Oecologia Australis
26(4):592–605, 2022
https://doi.org/10.4257/oeco.2022.2604.06

DIET COMPOSITION, CONDITION FACTOR AND INTESTINAL COEFFICIENT OF THE FISH *Astyanax lineatus* REFLECT THE ANTHROPOGENIC EFFECTS ON STREAMS IN CENTRAL BRAZIL

Anna Carolina Resende[1], *Francisco Severo-Neto*[2] & *Fernando Rogério Carvalho*[3]*

[1] Universidade Federal do Paraná, Paraná, Setor de Ciências Biológicas, Departamento de Biologia Celular, Laboratório de Biologia Adaptativa, Av. Coronel Francisco Heráclito dos Santos, 100, CEP: 81531-980, Curitiba, PR, Brasil.

[2] Universidade Federal de Mato Grosso do Sul, Instituto de Biociências, Coleção Zoológica, Av. Costa e Silva, s/n, Cidade Universitária, CEP: 79070-900, Campo Grande, MS, Brasil.

[3] Universidade Federal de Mato Grosso do Sul, Campus Três Lagoas, Laboratório de Ictiologia, Colégio de Ictiologia de Três Lagoas. Av. Ranulpho Marques Leal, 3484, Distrito Industrial II, CEP: 79613-000, Três Lagoas, MS, Brasil.

E-mail: annac.resende@gmail.com, franciscoseveroneto@gmail.com, carvalhofr@gmail.com (*corresponding author).

Abstract: Human activities, such as urbanization, can cause instability in the aquatic biota. This instability can modify aquatic food resource availability, consequently shifting the diet composition of fish. Because the diet consumed by fish closely affects the anatomy of their digestive tract, it can also alter their intestinal coefficient. In this study, we analyzed the diet composition, condition factor and intestinal coefficient of *Astyanax lineatus* (Perugia, 1891) from two distinct habitats: a "degraded habitat" (Cabaça stream) in a reserve inside the city perimeter and a "preserved habitat" (Salobra River) in Mato Grosso do Sul State, Central Brazil. We found a total of 15 food items, all of which were found in the urban stream, with a predominance of detritus and Chironomidae larvae, and six in the natural area, with a predominance of plant remains. There was a distinct difference in diet composition between fishes in the two areas ($p < 0.05$, PERMANOVA); however, there was no significant difference in inter-individual variability. The most frequent food items were detritus in the "degraded habitat", while in the "preserved habitat" plant and insect remains were most frequent. The relative condition factor measured by the fish's length-weight relationship was not significantly different between the two habitats. The intestinal coefficient was significantly different between the individuals from each habitat, and it was longer in fish from the natural habitat. Therefore, even though *A. lineatus* is known to be a generalist species, its feeding plasticity depends on the ecological integrity of the two types of habitats.

Keywords: urbanization; diet shift; feeding plasticity

INTRODUCTION

Fish ecology is extremely important to understand the trophic adaptability of species concerning the diversity, density, and availability of food resources in stream environments (Lowe-McConnell 1987, Rezende *et al.* 2011). Many factors can affect the availability of food resources. These include the complex habitat heterogeneity that streams present, such as spatial, temporal, and physical heterogeneity (Silva *et al.* 2012). The presence or absence of vegetation cover can also affect the density and composition of food resources (Casatti 2010, Ferreira *et al.* 2012a, Leite *et al.* 2015).

In addition, anthropogenic disturbances such as urbanization can profoundly modify stream dynamics (Bonato *et al.* 2012, Alonso *et al.* 2019).

Urbanization is one of the major conservation challenges for stream fauna because it directly modifies the natural structures of habitats, affecting hydrology, temperature, and soil characteristics that create serious threats to aquatic environments (Paul & Meyer 2008, Tófoli *et al.* 2013, Forman 2014). The expansion of urban centers into catchments of tropical streams, the consumption of aquatic resources and the disposal of materials have contributed to stream degradation (Bonato *et al.* 2012). Moreover, when released into the water, high inputs of nutrients from human activities often have severe effects on the fish and invertebrate communities and can homogenize the type of resources available (Baeta *et al.* 2017, Alonso *et al.* 2019). This pollution alters the contribution of allochthonous and autochthonous resources available, which changes the feeding habits of fish (Ganassin *et al.* 2020) and forces an adjustment in their diets when facing different habitat conditions (Alonso *et al.* 2019, Oliveira *et al.* 2021). Thus, species with trophic plasticity have the advantage of being able to shift their diet in response to environments with different shifts in resource availability (Welker & Scarnecchia 2006, Kokubun *et al.* 2018, Oliveira *et al.* 2021).

The analysis of diet in fishes has constituted an important source of information for greater insights into the processes that regulate tropical aquatic ecosystems (Manna *et al.* 2019, Soe *et al.* 2021, Goddard *et al.* 2022). Also, it provides essential data on the ecology and biology of the species that cohabitate, with evidence about the role of each species in the ecosystem (Teixeira 1989, Zavala-Camin 1996, Manna *et al.* 2012, Bonato *et al.* 2012, Peressin *et al.* 2018, Alonso *et al.* 2019). The diet and type of food consumed by fish closely affect the anatomy of their digestive tract. Changes in diet can alter the intestinal length and intestinal coefficient, even intraspecifically, because it is a variable that responds sensitively to shifts in feeding conditions (Winemiller 1989, Angelescu & Gneri 1949, Kapoor *et al.* 1976, Dala-Corte *et al.* 2016). Furthermore, other morphological traits such as size and weight can be altered depending on the variety and amount of food ingested by the fish, since fish body composition is influenced by food type and food intake (Abbas & Siddiqui 2009, Trindade & Queiroz 2012, Kokubun *et al.* 2018). The relationship between individuals' length and weight in a fish population is a quantitative description used as a basic tool for assessing natural populations (Froese 2006, Labocha & Hayes 2012, Khristenko & Kotovska 2017). Moreover, the relative condition factor (*Kn*), described by Le Cren (1951), derived from the length-weight relationship, is a powerful tool for determining the well-being of a population and provides an opportunity to compare populations of species among regions (Khristenko & Kotovska 2017, Gubiani *et al.* 2020).

Freshwater fish species can tolerate anthropogenic environmental modifications (Weaver & Garman, 1994, Teresa *et al.* 2015) and it is known to occur in most *Astyanax* species (Carvalho *et al.* 2015). *Astyanax lineatus* (Perugia 1891) is recognized popularly as a tetra, 'piaba', or 'lambari' from the Paraguay River basin (Fricke *et al.* 2020) and has been recently reported for the upper Paraná River basin (Ferreira *et al.* 2012b). It occurs preferably in the headwaters of every main drainage basin of the region, where it is usually the most numerically dominant species (Castro *et al.* 2005). Furthermore, this species occurs in aquatic environments with different degrees of anthropogenic impacts (Mehanna & Penha 2011). It can be found in urban areas with higher levels of perturbation and in less degraded natural areas (Casatti *et al.* 2010). Given the increasing anthropogenic alterations of aquatic ecosystems and their substantial impacts on fishes' survival, studies addressing fish diet and its consequent effects are becoming increasingly important (Fernando & Súarez 2020) (Ceneviva-Bastos & Casatti 2007).

The objective of this study was to evaluate the diet, the intestinal coefficient and the relative condition factor of *A. lineatus* in two habitats located in Mato Grosso do Sul state in Brazil: one "preserved habitat" (Salobra River, Serra da Bodoquena National Park) and one "degraded habitat" (Cabaça stream). The objective was to determine a diagnostic measure of the effects of the anthropogenic environmental pressure on the populations of *A. lineatus*. Thus, we hypothesized that the diet, the intestinal coefficient and relative condition factor will be different between the two assessed habitats. In response to different degrees of anthropogenic pressures in these two streams, we expect that individuals from the urban stream would present a smaller diet breadth and higher ingestion of autochthonous items due to the homogenization of the available resources, as well as a lower intestinal coefficient and condition factor.

MATERIAL AND METHODS

A total of 60 specimens of *Astyanax lineatus* were used: 30 specimens from the "degraded habitat" (Figure 1A): ZUFMS 5459, 53.7-126.6 mm SL, Cabaça stream, collected on December 7th, 2016, and 30 specimens from the "preserved habitat" (Figure 1B): ZUFMS 2637, 43.0-94.1 mm SL, Salobra River, collected on September 3rd, 2005. The precipitation in the two habitats during the sampling period ranged from 100-200 mm in the Cabaça stream and 100-150 mm in the Salobra river (CPTEC/INPE, 2021). The sampling sites of the Cabaça stream and the Salobra River are first and fourth-order drainages (*sensu* Strahler 1987), respectively. The Cabaça stream starts in an urban area in Campo Grande and receives domestic and industrial effluents along its course ("degraded habitat"). The sampling area of the Cabaça stream is located inside the Private Natural Heritage Reserve (RPPN), which belongs to the Universidade Federal de Mato Grosso do Sul, and it covers 30% of the total length in the final stretch of the stream (personal observation). Native riparian vegetation has been mostly suppressed along the stream, which directly impacts the entry of light into the stream (Fernando & Súarez 2020). Moreover, the quality of the water is often altered, primarily due to the urban effluents that increase concentrations of nutrients, metals, bacteria, organic matter, and suspended materials (Silva 2010). In contrast, the Salobra river originates in a conserved area inside the Serra da Bodoquena National Park (Figure 2), a "preserved habitat", and has waters free of toxic effluents, more vegetation

Figure 1. Habitats of *Astyanax lineatus*: (A) Cabaça stream (on December 7th, 2016), municipality of Campo Grande, Mato Grosso do Sul State and, (B) Salobra River (on September 3rd, 2005), municipality of Bodoquena inside the Serra da Bodoquena National Park, Mato Grosso do Sul State.

cover along its margins, and no human occupation near the river.

Only adult fishes were used to avoid potential differences that can occur during the ontogeny (Gatz 1979). The method used for diet analysis consisted of retrieving the stomach through a lateral incision, on the right side, initiating in the anal opening and ending next to the operculum region (Kassim *et al.* 2018). The stomachs were stored in 2 mL tubes with 70% ethanol solution. Their contents were later examined with a stereomicroscope and identified to the lowest taxonomic level possible.

The stomach contents were analyzed using two methods: (a) frequency of occurrence (%Fo), the number of times each item occurs as a percentage of the total number of occurrences of all items (Hynes 1950), and, (b) volume (V), where each item was calculated by the volumetric method (Hyslop 1980) that consists in examination of the material using glass slides in a Petri dish (Hellawell & Abel 1971), with a conversion to volume (1 mm^3 = 0.001 mL).

The ingested items were classified as: i) allochthonous foods, produced outside the stream; ii) autochthonous food, produced in stream (Ricklefs 2003); and iii) detritus, comprising all unidentified decomposed organic matter (Kokubun *et al.* 2018). All foods were identified according to Mugnai *et al.* (2010) and Rafael (2012). The intestines were also removed and measured with a digital caliper, as well as the standard length of the fish (measured from the tip of the snout until the hypural plaque in the caudal peduncle).

All statistical analyses were performed with n = 60. A homogeneity test of multivariate dispersion (PERMDISP) was used to assess differences in diet breadth and individual variation. Using PERMDISP, we calculated the distance of the centroid through a principal coordinate analysis (PCoA), which was performed using the dissimilarity measure of Bray-Curtis, allowing for the comparison of the average dissimilarity in individual observations within groups (Anderson 2006). The resulting F statistic of this analysis was tested using the Monte Carlo method with 999 randomizations to compare the average distance of each sample to the centroid

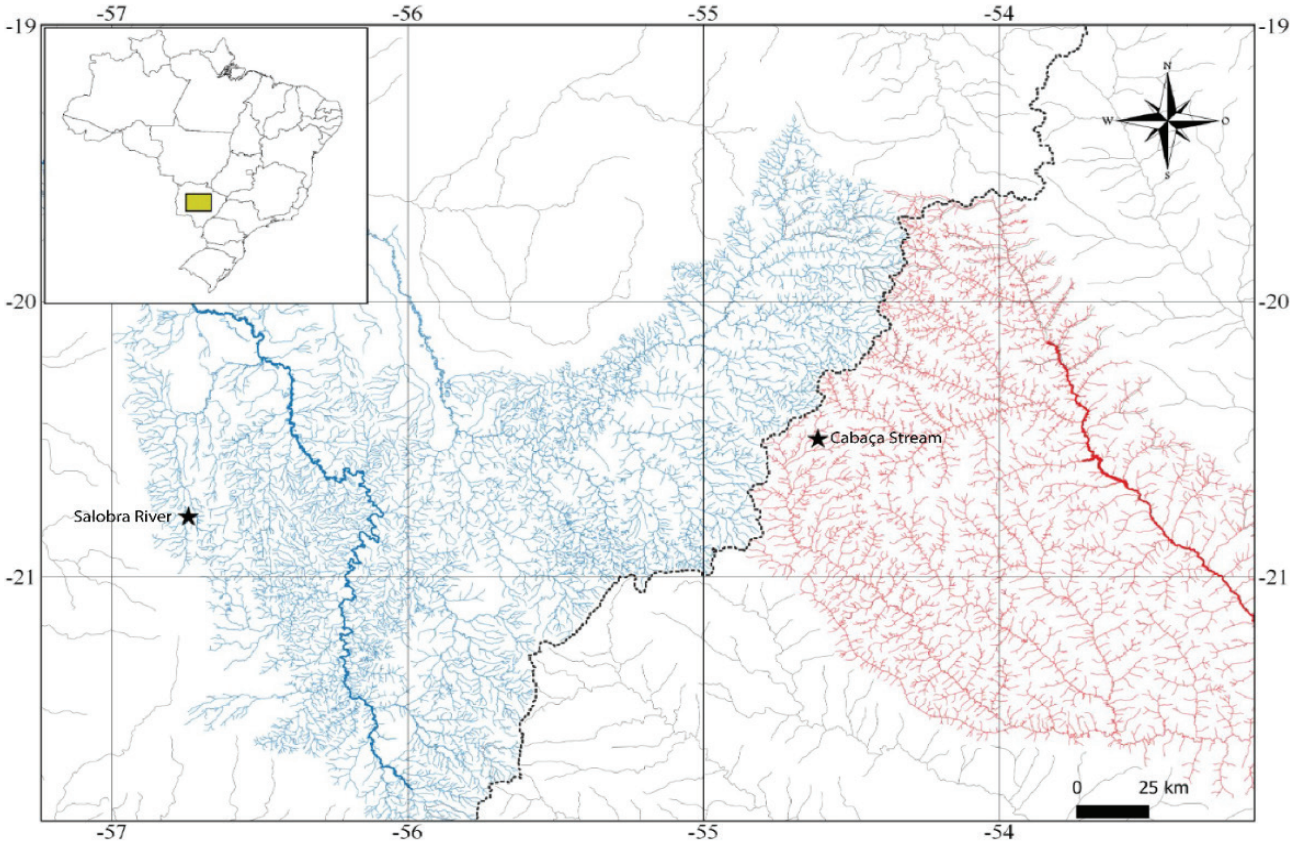

Figure 2. Sampling sites of *Astyanax lineatus* (stars points) in the upper Paraguay River basin (blue drainages) on September 3rd, 2005, and upper Paraná River basin (red drainages) on December 7th, 2016. The main rivers are represented in bold, the Miranda River (blue) and the Pardo River (red). The dashed line divides the Paraguay/Paraná hydrographic basins.

of the group (Anderson 2001, 2006). To analyze the volume of all food items to compare diet composition according to the habitats, we used the PERMANOVA test with the *adonis2* function in the *vegan* package, using the Bray-Curtis dissimilarity method (Anderson 2001, Oksanen *et al.* 2013). Furthermore, we used an analysis of similarity percentages (SIMPER) (Clarke 1993) to calculate the contribution of each food item group to the observed patterns shown in the PERMDISP ordination. The relative condition factor (*Kn*) was determined according to the equation:

$$Kn = \frac{W}{(a \times SL^b)}$$

(Le Cren 1951), where W is the total weight (g), SL is the standard length (cm), and *a* and *b* are the exponential form of the intercept and slope, of the logarithmic length-weight equation, estimated by a regression given by Le Cren (1951). The growth condition of the fish was then categorized using the *b* values; when $b = 3$, the fish attained isometric growth, $b < 3$ indicated negative allometric growth, and $b > 3$ indicated positive allometric growth (Lim *et al.* 2013, Srithongthum *et al.* 2020).

We calculated the Intestinal Coefficient (QI) as the mean of the ratios between the intestinal length and the standard length of the body (SL) (Gneri & Angelescu 1951). To test if the relative condition factor and the intestinal coefficient of the fish varied between the two areas, we used ANOVA with a regression conducted using the *lmPerm* package (Wheeler & Torchiano 2016), which calculates a *p* value based on a permutation procedure that is robust to non-homogeneity of variance. The bar plot values were presented as mean and standard deviation using the *ggplot2* package (Wickham 2016). The statistical analysis and the graphic representations were made in the R Project for Statistical Computing Software, version 4.0.2 (R Core Team 2020).

RESULTS

We identified 15 food items consumed by *Astyanax lineatus*: all of which were found in the Cabaça stream and six in the Salobra River (Table 1). In the “degraded habitat”, Cabaça stream, only one individual had an empty stomach, while in the “preserved habitat”, Salobra River, four individuals did not have any content in their stomachs.

The occurrence of allochthonous items was prevalent in both areas. In the degraded Cabaça stream, allochthonous material represented 57.14% and consisted of adult terrestrial insects (Coleoptera, Diptera, Ephemeroptera, Hymenoptera, Orthoptera), Araneae, and plant matter. Among these, the most frequent item was plant remains, which also had the highest volume (*i.e.*, leaves, flowers and branches). Conversely, the autochthonous item predominant in the stomach of *A. lineatus* from the Cabaça stream was Chironomidae larvae (*Tanypus* sp.), occurring in 80% of their stomachs. However, the higher volume of autochthonous food was composed of fish (*Poecilia reticulata*), representing 16.4% of the total ingested food volume. Other autochthonous items found were immature insects (Chironomidae, Coleoptera), mollusk (*Biomphalaria* sp.) and filamentous algae. Many items could not be identified; therefore, they were considered detritus (*i.e.*, rest of organic matter of unknown source), which were in 80% of the stomachs and represented 46.8% of the total volume of food ingested.

In the Salobra River (“preserved habitat”), the allochthonous resources represented 83.3% of the diet of *A. lineatus*. The predominant food items were plant remains, occurring in 90% of the stomachs analyzed and they represented the highest volume of food ingested. In addition to plant remains, adult aquatic insects (Hymenoptera, Diptera, Coleoptera) and algae were the only autochthonous food items found in their stomachs. No detritus was found in any stomach in this stream.

The ordering produced by PERMDISP showed a distinct diet composition according to the food items in the sampled areas (Figure 3), with a significant difference in diet composition, as confirmed by the PERMANOVA results (pseudo-$F = 21.14$, $R^2 = 0.285$, $p = 0.001$). However, the Monte Carlo test for PERMDISP indicated no significant difference in the inter-individual variability in the *A. lineatus* diet between the assessed areas ($F = 1.09$, $p = 0.30$).

Certain food items represented the main dissimilarities in diet composition between the Cabaça stream and Salobra River. According to

Table 1. Frequency of occurrence (Fo%) and volume (V%) of food items in the stomachs of *Astyanax lineatus* from distinct habitats. Values in bold represent the highest percentage value for each resource origin.

	Degraded Habitat		Preserved Habitat	
	Fo%	**V%**	**Fo%**	**V%**
Allochthonous items				
Aranae	3.33	0.03	-	-
Coleoptera	3.33	0.03	3.33	3.47
Diptera	13.33	1.66	3.33	0.24
Ephemeroptera	6.67	0.20	-	-
Hymenoptera	53.33	3.46	13.33	3.62
Insect remains	46.67	6.10	26.67	13.07
Orthoptera	10.00	0.23	-	-
Plant remains	**76.67**	**11.56**	**90.00**	**79.46**
Autochthonous Items				
Algae	13.33	0.25	**3.33**	**0.12**
Chironomidae larvae	**80.00**	5.40	-	-
Chironomidae pupae	50.00	1.64	-	-
Coleoptera larvae	23.33	0.67	-	-
Fish	10.00	**16.47**	-	-
Mollusk	16.67	5.51	-	-
Detritus	**80.00**	**46.80**	-	-

the SIMPER analysis, the most frequent food items were detritus, plant remains and insect remains. Combined, these three items accounted for 76.46% of the dietary differences between the sampled areas, with major contributions of detritus (33.38%) for Cabaça stream and plant remains (32.51%) for Salobra River.

The investigation of relative condition factors (*Kn*) of *A. lineatus* revealed that fish from both types of habitats had positive allometric growth, as the b value for each habitat was higher than 3 (Table 2). There was no significant difference between the *Kn* values for each habitat. Furthermore, there was a significant difference in the intestinal coefficient when comparing both habitats (ANOVA, R^2 = 0.1811, p = 0.00041) (Figure 4), with higher values for the "preserved habitat".

DISCUSSION

The environmental conditions and the availability of resources can affect the feeding habits of fish (Dudgeon 2008, Alonso *et al.* 2019, Brasil *et al.* 2020). In the present study, the analysis of stomach contents of *Astyanax lineatus* indicated the consumption of detritus, plants, insects, fish and mollusk. The individuals from the "degraded habitat" ingested a greater range of food items than those from the preserved habitat, even though it was expected that fish from the urban stream would demonstrate homogenization of their diet. This disparity could have occurred because although the Cabaça stream ("degraded habitat") has had its native riparian vegetation suppressed, some native plant species are remaining in the RPPN area, where fish were collected (Silva 2010). Nevertheless, in its margins, there is exotic arboreal vegetation (*Leucaena leucocephala*) that could have generated greater input of terrestrial invertebrates in their diets (Silva 2010, Lopes *et al.* 2016). Furthermore, the Cabaça stream ("degraded habitat") is a low-order stream and is known to have high terrestrial prey input (Mello *et al.* 2018). Our observations were consistent with many studies conducted in Brazilian first-order streams, where invertebrates and detritus represented the main ingested items in fish diets (Casatti 2002, Cenevita-Bastos *et al.* 2012, Silva *et al.* 2012, Neves *et al.* 2015, Lopes *et al.* 2016).

The variety and amount of food ingested can affect the body weight and size of individuals and consequently affect their well-being (Lall & Tibbetts 2009, Sánchez-Hernández *et al.* 2019). Differences in conditions can be measured using the *Kn*. We observed no significant difference between the *Kn* of the individuals from the two habitats. Also, both populations showed a *b* value higher than 3, therefore, all the individuals were considered to have achieved the ideal growth (Le Cren 1951, Khristenko & Kotovska 2017). Nonetheless, among *Astyanax lineatus* the intestinal coefficient (QI) was significantly different between the two habitats, with higher values in the "preserved habitat". Fish with a tendency toward an herbivorous diet tend to have a higher intestinal coefficient, as they require a larger area of the intestine for nutrient absorption (Barbieri *et al.* 1994, Delariva & Neves 2020). Therefore, the high contribution of allochthonous plant items in the Salobra River ("preserved habitat") likely caused the difference in the intestinal coefficient between the populations. Delariva & Neves (2020) evaluated the morphological traits that changed due to diet in five Characidae species and also found that higher intestinal coefficient values were observed in species that consumed a larger proportion of plants. As the gut length is proportional to the fish's body length, the QI of fish has been investigated in many fish species and used as an important criterion for classifying feeding (Albrecht *et al.* 2001, Moraes *et al.* 2004, Cao *et al.* 2011, Dinh *et al.* 2017). The QI helps to highlight the differences in diet composition between the individuals from both habitats in this study. In addition, the PERMDISP analysis showed that there was no diet variability in individuals from the same habitat. This probably occurred because each of the assessed habitats presented similar levels of riparian vegetational cover and composition. Because fish diet composition is affected by both resource availability and environmental characteristics (Schneider *et al.* 2011), it is not unexpected that there was no inter-individual variation in diet composition.

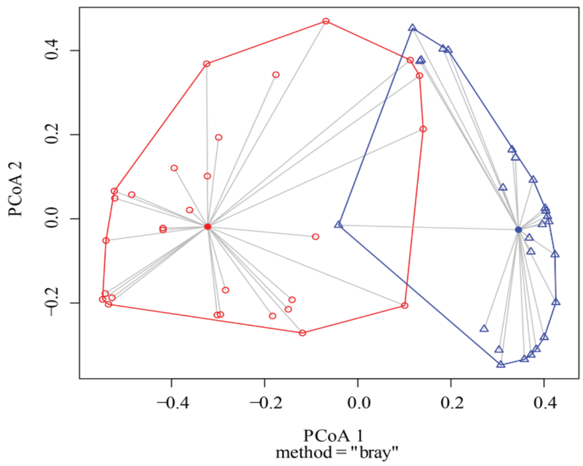

Figure 3. Ordination of dietary data of *Astyanax lineatus* individuals from each evaluated area (using the first and second axis of principal coordinates analysis, PCoA), in the Cabaça stream ("degraded habitat" - red circles) and Salobra River ("preserved habitat" - blue triangles), and the distance between each individual and the group median (centroid).

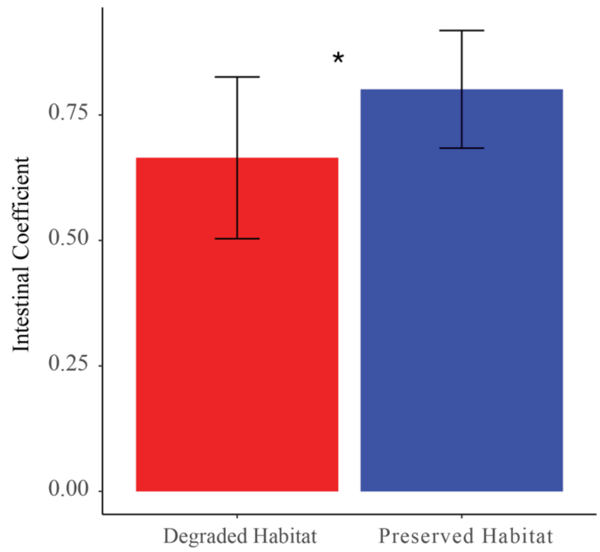

Figure 4. Intestinal coefficient of *Astyanax lineatus* individuals in two areas under different anthropogenic pressures, Cabaça stream (red) and Salobra River (blue) represented as means standard deviations. Asterisks indicate significant differences between habitats ($p < 0.05$).

Table 2. Body composition, equation parameters and relative condition factors (*Kn*) of *A. lineatus* in each evaluated habitat.

Habitat	Standard length (cm)		Weight (g)		*a*	*b*	R^2	*Kn*
	Min	Max	Min	Max				Mean ± SD
Degraded	5.37	12.66	3.4	52.3	0.00896	3.039	0.947	2.36 ± 0.295
Preserved	4.30	9.41	1.7	19.7	0.00574	3.279	0.973	2.31 ± 0.288

Our results show that there were some items in common in the diet composition of the individuals from both habitats, represented by Coleoptera, Diptera, Hymenoptera, insect remains, plant remains, and algae. Interestingly, *Astyanax lineatus* had a significant difference in diet composition in the two habitats. Individuals from the Cabaça stream ("degraded habitat") consumed more animal prey, whereas individuals from the Salobra River ("preserved habitat") consumed more plant remains. This difference has considerable implications on the trophic ecology of this species and probably occurred because anthropogenic impacts can alter habitat integrity (Ceneviva-Bastos & Casatti 2007), potentially affecting the diet composition of fish in urban streams (Oliveira & Bennemann, 2005, Alonso *et al.* 2019). Similarly, in closely related species (*Astyanax lacustris* and *Astyanax taeniatus*), Alonso *et al.* (2019) found a shift in their diet depending on the environmental condition, when sampling at short to long distances from sewage treatments. Likewise, Oliveira & Bennemann (2005) found that in urban environments with different levels of disturbance, other Characidae fish presented a shift in their diet and fed on unusual resources. Fernando & Súarez (2020), when studying *A. lineatus*, found that the diet composition was directly affected by environmental variables, such as vegetation cover, streamflow, and dissolved oxygen. In the present study, the proportion of allochthonous items in the *A. lineatus* diet was lower when the vegetation cover and stream flow were reduced. Therefore, it is possible that human actions on the Cabaça stream ("degraded habitat") margins are responsible for some of the alterations in *A. lineatus* diet composition. The Cabaça stream also receives a discharge of urban and industrial effluents, food scraps, plastic, and other types of detritus from human activity, known to cause fish to feed on unusual food resources (McClelland & Valiela 1998, Costa & Zalmon 2017, Fernando & Súarez 2020).

Astyanax lineatus from the Cabaça stream ("degraded habitat") had a diet with a high composition of detritus. A few studies have shown that detritus increased its importance in urbanized areas because land-use alteration can increase detritus availability and favor generalist and opportunistic fish (Noel *et al.* 1986, Bonato *et al.* 2012, Souza & Lima-Junior 2013, Peressin *et al.* 2018). The second most frequent feeding resource consumed by *A. lineatus* was aquatic insect larvae, Chironomidae (*Tanypus* sp.). They are known to present an important nutritional source for fish communities (Winemiller & Leslie 1992, Hartz *et al.* 2000), and can be abundant in urban streams because individuals of the Chironomidae family are resistant to environmental perturbations due to their ability to survive under low concentrations of dissolved oxygen and high indices of organic matter (Cranston 2007). Our observations were consistent with the findings of Peressin *et al.* (2018), who found that the most generalist species (like *A. lineatus*) consumed more detritus and chironomid larvae in urban sections. Souza & Lima-Junior (2013) found that in degraded areas, *Astyanax altiparanae* (= *A. lacustris*) and *Astyanax paranae* also ingested chironomids as the most common food resource. Even though chironomid larvae were the most frequent item, the highest autochthonous volume in *A. lineatus* from the Cabaça stream ("degraded habitat") was represented by *P. reticulata*. This is an exotic fish that has been reported to occur in degraded streams and accounts for a large proportion of the fish density under such conditions (Cunico *et al.* 2006, Casatti *et al.* 2009, Casatti *et al.* 2010). Because *A. lineatus* is a generalist and/or opportunist species (Alonso *et al.* 2019), it probably ingested *P. reticulate* due to its abundance.

Individuals from the Salobra River ("preserved habitat") tended to herbivory because their diet composition was mainly characterized by plant remains. Similarly, Andrian *et al.* (2001) found that medium and large *Astyanax bimaculatus* (= *A. lacustris*) individuals, in pristine areas with riparian vegetation, fed mostly on Dicotyledons. Another study showed that *Astyanax bimaculatus* (= *A. lacustris*) and *Astyanax fasciatus* larger than 65-70 mm SL fed mainly on algae and plant matter in a lake with extensive emergent vegetation on the margin (Esteves 1996). Santos *et al.* (2009), found that *A. lineatus* from the Taquaruçu stream in Serra da Bodoquena's Plateau (a narrow and shallow drainage area inside a pasture with bamboo on the margins) tended to be insectivorous, with mostly aquatic insects in their diet. The tendency for herbivory for this species might be related to the integrity and heterogeneity of the riparian vegetation on the margins of the river.

Neotropical fishes, mainly characids, have high trophic plasticity that reflects the predominance of opportunists and generalist species (Abelha *et al.* 2001, Corrêa & Silva 2010). Generalist species can feed on different items than those that occur in their usual diet. They will eat whatever is available, with no selectivity (Gerking 1994, Alonso *et al.* 2019), making it possible for fish to survive even in altered habitats (*i.e.*, urban) with unusual resources available (Oliveira & Bennemann, 2005, Peressin *et al.* 2018). Our results suggest that urban disturbance potentially altered the diet and intestinal coefficient of *A. lineatus* from this degraded habitat (Cabaça stream). Most fish species of *Astyanax* Baird & Girard, 1854 present feeding plasticity in response to environmental changes and food availability (Alonso *et al.* 2019). Based on our study, we conclude that the feeding plasticity in *A. lineatus* was based on habitat integrity and resource availability. This species responds to habitat impacts and biotic changes. It has wide diet plasticity, allowing it to survive in anthropogenically modified environments.

ACKNOWLEDGEMENTS

We thank Maria José Alencar Vilela (UFMS) for helping in the laboratory, Juliana Terra for helping with the statistical analyses and Livia Cordeiro for the helpful suggestions. FRC is granted by CNPq (process # 420620/2018-4) and FUNDECT ("Fundação de Apoio ao Desenvolvimento do Ensino, Ciência e Tecnologia do Estado de Mato Grosso do Sul", process # 59/300.093/2017, SIAFEM 27248). We also thank Alan P. Covich for the English review of the manuscript.

REFERENCES

Abbas, G., & Siddiqui, P. J. A. 2009. Effects of different feeding levels on the growth, feed efficiency, and body composition of juvenile mangrove red snapper, *Lutjanus argentimaculatus* (Forsskal 1775). Aquaculture Research, 40(7), 781–789. DOI: 10.1111/j.1365-2109.2008.02161.x

Abelha, M. C. F., Agostinho, A. A., & Goulart, E. 2001. Plasticidade trófica em peixes de água doce. Acta Scientiarum. Biological Sciences, 23, 425–434. DOI: 10.4025/actascibiolsci.v23i0.2696

Albrecht, M. P., Ferreira, M. F. N., & Caramaschi, E. P. 2001. Anatomical features and histology of the digestive tract of two related neotropical omnivorous fishes (Characiformes; Anostomidae). Journal of Fish Biology, 58(2), 419–430. DOI: 10.1111/j.1095-8649.2001.tb02261.x

Alonso, M. B., de Carvalho, D. R., Alves, C. B. M., Moreira, M. Z., & Pompeu, P. S. 2019. Changes in trophic characteristics of two fish species of *Astyanax* (Teleostei: Characidae) in response to aquatic pollution. Zoologia, 36, 1–12. DOI: 10.3897/zoologia.36.e30445

Anderson, M. J. 2001. A new method for non-parametric multivariate analysis of variance: Non-parametric Manova for Ecology. Austral Ecology, 26(1), 32–46. DOI: 10.1111/j.1442-9993.2001.01070.pp.x

Anderson, M. J. 2006. Distance-based tests for homogeneity of multivariate dispersions. Biometrics, 62(1), 245–253.

Andrian, I. de F., Silva, H. B. R., & Peretti, D. 2001. Dieta de *Astyanax bimaculatus* (Linnaeus, 1758) (Characiformes, Characidae), da área de influência do reservatório de Corumbá, Estado de Goiás, Brasil. Acta Scientiarum. Biological Sciences, 23, 435–440. DOI: 10.4025/actascibiolsci.v23i0.2735

Angelescu, V., & Gneri, F. S. 1949. Adaptaciones del aparato digestivo al régimen alimenticio in algunos peces del rio de la Plata. I. Tipo omnívoro e íliofago en representantes de las familias "Loricariidae" y "Anostomiidae". Revista del Instituto Nacional de Investigación de las Ciencias Naturales anexo al Museo Argentino de Ciencias Naturales "Bernardino Rivadavia" Zoologia, Buenos Aires, Argentina, 1(6), 161–272.

Baeta, A., Vieira, L. R., Lírio, A. V., Canhoto, C., Marques, J. C., & Guilhermino, L. 2017. Use of stable isotope ratios of fish larvae as indicators to assess diets and patterns of anthropogenic nitrogen pollution in estuarine ecosystems. Ecological Indicators, 83, 112–121. DOI: 10.1016/j.ecolind.2017.07.062

Barbieri, G., Peret, A. C., & Verani, Jr. 1994. Notas sobre a adaptação do trato digestivo ao regime alimentar em peixes da região de São Carlos

(SP) I. Quociente Intestinal. Revista Brasileira de Biologia, 54, 63–69.

Bennemann S.T., Gealh A.M., Orsi M.L., & Souza L.M. 2005. Ocorrência e ecologia trófica de quatro espécies de *Astyanax* (Characidae) em diferentes rios da bacia do rio Tibagi, Paraná, Brasil. Iheringia, Série Zoologia 95(3), 247–254. DOI: 10.1590/S0073-47212005000300004

Bonato, K. O., Delariva, R. L., & Silva, J. C. da. 2012. Diet and trophic guilds of fish assemblages in two streams with different anthropic impacts in the northwest of Paraná, Brazil. Zoologia, 29(1), 27–38. DOI: 10.1590/S1984-46702012000100004

Brasil, L. S., de Lima, E. L., Spigoloni, Z. A., Ribeiro-Brasil, D. R. G., & Juen, L. 2020. The habitat integrity index and aquatic insect communities in tropical streams: A meta-analysis. Ecological Indicators, 116, 106495. DOI: 10.1016/j.ecolind.2020.106495

Cao, X. J., Wang, W. M., & Song, F. 2011. Anatomical and histological characteristics of the intestine of the topmouth culter (*Culter alburnus*): Topmouth culter intestine. Anatomia, Histologia, Embryologia, 40(4), 292–298. DOI: 10.1111/j.1439-0264.2011.01069.x

Carvalho D. R., Castro D., Callisto M., Moreira M. Z., & Pompeu P. S. 2015. Isotopic variation in five species of stream fish under the influence of different land uses. Journal of Fish Biology 87(3), 559–578. DOI: 10.1111/jfb.12734

Casatti, L. 2002. Alimentação dos peixes em um riacho do Parque Estadual Morro do Diabo, bacia do Alto Rio Paraná, sudeste do Brasil. Biota Neotropica, 2(2), 1–14. DOI: 10.1590/S1676-06032002000200012

Casatti, L. 2010. Alterações no Código Florestal Brasileiro: Impactos potenciais sobre a ictiofauna. Biota Neotropica, 10(4), 31–34. DOI: 10.1590/S1676-06032010000400002

Casatti, L., de Paula Ferreira, C., & Carvalho, F. R. 2009. Grass-dominated stream sites exhibit low fish species diversity and dominance by guppies: An assessment of two tropical pasture river basins. Hydrobiologia, 632(1), 273–283. DOI: 10.1007/s10750-009-9849-y

Casatti, L., Romero, R. M., Teresa, F. B., Sabino, J., & Langeani, F. 2010. Fish community structure along a conservation gradient in Bodoquena Plateau streams, central West of Brazil. Acta Limnologica Brasiliensia, 22(01), 50–59. DOI: 10.4322/actalb.02201007

Castro, R. M. C., Casatti, L., Santos, H. E., Vari, R. P., Melo, A. L. A., Martins, L. S. E., Abreu, T. X., Benine, R. C., Gibran, F. Z, Ribeiro, A. C., Bockmann, F. A., Carvalho, M., Pelicao, G. Z. P., Ferreira, K. M., Stopiglia, R., & Akama, A. 2005. Structure and composition of the stream ichthyofauna of four tributary rivers of the upper Rio Parana basin, Brazil. Ichthyological Exploration of Freshwaters, 16(3), 193-214.

Ceneviva-Bastos, M., & Casatti, L. 2007. Oportunismo alimentar de *Knodus moenkhausii* (Teleostei, characidae): Uma espécie abundante em riachos do noroeste do Estado de São Paulo, Brasil. Iheringia. Série Zoologia, 97(1), 7–15. https://doi.org /10.1590/S0073-47212007000100002

Ceneviva-Bastos, M., Casatti, L., & Uieda, V. 2012. Can seasonal differences influence food web structure on preserved habitats? Responses from two Brazilian streams. Community Ecology, 13(2), 243–252. DOI: 10.1556/ComEc.13.2012.2.15

Clarke, K. R. (1993). Non-parametric multivariate analyses of changes in community structure. Austral Ecology, 18(1), 117–143. DOI: 10.1111/j.1442-9993.1993.tb00438.x

Clima monitoramento Brasil, 2021. CPTEC/INPE - World Wide Web electronic publication. Retrieved from https://clima1.cptec.inpe.br/monitoramentobrasil/pt. Accessed at 19/04/2021.

Corrêa, F., & Silva, G. C. 2010. Hábito alimentar de *Astyanax asuncionensis* (Géry, 1972) durante um período de seca e cheia, no Córrego do Onça, Coxim, Mato Grosso do Sul. Revista Brasileira de Biociências, 8(4), 368-372.

Costa, L. L., & Zalmon, I. R. 2017. Surf zone fish diet as an indicator of environmental and anthropogenic influences. Journal of Sea Research, 128, 61–75. DOI: 10.1016/j.seares.2017.08.003

Cranston, P. S. 2007. The identity of *Dactylocladius commensalis* (Diptera: Chironomidae) revealed. Aquatic Insects, 29(2), 103–114. DOI: 10.1080/01650420701308844

Cunico, A. M., Agostinho, A. A., & Latini, J. D. 2006. Influência da urbanização sobre as assembléias de peixes em três córregos de Maringá, Paraná. Revista Brasileira de Zoologia, 23(4), 1101–1110. DOI: 10.1590/S0101-81752006000400018

Dala-Corte, R. B., Silva, E. R., & Fialho, C. B. 2016. Diet-morphology relationship in the stream-dwelling characid *Deuterodon stigmaturus* (Gomes, 1947) (Characiformes: Characidae) is partially conditioned by ontogenetic development. Neotropical Ichthyology, 14(2). DOI: 10.1590/1982-0224-20150178

Delariva, R. L., & Neves, M. P. 2020. Morphological traits correlated with resource partitioning among small characin fish species coexisting in a Neotropical river. Ecology of Freshwater Fish, 29(4), 640–653. DOI: 10.1111/eff.12540

Dinh, Q. M., Qin, J. G., Dittmann, S., & Tran, D. D. 2017. Seasonal variation of food and feeding in burrowing goby *Parapocryptes serperaster* (Gobiidae) at different body sizes. Ichthyological Research, 64(2), 179–189. DOI: 10.1007/s10228-016-0553-4

Dudgeon, D. 2008. Tropical stream ecology. Academic Press. p. 370.

Esteves, K. E. 1996. Feeding ecology of three *Astyanax* species (Characidae, Tetragonopterinae) from a floodplain lake of Mogi-Guaçu River, Paraná River Basin, Brazil. Environmental Biology of Fishes, 46(1), 83–101. DOI: 10.1007/BF00001701

Fernando, A. M. E., & Súarez, Y. R. 2020. Resource use by omnivorous fish: Effects of biotic and abiotic factors on key ecological aspects of individuals. Ecology of Freshwater Fish, eff.12578. DOI: 10.1111/eff.12578

Ferreira, A., de Paula, F. R., de Barros Ferraz, S. F., Gerhard, P., Kashiwaqui, E. A. L., Cyrino, J. E. P., & Martinelli, L. A. 2012a. Riparian coverage affects diets of characids in neotropical streams: Riparian coverage affects diets of characids. Ecology of Freshwater Fish, 21(1), 12–22. DOI: 10.1111/j.1600-0633.2011.00518.x

Ferreira, A., Gerhard, P., & Cyrino, J. E. P. 2012b. Diet of *Astyanax paranae* (Characidae) in streams with different riparian land covers in the Passa-Cinco River basin, southeastern Brazil. Iheringia. Série Zoologia, 102(1), 80–87. DOI: 10.1590/S0073-47212012000100011

Forman, R. T. T. 2014. Urban ecology: Science of cities. Cambridge University Press. p. 474.

Fricke, R., Eschmeyer, W. N., & Van der Laan, R. 2020. Eschmeyer's Catalog of Fishes: Genera, Species, References, Retrieved from http://researcharchive.calacademy.org/research/ichthyology/catalog/fishcatmain.asp. Accessed at 09/13/2020.

Froese, R. 2006. Cube law, condition factor and weight–length relationships: History, meta-analysis and recommendations. Journal of Applied Ichthyology, 22(4), 241–253. DOI: DOI: 10.1111/j.1439-0426.2006.00805.x

Ganassin, M. J. M., Frota, A., Muniz, C. M., Baumgartner, M. T., & Hahn, N. S. 2020. Urbanisation affects the diet and feeding selectivity of the invasive guppy *Poecilia reticulata*. Ecology of Freshwater Fish, 29(2), 252–265. DOI: 10.1111/eff.12511

Gatz, A. J. 1979. Community organization in fishes as indicated by morphological features. Ecology, 60(4), 711–718. DOI: /10.2307/1936608

Gerking, S. D. 1994. Feeding ecology of fish. Academic Press, San Diego. p. 416.

Gneri, F.S., & Angelescu, V. 1951. La nutricion de los peces iliofagos en relacion con el metabolismo general del ambiente acuatico. Revista del Instituto Nacional de Investigación de las Ciencias Naturales anexo al Museo Argentino de Ciencias Naturales "Bernardino Rivadavia". Zoologia, Buenos Aires, Argentina, 2(1), 1–44.

Goddard, B. K., Becker, A., Harasti, D., Smith, J. A., Subramaniam, R. C., & Suthers, I. M. 2022. The trophic basis of fish assemblages in temperate estuarine and coastal ecosystems. Marine Biology, 169(2), 19. DOI: 10.1007/s00227-021-04001-y

Gubiani, É. A., Ruaro, R., Ribeiro, V. R., & Santa Fé, Ú. M. G. 2020. Relative condition factor: Le Cren's legacy for fisheries science. Acta Limnologica Brasiliensia, 32, e3. DOI: 10.1590/s2179-975x13017

Hartz, S. M., Verani, J. R., & Barbieri, G. 2000. Partilha de recursos entre as espécies de ciclídeos (Teleostei, Perciformes) em uma lagoa no litoral norte do Rio Grande do Sul, Brasil. Biociências, 8(1), 33–58.

Hellawell, J. M., & Abel, R. 1971. A rapid volumetric method for the analysis of the food of fishes. Journal of Fish Biology, 3(1), 29–37. https://doi.org /10.1111/j.1095-8649.1971.tb05903.x

Hynes, H. B. N. 1950. The food of fresh-water sticklebacks (*Gasterosteus aculeatus* and *Pygosteus pungitius*), with a review of methods used in studies of the food of fishes. The Journal of Animal Ecology, 19(1), 36. DOI: 10.2307/1570

Hyslop, E. J. 1980. Stomach contents analysis-a review of methods and their application. Journal of Fish Biology, 17(4): 411–429. DOI: 10.1111/j.1095-8649.1980.tb02775.x

Kapoor, B. G., Smit, H., & Verighina, I. A. 1976. The alimentary canal and digestion in teleosts. Advances in Marine Biology, 13, 109–239. DOI: 101016/S0065-2881(08)60281-3

Kassim, Z., Majid, M. S., Alwi, N. Y. M., & Hasnan, H. H. 2018. Diet preferences of small fishes at Setiu Lagoon, Malaysia. Ecology and Sustainable Development, 1(1). DOI: 10.22606/esd.2018.11002

Khristenko, Dmytro. S., & Kotovska, Ganna. O. 2017. Length-weight relationship and condition factors of freshwater bream *Abramis brama* (Linnaeus, 1758) from the Kremenchug Reservoir, Middle Dnieper. Turkish Journal of Fisheries and Aquatic Sciences, 17(1). DOI: 10.4194/1303-2712-v17_1_09

Kokubun, É. E., Bonato, K. O., Burress, E. D., & Fialho, C. B. 2018. Diet and body shape among populations of *Bryconamericus iheringii* (Otophysi: Characidae) across the Campos Sulinos ecosystem. Neotropical Ichthyology, 16(4). DOI: 10.1590/1982-0224-20170167

Labocha, M. K., & Hayes, J. P. 2012. Morphometric indices of body condition in birds: A review. Journal of Ornithology, 153(1), 1–22. DOI: 10.1007/s10336-011-0706-1

Lall, S. P., & Tibbetts, S. M. 2009. Nutrition, feeding, and behavior of fish. Veterinary Clinics of North America: Exotic Animal Practice, 12(2), 361–372. DOI: 10.1016/j.cvex.2009.01.005

Le Cren, E. D. 1951. The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). The Journal of Animal Ecology, 20(2), 201. DOI: 10.2307/1540

Leite, G. F. M., Silva, F. T. C., Gonçalves, J. F. J., & Salles, P. 2015. Effects of conservation status of the riparian vegetation on fish assemblage structure in neotropical headwater streams. Hydrobiologia, 762(1), 223–238. DOI: 10.1007/s10750-015-2351-9

Lim, L.-S., Chor, W.-K., Tuzan, A. D., Malitam, L., Gondipon, R., & Ransangan, J. 2013. Length-weight relationships of the pond-cultured spotted barb (*Puntius binotatus*). Undefined. Research Journal of Biological Sciences, 2, 61-63.

Lopes, E. N., Abelha, M. C. F., Batista-Silva, V. F., Kashiwaqui, E. A. L., & Bailly, D. 2016. Fish trophic structure in a first order stream of the Iguatemi River Basin, Upper Paraná River, Brazil. Acta Scientiarum. Biological Sciences, 38(4), 429. DOI: 10.4025/actascibiolsci.v38i4.31515

Lowe-McConnell, R. H. 1987. Ecological studies in tropical fish communities. Cambridge University Press. p. 382.

Manna, L. R., Rezende, C. F., & Mazzoni, R. 2012. Plasticity in the diet of *Astyanax taeniatus* in a coastal stream from south-east Brazil. Brazilian Journal of Biology, 72(4), 919–928. DOI: 10.1590/S1519-69842012000500020

Manna, L. R., Villéger, S., Rezende, C. F., & Mazzoni, R. 2019. High intraspecific variability in morphology and diet in tropical stream fish communities. Ecology of Freshwater Fish, 28(1), 41–52. DOI: 10.1111/eff.12425

McClelland, J. W., & Valiela, I. 1998. Changes in food web structure under the influence of increased anthropogenic nitrogen inputs to estuaries. Marine Ecology Progress Series, 168: 259–271. DOI: 10.3354/meps168259

Mehanna, M., & Penha, J. 2011. Fatores abióticos que afetam a distribuição do gênero *Astyanax* Baird & Girard, 1854 em riachos de cabeceiras de Chapada dos Guimarães, bacia do rio Cuiabá, Mato Grosso. Bioscience Journal, 27(1), 125-137.

Mello, K. de, Valente, R. A., Randhir, T. O., dos Santos, A. C. A., & Vettorazzi, C. A. 2018. Effects of land use and land cover on water quality of low-order streams in Southeastern Brazil: Watershed versus riparian zone. CATENA, 167, 130–138. DOI: 10.1016/j.catena.2018.04.027

Moraes, M. F., Barbola, I. D. F., & Duboc, L. 2004. Feeding habits and morphometry of digestive tracts of Geophagus brasiliensis (*Osteichthyes, cichlidae*), in a lagoon of high Tibagi River, Paraná State, Brazil. Ciências Biológicas e da Saúde, 10, 37–45.

Mugnai, R., Nessimian, J. L., & Baptista, D. F. 2010. Manual de identificação de macroinvertebrados aquáticos do Estado do Rio de Janeiro: Para atividades técnicas, de ensino e treinamento em programas de avaliação da qualidade ecológica dos ecossistemas lóticos. Technical Books Editora. p. 174.

Neves, M. P., Delariva, R. L., & Wolff, L. L. 2015. Diet and ecomorphological relationships of an endemic, species-poor fish assemblage in a stream in the Iguaçu National Park. Neotropical Ichthyology, 13(1), 245–254. DOI: 10.1590/1982-0224-20140124

Noel, D. S., Martin, C. W., & Federer, C. A. 1986. Effects of forest clearcutting in New England on stream macroinvertebrates and periphyton. Environmental Management, 10(5), 661–670. DOI: 10.1007/BF01866770

Oksanen, J., Blanchet, G. F., Friendly, M., Kindt, R., Legendre, P., McGlinn, D., Minchin, P. R., O'Hara, R. B., Simpson G. L., Solymos, P., Stevens, M. H., Szoecs, E. & Wagner H. 2019. vegan: Community Ecology Package. R package version 2.5-6. https://CRAN.R-project.org/package=vegan

Oliveira, D. C. de, & Bennemann, S. T. 2005. Ictiofauna, recursos alimentares e relações com as interferências antrópicas em um riacho urbano no sul do Brasil. Biota Neotropica, 5(1), 95–107. DOI: 10.1590/S1676-06032005000100011

Oliveira, E., Ignácio, A. R. A., Lázaro, W. L., Muniz, C. C., Campos, D. V. S., Costa, J. V. M., Ribeiro, T., & Santos-Filho, M. 2021. Feeding aspects of *Knodus heteresthes* (Eigenmann, 1908) and *Moenkhausia lepidura* (Kner, 1858) (Characiformes, Characidae) in the Teles Pires and Juruena Rivers, Southern Amazon. Brazilian Journal of Biology, 81(2), 343–350. DOI: 10.1590/1519-6984.226136

Paul, M. J., & Meyer, J. L. 2008. Streams in the urban landscape. In J. M. Marzluff, E. Shulenberger, W. Endlicher, M. Alberti, G. Bradley, C. Ryan, U. Simon, & C. ZumBrunnen (Eds.). Urban Ecology. pp. 207–231. Springer. DOI: 10.1007/978-0-387-73412-5_12

Peressin, A., da Silva Gonçalves, C., & Cetra, M. 2018. Ichthyofauna diet changes in response to urbanization: The case of upper Paranapanema River basin (Brazil). Urban Ecosystems, 21(4), 795–803. DOI: 10.1007/s11252-018-0755-9

R Core Team. 2020. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Rafael, J. A. 2012. Insetos do Brasil: Diversidade e taxonomia. Holos Editora. p. 810.

Rezende, C., Mazzoni, R., Pellegrini Caramaschi, É., Rodrigues, D., & Moraes, M. 2011. Prey selection by two benthic fish species in a Mato Grosso stream, Rio de Janeiro, Brazil. Revista de Biología Tropical, 59(4), 1697-1706. DOI: 10.15517/rbt.v59i4.3432

Ricklefs, R. E. 2003. A economia da natureza. Guanabara-Koogan. p. 54.

Sánchez-Hernández, J., Nunn, A. D., Adams, C. E., & Amundsen, P.-A. 2019. Causes and consequences of ontogenetic dietary shifts: A global synthesis using fish models: Ontogenetic dietary shifts. Biological Reviews, 94(2), 539–554. DOI: 10.1111/brv.12468

Santos, A. R., Oliveira, F. R., & Moralles, A. C. 2009. Análise do conteúdo estomacal de *Astyanax lineatus* (Perugia, 1891) (Characiformes: Characidae), provenientes da Serra da Bodoquena, Estado de Mato Grosso do Sul, Brasil. Nucleus, 6(2), 211–232. DOI: 10.3738/1982.2278.201

Schneider, M., Aquino, P. D. P. U. de, Silva, M. J. M., & Fonseca, C. P. 2011. Trophic structure of a fish community in Bananal stream subbasin in Brasília National Park, Cerrado biome (Brazilian savanna), DF. Neotropical Ichthyology, 9(3), 579–592. DOI: 10.1590/S1679-62252011005000030

Silva, J. 2010. Quality of urban runoff water in the Cabaça Stream basin. Master Thesis. Federal University of Mato Grosso do Sul, Campo Grande, Brazil, p. 96.

Silva, J. C. da, Delariva, R. L., & Bonato, K. O. 2012. Food-resource partitioning among fish species from a first-order stream in northwestern Paraná, Brazil. Neotropical Ichthyology, 10(2), 389–399. DOI: 10.1590/S1679-62252012005000008

Soe, K. K., Pradit, S., & Hajisamae, S. 2021. Feeding habits and seasonal trophic guilds structuring fish community in the bay mouth region of a tropical estuarine habitat. Journal of Fish Biology, 99(4), 1430–1445. DOI: 10.1111/jfb.14851

Souza, R. G., & Lima-Junior, S. E. 2013. Influence of environmental quality on the diet of *Astyanax* in a microbasin of central western Brazil. Acta Scientiarum Biological Sciences, 35(2), 179–184. DOI: 10.4025/actascibiolsci.v35i2.15570

Srithongthum, S., Amornsakun, T., Musikarun, P., Promkaew, P., Au, H.-L., Kawamura, G., T. M. Lal, M., & Lim, L.-S. 2020. Length-weight relationship and relative condition factor of the Sultan fish, *Leptobarbus hoevenii* broodstock farmed in earthen ponds. Egyptian Journal of Aquatic Biology and Fisheries, 24(3), 53–59. DOI: 10.21608/ejabf.2020.91657

Strahler, A. N. 1957. Quantitative analysis of watershed geomorphology. Transactions, American Geophysical Union, 38(6), 913. DOI: 10.1029/TR038i006p00913

Teixeira, R. L. 1989. Aspectos da ecologia de alguns peixes do arroio Bom Jardim, Triunfo, RS. Revista Brasileira de Biologia, 49, 183–192.

Teresa, F. B., Casatti, L., Cianciaruso, M. V., 2015. Functional differentiation between fish assemblages from forested and deforested streams. Neotropical Ichthyology, 13(2), 361–370. DOI: 10.1590/1982-0224-20130229

Tófoli, R. M., Alves, G. H. Z., Higuti, J., Cunico, A. M., & Hahn, N. S. 2013. Diet and feeding selectivity of a benthivorous fish in streams: Responses to the effects of urbanization: diet and feeding selectivity. Journal of Fish Biology, 83(1), 39–51. DOI: 10.1111/jfb.12145

Trindade, M. E. de J., & Queiroz, H. L. 2012. Feeding ecology and morphometry of the digestive tract of *Astronotus ocellatus* (Cichlidae) in várzea environments of the Middle Solimões Region, Central Amazon, Brazil. Scientific Magazine UAKARI, 8(1), 45–57. DOI: 10.31420/uakari.v8i1.109

Weaver, L. A., & Garman, G. C. 1994. Urbanization of a watershed and historical changes in a stream fish assemblage. Transactions of the American Fisheries Society, 123(2), 162–172. DOI: 10.1577/1548-8659(1994)123<0162:UOAWAH>2.3.CO;2

Welker, T. L., & Scarnecchia, D. L. 2006. River alteration and niche overlap among three native minnows (Cyprinidae) in the Missouri River hydrosystem. Journal of Fish Biology, 68(5), 1530–1550. DOI: 10.1111/j.0022-1112.2006.001041.x

Wheeler, B, & Torchiano, M. 2016. lmPerm: Permutation Tests for Linear Models. R package version 2.1.0. https://CRAN.R-project.org/package=lmPerm

Wickham, H. 2016. ggplot2: Elegant Graphics for Data Analysis. Springer-Verlag, New York.

Winemiller, K. O. 1989. Ontogenetic diet shifts and resource partitioning among piscivorous fishes in the Venezuelan ilanos. Environmental Biology of Fishes, 26(3), 177–199. DOI: 10.1007/BF00004815

Winemiller, K. O., & Leslie, M. A. 1992. Fish assemblages across a complex, tropical freshwater/marine ecotone. Environmental Biology of Fishes, 34(1), 29–50. DOI: 10.1007/BF00004783

Zavala-Camin, L. A. 1996. Introdução ao estudo sobre alimentação natural de peixes. Eduem, Maringá, PR. p. 129.

Submitted: 8 February 2022
Accepted: 8 August 2022
Published online: 26 August 2022
Associate Editor: José Luís Novaes