BOLETIM DO INSTITUTO DE PESCA
ISSN 1678-2305 online version
Scientific Article

Diet of *Psalidodon* aff. *fasciatus* (Cuvier, 1819) (Teleostei: Characidae) in a neotropical river before reservoir formation

José Rafael Soares Fonseca[1]*
Carlos Henrique Orsi[1]
Matheus Tenório Baumgartner[2]
Anderson Luís Maciel[1]
Elaine Antoniassi Luiz Kashiwaqui[1,3]
Gilmar Baumgartner[1]

[1]Universidade Estadual do Oeste do Paraná, Centro de Engenharias e Ciências Exatas, Programa de Pós-Graduação em Recursos Pesqueiros e Engenharia de Pesca – Toledo (PR), Brazil.

[2]Universidade Estadual de Maringá, Programa de Pós-Graduação em Ecologia de Ambientes Aquáticos Continentais – Maringá (PR), Brazil.

[3]Universidade Estadual de Mato Grosso do Sul, Programa de Pós-Graduação em Recursos Naturais – Dourados (MS), Brazil.

*Corresponding author: José Rafael Soares Fonseca, Rua da Faculdade, 645, CEP: 85903-000 – Toledo (PR), Brazil. E-mail: ra.phb@hotmail.com

Received: March 7, 2022
Approved: December 6, 2022

ABSTRACT

The main objective of this study was to identify spatial and seasonal variations on the diet of *Psalidodon* aff. *fasciatus* from the Tibagi River (South Brazil) before the construction of the Tibagi Montante hydropower plant. Fish were collected quarterly between October 2017 and July 2019. 536 stomachs containing feeding items and identified to the lowest taxonomic level as possible have been analyzed. Results showed that plants, Hymenoptera, and insect parts in general were the most consumed items. The analysis of feeding strategy showed a diet based on rare items but with individuals varying among specialist, generalist, and opportunistic trends depending on the season. The non-metric multidimensional scaling (NMDS) revealed diet overlap in both spatial and seasonal terms, which was confirmed by the permutational analysis of variance (PERMANOVA). The indicator value analysis (IndVal) identified 15 items as the most important components of this species' diet such as superior plants, Hymenoptera and insect parts. Therefore, before the formation of the reservoir, *P*. aff. *fasiatus* could be characterized as predominantly herbivore with a strong trend for insectivory. Across seasons, this species had a specialized diet all year, although with more specialized preferences in the spring when the consumption of plants was increased.

Keywords: before the construction; feeding; specialist; generalist; opportunistic.

Dieta de *Psalidodon* aff. *fasciatus* (Cuvier, 1819) (Teleostei: Characidae) antes da formação de reservatório na região neotropical

RESUMO

O objetivo deste trabalho foi identificar variações espaciais e sazonais da dieta do *Psalidodon* aff. *fasciatus* do rio Tibagi (Sul do Brasil) antes da construção da usina hidrelétrica Tibagi Montante. Os peixes foram amostrados trimestralmente entre outubro de 2017 e julho de 2019. Foram analisados 536 estômagos contendo itens alimentares e identificados até o menor nível taxonômico possível. Os resultados indicaram que vegetais, Hymenoptera e restos de insetos em geral foram os itens mais consumidos. A análise da estratégia alimentar mostrou uma dieta baseada em itens raros, mas com indivíduos variando entre tendências especialistas, generalistas e oportunistas, dependendo da estação. O escalonamento multidimensional não-métrico (NMDS) mostrou sobreposição da composição da dieta tanto em escala espacial quanto sazonal, o que foi confirmado pela análise de variância permutacional (PERMANOVA). A análise do valor indicador (Indval) identificou 15 itens como os componentes mais importantes na dieta desta espécie, como plantas superiores, Hymenoptera e resto de insetos. Portanto, antes da formação do reservatório, *P.* aff. *fasciatus*, pode ser caracterizada como predominantemente herbívora com forte tendência insetívora. Ao longo das estações, esta espécie apresentou dieta especializada durante todo o ano, embora com especialização na primavera, quando houve aumento do consumo de vegetais.

Palavras-chave: antes da construção; alimentação; especialista; generalista; oportunista.

INTRODUCTION

Spatial and seasonal variations occur in freshwaters as a result of environmental factors and, more recently, as the consequence of human influences affecting the behavior of resident species (Silva et al., 2012; Leite et al., 2021). The study of these environmental variations has directly contributed towards sustainable use of natural resources, for example, through assessments of how species feed themselves and how such variations arise from environmental-related factors, especially for fish (Jorge et al., 2019; Leite et al., 2021). In addition to disentangling important biological and behavioral patterns, tracking how feeding strategies adapt to these variations has enhanced the maintenance of natural resources (Zavala-Camin, 1996; Silva et al., 2012).

Feeding habits of freshwater fish species have been extensively studied in Brazil, especially in rivers that run through Southern regions due to the large number of dams for the production of electric energy in these more economically developed regions (Novakowski et al., 2007; Silva et al., 2019). These impoundments cause immediate impacts in spatial and seasonal variations, with inevitable consequences for fish (Agostinho et al., 2007; Baumgartner et al., 2018; Granzotti et al., 2018). Such alterations in spatial and temporal dynamics affect how fish occupy the landscape based on the geography, which is directly related to fish movement across habitats, as well as it affects how biotic relationships occur (Wang et al., 2019). The mechanistic explanation is that any spatio-temporal potentially affects prey availability, whereas fish species have evolved to develop compensation strategies related to diet flexibility so they could compensate for prey shortages by feeding on other resources during their lifespan (Wang et al., 2019).

Most of the largest hydrographic basins of South America are located in Brazil and are now occupied by more than 700 reservoirs, especially the Upper Paraná River basin (Agostinho et al., 2007). Most of these reservoirs were built for energy production and several studies have revealed effects on the aquatic flora and fauna. These studies report effects on species composition and abundance, including population collapses and local extinctions (Agostinho et al., 2007; Agostinho et al., 2016). However, it is only possible to identify changes arising from dam construction and subsequent reservoir formation when the previous states are known, which is what motivated the mainstem of this study.

Within the Upper Paraná River basin, there is a recently increasing interest in dam constructions in Tibagi River, located in the state of Paraná, which has a hydrographic basin composed of 65 direct tributaries and hundreds of small rivers (De França, 2002; Medri et al., 2002). Tibagi River has a relatively high species abundance, especially composed of small-sized species, where the *Psalidodon* aff. *fasciatus* (Cuvier, 1819) figures as one of the most abundant ones (Galvis et al., 1997; Matoso et al., 2010). This is a small-sized Characidae species that lives in streams and low-flow rivers under intermediate population densities (Matoso et al., 2010). It is popularly known as "lambari-do-rabo-vermelho" ("red-tail minnow") or "piaba" because of its morphological characteristics of red colors in the caudal fin (Garcia et al., 2001). Previously named as *Astyanax* aff. *fasciatus*, this species was revised and reintroduced as belonging to the *Psalidodon* genus (Terán et al., 2020), which is the form used hereafter. Geographically distributed from North to South America (Zanata and Camelier, 2009; Schmitter-Soto, 2017; Terán et al., 2020), this species is also commonly found in Tibagi River basin. Within this species' range, it is characterized as generalist and opportunistic feeder (Bennemann et al., 2005) and consequently has an intimately relationship with local diversity of prey (Wolff et al., 2009; Silva et al., 2014), especially because of its potential to adapt to recently altered environments such as reservoirs (Bennemann et al., 2005; Andrian et al., 2006; Mise et al., 2013).

Thus, this study aimed to characterize the diet of *P.* aff. *fasciatus* in Tibagi River before the impoundment caused by Tibagi Upstream hydropower plant, and the associated spatial and temporal variations in diet. Specifically, we aimed at three questions:

- how can the diet of *P.* aff. *fasciatus* be described in terms of the most consumed items?;
- are there spatial and seasonal variations in diet?;
- if so, what are the items that are responsible for these differences in diet?

With these answers at hand, we argue that diet switching is important for local populations and that species that present trophic plasticity have increased potential for colonizing altered environments such as newly formed reservoirs.

MATERIAL AND METHODS

Study area

This study was conducted in a stretch of Tibagi River that is located in Tibagi City, Paraná State, Brazil. Sampling sites were located within the area of influence of Tibagi Montante hydropower plant. Surveys were conducted at five sites in the main river channel: Downstream (Dow: 24°31'41.17"S e 50°24'25.50"O), a site with high water flow but with the formation of small backwaters, high depth, and with a rocky bottom that was commonly filled with sandy and muddy substrate; Dam (Dam: 24°32'49.70"S e 50°24'02.27"O), the site where the dam was constructed further, previously located between two riffles, with moderate flow, rocky substrate covered with sand, and few riparian vegetation; Intermediary (Int: 24°36'26.82"S e 50°25'31.85"O), a site with slow-flowing waters that allowed for muddy and sandy substrate, and relatively preserved riparian vegetation; Backwater (Bac: 24°38'57.01"S e 50°25'32.81"O), a site with slower water flow, rocky substrate, and few riparian vegetation; Upstream (Ups: 24°41'25.50"S e 50°23'35.83"O), a site with rapid water flow, small stretches of backwaters, rocky and sandy substrate, and well-preserved riparian vegetation; and Tributary (Tri: 24°38'46.18"S e 50°26'00.32"O), a site located at the confluence of Tibagi River with a tributary from its left margin, with rocky substrate that was composed of silt in the margins and predominantly sand in the middle, whereas the riparian vegetation was moderately preserved (Figure 1).

Samplings

Fish were collected every three months between October 2017 and July 2019, with one survey at each season. Specimens were caught using 10-meter gillnets set at the littoral zones in each sampling site, with meshes of 2.4, 3, 4, and 5 cm between nonopposite knots. Gillnets were exposed for 16 hours, re-visited every 8 hours. After samplings, individuals were euthanized with benzocaine solution (250 mg/L), stored in plastic gallons containing 10% formaldehyde solution, and transferred to the laboratory of ichthyofauna of the Grupo de Pesquisas em Recursos Pesqueiros e Limnologia (GERPEL), at the Universidade Estadual do Oeste do Paraná (Unioeste), *campus* of Toledo, Paraná, Brazil. This sampling protocol was approved on October 19th, 2016 by the Comitê de Ética no Uso de Animais, from Unioeste.

In the laboratory, we measured the total length and weight of each individual, and determined their sex based on visual inspection of gonads, as well as their degree of stomach filling based on Zavala-Camin (1996). Specimens classified as degree 2 or 3 (partially or completely filled, respectively) had their stomachs extracted and stored in alcohol 70% solution. The contents of each stomach were identified under stereoscopic microscope based on Bicudo and Bicudo (1970), Pérez (1988), Higuti and Franco (2001), Bicudo and Menezes (2006), Costa et al. (2006) and Mugnai et al. (2010). The volumes of items were calculated using two methods:

- the difference in water column height using a graduated beaker, whenever their volume was higher than 0.1 mL;
- the space occupied on a millimetric plate whenever their volume was lower than 0.1 mL (Hellawell and Abel, 1971).

Diet analysis

After identifying and quantifying each diet item, we built an accumulation curve to estimate the diversity of items as the number of analyzed stomachs increased (Ferry et al., 1996). The quantitative variables derived from the analyses of stomachs' contents were: frequency of occurrence (FO%), volume (VO%),

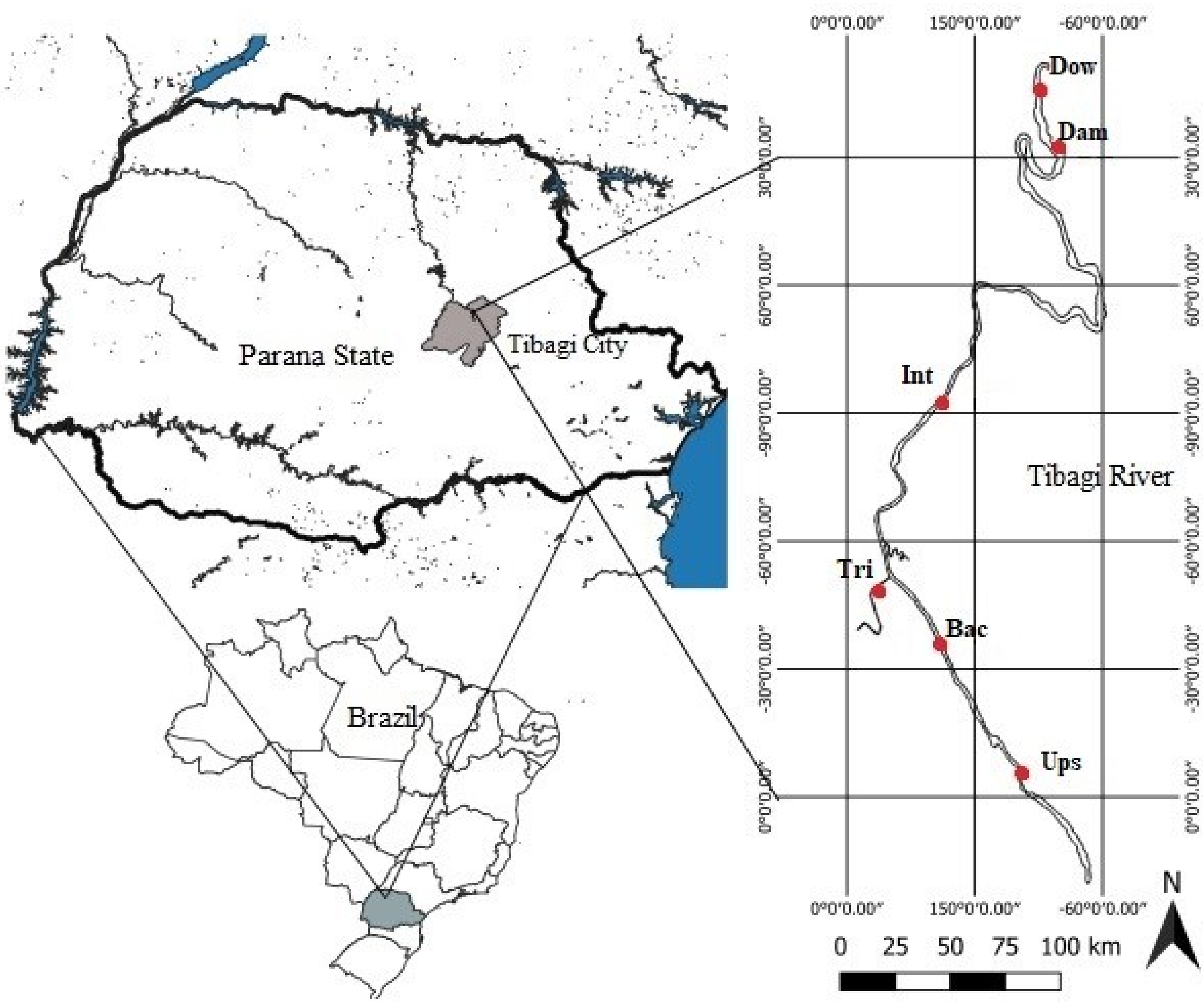

Figure 1. Map with the location of the five sampling sites (Dow = Downstream; Dam = Dam Int = Intermediary; Bac = Backwater; Ups = Upstream; Tri = Tributary) where individuals of *Psalidodon* aff. *fasciatus* were collected from October 2017 to July 2019 in Tibagi River, Tibagi, Paraná, Brazil.

and dominance (DO), as proposed by Hynes (1950) and Hyslop (1980). By using these variables, we calculated the prevalence of each item based on the feeding diet using the index (IAi%) proposed by Kawakami and Vazzoler (1980) (Equation 1):

$$IAi = (FO\% * VO\%) / \Sigma(FO\% * VO\%) \quad (1)$$

In order to describe the feeding strategy across space and time, we used the graphical method proposed by Costello (1990) and modified by Amundsen et al. (1996), which is calculated as Equation 2:

$$Pi\% = (DO/FO\%) * 100 \quad (2)$$

In the graphical representation, the Y-axis always represents FO%, whereas the X-axis portrays either Pi, DO or FO.

The matrix containing the raw volumes (in mL) of each item (columns) in each stomach (rows) was transformed using the Hellinger transformation to deal with extreme values and the high frequency of zeroes (Legendre and Gallagher, 2001). Then, we used the transformed data to calculate a stomach-by-stomach dissimilarity matrix based on the Bray-Curtis dissimilarity index (Anderson, 2014). We then applied a Non-Metric Multidimensional Scaling (NMDS; Kruskal, 1964) to visualize the differences in diet composition among individuals based on the consumed items. To test for visual differences between sampling sites and seasons, as identified in the NMDS, we applied a Permutational Multivariate Analysis of Variance (PERMANOVA) using 9999 permutations under a reduced model, and subsequent pair-wise tests (Anderson, 2001; 2014).

In order to identify the items that were responsible for the differences identified in the steps above, we applied an Indicator Value (IndVal) analysis, following Dufrêne and Legendre (1997). This analysis works by grouping the variables (diet items) that showed significant differences between the tested groups (in our case, the five sites and the four seasons). All data preparation, handling, and analyses were conducted in R version 4.0.2 (R Core Team, 2020).

RESULTS

Diet composition

We analyzed 536 stomachs, from which 50.74% were male individuals with mean (± SD) standard length of 8.02 (± 1.57) cm and mean weight of 12.81 (± 7.23) g, and 49.26% were female individuals with mean standard length of 9.25 (± 1.66) cm and mean weight of 19.90 (± 11.49) g. The accumulation curve of items stabilized, on average, at 44 consumed items as long as 490 stomachs were analyzed (Figure 2). The number of consumed items varied among sampling sites, with the Dam (47 items) as the site where individuals consumed the highest number of items, followed by Backwater (33 items), Tributary (28 items), upstream (26 items), downstream (24 items), and Intermediary (22 items).

Regarding the seasons, *P.* aff. *fasciatus* individuals had an increased diversity of items in their diet during the spring, with 38 items in total (Table 1). From autumn to winter, the number of consumed items increased from 28 to 32 items. Among the most consumed items in terms of frequency in their stomachs (IAi%), we found:

- superior plants, during all four seasons, especially during autumn, and in most individuals found in all sampling sites;
- Hymenoptera and other insect parts, especially during spring (Table 1).

Despite these dominant items, we also observed larvae, parts and adults of Bivalvia, Odonata, Thysanoptera, Muscidae, and small fishes, with both spatial and temporal variations in their dominance (Table 1).

The analysis of feeding strategy indicated that the individuals of *P.* aff. *fasciatus* consumed a variety of items that could be considered rare or only occasionally ingested. However, their diet was predominantly composed of plant parts, besides filamentous algae, insect parts, and adult individuals of Hymenoptera and Lepidoptera, especially in spring (Figure 3A). In summer, individuals also consumed Bacillariophyceae and seeds (Figure 3B), whereas Corbiculidae and Gomphidae invertebrates were more consumed during autumn and winter (Figures 3C and 3D).

Among sampling sites, we found that the individuals of *P.* aff. *fasciatus* showed increased specialization, preferentially consuming plants (Figure 4). Spatially, the identity of the most consumed items varied among sampling sites. This increased variation has contributed to widening the trophic niche more than across time, comparatively. As noticed from raw data, the NMDS (stress = 0.13) suggested niche overlap in the diet of *P.* aff. *fasciatus* in both spatial and temporal scales (Figure 5), with clearly higher variability in consumed items during spring.

Differences in diet composition

The diet of *P.* aff. *fasciatus* varied significantly depending on the sampling site (PERMANOVA; Pseudo-F = 9.734; $p < 0.001$) and the season (PERMANOVA; Pseudo-F = 35.733; $p < 0.001$), as well as for the interaction between sites and seasons (PERMANOVA; Pseudo-F = 3.644; $p < 0.001$), showing that the spatial differences in the diet of *P.* aff. *fasciatus* varied depending on the considered season. The pair-wise tests showed that the differences between Ups x Dam and Dam x Tri were consistent among all seasons (Table 2). In addition, the comparisons Bac x Int showed no differences in diet seasonally (Table 2). By comparing all sites across seasons, we found that the diet of *P.* aff. *fasciatus* did not differ between Ups x Dam during all seasons (Table 3).

The IndVal analysis indicated that 15 items as the most responsible for the observed differences in the diet composition of *P.* aff. *fasciatus* during the studied period (Table 4). As indicators of site and season, Isoptera, Chlorophyceae, and insect parts were more frequently found in stomachs during the spring and in the Upstream site (Table 4), whereas Cyanophyceae,

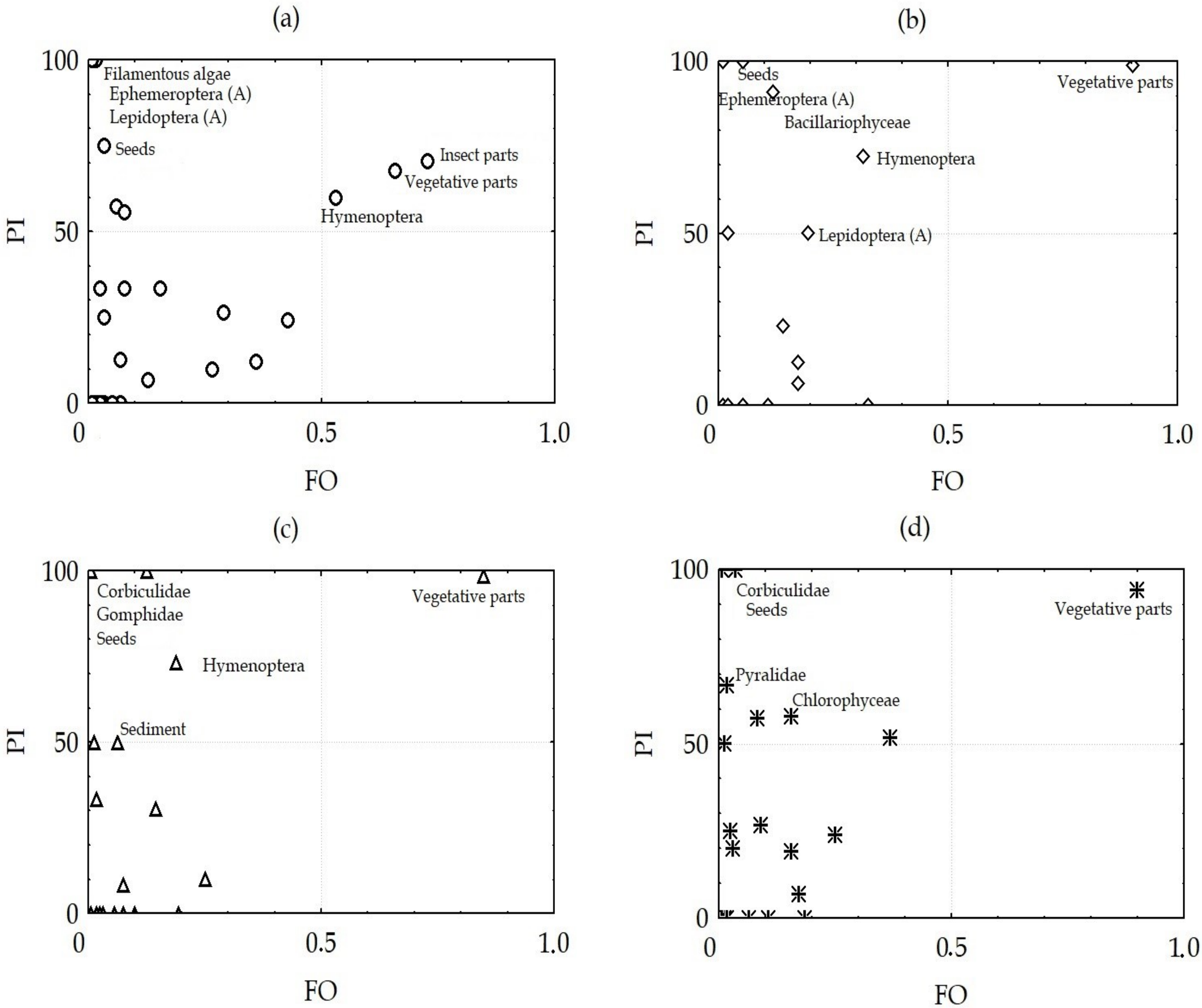

Figure 2. Accumulation curve of the number of diet items that occurred as the number of analyzed stomachs increased for 536 individuals of Psalidodon aff. fasciatus from Tibagi River, Paraná, Brazil, collected from October 2017 to July 2019.

Bacillariophyceae, and detritus were also common in the same site, but during summer. In contrast, superior plants and seeds, and adult Thichoptera were most frequently consumed in sites such as Downstream, Tributary, and Dam during summer. Finally, Diptera (in both adult and larvae stages) were more intensively consumed during summer in Upstream (Table 4).

DISCUSSION

The number of stomachs that were partially filled or completely full (degrees 2 or 3, respectively) was high enough for us to be confident that the diet of *P.* aff. *fasciatus* in Tibagi River before the construction of Tibagi Montante hydropower plant could be described. As suggested by Teixeira and Gurgel (2002), the analysis of stomach contents is as robust as the number of non-empty stomachs so that the diversity of items in their content is potentially maximized. As seen in the accumulation curve based on the analyzed stomachs for this paper, the number of items stabilized with slightly more than 40 analyzed stomachs. In addition to the temporal and spatial variability, the total number of stomachs on which we based our analyzes (N = 536) was significantly higher than this stabilization threshold.

We found that *P.* aff. *fasciatus* could be characterized as euriphagic (Zavala-Camin, 1996; Abelha et al., 2001), with variations within generalist and opportunistic feeding behaviors.

Table 1. Items and their contribution to the feeding diet index (IAi%) of *Psalidodon* aff. *fasciatus* from five sampling sites in Tibagi River, Paraná, Brazil, between October 2017 and July 2019.

	Sampling Site						Season			
	Dow	**Dam**	**Int**	**Bac**	**Ups**	**Tri**	**Sp**	**Su**	**Au**	**Wi**
Stomachs	71	152	58	74	77	104	117	92	159	168
Item/IAi%										
Sediment	**0.093**	**0.002**	**0.003**	**0.021**	**0.270**		**0.001**	**0.245**	**0.005**	**0.006**
Algae										
Filamentous algae	0.006	*					0.005			
Bacillariophyceae		0.062		0.001	2.227		0.260	0.958		
Chlorophyceae	0.144	0.173	0.071	1.063	0.532	0.202	2.693	0.003	0.001	0.327
Cyanophyceae	0.010	0.000	0.003		0.059	0.000		0.099		
Superior plants										
Seeds	38.480	0.039	2.016	0.008	0.679	0.649	0.701	0.937	8.850	0.338
Vegetative parts	57.377	94.769	93.167	75.935	72.827	79.644	27.717	90.690	88.671	93.402
Bivalvia										
Bivalvia		*								
Corbiculidae				0.018		0.003			0.001	0.001
Annelida										
Hirudinea	0.010	0.016	0.005	0.003	*	*	0.002	0.011	0.010	0.003
Ephemeroptera										
Ephemeroptera (A)	0.003	0.056	0.004		0.010	0.001	0.033	0.002	0.004	0.005
Ephemeroptera (N)		0.007		*	0.001	0.005	0.032			0.002
Baetidae	*	0.103	0.005	0.108	0.005	0.003	0.072		0.046	0.032
Leptohyphidae		0.003		0.004			0.015			
Leptophlebiidae				*						
Odonata										
Odonata (N)		*		0.002						
Gomphidae		0.001							0.001	
Isoptera		**0.015**		**0.020**	**0.236**		**0.506**			
Thysanoptera	*	*		*		*	**0.001**			
Hemiptera										
Hemiptera	0.001	0.006	0.001	0.002	0.010	0.020	0.073	0.001	0.005	*
Mesoveliidae		*		0.013			0.008			
Homoptera	*	**0.003**	**0.003**	**0.003**	**0.046**	**0.003**	**0.019**	**0.006**		**0.005**
Coleoptera										
Coleoptera (A)	0.166	0.969	0.275	0.573	0.106	1.315	5.537	1.091	0.076	0.154
Elmidae	0.001	0.001	0.001		0.001	*		0.001	0.001	
Lepidoptera										
Lepidoptera (A)	0.001	0.013		0.005	0.017	0.034	0.046	0.016	0.001	0.008
Lepidoptera (L)		0.001				0.001	0.010			
Pyralidae	0.001	*	0.008	0.364		0.006		0.007	0.001	0.050

Continue...

Table 1. Continuation.

	Sampling Site						Season			
	Dow	**Dam**	**Int**	**Bac**	**Ups**	**Tri**	**Sp**	**Su**	**Au**	**Wi**
Diptera										
Diptera (A)	0.001	0.043		0.136	1.208	0.151	0.442	0.007	0.032	0.152
Diptera (L)		*								
Diptera (P)	0.064	0.263	0.103	0.050	0.035	0.077	0.958	0.072	0.003	0.106
Chironomidae	0.001	0.008	*	0.007	0.020	0.002	0.005		0.005	0.009
Muscidae						0.004				0.001
Simuliidae		0.078	*	0.013	0.046		0.002			0.177
Hymenoptera	**1.498**	**1.443**	**3.169**	**11.193**	**17.022**	**14.201**	**21.930**	**5.730**	**1.545**	**4.284**
Trichoptera										
Trichoptera (A)		0.065	0.003	0.034	0.347	0.662	0.519		0.509	0.001
Trichoptera (L)		*					0.000			
Trichoptera (C)	*	*	0.001	0.005	0.001	*	0.008		0.001	
Hydropsychidae	0.001	0.001	*	0.001	0.001	*	0.003		0.001	
Leptoceridae				*						
Polycentropodidae			*	*						
Insect parts	**2.144**	**1.860**	**1.163**	**10.415**	**4.293**	**3.007**	**38.384**	**0.124**	**0.231**	**0.936**
Araneae		**0.001**		**0.001**		**0.002**	**0.017**			
Fish										
Fish parts						0.006				0.001
Scales	*			0.001	*		0.001			

Dow: Downstream; Int: Intermediary; Bac: Backwater; Ups: Upstream; Tri: Tributary; Sp: spring; Su: summer; Au: autumn; Wi: winter; A: adult; L: Larvae; N: nymph; C: cocoon; P: pupa; *values below 0.001.

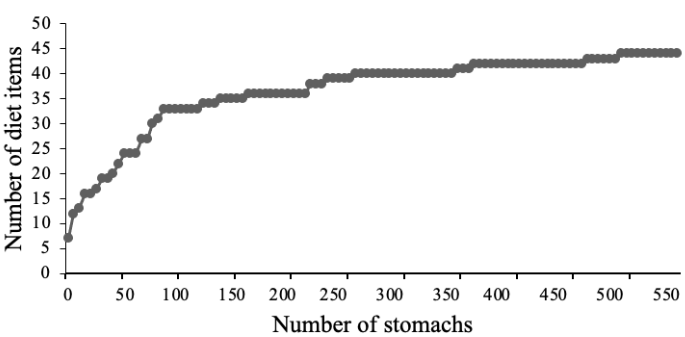

Figure 3. Costello diagram, as modified by Amundsen et al. (1996), showing the relationships between the number of items (i.e., prey richness, PI) and the frequency of occurrence (FO) of items in the diet of *Psalidodon* aff. *fasciatus* from five sites in Tibagi River, Paraná, Brazil. (A) spring; (B) summer; (C) autumn; (D) winter.

This was much likely a result of the diversity of items that the free-flowing river provided by the time of fish samplings, in combination with seasonal variations. This spatial and temporal heterogeneity contributes to widening the trophic niche of resident species in several riverine ecosystems (Hahn et al., 2004). The feeding patterns that we found here match the observed by Silva et al. (2014) for the same species in Paraná River. Similar results were found by congeneric species such as *Astyanax lacustris* (Lütken, 1875) (Silva et al., 2012) and *Astyanax abramis* (Jenyns, 1842) (Leite et al., 2021), which seems to be expected for all species belonging to the Characidae family (Mise et al., 2013; Silveira et al., 2020).

The results pointing towards an herbivorous diet are based on the predominance of algae and superior plants in the analyzed stomachs of *P.* aff. *fasciatus*. This feeding pattern has been reported elsewhere (Bennemann et al., 2005; Wolff et al., 2009;

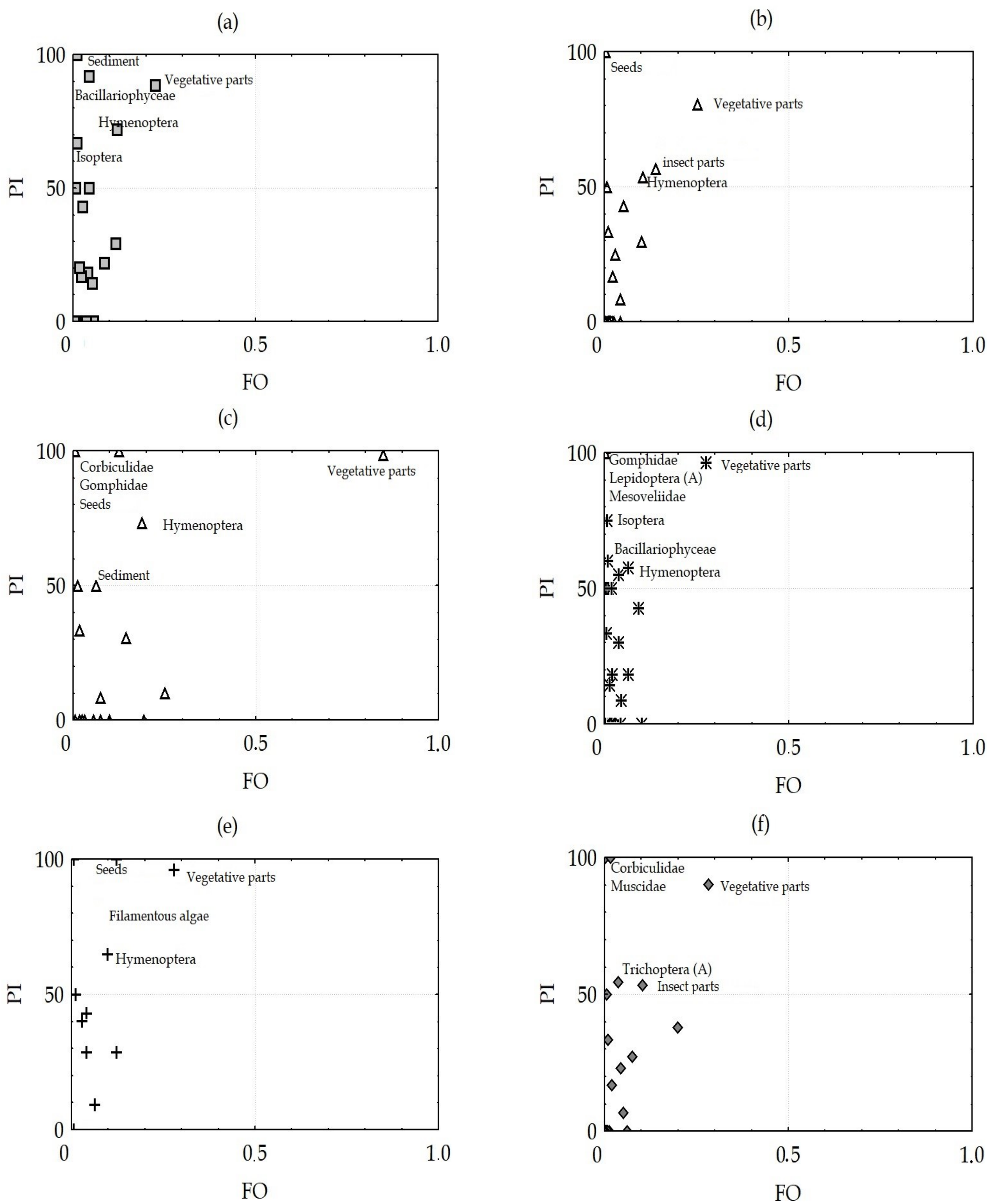

Figure 4. Costello diagram, as modified by Amundsen et al. (1996), showing the relationships between the number of items (i.e., prey richness, PI) and the frequency of occurrence (FO) of items in the diet of *Psalidodon* aff. *fasciatus* from five sites in Tibagi River, Paraná, Brazil. (A) Downstream; (B) Dam; (C) Intermediary; (D) Backwater; (E) Upstream; (F) Tributary.

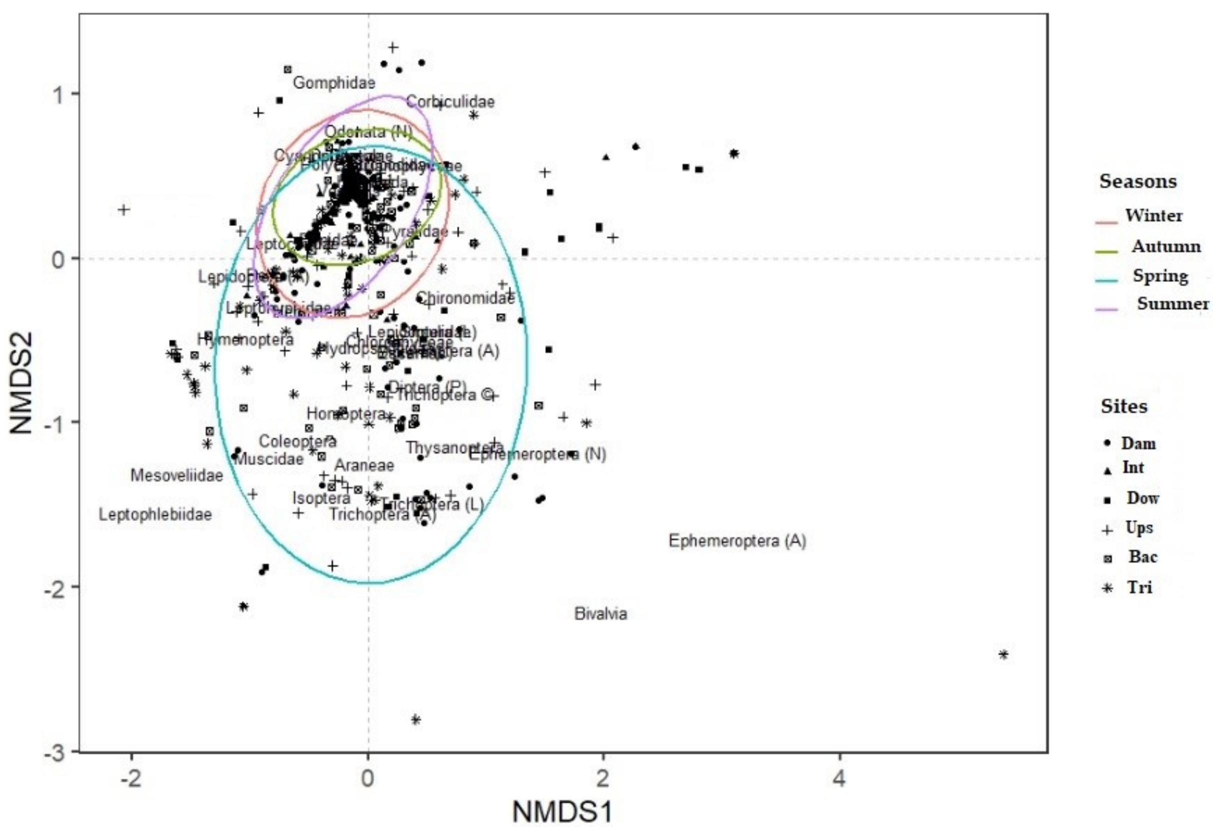

Figure 5. Ordination resulting from the Non-metric Multidimensional Scaling (NMDS) applied to the stomach-by-stomach dissimilarity matrix, built based on the Bray-Curtis index, of the diet of *Psalidodon* aff. *fasciatus* collected in five sites (Dow = Downstream; Dam = Dam; Int = Intermediary; Bac = Backwater; Ups = Upstream and Tri = Tributary) from October 2017 to July 2019 in the Tibagi River, Paraná, Brazil.

Table 2. Results of the pair-wise Permutational Multivariate Analysis of Variance (PERMANOVA) applied to Bray-Curtis dissimilarities in the diet of *Psalidodon* aff. *fasciatus* collected in five sites in Tibagi River, Paraná, Brazil, from October 2017 to July 2019.

Sampling site	Spring		Summer		Autumn		Winter	
	Pseudo-F	*p*	Pseudo-F	*p*	Pseudo-F	*p*	Pseudo-F	*p*
Ups x Bac	2.754	**0.024**	5.212	**0.001**	0.859	0.491	14.699	**0.001**
Ups x Int	4.850	**0.001**	9.314	**0.001**	0.401	0.865	10.167	**0.001**
Ups x Dam	2.792	**0.015**	3.919	**0.007**	7.117	**0.001**	27.991	**0.001**
Ups x Dow	1.187	0.298	6.735	**0.001**	14.644	**0.001**	3.148	**0.007**
Ups x Tri	2.523	**0.042**	2.470	**0.038**	2.733	**0.026**	14.791	**0.001**
Bac x Int	1.965	0.084	0.436	0.691	0.363	0.945	0.924	0.452
Bac x Dam	3.718	**0.003**	2.266	0.073	1.829	0.150	3.039	**0.015**
Bac x Dow	1.554	0.162	2.009	0.096	5.189	**0.031**	0.908	0.474
Bac x Tri	0.770	0.502	3.019	0.089	1.689	0.145	4.788	**0.001**
Int x Dam	4.218	**0.002**	1.794	0.131	2.418	**0.041**	1.712	0.105
Int x Dow	2.600	**0.038**	1.466	0.202	4.548	**0.041**	0.560	0.860
Int x Tri	3.968	**0.010**	2.185	0.084	1.173	0.369	2.367	**0.053**
Dam x Dow	1.958	**0.054**	2.157	0.07	43.441	**0.001**	2.877	**0.041**
Dam x Tri	4.177	**0.002**	3.515	**0.006**	15.373	**0.001**	4.873	**0.004**
Dam x Tri	1.930	0.092	1.815	0.118	6.678	**0.001**	1.517	0.190

Dow: Downstream; Int: Intermediary; Tri: Tributary; Bac: Backwater; Ups: Upstream; Significant tests (at p = 0.05) are in bold.

Silva et al., 2014), eventually combined with carnivorous or omnivorous feeding, or increased consumption of insects (Andrian et al., 2006; Silva et al., 2012; Silva et al., 2014). These findings confirm the expected plasticity for Characidae species (Abelha et al., 2001; Coswosck and Duboc, 2015).

The niche overlap in both spatial and temporal dimensions showed a considerably consistent diet among sites and seasons. Despite this similarity in terms of composition, we may point out that the differences in the number of consumed items was remarkable, with individuals consuming more items during spring in all sampling sites. Previous evidence for many species (Winemiller, 1990; Neves et al., 2021) shows that seasonal variations are the main sources of variation in species' diets because of their direct influence on climatic conditions and therefore resource availability, as well as it affects the spatial distribution of individuals. These season-induced effects were also reported by Wolff et al. (2009), with extended influences on onthogenetic shifts in the diet of *P*. aff. *fasciatus*. Nevertheless, in this study, we believe that this variation was offset by the proximity of sampling sites (Zavala-Camin, 1996; Neves et al., 2021) and the more homogeneous riverine condition before the construction of the hydropower plant.

The increased consumption of superior plants, Hymenoptera, and insect parts, as found for the individuals of *P*. aff. *fasciatus*

Table 4. Results of the Indicator Value (IndVal) analysis applied to diet data of *Psalidodon* aff. *fasciatus* collected in five sites from October 2017 to July 2019 in the Tibagi River, Paraná, Brazil.

Item	Site/Season	Indicator Value	*p*
Superior plants	Dam.Au	0.059	**0.031**
Diptera	Dam.Sp	0.127	**0.019**
Seeds	Dow.Au	0.176	**0.004**
Chironomidae	Ups.Wi	0.185	**0.003**
Diptera (A)	Ups.Wi	0.401	**0.000**
Insect parts	Ups.Sp	0.112	**0.021**
Chlorophyceae	Ups.Sp	0.152	**0.008**
Isoptera	Ups.Sp	0.226	**0.004**
Detritus	Ups.Su	0.156	**0.015**
Bacillariophyceae	Ups.Su	0.179	**0.007**
Cyanophyceae	Ups.Su	0.438	**0.000**
Coleoptera (A)	Bac.Su	0.121	**0.020**
Trichoptera (A)	Tri.Au	0.123	0.027
Hymenoptera	Tri.Sp	0.099	0.027

Dow: Downstream; Int: Intermediary; Tri: Tributary; Bac: Backwater; Ups: Upstream; Sp: spring; Su: summer; Au: autumn; Wi: winter; Significant tests (at p = 0.05) are in bold.

Table 3. Results of the pair-wise Permutational Multivariate Analysis of Variance (PERMANOVA) applied to Bray-Curtis dissimilarities in the diet of *Psalidodon* aff. *fasciatus* collected in five sites in Tibagi River, Paraná, Brazil, from October 2017 to July 2019.

Upstream	**Pseudo-F**	***p***	**Backwater**	**Pseudo-F**	***p***
Ups.Sp x Ups.Au	18.835	**0.001**	Bac.Sp x Bac.Au	5.645	**0.002**
Ups.Sp x Ups.Su	6.648	**0.001**	Bac.Sp x Bac.Su	4.807	**0.005**
Ups.So x Ups.Wi	7.387	**0.001**	Bac.Sp x Bac.Wi	9.882	**0.001**
Ups.Au x Ups.Su	10.682	**0.001**	Bac.Au x Bac.Su	0.845	0.379
Ups.Au x Ups.Wi	15.866	**0.001**	Bac.Au x Bac.Wi	1.108	0.345
Ups.Su x Ups.Wi	10.023	**0.001**	Bac.Su x Bac.Wi	2.506	**0.050**
Intermediary	**Pseudo-F**	***p***	**Dam**	**Pseudo-F**	***p***
Int.Sp x Int.Au	0.293	0.658	Dam.Sp x Dam.Au	63.295	**0.001**
Int.Sp x Int.Su	1.550	0.172	Dam.Sp x Dam.Su	8.397	**0.001**
Int.Sp x Int.Wi	0.700	0.618	Dam.Sp x Dam.Wi	36.662	**0.001**
Int.Au x Int.Su	0.990	0.443	Dam.Au x Dam.Su	7.253	**0.002**
Int.Au x Int.Wi	0.588	0.658	Dam.Au x Dam.Wi	4.156	**0.002**
Int.Su x Int.Wi	0.780	0.522	Dam.Su x Dam.Wi	3.992	**0.010**
Downstream	**Pseudo-F**	***p***	**Tributary**	**Pseudo-F**	***p***
Dow.Sp x Dow.Au	5.360	**0.005**	Tri.Sp x Tri.Au	8.464	**0.001**
Dow.Sp x Dow.Su	10.778	**0.001**	Tri.Sp x Tri.Su	4.951	**0.005**
Dow.Sp x Dow.Wi	1.836	0.121	Tri.Sp x Tri.Wi	15.438	**0.001**
Dow.Au x Dow.Su	10.835	**0.002**	Tri.Au x Tri.Su	1.370	0.262
Dow.Au x Dow.Wi	1.359	0.338	Tri.Au x Tri.Wi	3.352	**0.021**
Dow.Su x Dow.Wi	0.935	0.393	Tri.Su x Tri.Wi	0.712	0.530

Sp: spring; Su: summer; Au: autumn; Wi: winter; Significant tests (at p = 0.05) are in bold.

analyzed here, is common for fish that belongs to the genus *Astyanax* (Coswosck and Duboc, 2015; Leite and Silva, 2018; Neves et al., 2021). These items figured as the most ingested by individuals from all sampling sites and across all seasons. As also argued above, these findings are likely associated with the presence of riverine characteristics and the presence of relatively preserved riparian vegetation (Leite and Silva, 2018). Some studies underline the importance of preserving vegetation across river courses as they serve as sources of food and shelter for species, connecting the river body with its surroundings and increasing ecosystem complexity (Silva et al., 2014; Leite et al., 2015; Leite and Silva, 2018). Associated with vegetation, these riparian complexes provide habitat for terrestrial insects, seeds, fruits, and superior plants that represents an important fraction of the allochthonous material that are integrated into the river food web (Leite et al., 2015; Pini et al., 2019). In the paper by Rautenberg et al. (2021), the diet composition of *Psalidodon paranae* (Eigenmann, 1914) differed across seasons and evidenced the importance of riparian vegetation. Thus, we provide additional evidence that there is a complex overlap of diet composition in both spatial and temporal terms for the feeding ecology of Characidae species.

We also found that more than 30% of items (15 out of 44 items) presented significant participation in differentiating the diet of *P.* aff. *fasciatus*. Considering the spatial axis, the most upstream site was that with the highest number of indicative items, showing a more particular diet for individuals, but still with seasonal influences. The remaining items were clearly representative of their spatial context, depending on the considered site and the environmental conditions. According to Podani and Csányi (2010), the indicator values were robust to demonstrate the importance of each feeding item for the trophic ecology of this species and the associated spatial and seasonal variations in Tibagi River, besides detecting changes in the availability of resources (Antonelli et al., 2016).

CONCLUSION

This study has described important characteristics of the diet of *Psalidodon* aff. *fasciatus* in Tibagi River, before the construction of Tibagi Montante hydropower plant. This species was characterized as specialist, although with strong preferences for vegetative parts of superior plants, especially during autumn, winter, and summer. There was a weaker but considerable trend for opportunistic behavior in spring, when individuals ingested insects more frequently. These results are indicative of how environmental characteristics affect the diet composition of fish species through resource availability and that impoundments are expected to cause significant trophic consequences for resident species.

CONFLICT OF INTERESTS

Nothing to declare.

FINANCIAL SUPPORT

Universidade do Oeste do Paraná (UNIOESTE), Research Group on Fishing Resources and Limnology (GERPEL) and Coordination for the Improvement of Higher Education Personnel (CAPES).

AUTHOR'S CONTRIBUTIONS

Fonseca, J.R.S.: conceptualization, data curation, formal analysis, investigation, methodology, writing — original draft, writing — review & editing. Orsi, C.H.: investigation, methodology, data curation, formal analysis, writing — original draft. Baumgartner, M.T.: investigation, methodology, data curation, formal analysis, writing – original draft. Maciel, A.L.: investigation, methodology, data curation, formal analysis, writing — original draft. Kashiwaqui, E.A.L.: methodology, validation, writing — review & editing. Baumgartner, G.: funding acquisition, project administration, resources, software, visualization, writing — review & editing.

REFERENCES

Abelha, M.C.F.; Agostinho, A.A.; Goulart, E. 2001. Trophic plasticity in freshwater fishes. Acta Scientiarum. Biological Sciences, 23(2): 425-434.

Agostinho, A.A.; Gomes, LC.; Pelicice, F.M. 2007. Ecologia e manejo de recursos pesqueiros em reservatórios do Brasil. UEM, Maringá, 501 p.

Agostinho, A.A.; Gomes, L.C.; Santos, N.C.; Ortega, J.C.; Pelicice, F.M. 2016. Fish assemblages in Neotropical reservoirs: colonization patterns, impacts and management. Fisheries Research, 173(Part 1): 26-36. https://doi.org/10.1016/j.fishres.2015.04.006

Amundsen, P.A.; Gabler, H.M.; Staldvik, F.J. 1996. A new approach to graphical analysis of feeding strategy from stomach contents data – modification of the Costello (1990) method. Journal of Fish Biology, 48(4): 607-614. https://doi.org/10.1111/j.1095-8649.1996.tb01455.x

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

Anderson, M.J. 2014. Permutational Multivariate Analysis of Variance (PERMANOVA). Wiley StatsRef: Statistics Reference Online. https://doi.org/10.1002/9781118445112.stat07841

Andrian, I.F.; Peretti, D.; Lambrecht, D. 2006. Recursos alimentares explorados por Astyanax (Characiformes, Characidae) em diferentes bacias hidrográficas. Arquivos do Mudi, 10(1): 21-27.

Antonelli, L.; Foata, J.; Quilichini, Y.; Marchand, B. 2016. Influence of season and site location on European cultured sea bass parasites in Corsican fish farms using indicator species analysis (IndVal). Parasitology Research, 115(2): 561-568. https://doi.org/10.1007/s00436-015-4772-9

Baumgartner, M.T.; Baumgartner, G.; Gomes, L.C. 2018. Spatial and temporal variations in fish assemblage: testing the zonation concept in small reservoirs. Brazilian Journal of Biology, 78(3): 487-500. https://doi.org/10.1590/1519-6984.170424

Bennemann, S.T.; Gealh, A.M.; Orsi, M.L.; Souza, L.M.D. 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. https://doi.org/10.1590/S0073-47212005000300004

Bicudo, C.E.M.; Bicudo, R.M.T. 1970. Algas de águas continentais brasileiras. Fundação Brasileira para o Desenvolvimento do Ensino de Ciências, 228 p.

Bicudo, C.E.M.; Menezes, M. 2006. Gêneros de algas continentais do Brasil (chave para identificação e descrição). 2ª ed. RiMa, Botânica, São Carlos, 502 p.

Costa, C.; Ide, S.; Simonka, C.E. 2006. Insetos imaturos: metamorfose e identificação. Holos, 249 p.

Costello, M.J. 1990. Predator feeding strategy and prey importance: a new graphical analysis. Journal of Fish Biology, 36(2): 261-263. https://doi.org/10.1111/j.1095-8649.1990.tb05601.x

Coswosck, M.D.A.; Duboc, L.F. 2015. Ecologia trófica de *Astyanax intermedius* (Characiformes: Characidae) em um trecho do rio Preto do Sul, bacia do rio São Mateus–ES. Boletim do Museu de Biologia Mello Leitão, 37(2): 165-192.

De França, V. 2002. O rio Tibagi no contexto hidrogeográfico paranaense. A bacia do rio Tibagi. Londrina.

Dufrêne, M.; Legendre, P. 1997. Species assemblages and indicator species: the need for a flexible asymmetrical approach. Ecological Monographs, 67(3): 345-366. https://doi.org/10.1890/0012-9615(1997)067[0345:SAAIST]2.0.CO;2

Ferry, L.A.; Caillet, G.M.; MacKinlay, D.; Shearer, K. 1996. Feeding Ecology and Nutrition in Fish. In: Symposium Proceedings, San Francisco State University, 213 p.

Galvis, G.; Mojica, J.I.; Camargo, M. 1997. Peces del Catatumbo. Asociación Cravo Norte, 118 p.

Garcia, J.A.D.; Chini, H.A.S.; Maistro, E.L.; Quagio-Grassiotto, I. 2001. Dynamics and cytochemistry of oogenesis in *Astyanax fasciatus* (CUVIER) (Teleostei, Characiformes, Characidae) from Rio Sapucaí, Minas Gerais State, Brazil. Revista Brasileira de Zoologia, 18(4): 1057-1064. https://doi.org/10.1590/S0101-81752001000400003

Granzotti, R.V.; Miranda, L.E.; Agostinho, A.A.; Gomes, L.C. 2018. Downstream impacts of dams: shifts in benthic invertivorous fish assemblages. Aquatic Sciences, 80(3): 1-14. https://doi.org/10.1007/s00027-018-0579-y

Hahn, N.S.; Fugi, R.; Andrian, IF. 2004. Trophic ecology of the fish assemblages. In: Thomaz, S.M.; Agostinho, A.A.; Hahn, N.S. (eds.). The Upper Paraná River and its floodplain: physical aspects, ecology and conservation. Leiden: Backhuys Publishers, p. 247-269.

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

Higuti, J.; Franco, G.M.S. 2001. Identificação de invertebrados para análise de conteúdo estomacais de peixes. UEM, Maringá, 110 p.

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. Journal of Animal Ecology, 19(1): 36-58. https://doi.org/10.2307/1570

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

Jorge, M.B.; Vilela, M.J.A.; Suarez, Y.R.; Lima Junior, S.E. 2019. Changes in diet of a neotropical cichlid in response to river damming. Acta Scientiarum. Biological Sciences, 41(1): e43880. https://doi.org/10.4025/actascibiolsci.v41i1.43880

Kawakami, E.; Vazzoler, G. 1980. Método gráfico e estimativa do índice alimentar aplicado no estudo de alimentação de peixes. Boletim do Instituto Oceanográfico, 29(2): 205-207. https://doi.org/10.1590/S0373-55241980000200043

Kruskal, J.B. 1964. Nonmetric multidimensional scaling: a numerical method. Psychometrika, 29: 115-129.

Legendre, P.; Gallagher, E.D. 2001. Ecologically meaningful transformations for ordination of species data. Oecologia, 129(2): 271-280. https://doi.org/10.1007/s004420100716

Leite, E.F.; Godoi, D.S.; Jacyntho, L.A.; Maceno, J.F.S.; Amaral Duarte, C.R. 2021. Feeding habits and reproductive biology of *Astyanax abramis*. Brazilian Journal of Development, 7(1): 2582-2597. https://doi.org/10.34117/bjdv7n1-176

Leite, G.F.M.; Silva, F.T.C. 2018. Effects of temporal changes on resource availability in the diet of *Astyanax paranae* (Pisces, Characidae) in tropical headwater streams. Limnetica, 37(1): 117-128. https://doi.org/10.23818/limn.37.10

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: 223-238. https://doi.org/10.1007/s10750-015-2351-9

Matoso, D.A.; Martins, C.; Artoni, R.F.; Galetti Jr., P.M. 2010. Preliminary qualitative analysis on mtDNA in *Astyanax fasciatus* populations Cuvier, 1819 (Teleostei: Characidae) indicate population distinctiveness. Brazilian Archives of Biology and Technology, 53(3): 663-667. https://doi.org/10.1590/S1516-89132010000300022

Medri, M.E.; Bianchini, E.; Pimenta, J. Á.; Colli, S.; Müller, C. 2002. Estudos sobre a tolerância ao alagamento em espécies arbóreas nativas da bacia do rio Tibagi. A bacia do Rio Tibagi. Londrina.

Mise, F.T.; Fugi, R.; Pagotto, J.P.A.; Goulart, E. 2013. The coexistence of endemic species of Astyanax (Teleostei: Characidae) is propitiated by ecomorphological and trophic variations. Biota Neotropica, 13(3): 21-28. https://doi.org/10.1590/S1676-06032013000300001

Mugnai, R.; Nessimian, J.L.; Baptista, D.F. 2010. Manual de identificação de macroinvertebrados aquáticos do Estado do Rio de Janeiro. Technical Books, São Paulo, 174 p.

Neves, M.P.; Kratina, P.; Delariva, R.L.; Jones, J.I.; Fialho, C.B. 2021. Seasonal feeding plasticity can facilitate coexistence of dominant omnivores in neotropical streams. Reviews in Fish Biology and Fisheries, 31(2): 417-432. https://doi.org/10.1007/s11160-021-09648-w

Novakowski, G.C.; Hahn, N.S.; Fugi, R. 2007. Alimentação de peixes piscívoros antes e após a formação do reservatório de Salto Caxias, Paraná, Brasil. Biota Neotropica, 7(2), 149-154. https://doi.org/10.1590/S1676-06032007000200017

Pérez, G.R. 1988. Guía para el estudio de los macroinvertebrados acuáticos del Departamento de Antioquia. Universidad de Antioquia, Bogotá, 217 p.

Pini, S.F.; Abelha, M.C.; Kashiwaqui, E.A.; Delariva, R.L.; Makrakis, S.; Makrakis, M.C. 2019. Food resource partitioning among species of

Astyanax (Characiformes: Characidae) in the Lower Iguaçu River and tributaries, Brazil. Neotropical Ichthyology, 17(4): 190028. https://doi.org/10.1590/1982-0224-20190028

Podani, J.; Csányi, B. 2010. Detecting indicator species: some extensions of the IndVal measure. Ecological Indicators, 10(6): 1119-1124. https://doi.org/10.1016/j.ecolind.2010.03.010

Rautenberg, K.A.; Silveira, E.L.; Vaz-dos-Santos, A.M. 2021. Feeding trends of Psalidodon paranae in an impacted Neotropical basin: a multifactor and integrative approach. Environmental Biology of Fishes, 104(2): 89-105. https://doi.org/10.1007/s10641-021-01058-y

Schmitter-Soto, J.J. 2017. A revision of Astyanax (Characiformes: Characidae) in Central and North America, with the description of nine new species. Journal of Natural History, 51(23-24): 1331-1424. https://doi.org/10.1080/00222933.2017.1324050

Silva, D.A.; Pessoa, E.K.R.; Costa, S.A.G.L.; Chellappa, N.T.; Chellappa, S. 2012. Ecologia alimentar de *Astyanax lacustris* (Osteichthyes: Characidae) na Lagoa do Piató, Assu, Rio Grande do Norte, Brasil. Biota Amazônia, 2(1): 74-82. https://doi.org/10.18561/2179-5746/biotaamazonia.v2n1p74-82

Silva, M.R.; Fugi, R.; Carniatto, N.; Ganassin, M.J.M. 2014. Importance of allochthonous resources in the diet of *Astyanax aff. fasciatus* (Osteichthyes: Characidae) in streams: a longitudinal approach. Biota Neotropica, 14(3): e20130016. https://doi.org/10.1590/1676-06032014001613

Silva, Z.; Nascimento, P.E.C.D.; Vitule, J.R.S.; Frehse, F.D.A.; Ferraz, M.S.O.; Mourgués-Schurter, L.R. 2019. Diet and resource sharing by two Pimelodidae species in a Southeastern Brazilian reservoir. Biota Neotropica, 19(3): e20180675. https://doi.org/10.1590/1676-0611-BN-2018-0675

Silveira, E.L.; Aranha, J.M.; Menezes, M.S.; Vaz-dos-Santos, A.M. 2020. Reproductive dynamics, age and growth of *Astyanax aff. fasciatus* in a Neotropical basin. Marine and Freshwater Research, 71(6): 670-683. https://doi.org/10.1071/MF19100

Teixeira, J.L.A.; Gurgel, H.D.C.B. 2002. Métodos de análise do conteúdo estomacal em peixes e suas aplicações. Arquivos do Mudi, 6(1): 20-25.

Terán, G.E.; Benitez, M.F.; Mirande, J.M. 2020. Opening the Trojan horse: phylogeny of Astyanax, two new genera and resurrection of Psalidodon (Teleostei: Characidae). Zoological Journal of the Linnean Society, 190(4): 1217-1234. https://doi.org/10.1093/zoolinnean/zlaa019

Wang, S.; Tang, J.P.; Su, L.H.; Fan, J.J.; Chang, H.Y.; Wang, T.T.; Wang, L.; Lin, H.J.; Yang, Y. 2019. Fish feeding groups, food selectivity, and diet shifts associated with environmental factors and prey availability along a large subtropical river, China. Aquatic Sciences, 81(2): 1-18. https://doi.org/10.1007/s00027-019-0628-1

Winemiller, K.O. 1990. Spatial and temporal variation in tropical fish trophic networks. Ecological Monographs, 60(3): 331-367. https://doi.org/10.2307/1943061

Wolff, L.L.; Abilhoa, V.; Rios, F.S.A.; Donatti, L. 2009. Spatial, seasonal and ontogenetic variation in the diet of *Astyanax aff. fasciatus* (Ostariophysi: Characidae) in an Atlantic Forest river, Southern Brazil. Neotropical Ichthyology, 7(2): 257-266. https://doi.org/10.1590/S1679-62252009000200018

Zanata, A.M.; Camelier, P. 2009. *Astyanax vermilion* and *Astyanax burgerai*: new characid fishes (Ostariophysi: Characiformes) from Northeastern Bahia, Brazil. Neotropical Ichthyology, 7(2): 175-184. https://doi.org/10.1590/S1679-62252009000200007

Zavala-Camin, L.A. 1996. Introdução aos estudos sobre alimentação natural em peixes. EDUEM, Maringá, 129 p.

ERRATUM

https://doi.org/10.20950/1678-2305/bip.2022.48.e728ERRATUM

In the manuscript "Diet of *Psalidodon* aff. *fasciatus* (Cuvier, 1819) (Teleostei: Characidae) in a neotropical river before reservoir formation" DOI: https://doi.org/10.20950/1678-2305/bip.2022.48.e728, published in Fonseca et al., Bol. Inst. Pesca 2022, 48: e728, on pages 5 and 7:

Page 5, figure 2

Where it reads:

Figure 2. Accumulation curve of the number of diet items that occurred as the number of analyzed stomachs increased for 536 individuals of *Psalidodon* aff. *fasciatus* from Tibagi River, Paraná, Brazil, collected from October 2017 to July 2019.

It should read:

Figure 2. Costello diagram, as modified by Amundsen et al. (1996), showing the relationships between the number of items (i.e., prey richness, PI) and the frequency of occurrence (FO) of items in the diet of *Psalidodon* aff. *fasciatus* from five sites in Tibagi River, Paraná, Brazil. (A) spring; (B) summer; (C) autumn; (D) winter.

Page 7, figure 3

Where it reads:

Figure 3. Costello diagram, as modified by Amundsen et al. (1996), showing the relationships between the number of items (i.e., prey richness, PI) and the frequency of occurrence (FO) of items in the diet of *Psalidodon* aff. *fasciatus* from five sites in Tibagi River, Paraná, Brazil. (A) spring; (B) summer; (C) autumn; (D) winter.

It should read:

Figure 3. Accumulation curve of the number of diet items that occurred as the number of analyzed stomachs increased for 536 individuals of *Psalidodon* aff. *fasciatus* from Tibagi River, Paraná, Brazil, collected from October 2017 to July 2019.