g/day (Chan et al., 2019). According to the Household Budget Survey, between 2017 and 2018, the estimated average *per capita* consumption of fish in Brazil was 15.5 g/day, the consumption in rural areas was 33.1 g/day and in urban areas was 12.5 g/day (Wagner et al., 2023). The total consumption of the Brazilian Amazon was estimated at 575,678.00 t/year (Isaac and Almeida, 2011). The *per capita* consumption in Paciência Island is lower compared to other Amazonian communities, such as in the rural area of Manacapuru, the estimated consumption is 542.1 g/day (Garcez et al., 2009). For relatively isolated communities in the lower Amazon River, Purus River and Trombetas River the rate of fish consumption is 462 g^{-1} *per capita* day^{-1}, which is higher than in countries such as Japan (Isaac et al., 2015). In the communities studied by Batista et al. (1998), among them Paciência Island, the authors estimated fish consumption between 510 and 600 g^{-1} *per capita* day^{-1}, above what is recommended to meet nutritional needs. The frequency and quantity of fish consumed depends on factors such as access to other sources of protein, may be related to proximity to the urban area, and purchasing power, as well as the family composition (Rivero et al. 2022; Wagner et al., 2023). In general, Amazonian populations are among the largest consumers of fish in the world (Tregidgo et al., 2020).

Fish consumption is recommended due to the quality of its protein, and it provides vitamins, minerals and other nutrients essential to human health (Smith and Sahyoun, 2005; Vieira et al., 2015). The diet of riverine populations is also composed of manioc flour, which is produced in an artisanal manner from cassava (*Manihot esculenta* Crantz), and banana (*Musa* spp.), also cultivated by the riverine populations in a proportional amount to other vegetables (Dufour et al., 2016; Silva et al., 2017). With the greater access of riverine populations to the urban market, they have begun to consume more processed foods; however, this is not a simple cause and effect relationship, since the purchasing power of individuals is a decisive factor (Isaac et al., 2015; Silva et al., 2017). Van Vliet et al. (2015) observed that, in urban areas of Colombia, there is greater consumption of beef by wealthier families, while in traditional communities along the Amazon River there is greater consumption of fish, which is replaced by chicken when the family can afford it.

The feeding of Amazonian populations depends on the availability of natural resources and the amount of labor expended for their exploitation. In general, the availability of natural resources, including fisheries, varies between the different phases of the fluvial regime (Fonseca and Pezzuti, 2013; Castello et al., 2015). The results obtained show that lower catches, and consequently the lower consumption of fish, also occurred during the period of rising water. In this period, with the increase in the flooded area, the fish are more dispersed in the environment (Ruffino, 2014), thus making it more difficult to catch them. To compensate, fishers increase fishing effort during high-water period (Garcez et al., 2009). The opposite occurs in the period of falling water, since during this period the extent of aquatic environments is reduced and the fish are confined to the open-water areas of the lakes, facilitating the capture by the riverine populations (Barthem and Fabré, 2004).

The falling-water and low-water periods are the most productive periods for riverine populations, as they can plant and fish, thus maximizing their yields (Almeida et al., 2011). Tregidgo et al. (2020) analyzed the effects of the seasonality of the aquatic environment on the food security of communities in the Purus River, and noted that during the high-water period there was a reduction in fish catches and a greater probability of not catching anything. For these

authors, the high-water period is the period when riverine populations are subject to food insecurity. If fishers do not catch anything, families have few options to replace the fish and may stop eating one meal a day. Food security is ensured when people have constant access to food and in sufficient quantities, in a safe way and that meets their nutritional needs and food preferences for a healthy life (Mertens et al., 2015). In addition, extreme oscillations of the river level, regardless of intensity or duration, such as the historical high waters that occurred in June 2021, when the height of 30.02 m was recorded in the Negro River, affect the life of the riverine populations economically and socially (Langill and Abizaid, 2020) and impact the acquisition of food for their subsistence.

In communities of the lower Amazon, where there is fishing management, fishing represents 31% of total family income, with agriculture, livestock and government benefits their other sources of income (Almeida et al., 2009). On Paciência Island, families that participate in the management of pirarucu obtain an extra income from the sale of this species during the falling-water period (Silva, 2017; Medeiros-Leal et al., 2021). The extra income for those who participate in the management can cover expenses such as travel to the urban area and medical care, which are fundamental for the quality of life of the riverine populations (Campos-Silva and Peres, 2016).

Subsistence fishing carried out by populations in rural areas, including those along the Amazon River, is essential in order to meet some of the UN's sustainable development goals, including the reduction of hunger and poverty (Gebremedhin et al., 2021). On Paciência Island, the management of the pirarucu (*Arapaima gigas*) favored the assemblages of fish of other species, which contributes to the food security of the community (Medeiros-Leal et al., 2021). The conservation of ecosystems is necessary in order to avoid a reduction in fish stocks, which would affect the populations that depend on these resources.

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Supplementary Material

Supplementary material accompanies this paper.

Appendix 1. Lakes of Paciência Island and their classifications according to Normative Instruction No. 02/11 (Manaus, 2011).
Appendix 2. Questionnaire (fish consumption).

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