Trophic organization the ichthyofauna of two semi-lentic environments in a flood plain on the upper Paraná River, Brazil

Estrutura trófica da ictiofauna em dois ambientes semi-lênticos da planície de inundação do Alto Rio Paraná, Brasil

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Abstract: Aim: The purpose of this study was to identify, using the guild concept, the trophic groups of ichthyofauna in little known environments called *ressaccos* (riverine inlets subject to periodic isolation depending on floodplain conditions) located on the flood plain of the upper Paraná River. **Methods:** Individuals were caught by nets and afterwards separated according to their stomach contents. To identify trophic groups, the unweighted pair-group method (UPGMA) was adopted. **Result:** By analyzing fish diets, we classified 13 fish species distributed within five trophic groups in the Manezinho *ressacco*, and 20 species of eight trophic groups in Bile *ressacco*. Of the total the species identified, 11 occurred in both environments. **Conclusion:** Even though Cladocera was the preferred food of the majority of the species found, an ampler quarrel of the use of the guild term is necessary since the variety of item ingested for the species.

Keywords: food, fishes, trophic groups, *ressaccos*.

Resumo: Objetivos: Identificar grupos tróficos da ictiofauna de ambientes pouco conhecidos como ressacos, na planície de inundação do alto rio Paraná utilizando o conceito de guilda. **Métodos:** Os exemplares de peixes foram capturados pelo método de captura ativa analisados posteriormente quando a preferência alimentar presente no conteúdo gástrico. Para a formação dos grupos tróficos, utilizou-se o método de agrupamento pareado igualmente ponderado (UPGMA). **Resultados:** A identificação do conteúdo estomacal possibilitou a classificação de 13 espécies de peixes em cinco grupos tróficos no ressaco do Manezinho e, das 20 espécies do Bile em oito categorias tróficas. Das 22 espécies examinadas, 11 foram comuns aos dois ambientes. **Conclusão:** Apesar do itém preferencial ser Cladocera para a maioria das espécies nos dois ambientes analisados, é necessária uma discussão mais ampla da utilização do termo guilda, devido à variedade de iténs ingeridos pelas espécies.

Palavras-chave: ictiofauna, grupos tróficos, guilda, *ressaccos*.

1. Introduction

A flood plain normally comprises various environmental types: rivers, temporary and permanent lakes, channels, and "*ressaccos"*, with unique characteristics that distinguish them from the other types. Considered semi-lentic (Fonseca and Rodrigues, 2005), these areas - located in fluvial islands in the Paraná River have been studied since the end of the last century by PELD, a Brazilian program dedicated to long-term research.

The knowledge of fish diets allows not only the identification of trophic categories but also inferences about their structure. Furthermore, it provides a basis for understanding the relationships between ichthyofauna and other organisms present in the community (Gaspar da Luz et al*.,* 2001; Abelha et al., 2001), and can provide data about habitat, food availability, and even behavioral features (Hahn et al*.,* 1997).

Concepts for guilds or trophic groups established vary in accordance with the purpose of studies. Root (1967) defines trophic groups or guilds, as representing a part of a community feeding on the same class of environmental resources. According to Simberloff and Dayan (1991), the concept for ecological guild includes subsets within species group, having high potential for competition. Austen et al. (1994) emphasized also that may provide a means to identify species with similar responses to environmental variation. In a review of the application of the guild concept in fisheries

management, Austen et al. (1994), distinguished between structural guilds (groups of species that use similar resources) versus guilds that functions as a 'super specie' (groups of species that collectively respond to environmental variation in a more or less consistent manner). Species within guilds based on dietary similarity (use similar resources) respond differently to key abiotic impacts such as flow alteration (Welcomme et al., 2006) limited the application of the concept. Furthermore, Regier et al. (1989) proposed the term "environmental guild", for identifying fish species that respond in similar manner to changing hidrology and geomorphology of river ecosystems.

In this study we analyze relationships between food-chain consumers for species fishes, aggregate entities by grouping of trophically similar species that are sometimes called guild with objective of the identify trophic groups in fishes found in the *ressaccos* of the flood plain of the upper Paraná River, an ecosystem with high spatial and temporal variations.

1.1 Study area

The Paraná River, which is next to the Municipality of Porto Rico, is divided into two main branches and a small canal by two islands, the Mutum and the Porto Rico. Both of these contain several lakes and *resaccos* (Cunico et al., 2002).

The studied area includes two *resaccos*, a popular term for riverine inlets, called Manezinho and Bile, both located on Mutum Island (Figure 1). In the years in which this study took place, these *ressaccos* were connected to the Paraná River only by a channel, which is not visible owing to prevailing morphological conditions.

The 582.6 m long Bile *resacco* (22° 45' 13.56" S and 53° 17' 9.48" W) had an average depth of 1.3 m during the period studied. Cyperacae and Leguminosae, such as *Mimosa pigra* e *Inga uruguensis*, are present in its margins.

The 100 m long Manezinho *resacco* (22° 46'44.7" S and 53° 20' 56.76" W) occupies a 1 ha area. In the studied period, its average depth was 2.1 m, and the unique

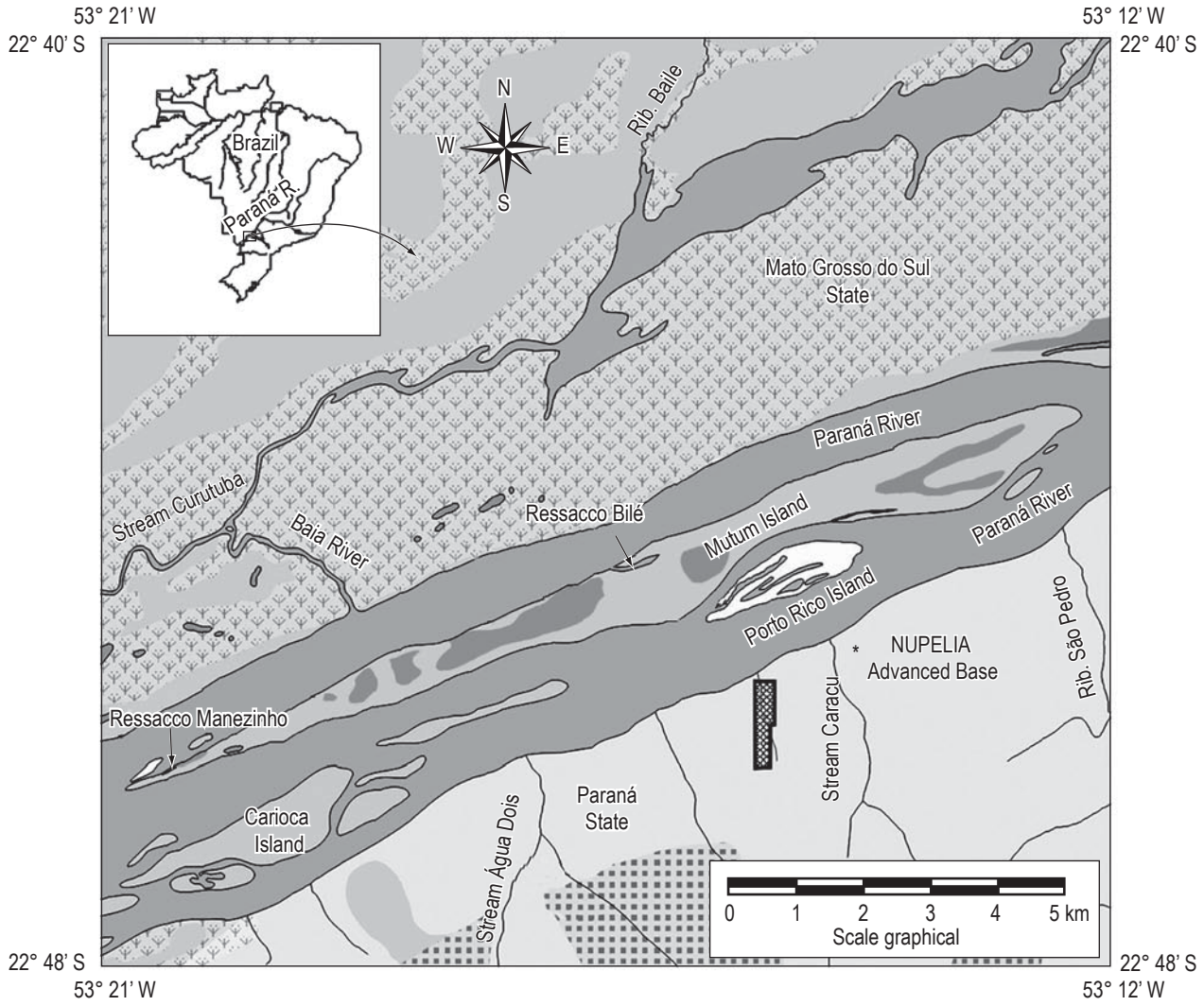

Figure 1. Location of Manezinho and Bile *ressaccos* on the flood plain of the Paraná River.

connection with the river was through a channel 1 m long and 3 m wide. The margins of Manezinho are covered by arboreous vegetation, with a predominance of *Cecropia* and *Inga* spp.

In this *resacco,* ichthyofauna sampling was done quaterly, in 2000 (February, May, August and October) and 2001 (February, May, August and November). Atypical years are not uncommon on flood plains because inundation can be delayed, e.g., at March/00, and at the end of January/01. According to Agostinho and Zalewski (1995), seasonal changes usually occur from November through March..

2. Material and Methods

Active capture with three attached drag nets (5 mm mesh, 50 m long, 2.8 m high) was used to collect fishes, which were measured, weighed, and dissected. Stomachs and respective contents were fixed in 4% formaldehyde.

Stomach content was analyzed with a stereoscopic microscope; items found were identified at the lowest possible taxonomic level. Calculations of volumetric frequency and occurrence were obtained by methods proposed by Hynes (1950) and Hyslop (1980). Using a graduated test tube (1, 2, and 5 mL), volumes were determined from liquid displaced.

Occurrence (Fo) and volumetric (Fv) frequencies were combined in the alimentary index (IAi) (Kawakami and Vazzoler, 1980). The IAi values were converted into percentages and then into cumulative sums. Based on these data, the preferred item and eating habits of a given species were indicated by the IAi percentage (≥50%) (Gaspar da Luz et al., 2001). Subsequently the cluster analysis was applied, based on the unweighted pair-group method (UPGMA), using Statistica.5.5. This analytical technique is useful in determining significant groups of individuals, or objects (Hair, 1987), or trophospecies. The IAi percentages were used for each *ressacco* in the analysis. According to Pinto-Coelho (2000), the percentages had a classificatory property, in this case signifying that all species were organized in distinct subgroups, in an ordered sequence of hierarchical levels.

3. Results

Examination of 230 gastric contents the twenty-two species, 13 from Manezinho and 20 from Bile was made for the determination of trophic organization in the two *ressaccos*. Of the 22 species, 11 were found in both environments.

In Manezinho *ressaco*, five trophic groups were registered (Table 1), of which zooplanktivory predomi-

Table 1. Number of stomachs analyzed; minimum and average length (LT)); trophic characterization; preferred food item; and IAi (Index of Alimentary Importance) of fish species found in the Manezinho *ressacco* on Mutum Island in the Paraná River, Brazil.

Species	Number of stomachs	LT minimum (cm)	LT average lengt (cm)	Preferred food item	%IAi	Tropic caracterization
Astyanax altiparanae (Garutti and Britski, 200)	1	7.2		Insects (Hymenoptera, Ortopthera and Diptera) Vegetable (fruit the macrophytes, Algae and plants remnants)	48.67	Omnivorus
Aphyocharax sp.	13	2.9	3.2	Cladoceran	51.33	(Begon et al., 1990)
Aphyocharax anisitsi (Eigenmann and Kennedy, 1903)	1	4.5		Cladoceran	61.56	Zooplanktophagous
Bryconameicus stramineus (Eigenmann, 1908)	16	2.7	4.1	Cladoceran	78.80	(Lansac-Tôha & Alves, 1994; Gaspar da Luz & Okada, 1999)
Serrapinnus notomelas	2	2.4	3.0	Cladoceran	69.25	Zooplanktophagous
Hyphessobrycon sp.	19	3.0	3.4	Cladoceran	83.33	Zooplanktophagous
Hemigrammus marginatus (Ellis, 1911)	9	4.1	4.4	Insects (Diptera and Hymenoptera)	61.14	Zooplanktophagous
Hoplias aff. malabaricus (Bloch, 1794)	1	9.6		Fish rest	59.80	Piscivores (Agotinho et al.,1997)
Moenkhausia intermedia (Eigenmann, 1908)	4	5.3	6.0	Cladoceran	100.00	Zooplanktophagous
Moenkhausia sanctaefilomenae (Steidachner, 1907)	2	3.3	3.7	Coleoptera	83.33	Insectivorous (Adrian, Lansac-Tôha & Alves, 1994; Gaspar da Luz & Okada, 1999)
Odontostilbe sp.	11	2.4	2.8	Cladoceran	71.67	Zooplanktophagous
Steindachnerina insculpta (Fernandes-Yépez, 1948)	3	3.5	3.5	Detritus	98.37	Detrivorous
Satanoperca pappaterra (Heckel, 1840)	2	2.2	2.1	Cladoceran	87.50	Zooplanktophagous

nated in eight species, representing 57% of total species found in this environment. In *Aphyocharax* sp., *Aphyocharax anisitsi, Bryconamericus stramineus*, *Serrapinnus notomelas*, *Hyphessobrycon* sp., *Moenkhausia intermedia*, *Satonoperca pappaterra* and *Odontostilbe* sp., cladoceran predominated.

Groups shown in the dendogram (Figure 2) comprise two sets. The first of these groups includes *B. stramineus* and *M. intermedia* because of high IAi rankings of cladoceran and diptera in stomach contents. Group 2, which presented IAi values above 60% for cladoceran, consisted of the previous two species plus *Aphyocharax* sp., *Aphyocharax anisitsi, Odontostilbe* sp., *Hyphessobrycon* sp., *S. notomela*, and *S. pappaterra*. The *Hemigrammus marginatus* isolated species of the two main groups shows no trophic similarity with the other groups because of its preference for cladoceran.

The fish assemblage of Bile *ressacco* was distributed in eight trophic groups (Table 2), which six species (30% of the total) were identified in the zooplanktivorous trophic groups: *Apareiodon affinis, Bryconamerius stramineus, Serrapinnus notomelas, Hyphessobrycon eques, Hemigrammus marginatus,* and *Moenkhausia intermedia*. Of these, three species (*B. stramineus, S.notomelas* and *M. intermedia*) were found in both *ressacco* environments.

The dendogram (Figure 3) shows four groups. The first includes the species *M. intermedia*, *A. affinis*, *H. marginatus*, *S.notomelas*, *H. eques*, and *B.stramineus*, classified together because their preferred dietary item (cladoceran) ranks on the IAi above 50%, and in some cases reaches 100%.

Group two comprised two species: *Serrasalmus marginatus* and *Metynnis cf. maculatus* because of the common presence in stomach content of algae, macrophytes, detritus, and scales.

Group three included the species *R. paranensis* and *Aphyocharax* sp., linked by the common consumption of Amphipoda, a food item restricted to this group.

The species *Aphyocharax anisitsi* and *Moenkhausia sanctaefilomenae* comprised group four, whose diet included cladoceran, diptera, detritus, Hemiptera, Conchostraca, and Ephemeroptera (Table 3).

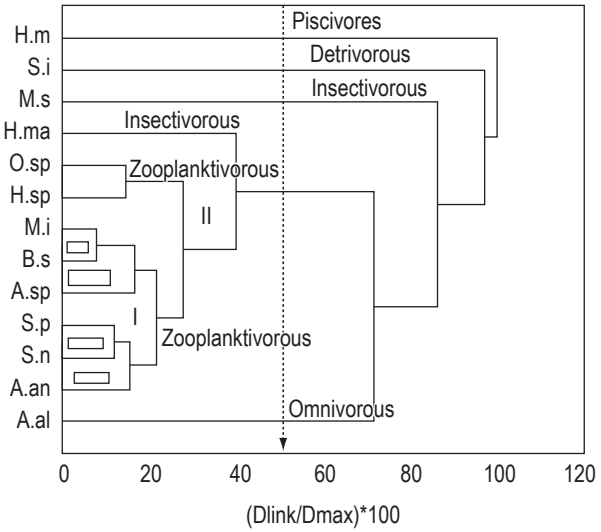

Figure 2. Dendogram grouping of IAi (Index of Alimentary Importance) values for 13 fish species found in the Manezinho *ressacco*, located on the floodplain of the upper Paraná River. Caption= (I, II, III) = separate groups; fish species (H.malaba = *Hoplias aff.malabaricus*; S.inscul = *Steidachenerina insculpta*; M.sancta = *Moenkhausia sanctaefilomenae*; H.margin = *Hemigrammus marginatus*; Odontos = *Odontostilbe* sp.; Hyphesso = *Hyphessobrycon* sp.; M.inter = *Moenkhausia intermedia*; Bstramin = *Bryconamericus stramineus*; Aphyocha=*Aphyocharax* sp.; S.pappat = *Satonoperca pappaterra*; S.notome = *Serrapinnus notomelas*; A.anists = *Aphyocharax anisitsi*; A.altipa = *Astyanax altiparanae*).

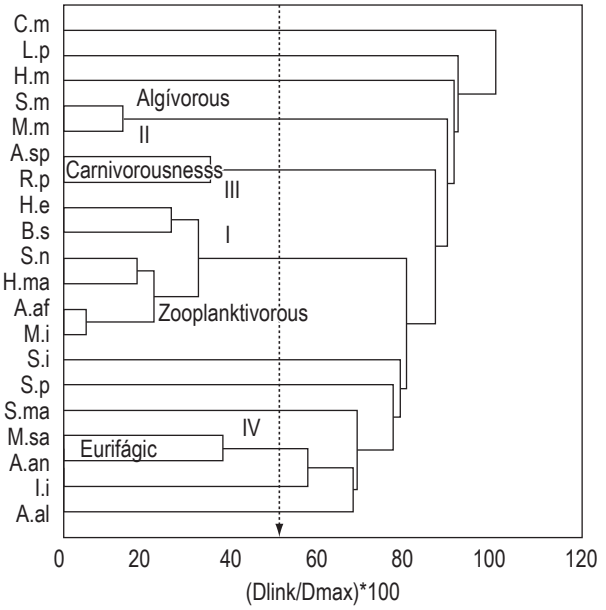

Figure 3. Dendogram grouping of IAi (Index of Alimentary Importance) values for 20 fish species found in the Marezinho *ressacco*, located on the floodplain of the upper Paraná River. Caption = (I, II, III) = separate groups; fish species (C.monoculu = *Cichla monoculus*; L.platym = *Loricariichtys platymetopon*; H.malaba = *Hoplias aff.malabaricus*; S.macula = *Serrassalmus maculatus*; M.macula = *Metynnis cf.maculatus*; Aphyocha = *Aphyocharax* sp.; R.parane = *Roeboide paranensis*; H.eques = *Hyphessobrycon eques*; B.strami = *Bryconamericus stramineus*; S.notome = *Serrapinnus notomelas*; H.margin = *Hemigrammus marginatus*; A.affini = *Apareidon affinis*; M.intermédia = *Moenkhausia intermedia*; S.inscul = *Steidachenerina insculpta*; S.pappat = *Satonoperca pappaterra*; M.sancta = *Moenkhausia sanctaefilomenae*; A.anists = *Aphyocharax anisitsi*; I.labros = *Iheringichthys labrosus*; A.altipa = *Astyanax altiparanae*).

Table 2. Number of stomachs analyzed; minimum and average length (LT)); trophic characterization; preferred food item; and IAi (Index of Alimentary Importance) of fish species found in the Bile *ressacco* on Mutum Island in the Paraná River, Brazil.

Species	Number of stomachs	LT minimum (cm)	LT average lengt (cm)	Preferred food item	%IAi	Tropic caracterization
Apareiodon affinis (Steindachener, 1879)	1	2.1		Cladoceran	100.00	
Astyanax altiparanae (Garutti and Britski, 200)	19	2.7	7.5	Macrophytes	57.80	Herbiorous
Aphyocharax sp.	1	4.6		Amphipod	100.00	
Aphyocharax anisitsi (Eigenmann and Kennedy, 1903)	6	3.1	4.0	Diptera	72.00	Insectivorous
Bryconamericus stramineus (Eigenmann, 1908)	12	3.3	5.0	Cladoceran	54.01	Zooplanktophagous
Cichla monoculus (Spix, 1831)	1	13.2		*S. pappaterra*	100.00	Psicivores (Agostinho et al., 1997)
Serrapinnus notomelas (Eigenmann, 1915)	7	3.0	3.7	Cladoceran	71.43	Zooplanktophagous
Hyphessobrycon eques (Steindachner, 1882)	12	2.5	3.5	Cladoceran	57.33	Zooplanktophagous
Hemigrammus marginatus (Bloch, 1794)	5	4	4.8	Cladoceran	79.20	Zooplanktophagous
Hoplias aff. malabaricus (Bloch, 1794)	11	2.7	31.0	Decapod	85.68	Carnivorousness
Lheringicthys labrosus (Lütken, 1874)	4	17.0	23.0	Bivalvia	60.13	Benthivorous
Loricariichthys platymetopon (Isbüeker and Nijssen, 1979)	6	2.8	16.1	Detritus	84.54	Detrivrous
Moenkhausia intermedia (Eigenman, 1908)	3	5.1	6.9	Cladoceran	94.70	Zooplanktophagous
Metynnis cf. maculatus (Knerr, 1858)	4	9.9	15.7	Algae	95.04	Algivorous
Moenkhausia sanctaefilomenae (Eigenmann, 1908)	19	3.2	4.9	Insects	73.74	Insectivorous
Roeboides paranensis (Pignalberi, 1975)	11	2.6	3.9	Amphipod	68.74	Carnivorousness
Steindachnerina insculpta (Fernández-Yépez, 1948)	10	3.3	7.9	Detritus	70.74	Detrivorous
Serrasalmus marginatus (Valenciennes, 1836)	5	2.3	17.6	Fish rest	56.33	Piscivores
Satanoperca pappaterra (Heckel, 1840)	3	2.5	18.8	Psocoptera	76.34	Insectivorous
Serrasalmus maculatus (Kner, 1858)	1	15.9		Algae	79.74	Pscivorous (Agostinho et al., 1997)

4. Discussion

The variety of food items available favors predominance of opportunists or generalists rather than specialists on the flood plain (Gaspar da Luz, 2000). Sudden environmental changes explain food item variations, particularly insects and other invertebrates found in stomachs of detrivorous species in the two *ressaccos* (Leão et al., 1991).

The studied period occurred in atypical years with severe droughts and late flooding on the flood plain of the upper Paraná River (Agostinho and Zalewski, 1995). Such conditions complicate distinguishing in guilds. However, Junk (1980) suggested that in environments with varying hydrological conditions, studies must be carried out under extreme conditions, which produce the greatest differences in available food items and which therefore force fish to utilize their adaptive capacities.

Another factor that makes guild delineation difficult is food plasticity. According to Gaspar da Luz et al. (2001), it consists in the interaction of quantity and quality of available food. Is is outstanding in tropical riverine ichthyofauna (Goulding, 1980; Hahn et al., 1997; Lowe-McConnell,

Table 3. Food items consumed by fish species in the *ressaccos* of Bile (●) and Manezinho (♦) on the flood plain of the Paraná River in 2000-2001.

Food resources	*Apareiodon affinis*	*Aphyocharax anisitsi*	*Aphyocharax* sp.	*Astyanax altiparanae*	*Bryconamericus stramineus*	*Cichla monoculus*	*Serrapinnus notomelas*	*Hyphessobrycon eques*	*Hoplias aff. malabaricus*	*Hemigrammus marginatus*	*Iheringichthys labrosus*	*Loricariichthys platymetopon*	*Moenkhausia intermedia*	*Metynnis cf. maculatus*	*Moenkhausia sanctaefilomenae*	*Roeboides paranaensis*	*Serrassalmus marginatus*	*Satanoperca pappaterra*	*Serrassalmus maculatus*	*Steindachnerina insculpta*	*Hyphessobrycon* sp.	*Odontostilbe* sp.
Trichoptera			♦		●					●	●		●		●		●					
Copepoda		●♦	♦							♦	●											
Cladocera	●	●♦	♦	●	●♦		●♦			●♦	●		●♦	●	●	●	●	♦		●	♦	♦
Diptera		●♦		●♦	●♦		●	●	●	●♦	●		●♦		●♦	●	●	●				
Hymnoptera		●		♦	♦					●♦					●					●		
Detritus		●			♦		●♦			●	●		●	●					●	♦	♦	♦
Hydracarina		●			●					♦					●							
Hemiptera		●		●				●	●	♦					●♦	●						
Decapoda		●			●♦			●	●	●♦	●			●			●		●			
Parts insects				●	♦					♦					●		●			●	♦	♦
Parts vegetable				●♦	●♦		●♦	●	●	♦	●			●	●	●			●	●	♦	♦
Acarina					♦		♦													●		
Fragments fishes								●	●♦								●					
Nematoda							●♦			♦		●	♦		●					●		
Conchostraca		●	♦		●								♦		●	●	●					
Ortophtera				♦																		
Fruit the macrophytes				●♦	●										●			●				
Algae				●♦	●		●	●	●				♦	●	●♦		●		●	●♦		
Scale fish		●		●										●	♦		●	♦	●			
Amphipoda			●													●		♦				
Coleoptera				●							●				●♦							
Lepidoptera				●																		
Gastropoda											●							●				
Bivalvia											●											
Neuroptera											●											
Macrophytes											●											
Matter ingested										●	●	●			●	●	●	●				
Tecameba													●							♦		
Ephemeroptera		●											●		●							
Odonata					●					●			●		●		●					
Satanoperca. pappaterra						●		●	●													
Homoptera					●																	
Annelida															●	●						
Culicidae															●							
Collembola															●							
Ceratopogonidae															●							
Psocoptera		●																●				
Parts seed					♦																♦	♦

1999), because it allows species to alter food item consumption in accordance with prevailing relative abundances.

In the present study, plasticity was observed in *R. paranensis*, which although classified as insectivorous on the flood plain (Hahn et al., 2002; Agostinho et al., 1997), the fish tends towards carnivorousness in the Bile *ressacco*, in which the predominant food item consumed was Amphipoda.

In spite of the prolonged drought occurring in the studied period, it appears that the environment never reached the destabilization level, since omnivorous species were limited to *A. altiparanae* in the Manezinho *ressacco*. According to Begon et al. (1990), trophic web theory views omnivorousness as a rare phenomenon because it is a destabilizing factor, i.e., species so characterized compete more intensely within their own trophic level, as well as being preyed upon by fish of higher trophic levels (Pimm 1982; 1991).

An unusual characteristic of the *ressaccos* was that only one herbivorous species, was recorded: *A. altiparanae* in Bile *ressacco*. This supports Junk's theory (1980), which postulates that when water levels are low, even though a great number of food items are available to predators this is untrue for herbivorous species, since macrophytes as well as vegetation in normally flooded areas have dried up.

The presence of piscivores was attributed to *H. aff. malabaricus*, which is common to the two environments, and *C. monoculus,* found only in Bile *ressacco*. According to Agotinho et al. (1997), in the flood plain of the Paraná River, piscivory by species whose life cycle occurs in lentic environments (like *H. aff. malabaricus*) is a permanent condition. In addition, this trophic category tends to have greater biomass in such environments, particularly when the water level is low. The same probably holds for *ressaccos.*

In the Manezinho *ressacco*, detritivory was attributed to *S. insculpta*, and, to *L. platymetopon* and *S. insculpta* in Bile. In general, only a small percentage of species feed on detritus. According to Bowen (1983), most fishes belong to higher trophic levels and use invertebrates as a link to the detrivorous base of the trophic chain.

Items only occasionally consumed by the species *S. insculpta* included cladoceran, nematodes, algae, insects, terrestrial vegetation, acarids, and thecamoebas, but as they comprised only a small percentage of items registered, species can be classified as detrivorous. The same variety was observed by Peretti and Andrian (2004) for the Pau Veio. Even *ressacco* so, Agostinho et al. (1997) classified *S. insculpta* as a mud-eater. These results show the alimentary plasticity of this fish species, i.e., the capacity to adapt to environmental circumstances affecting food quality.

The same variation showed that *ressaccos* have the same function as lakes along the banks of the river in the flood plain, namely their importance in maintaining intact regional biodiversity. Because of their supply of food items and types of suitable habitats e. g., for aquatic macrophytes, they are the preferred environment of small, sedentary species.

In the two Manezinho and Bile *ressacos*, the greatest number of fish species belonged to the zooplanktivorous trophic category because of their preferred food item: cladoceran. This may be associated with the availability of this resource in 2001 on the flood plain environments, as verified by Lansac-Tôha et al. (2002). However, in spite of the predominance of Cladoceran, these species presented a variety of food items in their diets, suggesting that they are actually opportunists, and thus cannot be grouped in a single guild, which would necessitate further study as to their foraging behavior.

Based on the findings presented in this work, we conclude that more study is needed on small fish (up to 5 cm) whose feeding habits have not yet been completely identified and, principally, their role (guild) within the trophic web, an approach to which is exemplified in the work of Hahn et al. (2002).

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