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A N I N T E R N A T I O N A L J O U R N A L

Diet of *Astyanax* species (Teleostei, Characidae) in an Atlantic Forest River in Southern Brazil

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ABSTRACT

Feeding habits of six species of Astyanax from river Maquiné are described. Fishes were sampled bi-monthly from November/95 to September/96 in two zones of the river. Items were identified, counted and had their abundance estimated according to a semi-quantitative scale. Frequency of occurrence, alimentary importance index (IFI) values and a similarity analysis of diets for each species-river zone sample were examined. All the species were considered typically omnivorous, with insects and vegetal matter being the most important items in their diet. These species could act as seed dispersers, particularly for macrophytes. Intra-specific spatial differences were not observed in comparisons of samples from two diferent regions of the river, except for A. fasciatus. The presence of Podostemaceae macrophytes in the mid-course of the river seemed to be important both as an autochthonous food resource and as habitat for several organisms preyed by the Astyanax species.

Key words: Diet, seed dispersal, fish, *Astyanax*, Atlantic Forest, Brazil

INTRODUCTION

The Atlantic Forest includes a large region in eastern Brazil, from the state of Rio Grande do Norte (north) to Rio Grande do Sul (south). It is one of the most biodiverse and endangered ecosystems in the world (Myers et al. 2000). Threats to the Atlantic Forest ecosystems include the degradation of natural streams and rivers caused by loss of riparian vegetation, erosion, siltation, organic and chemical pollution, sand mining, damming and introductions of exotic species (Menezes et al., 1990; Faria and Marques, 1999). Many stream fishes have been particularly affected by alterations in the forest ecosystem because it influenced light incidence, turbidity, pH, temperature and food resources (Menezes et al., 1990; Uieda and Kikuchi, 1995).

Fishes are probably the less known vertebrates in the Atlantic Forest, partly due to a lack of taxonomic and systematic information, but also because there are not many field studies (Rosa and Menezes, 1996). Most ecological investigations are restricted to the states of São Paulo and Rio de Janeiro (Uieda, 1984; Sazima, 1986; Costa, 1987; Menezes et al., 1990; Sabino and Castro, 1990 and Uieda et al., 1997).

Several fish species represent important links between aquatic and terrestrial trophic webs (Gelwick and Matthews, 1996) as predators or preys, but can also act as seed dispersers (Goulding et al., 1988; Crampton, 1999). The role

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of fish as predators or seed dispersers can be investigated by stomach content analysis.

In the Atlantic Forest, the relationship between fish and the forest has rarely been studied (Menezes et al, 1990; Uieda and Kikuchi, 1995). Some of the most common species in this ecosystem belong to the characid genus *Astyanax* Baird and Girard, 1854, which includes many species with Neotropical distribution and uncertain taxonomic situation (Jin and Toledo, 1975; Moreira-Filho and Bertollo, 1991; Garutti and Britski, 1997). There are several studies about the feeding habits of *Astyanax* species (Zaret and Rand, 1971; Barbosa and Matsumura-Tundisi, 1984; Costa, 1987; Teixeira, 1989; Arcifa et al, 1991; Esteves and Galetti Jr., 1995; Meschiatti, 1995; Esteves, 1996; Hartz et al., 1996; Uieda et al., 1997; Fugi, 1998 and Luiz et al., 1998) and it seems be consensual that *Astyanax* are opportunistic feeders with a highly variable diet composition.

This work describes the diet of the six *Astyanax* species found in Maquiné River, indicating their trophic roles and discussing their connections with the terrestrial environment. It also examines the hypothesis that because of the opportunistic character of these species, their diet would be different in the potamal and rithral zones of the river, where habitat conditions and biota are determined by physiographic conditions (Vannote et al., 1980; Baptista et al, 1998a; b).

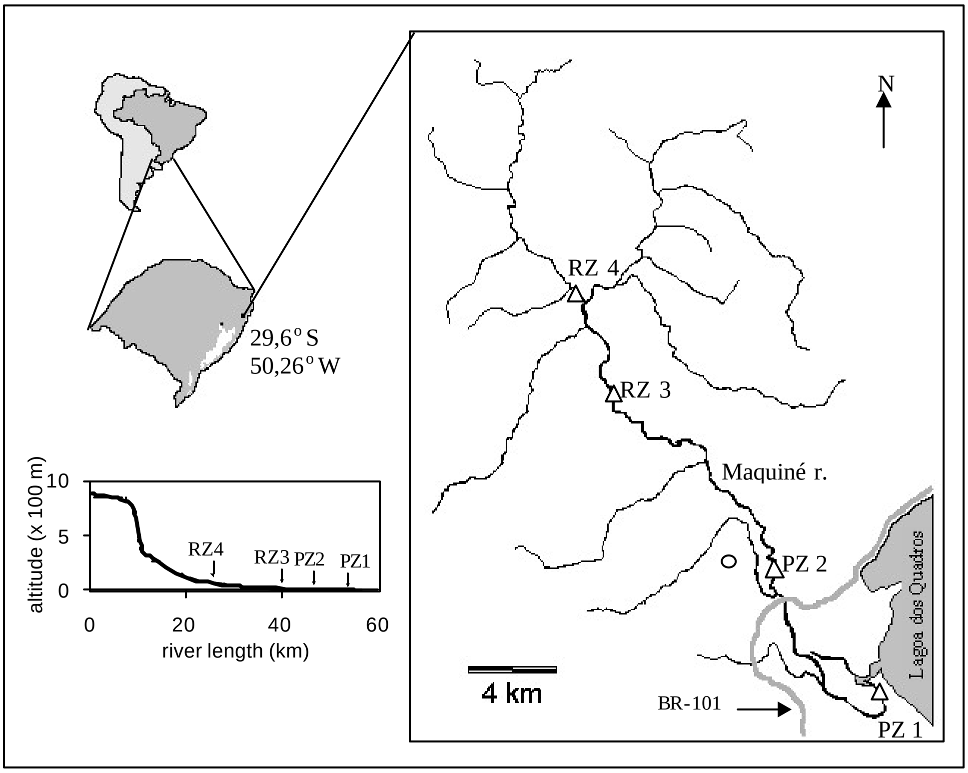

Figure 1 - Geographic situation of the Maquiné river drainage showing location of the sampling points (open circle = city of Maquiné). In the lower left corner, the position of the sampling points on the longitudinal profile of the river is shown.

MATERIALS AND METHODS

The Maquiné River watershed (approximately 29.6° S 50.26° W; Figure 1) is part of the Tramandaí River basin in northeastern Rio Grande do Sul. The headwaters are situated in the Serra Geral highlands (maximum altitude around 900 m) and the water runs approximately 50 km until Lagoa dos Quadros (altitude < 10 m), a freshwater lake in the Coastal Plain region.

Sampling occurred in two main zones of the river: the potamal zone and the rithral zone. The potamal zone (PZ) is situated in the lowlands of the Coastal Plain region, where the river is deeper and wider,

water transparency is low, channel bed is formed by sandy and silty substrates, and several types of macrophytes are abundant. In this area, a large volume of water flows slowly towards the river mouth and water level fluctuations usually occur within a period of weeks to months, flooding the surrounding lowlands. The rithral zone (RZ) is situated in an area of higher altitudes and slopes.
In this area, the river presents a riffle-pool structure, with high water transparency, rocky bottoms and lower abundance and richness of macrophytes. Water level fluctuations can occur within a period of hours to days.
Samples were obtained every two months, from November/1995 to September/1996. Four river reaches were sampled, two in the potamal zone (PZ1 and PZ2) and two in the rithral zone (RZ3 and RZ4). Fish were captured with gillnets exposed for 24 hours (except RZ4), seine nets, cast nets and dip nets, preserved in 10% formaline and then transferred to ethanol (70%.). Voucher specimens were deposited at Science Museum, Pontifícia Universidade Católica do Rio Grande do Sul (MCPUCRS).
Only full stomachs from adult specimens were examined (partially full stomachs were not considered). Food items where identified to the best possible taxonomic resolution. Abundance of each food item in a stomach was estimated by a semi-quantitative method, where abundance corresponded to categories representing the proportional area occupied by the item in relation to the total area occupied by all items. Four categories were defined following Guillen and Granado (1984): 0 - absent; 1 - rare (< 25% of the area of all items); 2 - abundant (25 to 50% of the area of all items) and 3 - very abundant (> 50% of the area of all items).
The importance of an item in the diet of each species was estimated by an index of food importance (IFI), which represents the relation between frequency of occurrence of that item (Hyslop, 1980) and its abundance. The IFI proposed by Granado-Lorencio and Garcia-Novo (1986) is calculated as

$$IFI = \frac{\Sigma(X_k.k)}{a - 1}$$

Where:

a = number of categories;

X_k = frequency of the item x_i with k value of abundance;

k = categorie of abundance.

The IFI value for each item varies from zero to one. *Rare* items have values lower than 0.15, *additional* items present values between 0.15 and 0.3, and *main* items present values equal or higher than 0.3.
Samples from the potamal zone (PZ1 and PZ2) and rithral zone (RZ3 and RZ4) were pooled for investigating diet variations in relation to the different regions of the river. Diet similarity among species and different river zone samples was examined by cluster analysis based on a correlation matrix for de IFI. In this analysis, each species sample from a particular river zone (e.g. *A. bimaculatus* from the rithral zone or *A. bimaculatus* from the potamal zone) was considered an Operational Taxonomic Unit (OTU). A Principal Coordinates Analysis (PCO) was employed to detect which food items were determinant in the formation of the identified clusters. Both analyses were processed in the software MULTIV (Pillar, 1997). In the graphical plot of the PCO analysis including all food categories, all the OTUs (except for *A. alburnus*) were clustered right on the PCO2, resulting in an unclear display. We re-ran this analysis without the food category “rests of insects” because of its potentially confounding effect on the process of analysis and interpretation. The result showed no major alterations but improved the graphic display of OTUs, so we used this procedure for analyzing the data.

RESULTS

Six species of *Astyanax* were captured during the study period: *A. alburnus* (Aa), *A. bimaculatus* (Ab), *A. eigenmanniorum* (Ae), *A. fasciatus* (Af), *A. scabripinnis* (Ay) and *Astyanax* sp. (As). All species were captured regularly in both the potamal and rithral zones, except for *A. alburnus*, which is typically a lowland species and *A. scabripinnis* which is typically a headwater species. This species was not considered in the cluster and PCO analysis because of the low number of individuals captured.
Table 1 lists the food items present in the stomachs of the six species in each zone of the river, with the respective values for frequency of occurrence and IFI. *Astyanax alburnus* showed the richest diet (25 food items) among all studied species (up to

eight items were found in a single stomach). Such richness of items was possibly influenced by the larger sample of stomachs examined for this species. The remaining species consumed from 15 (*A. bimaculatus*) to 19 (*A. fasciatus*) different food items. The maximum number of items observed in a single stomach was 10 for *A. fasciatus* and 7 for the remaining species. For all species (except *A. alburnus*), between 40 and 60% of the total number of items occurred in stomachs from both the potamal zone (PZ) and the rithral zone (RZ). Overall, the studied *Astyanax* species could be considered as omnivorous, preying on a variety of items, with insects and plant matter representing the most important animal and plant food items respectively.

The results of the cluster analysis for diet similarity among species and different river zones are presented in Figure 2. Three main groups can be observed, with *A. alburnus* alone in one cluster and the other species in the remaining two clusters. Except for *A. fasciatus*, all species presented similar diet in both river zones, indicating that differences of habitat and biota among the potamal and rithral zones did not influence the main diet characteristics of most *Astyanax* species.

The Principal Coordinates Analysis (Figure 3, Table 2) allowed the identification of the most important food items characterizing the diets of each species in each region of the river. The resultant ordination of OTU in three groups was concordant with the cluster analysis. In PCO1, which accounted for 44,4% of the variation in the data, species were ordinated according to the importance of Collembola, Copepoda, Amphipoda and plant debris. Among these, the first three (which are all animal items) were consumed almost exclusively by *A. alburnus*, while plant debris were of low importance for this species. The importance of microcrustacea (Copepoda and Amphipoda) and the low importance of plant debris were distinctive features in the diet of *A. alburnus* relative to the other *Astyanax* from Maquiné River.

In PCO2 (20.65% of variation in the data), ordination was mainly influenced by the consumption of Diptera. Species where consumption of Diptera was more important relative to other items, appeared in the lower group, while those where Diptera was less important were in the upper group.

Astyanax alburnus could be considered an omnivorous species with a marked tendency to carnivory because Collembola was the most frequent and abundant item (a main food item) and additional items included only animal organisms (Diptera, Amphipoda and Copepoda). The remaining *Astyanax* species were typically omnivorous because plant debris, algae and animal were always additional or main items, with differences among their diets being mainly related to the distinct importance of Diptera. More subtle differences could be discussed from data in Table 1.

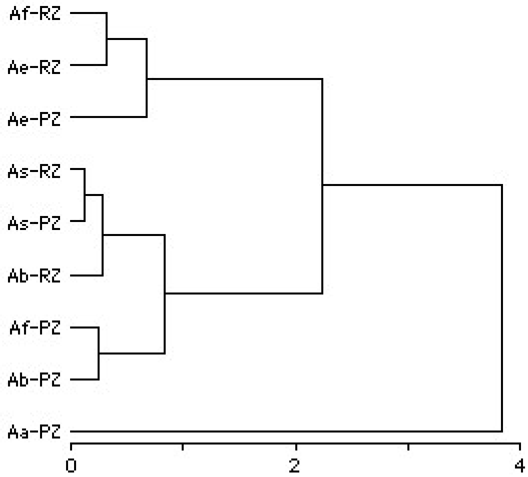

Figure 2 - Cluster analysis for diet similarity of five *Astyanax* species collected in two different zones of river Maquiné. Aa - *Astyanax alburnus*; Ab - *A. bimaculatus*; Ae - *A. eigenmanniorum*; Af - *A. fasciatus*; As - *A. sp.* PZ - potamal zone; RZ - rithral zone.

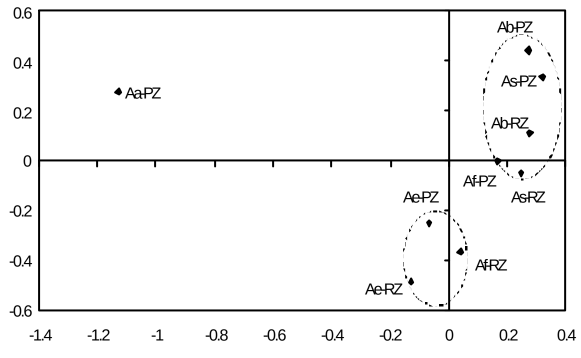

Figure 3 - Principal Coordinates Analysis on diet data of the Astyanax species from two different zones of river Maquiné. Aa - *Astyanax alburnus*; Ab - *A. bimaculatus*; Ae - *A. eigenmanniorum*; Af - *A. fasciatus*; As - *Astyanax sp;* PZ -potamal zone; RZ - rithral zone.

DISCUSSION

Astyanax species are not distributed evenly along the river. *A. alburnus was* practically limited to the potamal zone (a few individuals were captured in a single opportunity in RZ3). *A. scabripinnis*, besides being rare in the samples, appeared only **in** the rithral zone (RZ). *A. bimaculatus* and *Astyanax* sp. were common along the river, *A. eigenmanniorum* was more abundant in the potamal zone (PZ) and *A. fasciatus* in the rithral zone (RZ). These differences in species distribution and abundance influenced the corresponding number of stomachs examined for each zone of the river. As opportunistic fish, it could be expected that the diet of *Astyanax* would change from potamal to rithral zone because of differences in habitat and food resource availability. However, the cluster analysis showed that except for *A. fasciatus*, most *Astyanax* presented similar diets in the two different zones of the river, indicating that the general trophic role of each species remained the same. Clearly, this result was influenced by the taxonomic resolution employed in food category assignment, but this was also a matter of study objectives. Some differences in diet among species and between the two river zones are mentioned and discussed below, but no consistent and evident change of trophic role could be determined.

Although fish are known to have adaptable and versatile feeding habits, species classification according to the main trophic function is important in community studies (Austen et al., 1994). *Astyanax* are usually omnivorous fish (Nomura, 1975; Sazima, 1986; Teixeira, 1989; González et al., 1986; Escalante, 1992; Esteves, 1996; Meschiatti, 1995 and Hartz et al., 1996) and, as shown above, this is true for the *Astyanax* species from Maquiné River.

As mentioned above, the degree of resolution employed in determining food categories influences the results, and can lead to an overestimation of diet overlap (Sabino and Castro, 1990). However, detailed examination of diet composition allowed the identification of specific characteristic features not apparent from the cluster and PCO analyses.

A. alburnus is an insectivore-zooplanktivore species, preying basically on Collembola, Amphipoda, Copepoda and Diptera. The same was observed for *A. alburnus* in a coastal lake (Hartz et al., 1996), but with Cladocera as main item. Aquatic Collembola live associated to macrophytes and can be found in their leaves or submerged roots. In PZ1, there are large banks of *Eichornia* spp and flooded margins with Graminae, where *A. alburnus* probably have foraged close to the water surface and to the macrophyte roots. This is also indicated by the frequency of pupal and adult Diptera in its stomachs. However, the importance of Amphipoda and sediment (which can be related both to the macrophyte roots and to substrate), and of zooplanktonic Copepoda (particularly Ciclopoida and copepodits) suggests that *A. alburnus* explores the whole water column. Non-identified cysts were also an additional item. Although it could not be precisely identified, this item is certainly from animal origin. In a single stomach it was possible to identify similar cysts as mollusks of the family Hyriidae (Bivalvia), in young life stages. The Hyriidae are obligate fish parasites in their initial life stages.

A. bimaculatus seemed to be a more herbivore species, since plant debris was a main item both in the potamal and rithral zones. Similar observation was made by Luiz et al. (1998), who observed that in the lower course of two streams from the Paraná basin, *A. bimaculatus* preyed basically on algae, while in headwaters it preyed on higher plants debris. Nevertheless, slight differences in diet between the potamon and the rithron can be observed in Table 1. In the potamal zone, plant debris (mainly Gramineae and seeds of Cyperaceae) and fish scales were the main items in the diet and only this species preyed on fish, although fish scales were found in all species. In the rithral zone, the contribution of animal items to the diet of *A. bimaculatus* increased both in richness and abundance of items in spite of insects being only additional items. Plant debris were composed of seeds, fruits of *Ficus* sp (Moraceae), leaves and flowers from riparian vegetation, and rheophilous Podostemaceae (leaves and stalks).

A. eigenmanniorum could be considered a more insectivorous species, specially in the rithral zone, where plant debris presented lower importance and frequency, being partly compensated by an increase in algae importance. In the potamal zone, rests of insects, sediment and plant debris were main items in the diet. Mollusks appeared almost exclusively in this species, in the form of large white and flashy structures with no shell fragments. In one stomach, it was possible to distinguish bivalve larvae. Plant debris were seeds of Ciperaceae and Alistemataceae (*Echinodorus* sp.), fragments of Gramineae and fruits. Stalks, fruits and seeds of Podostemaceae were also found in the stomachs of *A. eigenmanniorum*.

Table 1 - Food items observed in the stomachs of *Astyanax* species from river Maquiné. Results for species samples from the potamal and rithral zones are presented separately. Values represent IFI and absolute frequency of occurrence ( ) of food items. Aa - *Astyanax alburnus*; Ab - *A. bimaculatus*; Ae - *A. engenmanniorum*; Af - *A. fasciatus*; As - *A.* sp; Ay - *A. scabripinnis*; PZ - potamal zone; RZ - rithral zone. N - number of stomachs examined.

Nº	Item	Aa-PZ	Ab-PZ	Ab-RZ	Ae-PZ	Ae-RZ	Af-PZ	Af-RZ	As-PZ	As-RZ	Ay-RZ
1	Sand	0,18 (42)	0,05 (2)	0,08 (4)	0,33 (14)	0,11 (2)	0,14 (4)	0,20 (13)	0,03 (1)	0,07 (5)	0,22 (2)
2	Algae	0,10 (20)		0,04 (2)	0,07 (3)	0,11 (2)	0,03 (1)	0,42 (16)	0,09 (4)	0,31 (11)	0,78 (3)
3	Plant materials	0,03 (8)	0,39 (6)	0,44 (10)	0,30 (12)	0,15 (4)	0,36 (5)	0,39 (18)	0,59 (15)	0,63 (21)	0,11 (1)
4	Rotifera						0,03 (1)				
5	Copepoda	0,21 (47)					0,08 (1)				
6	Cladocera	0,03 (4)									
7	Nematoda				0,02 (1)						
8	Mollusca	0,01 (1)			0,15 (4)						
9	Amphipoda	0,29 (39)	0,08 (1)	0,04 (1)							
10	Decapoda	0,01 (2)			0,20 (5)		0,11 (2)			0,04 (1)	
11	Blattaria	0,01 (1)									
12	Coleoptera	0,09 (19)	0,08 (3)	0,23 (9)	0,19 (6)	0,08 (2)	0,03 (1)	0,28 (13)	0,08 (4)	0,17 (10)	0,11 (1)
13	Collembola	0,79 (69)			0,02 (1)						
14	Diptera	0,28 (63)	0,03 (1)	0,15 (7)	0,24 (10)	0,37 (8)	0,25 (6)	0,30 (20)	0,03 (2)	0,15 (10)	0,22 (2)
15	Ephemeroptera		0,05 (2)	0,02 (1)		0,07 (2)	0,03 (1)	0,27 (14)		0,07 (4)	0,22 (2)
16	Hemiptera	0,03 (7)		0,06 (1)					0,02 (1)		
17	Hymenoptera	0,05 (9)		0,15 (3)	0,02 (1)	0,15 (4)	0,17 (2)	0,03 (1)	0,14 (5)	0,17 (8)	
18	Homoptera	0,03 (7)			0,02 (1)		0,06 (2)		0,06 (2)		
19	Lepidoptera			0,02 (1)				0,06 (4)		0,03 (2)	
20	Plecoptera	0,01 (1)					0,03 (1)	0,14 (8)		0,05 (2)	0,33 (1)
21	Thysanoptera	0,01 (2)				0,04 (1)		0,02 (1)			
22	Trichoptera	0,01 (1)		0,04 (2)	0,04 (2)	0,04 (1)		0,11 (7)	0,02 (1)	0,09 (7)	0,11 (1)
23	Rests of insects	0,06 (8)	0,23 (6)	0,27 (8)	0,32 (13)	0,59 (7)	0,22 (6)	0,42 (19)	0,27 (9)	0,24 (14)	0,11 (1)
24	Insect eggs			0,02 (1)				0,05 (3)			
25	Ácarina	0,01 (3)						0,02 (1)			
26	Araneae	0,01 (3)	0,03 (1)	0,02 (1)							
27	Pisces	0,01 (22)	0,13 (3)								
28	Fish scales	0,02 (4)	0,36 (7)	0,19 (6)	0,11 (6)	0,04 (1)	0,22 (5)	0,15 (9)	0,17 (7)	0,03 (2)	0,11 (1)
29	Cists	0,26 (53)			0,04 (2)						
30	Ni	0,03 (6)	0,26 (6)	0,25 (6)	0,11 (5)	0,30 (4)	0,22 (6)	0,09 (6)	0,06 (4)	0,24 (15)	0,22 (2)
	N	77	13	16	18	9	12	22	22	25	3
	Number of items	24	10	15	15	11	14	15	11	13	10

Table 2 - Results of the Principal Coordinates Analysis on stomach content data of Astyanax species in river Maquiné. Only food items with scores higher than ± 0.5 in PCO1 and PCO2 are shown.

Item	PCO 1	Item	PCO 2
Cists	-0.9503	Diptera	-0.7933
Collembola	-0.9390	Thysanoptera	-0.6555
Cladocera	-0.9351	Araneae	0.6400
Blattaria	-0.9351	Trichoptera	-0.5971
Copepoda	-0.8541	Pisces	0.5382
Amphipoda	-0.8532	Ephemeroptera	-0.5190
Plant materials	0.8291	Sand	-0.5026
Acarina	-0.6257		
Fish scales	0.5531		
Diptera	-0.5377		
Ni	0.5089		
Eigenvalue	1.6394		0.8371
% of variance	40.444		20.651

The presence of relatively undigested parts of Podostemaceae in the stomachs from lower course (PZ1) individuals indicates that this species can realize considerable spatial movements along the river. As Podostemaceae are typical from rithral areas, individuals of *A. eigenmanniorum* probably move from these areas to the lower course, tamal areas in a relatively short period. *A. eigenmanniorum* from Maquiné River was also found to be more insectivorous than the populations studied by Escalante (1982) and Teixeira (1989), for which plant debris were the most characteristic food items. Hartz et al. (1996) observed that higher plants were more important in warmer periods of the year, while insects (mainly Diptera) were most important in cooler periods, indicating that seasonal differences must also be investigated. According to their IFI values, the item "rests of insects" was considered a main item in both river zones. It must be noted, however, that this category was composed basically by exoskeleton pieces that should be transformed into small fragments before passing through the intestine. As a result, the importance of insect rests as food was probaly overestimated, because they probably had longer residence period within the stomachs, and were less efficiently digested when compared to "softer" items.

Stomachs of *A. fasciatus* from the potamal zone contained mainly rests of leaves, flowers and Gramineae, with very low importance to algae. In contrast, algae were a main item in the rithral zone as well as Coleoptera and Ephemeroptera.

Populations of *A. fasciatus* from reservoirs and floodplain lakes have been found omnivore feeders with a tendency to insect feeding (Esteves and Galetti Jr., 1995; Meschiatti, 1995) and zooplankton feeding (Barbosa and Matsumura-Tundisi, 1984). Esteves (1996) observed an ontogenetic shift in the diet of this species, from zooplankton to algae and higher plants. In Maquiné River, only adult specimens were studied and foods from vegetal origin were main items in both zones of the river. Esteves (1996) also states that in rivers *A. fasciatus* and *A. bimaculatus* tend to explore the same food resources (algae, higher plants, insects and scales). In Maquiné River, the similarity between the diet of these species was higher in the potamal zone, while in the rithral zone *A. fasciatus* consumed more algae, sediment and insects (Diptera, Ephemeroptera, Plechoptera and Trichoptera). *Astyanax* sp from the potamal zone consumed mainly leaves and flowers, especially Gramineae. Starch grains could be observed in some stomachs. Similarly to *A. fasciatus*, in the rithral zone the importance of plant debris and algae was higher for *Astyanax* sp. However, the low importance of sediment and Diptera make the diet of this species more similar to that of *A. bimaculatus*.

Fish scales were found in stomachs from all examined *Astyanax* species and presented higher IFI values in the potamal zone for almost all species. The scales found in the stomachs were usually clustered and firmly bent, and were apparently being digested. Some empty stomachs contained only this clustered mass of scales. The consumption of fish scales by *Astyanax* species has been observed by other authors (Nomura, 1975; Meschiatti, 1995; Hartz et al. 1996; Uieda et al., 1997), but it is not clear if this is a consequence of behavioral interactions or feeding habits. In underwater observations, it has been observed that individuals preyed on scales deposited on the bottom of river pools (Virgínia Uieda, pers. comm.). However, according to Arcifa et al., 1991, the ingestion of scales could be a consequence of interspecific antagonistic interactions in the larger multispecific schools formed in lentic waters. Whatever the case, fish scales contain about 20% of the total calcium in the body of some species (Takagi et al. 1989), and may be a source of this element for the fish feeding on them.

Sand was present in the diet of all *Astyanax* species from the Maquiné river, being a principal item for *A. eigenmanniorum* in the potamal zone. The frequent presence of this item suggested it might be important in the diet of *Astyanax*. In the present study, the scale of analysis was not adequate to evaluate this question, but possible reasons for the ingestion of sand are: the consuption of biofilm associated to the sediment, as an auxilliary item for mechanic destruction of plant items or hard parts of insects and crustaceans; or a low efficiency of the gill rakers in avoiding the ingestion of sand with the actual food items. Barbosa and Matsumura-Tundisi (1984)) and Hartz et al. (1996) also observed the presence of sand in the stomachs of *Astyanax* species, but did not discuss its role as a feeding item.

The importance of allochthonous food sources for stream fishes is well known (Sabino and Zuanon, 1998). According to Uieda and Kikuchi (1995), many stream fish depend primarily on allochthonous materials, preying on terrestrial insects and plant debris. In Maquiné River, allochthonous items are evidently important for *Astyanax* spp. However, the occurrence of Podostemaceae in riffles represents a notable source of autochthonous food, both in its own and as habitat for macroinvertebrates.

The presence of Podostemaceae was also observed in Amazonian fish stomachs (Santos et al., 1997; Santos and Rosa, 1998), but had not yet been mentioned for Atlantic Forest fishes. This plants are typically found in lotic environments, on sandy and rocky substrates being associated to coarse litter from the riparian forest, roots, algae and a wide variety of insects (Santos et al., 1997; Santos and Rosa, 1998). Podostemaceae thus function as an autochthonous food source for fish and aquatic invertebrates, as well as a habitat for larval forms of many insect groups. Philbrick and Novelo (1997) stated that little is known about Podostemaceae seed dispersion by biological vectors, so that the presence of Podostemaceae in the stomachs of *Astyanax* could have connections with the biology of this plants.

The presence of fruits and seeds in the diet of fish has been recognized in the literature (Gottsberger, 1978; Goulding, 1980; Kubitzki, 1985; Kubitzki and Ziburaki, 1993; Souza-Steveaux et al, 1994; Araújo Lima et al., 1995), which indicated the role of characiforms and siluriforms as the most important fish seed dispersers in Amazonian waters. Because of the presence of apparently intact plant seeds in *Astyanax* stomachs, it is possible that these fish could act as seed dispersers. *Astyanax* species are mentioned in the literature as exploratory fish that are able to move along considerable distances along rivers, occupying a variety of habitats (Edwards, 1977; López, 1978; Uieda, 1984; Meschiatti, 1995; Bertaco et al., 1998). This behavior and the observed consumption of seeds suggest that these species could be potential plant dispersers, particularly for macrophytes, as terrestrial plant species present a wide range of possibly more efficient seed dispersal mechanisms. The role of fish as seed dispersers is still to be investigated in Atlantic Forest fish species, and seed viability studies would be necessary to determine if *Astyanax* species act as seed dispersers or predators, as well as the relative importance of ichthyochory in comparison to other dispersal mechanisms for the plant species envolved.

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RESUMO

Seis espécies do gênero *Astyanax*, presentes no rio Maquiné, RS, foram estudadas quanto aos seus hábitos alimentares. Os exemplares foram amostrados bimensalmente de novembro de 1995 a setembro de 1996 nas zonas ritral e potamal do rio. Os itens alimentares foram identificados e quantificados de acordo com uma escala semi-quantitativa de abundância, utilizando-se para análise a frequência de ocorrência e um índice de importância alimentar para cada espécie e zona do rio. Análises multivariadas de agrupamento e ordenação foram utilizadas para comparar as dietas intra e interespecíficas. Todas as espécies foram consideradas onivoras, sendo que os itens mais importantes foram os insetos e restos de vegetais superiores. Sugere-se que as espécies estudadas possam atuar como dispersoras de sementes, particularmente para macrófitas. Diferenças espaciais intraespecíficas não foram encontradas, exceto para *A. fasciatus*. A presença de Podostemaceae no curso médio do rio parece ser uma fonte importante de alimento para as espécies, além de servir de refúgio para diversos organismos que são predados por *Astyanax* sp.

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