Fish diversity and community structure in a tributary stream of the Paraná River

Diversidade e estrutura da comunidade de peixes em um arroio tributário do Rio Paraná

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Abstract: Aim: The purpose of this study was to analyze the spatial and temporal variation in the structure of the fish assemblage of the Garupá Stream, one of the tributaries of the Paraná River, by considering composition, abundance and diversity. **Methods:** Eight samplings were carried out from April 2003 to December 2004 in the upper, middle and lower stretches of the stream, with six gill nets with mesh sizes ranging from 3 to 12 cm (between opposite knots). **Results:** Fifty seven species, grouped in 5 orders, 16 families and 41 genera, were identified. The Garupá stream presents a longitudinal zonation, the lower stretch presented a high diversity (4.73 bits) as compared to the middle (2 bits) and upper stretches (2.9 bits), and too the highest capture per unit of effort (4,234 g 24 h/130 m²), *Astyanax cf. fasciatus* was the most abundant species in the upper and middle stretches and *Hypostomus luteomaculatus*, *Schizodon nasutus* and *Hypostomus commersoni* were the most abundant species in the lower stretch. By means of cluster analysis of species diversity of sites and season sampling, the upper and middle stretches were clustered together. The lower stretch, on the other hand, presented seasonal variations in diversity. **Conclusions:** the great predominance of Characiformes over Siluriformes was evident in the upper stretch of the Garupá stream, whereas it was not so evident in the mouth. This difference may be related to the different environments of the stream. Species richness in this study can be considered high. The greatest diversity was recorded in the potamon. Autumn and winter being the seasons of highest diversity, these variations could be associated with the use of the environment by the fishes of the Paraná river.

Keywords: biodiversity, Neotropical fish fauna, Garupá Stream, composition, diversity, abundance.

Resumo: Objetivo: O objetivo do presente trabalho foi analisar a variação espacial e temporal na estrutura da assembléia de peixes do arroio Garupa, Misiones, Nordeste Argentino. **Métodos:** Foram realizadas oito operações de pescaria sazonais, de abril de 2003 a dezembro de 2004, na nascente, meio e foz, com uma bateria de redes de emalhar, de 3 a 12 cm entre nó opostos. **Resultados:** Foram reconhecidas 57 espécies agrupadas em cinco ordens, 16 famílias e 41 gêneros. O arroio Garupa mostrou uma distribuição longitudinal, a foz apresentou diversidade alta (4,73 bits), comparada com a do meio (2 bits) e da nascente (2,9 bits), e também registrou a maior captura por unidade de esforço (4,234 g 24 h/130 m²). *Astyanax cf. fasciatus* foi a espécie mais abundante na nascente e no meio, enquanto que *Hypostomus luteomaculatus*, *Schizodon. nasutus* e *Hypostomus commersoni* foram as mais abundantes na foz. A análise de cluster da diversidade específica por ponto de amostragens e época do ano mostrou um agrupamento envolvendo a nascente e o meio. A foz apresentou variações temporais na diversidade. **Conclusões:** As estações do outono e inverno foram as de maior diversidade, fato que poderia estar associado ao uso do ambiente pelos peixes do rio Paraná.

Palavras-chave: Biodiversidade, fauna íctica neotropical, arroio Garupá, composição, diversidade, abundância..

1. Introduction

The Neotropical Fish Fauna is considered the richest in the world and has already been studied in large rivers of Brazil such as the Amazon, the Paraná and the San Francisco, among others; however, this fish community is not completely known yet. Up to the present, a total of 2,400 species have been identified (López et al., 2005). About 181 of these have been recorded in the Argentine Upper Paraná River area and 250 in the Brazilian one

(Agostinho and Ferreira Júlio, 1999; Lowe McConnell, 1999; Agostinho et al., 2000).

Large rivers have numerous small tributaries with special physical, chemical and biological characteristics. These environments have been studied by means of the "River Continuum Concept" proposed by Vannote et al. (1980). This concept assumes that the geo-physical variables within a river system present a continuous gradient from the source

to the mouth and that the organism communities follow one another along the river course so that energy loss is reduced to a minimum.

Bennenman et al. (2000) consider that fish communities in small rivers or streams are the reflection of the biotic and abiotic factors that are taking place at a certain moment and that are influencing the distribution, abundance and interaction between species. Woottom (1990), on the other hand, proposes that the resource distribution is the common characteristic in a fish assemblage.

Misiones, a North Eastern Argentine Province, which forms part of the Neotropical Region, is characterized by a large hydrographical network with high biodiversity. In the Province of Misiones, the fishes communities have not been sufficiently studied, some research has been done by Ringuelet (1975), COMIP (1987, 1994), Gomez and Chevez (1996), Hirt de Kunkel and Flores (1996), Hirt and Flores (1999), Roa and Permingeat (1999), Araya et al. (2003).

One of the many streams that characterize the Province of Misiones is the Garupá Stream. This stream is a tributary of the Paraná River, in the sector where the waters of the Paraná form the Yacyretá dam. The present work is the first contribution to the study of the fish community of the Garupá Stream and provides information previous to the definite height (83 m asl) of the dam, in the Posadas-Encarnación axis. The increase in the water level will produce substantial changes in the drainage regime of the Garupá Stream, the quality of its waters and its biodiversity. Thus, the aim of this work was to analyze the composition, the diversity and the abundance of the ichthyofauna of the Garupá Stream, assuming a spatial and temporal variation of the community.

2. Material and Methods

2.1. Study area

The Garupá Stream is a 55 km long medium-sized Upper Paraná River tributary, whose potamic stretch includes lagoons, semi-permanent marshlands and a developed floodplain. The basin is dendritic with a great slope and a rocky bed, and its water velocity and dissolved oxygen concentration are high (2 m.s⁻¹ and 9.23 ppm respectively) (Hirt et al., 2004). The Garupá Stream receives two tributaries: the Upper Pindapoy and the Garupá itself, which also collect the contribution from several other smaller tributaries.

The Province climate, due to its geographical position as to the Tropic of Capricorn, is subtropical without a dry season and the stream basin has a warm climate, attenuated by rainforest galleries and frequent rainfalls that flood the areas surrounding the Garupá Stream (Russo et al., 1996).

The three sampling sites selected along the stream course are shown in Figure 1: 1) an Upper Stretch (27° 42' 00" S and 55° 39' 53.5" W), which shows both margins with a rainforest gallery, variable with of the river channel, banks are 2 m high, and the river bed is composed of stone, gravel and mud and varies in depth between 0.30 and 1.00 m during low-water periods and can increase notably during flooding; 2) a Middle Stretch (27° 33' 27.5" S and 55° 41' 16.5" W), which has a depth that varies between 1.00 and 2.00 m and a width of 20 m during low-water periods; in the flood season, water overflows, flooding stretches of even 100 m on each side; both banks have an important rainforest gallery that in some sectors covers the river channel width; and 3) a Lower Stretch (27° 28' 44.5" S and 55° 48' 56.3" W); where the stream channel widens and deepens, with an average depth of more than 4.00 m and a slower surface water flow velocity (0.13 m.s⁻¹); these environmental conditions, among others, favour the growth of *Eichornia crassipes,* together with an important floodplain, which provides habitat diversity and food sources (Agostinho et al., 1999).

Eight samplings, coinciding with the Southern Hemisphere seasons, from April 2003 to December 2004, were carried out.

Six panels of monofilament gillnets (mesh with 3, 4, 6, 8, 10 and 12 cm) measuring 15-30 m long and 1-2 m in height were used in the catches. At each sampling site, the nets remained submerged for 24 hours.

The standard length (mm) and total weight (g) of fishes were recorded and then placed in formalin 10%. These are deposited in the Ichthyofauna Taxonomic Collection Project belonging to the School of Sciences, National University of Misiones, Argentina.

The species were identified using original descriptions and taxonomic updated revisions (Ringuelet et al., 1967; López et al., 1987; 2003; 2005; Menni et al., 1995; Britski et al., 1999; Reis et al., 2003) in order to determine the species composition per sample, season and sites.

The species constancy (C) was calculated as a measurement of the species appearance frequency of each sampling, as follows: C = (x/n) x 100, where x: number of times a species appeared in the sampling and n: total number of samplings. The species were classified according to the categories proposed by Lasso (2000), where C1: rare or accidental (C < 25%), C2: common or accessory (C > 25% and < 50%) and C3: common or frequent (C3 ≥ 50%).

With the aim to identify the dominant species present in each stretch of the stream, the Community Dominance Index (CDI) was calculated according to McNaughton (Goulding et al., 1988) by the equation CDI = (Y1 + Y2 / Y) x 100, where Y1 + Y2 is the sum that results from the abundance of two dominant species and Y is total species abundance.
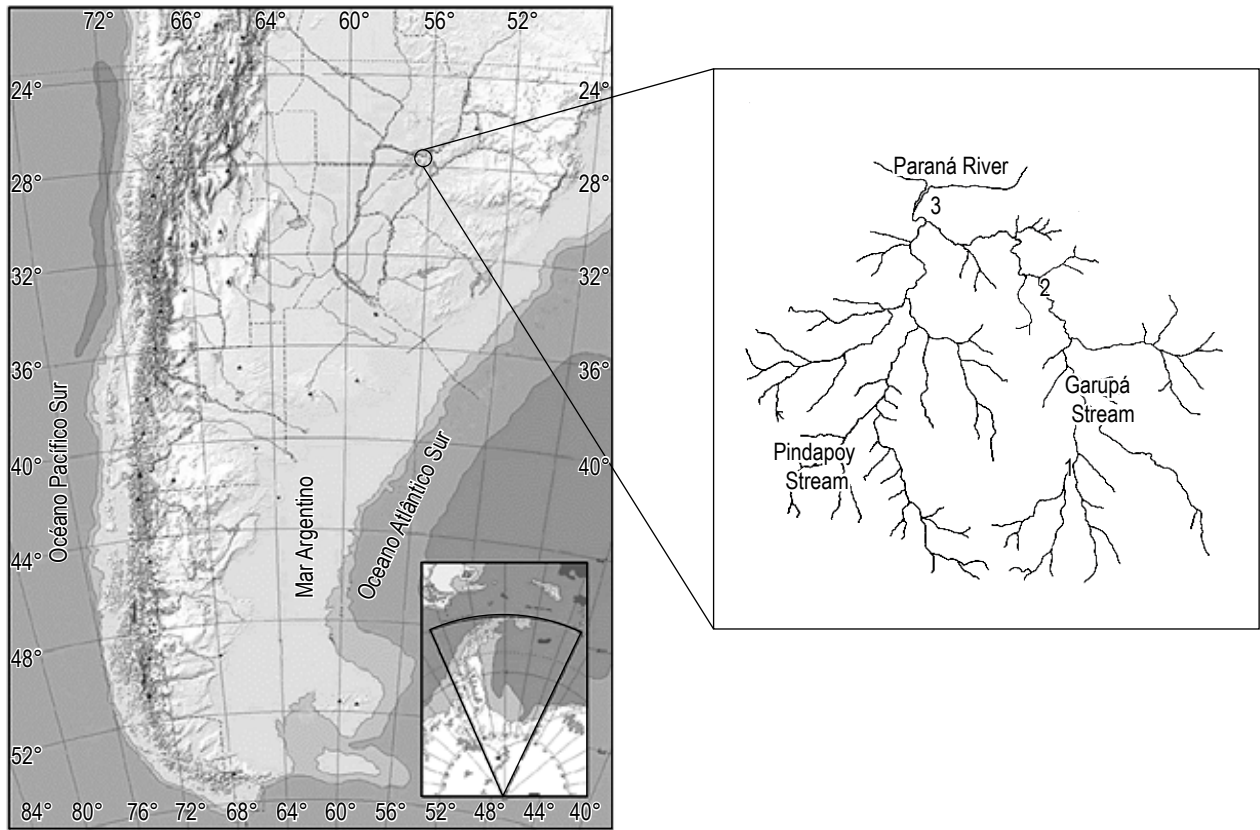
Figure 1. The study area with the sampling sites in Garupá Stream: 1) Upper Stretch, 2) Middle Stretch, 3) Lower Stretch.

The total biomass for each sampling site was calculated and expressed as catch per unit of effort *(CPUE)* as g/24 h/130 m² of gillnet.

Local diversity (α) was based on Shannon's diversity index (H') (Shannon and Wiener, 1963), defined as H' = –Σ p_i + $\log_2$ (p_i), where p_i is the proportion sample species (Pielou, 1975). Equitability (E) was calculated through the expression E = H' / H'$_{maximum}$ (Pielou, 1969), in the distribution of individuals caught between two sampling sites, in which H′ is Shannon's diversity and H'$_{maximum}$ is maximum diversity.

Similarity between sampling sites was established by the Sorenson's Index (Sörensen, modified by Bray and Curtis, 1957), which presents the advantage of considering the number of the least abundant species. The equation was: C_N = 2jN/ (aN + bN), where aN: is number of individuals at Site A, bN: number of individuals at Site B, jN: sum of lower abundances of species found at sites A and B.

For the arrangement of sampling sites per season according to diversity attributes, a hierarchical cluster analysis UPGMA (James and McCulloch, 1990) was used. The variable used was species diversity and the sampling units were the three sites (upper, middle and lower stretches) in the four seasons.

3. Results

A total of 57 fish species (969 fishes), grouped in 5 orders, 16 families and 41 genera, were identified (Table 1). The best represented order was Characiformes (26 species), followed by Siluriformes (21 species), Perciformes (7 species), Gymnotiformes (2 species) and Clupeiformes (1 species).

The highest capture was recorded in the middle stretch (42.57%), followed by those found in the lower (32.16%) and upper stretches (25.5%). In the upper stretch, the species with highest abundance (which represented 69.6% of the capture) were *Astyanax* cf. *fasciatus* (Cuvier, 1819) *Steindachnerina biornata* (Braga and Azpelicueta, 1987) and *Ancistrus cirrhosus* (Valenciennes, 1836). In the middle stretch, the most abundant species was *A.* cf. *fasciatus* (68%), and in the lower stretch, 61% of the capture consisted of nine different species: *Pachyurus bonariensis* Steindachner, 1879, *Loricaria simillima* Regan, 1904, *Schizodon nasutus* Kner, 1858, *S. biornata, Hypostomus luteomaculatus* (Devincenzi, 1942), *Roeboides bonariensis* (Reinhardt, 1851), *Trachydoras paraguayensis* (Hegenmann and Ward, 1907), *Paraloricaria vetula* (Velenciennes, 1836) and *Lorycarichthys platymetopon* Isbrücker, 1979 (Table 1).

Table 1. Systematic position of identified species of Garupá Stream and relative abundance (%) for sampling sites.

Systematic position of identified species	Upper Stretch	Middle Stretch	Lower Stretch
Order CLUPEIFORMES			
Family ENGRAULIDAE			
Lycengraulis grossidens (Agassiz, 1829)	-	-	0.32
Order CHARACIFORMES			
Family HEMIODONTIDAE			
Hemiodus orthonops Eigenmann & Kennedy, 1903	-	-	2.88
Family CURIMATIDAE			
Steindachnerina biornata (Braga & Azpelicueta, 1987)	13.39	2.90	5.77
Steindachnerina brevipinna (Eigenmann & Eigenmann, 1889)	0.45	-	-
Cyphocharax voga (Hensel, 1870)	0.89	-	0.64
Cyphocharax spilotus (Vari, 1987)	2.23	-	-
Family ANOSTOMIDAE			
Leporinus obtusidens (Valenciennes, 1836)	-	-	0.96
Leporinus striatus Kner, 1858	0.89	-	0.32
Leporinus acutidens (Valenciennes, 1836)	-	2.42	1.28
Schizodon nasutus Kner, 1858	3.13	-	8.65
Leporellus pictus (Kner, 1858)	0.45	2.90	2.88
Family CYNODONTIDAE			
Rhaphiodon vulpinus Spix & Agassiz, 1829	-	-	0.32
Family ERYTHRINIDAE			
Hoplias malabaricus (Bloch, 1794)	2.68	0.48	1.92
Family ACESTRORHYNCHIDAE			
Acestrorhynchus pantaneiro Menezes, 1992	0.45	2.66	1.92
Family CHARACIDAE			
Astyanax cf. fasciatus (Cuvier, 1819)	44.20	68.12	1.60
Astyanax abramis (Jenyns, 1842)	-	-	0.32
Astyanax sp. 2	7.59	3.86	0.32
Astyanax asuncionensis Géry, 1972	1.79	4.59	-
Galeocharax humeralis (Valenciennes, 1834)	-	0.24	0.96
Cynopotamus argenteus (Valenciennes, 1836)	-	-	0.32
Cynopotamus kincaidi (Schultz, 1950)	-	-	0.32
Oligosarcus oligolepis (Steindachner, 1867)	-	0.24	-
Serrasalmus maculatus Kner, 1858	-	-	0.32
Serrasalmus marginatus Valenciennes, 1836	-	-	0.32
Roeboides bonariensis (Reinhardt, 1851)	-	-	4.81
Triportheus nematurus (Kner, 1858)	-	-	1.28
Tetragonopterus argenteus Cuvier, 1816	-	1.21	0.32
Order SILURIFORMES			
Family CALLICHTHYIDAE			
Callichthys callichthys (Linnaeus, 1758)	-	-	0.32
Family DORADIDAE			
Platydoras armatulus (Valenciennes, 1840)	-	-	1.28
Rhinodoras dorbignyi (Kner, 1855)	-	-	1.60
Trachydoras paraguayensis (Eigenmann & Ward, 1907)	-	-	4.49
Family AUCHENIPTERIDAE			
Trachelyopterus galeatus (Linnaeus, 1766)	-	-	0.64
Auchenipterus osteomystax Miranda Ribeiro, 1918	-	-	1.28
Family PIMELODIDAE			
Pimelodus maculatus Lacépède, 1803	-	-	1.92
Iheringichthys labrosus (Lütken, 1874)	-	0.24	2.56

Table 1. Continued...

Systematic position of identified species	Upper Stretch	Middle Stretch	Lower Stretch
Family HEPTAPTERIDAE			
Pimelodella gracilis (Valenciennes, 1835)	0.45	-	0.32
Rhamdia quelen (Quoy & Gaimard, 1824)	2.68	0.24	-
Rhamdella sp.	-	-	0.32
Family LORICARIIDAE			
Hypostomus luteomaculatus (Devincenzi, 1942)	-	3.38	5.13
Hypostomus comersonii Valenciennes, 1836	4.02	1.45	2.24
Hypostomus luetkeni. (Steindachner, 1877)	-	-	0.32
Hypostomus cochliodon Kner, 1854	-	-	1.28
Loricariichthys labialis (Boulenger, 1895)	-	-	0.32
Loricariichthys platymetopon Isbrücker & Nijssen, 1979	-	-	3.21
Loricaria simillima Regan, 1904	-	-	9.32
Paraloricaria vetula (Valenciennes, 1836)	-	-	3.53
Paraloricaria agastor Isbrücker, 1979	-	-	0.32
Sturisoma robustum (Regan, 1904)	-	-	0.64
Ancistrus cirrhosus (Valenciennes, 1836)	12.05	4.59	-
Order GYMNOTIFORMES			
Family GYMNOTIDAE			
Gymnotus inaequilabiatus (Valenciennes, 1839)	0.45	-	-
Family STERNOPYGIDAE			
Sternopygus macrurus (Bloch & Schneider, 1801)	-	-	0.32
Order PERCIFORMES			
Family CICHLIDAE			
Crenicichla lepidota Heckel, 1840	-	0.48	0.32
Crenicichla niederleinii (Holmberg, 1891)	-	-	0.32
Gymnogeophagus balzanii (Perugia, 1891)	0.45	-	
Gymnogeophagus australis (Eigenmann,1907)	1.79	-	0.32
Family SCIAENIDAE			
Pachyurus bonariensis Steindachner, 1879	-	-	16.03
Plagioscion ternetzi Boulenger, 1895	-	-	2.56

The results of species constancy show that, in the upper stretch, the most common species was *A.* cf. *fasciatus,* although *S. biornata* was abundant, it was rare or accidental. In the middle stretch, the only constant species was *Acestrorhynchus pantaneiro* Menezes, 1992, although it showed 3% abundance. *A.* cf. *fasciatus* was common or accessory, and the most abundant species. In the lower stretch, *P. bonariensis, S. biornata* and *L. simillina,* which were among the most abundant species, were also very common. Another abundant but accessory species in this stretch was *S. nasutus.*

The Community Dominance Index (CDI) showed differences between the sampling sites (Table 2). The value CDI decreased as the species richness increased.

Total biomass was 60,333 g, and abundance, expressed as capture per unit of effort (CPUE), varied from 1011.20 g/24 h/130 m² in the upper basin to 2,306 g/24 h/130 m² in the middle basin, and was 4,234 g/24 h/130 m² for the lower basin. *A.* cf. *fasciatus* was the most abundant species and the species with the highest CPUE in the middle and upper basins. The lower stretch "vieja del agua" *H. luteomaculatus*, *S. nasutus,* and "vieja del agua" *Hypostomus commersoni* Valenciennes, 1836 were the species with highest CPUE (Figure 2).

Diversity of Garupa stream was high (3.28 bits). The lowest values for H′ were evidenced in the middle basin (2 bits), while the highest values were obtained in the lower basin (4.37 bits). The values of equitability per sampling site presented the same variation (Figure 3). We observed significant differences in diversity (P < 0.05), as shown by the *t*-test between the upper stretch and the mouth (d.f. 474), between the middle and upper stretch (d.f. 610) and between the middle stretch and the mouth (d.f. 710).

The greater similarity per sampling site was between the upper and middle basins (0.52), as compared to the

Table 2. Community Dominance Index (CDI) and dominant species per sampling sites. n: absolute abundance; S: species richness.

Sampling sites	n	S	CDI	Dominant species
Upper Stretch	224	19	57.59	*Astyanax* cf. *fasciatus*
				Steindachnerina biornata
Middle Stretch	414	17	72.71	*Astyanax* cf. *fasciatus*
				Astyanax asuncionencis
Lower Stretch	312	49	25.64	*Pachyurus bonariensis*
				Loricaria simillima
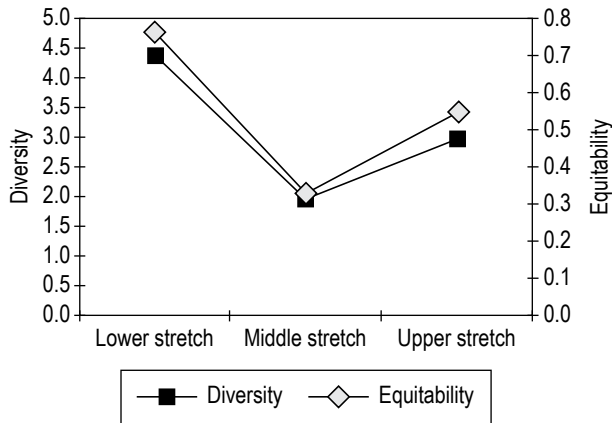
Figure 2. Diversity and equitability according to sampling sites.

similarity between the middle and lower and between the upper and lower stretches (0.17 and 0.19, respectively).

Cluster analysis grouped the upper and middle stretches by affinity, in relation with the species diversity variable, thus leaving the lower stretch in a different cluster. In the first group, there were no differences in the diversity between the different seasons (seasonal dimension). In contrast, the lower stretch presented seasonal differences in relation to diversity: the autumn-summer period presented a higher similarity to the rest of the basin, whereas during autumn and winter, the diversity of the sector was higher, thus forming a different cluster (Figure 4). Some of the species that contributed most to diversity were: *L. platymetopon, P. vetula, Paraloricaria agastor* Isbrücker, 1979, *Pimelodella gracilis* Valenciennes, 1835, *Iheringhichtys labrosus* (Lütken, 1874), *T. paraguayensis* and *Raphiodon vulpinus* Spix and Agassiz, 1829.

4. Discussion

The fish community of the Garupá stream was represented both by its taxonomic diversity and by the abundance of species belonging to the Characiformes and Siluriformes orders (Benedito Cecilio, 1994; Dias, 1995; Agostinho et al., 1997; Lowe Mc Connell, 1999).

The changes in the proportion between Characiformes and Siluriformes are related to the variations in the habitat (Araujo Lima et al., 1995). Our results demonstrate a differential longitudinal distribution between stretches, with a predominance of species of the order Characiformes in the upper stretch as compared to Siluriformes, which could be due to the fact that most species belonging to the Characiformes order found in the source presented adaptations that could restrict their distribution to shallow habitats with a rocky bed, a higher speed, high oxygenation, shadow and entry of allochthonous resources.

Although the Characiformes were most abundant in the lower stretch, their proportion was not the same in the upper stretch. The mouth of the stream presents a high heterogeneity of habitats and is characterized by a significant depth and width of the river, a substrate of sand, clay and rock, a lower speed of the current and a higher primary production. These features, together with the entry of fishes from the Paraná River, could explain the difference in the distribution of these orders, since a great number of species belonging to the Siluriformes use these habitats.

Considering the habitat and the size of species, the fish community of the Garupá Stream could be divided into three groups of fish: a first group composed of small-sized species, characteristic of small rivers and streams, such as the "dientudo" *Oligosarcus oligolepis* (Steindachner, 1867), the "sabalito" *Cyphocharax spilotus* (Vari, 1987), the "sabalito" *Cyphocharax voga*, (Hensel, 1870), the "bagre cobi" *P. gracilis* and the "bagrecito" *Rhamdella* sp.; a second group including medium and large sized species that inhabit floodplains, which go to the main channel during the low water period and whose alevine and juvenile individuals transitorily look for refuge and food in these environments. This group was represented by the "boga" *Leporinus acutidens* (Valenciennes, 1836), the "boga" *Leporinus obtusidens*, (Valenciennes, 1836), *S. nasutus,* and the "bagre amarillo" *Pimelodus maculatus* Lacépede, 1803; and a third group formed by small-sized species including genera with an extensive distribution, such as *Astyanax* and *Gymnogeophagus,* among others. This clustering has already been carried out for other tributaries of the Paraná River in Brazil (Agostinho and Ferreira Júlio, 1999) and has allowed a simple characterization of the ichthyofauna.
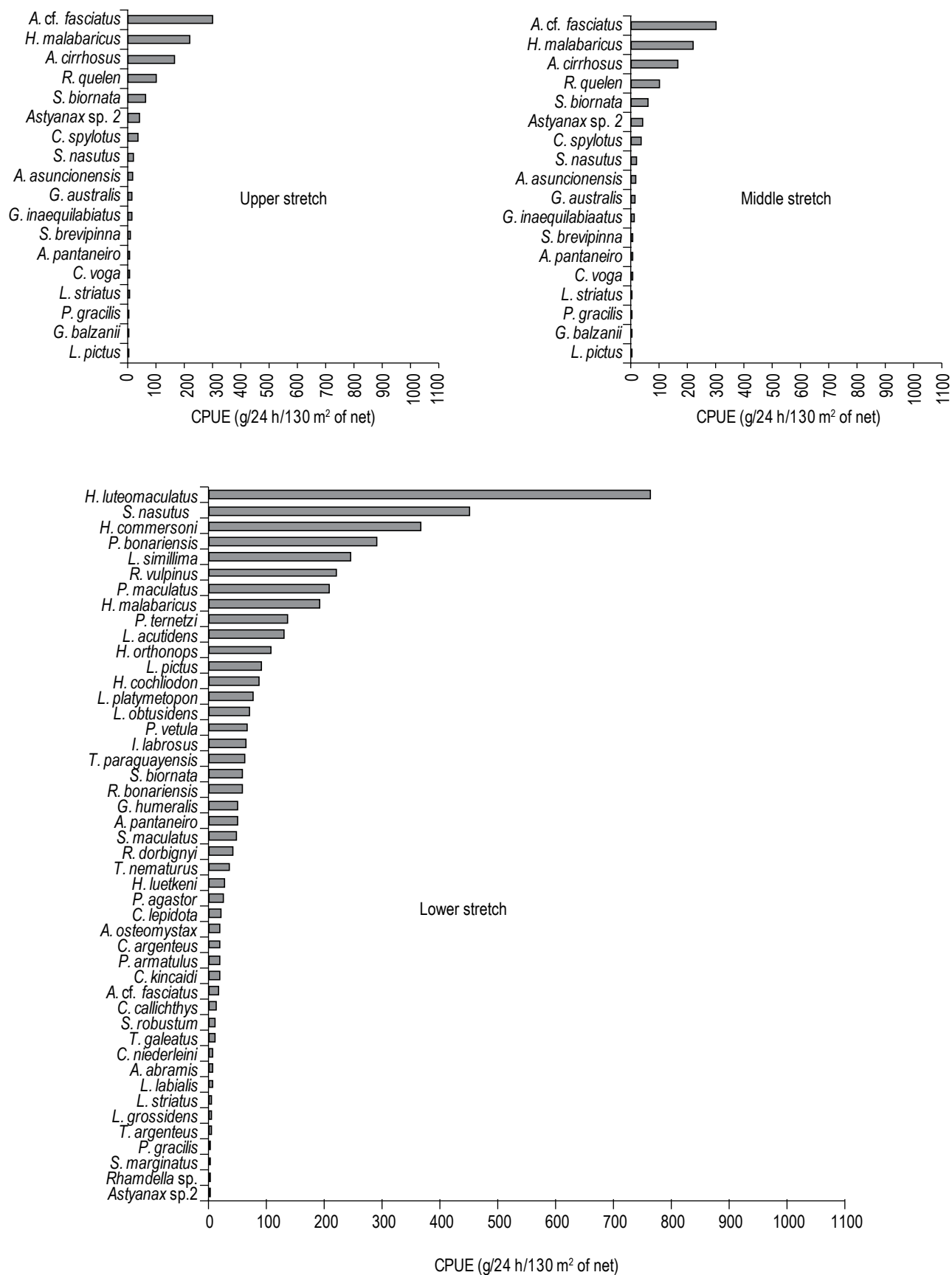
Figure 3. Abundance of species for sampling sites expressed as catch per unit of effort (CPUE).
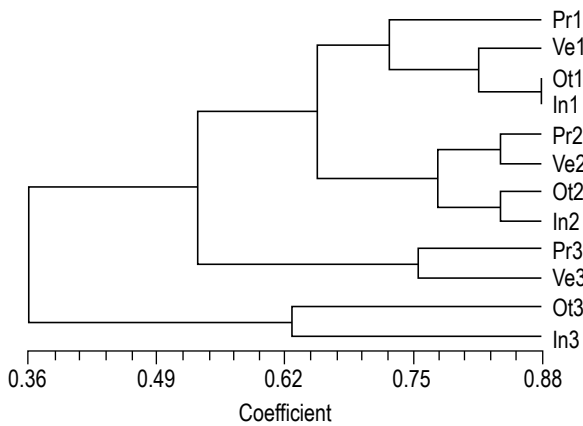
Figure 4. Cluster analysis of species diversity per sampling sites and season Pr: Spring, Ve: Summer, Ot: Autumn, In: Winter. 1: Upper Stretch, 2: Middle Stretch, 3: Lower Stretch.

According to Fontes de Oliviera et al. (2005), the dominant species can vary in a space gradient through a natural system; this suggests that there is a differential pattern of distribution of species. In the present work, only seven of the identified species are common to the three sampling sites; among them, *A.* cf. *fasciatus* was the dominant species in the ritron and *P. bonariensis* and *L. simillima* in the potamon areas.

The data of species constancy also indicate differences between the stretches of the stream: in the upper stretch, *A.* cf. *fasciatus*, which was captured during all the four seasons, was the most common and abundant species. In the middle stretch, *A. pantaneiro* was constant but not abundant, and in the mouth, *P. bonariensis* was most common species. This phenomenon is generally associated with habitat needs; the rare species are extremely sensitive to changes in environmental conditions, such as hydrological factors and nutrient availability (Fontes de Oliveira et al., 2005).

In the present study, the relative abundance of species seems to adjust to the pattern of multi-species communities, where one or two species are the most abundant, as is the case of *A.* cf. *fasciatus*, followed by numerous species categorized as rare, with very low abundance, such as *Rhamdella* sp.*,* the "bagre hocicón" *Auchenipterus osteomystax* Miranda Ribeiro, 1918, the "cascudo", *Callichthys callichthys* (Linnaeus, 1758) and the "morena", *Gymnotus inaequilabiatus* (Valenciennes, 1839), among others.

Taking into consideration that the values above 3 bits indicate a high diversity in fish communities (Goulding et al., 1988), the diversity of the Garupá Stream is high. The highest diversity of fish in a certain system can be attributed to several factors, such as habitat heterogeneity, niche availability and the incorporation of main system tributaries (Lowe McConnell, 1999). Misiones is one of the Argentinean provinces with highest diversity of the ichthyo-

fauna, with a total of 253 species, 18 of which are endemic (López et al., 2005). Up to the present, these endemic species have not been recorded in the Garupá Stream, although the possibility of their presence is not discarded.

In the present research, the specific diversity recorded in the potamon zone was higher than in the ritron zone. By means of cluster analysis, we found that diversity is variable along the year only in the mouth. This habitat is used by a great number of species that are also present in the Upper Paraná River and are of frequent capture in this system. Some of these species were: *L. obtusidens*, *P. maculatus*, the "machete" *R. vulpinus*, the "corvina" *Plagioscion ternetzi* Boulenger, 1895, *S. nasutus*, *Galeocharax humeralis* (Valenciennes, 1834) and *Hoplias malabaricus* (Bloch, 1794), and contributed to the higher diversity recorded in this sampling site. These species use the Garupá Stream's lower stretch as a spawning area (Hirt, et al., 2003, 2004), thus indicating the importance of these environments in reproductive events, as has been highlighted by Moraes Vazzoler et al. (1997) and Suzuki and Agostinho (1997).

On the other hand, the physical, chemical and biological characteristics of the potamon allow the presence of species that exploit the habitat, which may justify the predominance of species with a detritivorous feeding habit such as *L. platymetopon*, *P. vetula*, *P. agastor* and *P. gracilis.*

Wootton (1990) suggests that species distribution is related to the potential food resources, whereas Lowe McConnell (1999) reports that fish which live in the ritronic areas, feed from allochthonous vegetation and insects, while those species that live in the stream mouth zones use detritus as their main food source. In the current study, *A.* cf. *fasciatus* was present in all the environments studied and used the allochthonous resources from ritron, and the detritus from the potamon (Araya et al., 2005).

In summary, the results of the present work show that the pattern of longitudinal distribution of the fish community of the Garupá stream presents a transition between two stretches, one formed by the upper and middle stretches, which were found to be similar as regards composition and diversity by the similarity index and the cluster analysis, and the other one by the lower stretch, which presented a higher diversity.

We also clearly established the influence of the Paraná River on the diversity, especially in autumn-winter. This may be due to the movement of the fish from the Paraná river, since the species present in this site, such as *R. vulpinus*, *I. labrosus* and *T. paraguayensis* are frequently captured in river environments (Roa, 2005). Similar observations have been made by Agostinho and Jùlio Jr. (1999) for tributaries of the Itaipú dam.

Finally, the Garupá Stream constitutes an environment that should be preserved and conserved both because of its diversity and for being a place for shelter, feeding and reproduction of the ichthyofauna of the Paraná River.

Acknowledgements

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