

Fishes from first order streams of lower Paranapanema and Ivaí rivers, upper Paraná River basin, Paraná, Brazil

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ABSTRACT: This study was developed as a research of first order streams fish assemblages located in two Conservation Units in Northwestern Paraná, Brazil, with the purpose of providing information about ichthyofauna composition of these water bodies while they are still under protection. There were captured 2,557 individuals belonging to six orders, nine families and 10 species in three streams. The most abundant species were *Phallocheres harpagos* (44%) from Conceição stream, *Astyanax* aff. *paranae* (14%) and *P. harpagos* (12%) from Jurema stream, and *Melanorivulus apiamici* (9%) from Conceição stream. *Trichomycterus* sp. could not be identified into a specific level, meaning it can represent an undescribed species to science, registered for the first time at the upper Paraná River basin.

INTRODUCTION

The upper Paraná River basin reaches more than 900,000 km², with different habitats, including the floodplain, lagoons, canals and streams. The estimated fish richness in this system ranges up to 310 species (Langeani *et al.* 2007), and recent inventories have highlighted the necessity of sampling efforts in Neotropical ecosystems, due to great diversity of fishes yet to be described (Maier *et al.* 2008).

In particular, streams can exhibit the occurrence of high fish diversity (Casatti *et al.* 2001; Castro *et al.* 2003; 2005; Suárez 2008). These habitats are characterized by their small size, which also represents one of the major reasons they are neglected when conservation comes to matter. They must be primarily investigated, since their small size and unstable environmental conditions provides habitat for distinct fish communities, represented by small sized species. These species depend on terrestrial organic matter as food and shelter resources (Araújo and Garutti 2002) and due to their restricted mobility, may present high endemism (Castro and Menezes 1998).

According to Castro *et al.* (2003) small sized species represent about 50% of total freshwater fish, and in their study conducted at 17 streams from the upper Paraná River basin, 3,683 specimens, belonging to 52 species were reported. Some other researchers have registered high diversity for these ecosystems, such as 46 species from seven streams of Ivinheima River basin (Suárez 2008), 28 species from 18 streams of Sorocaba and Paranapanema River basins (Cetra *et al.* 2012), and 20 species of one first order stream from Ivaí River basin, under agricultural influence (Araújo *et al.* 2011).

Considering the importance of such water bodies

to the whole basin, the ichthyofauna of three first order streams situated at different Conservation Units (Estação Ecológica do Caiuá and Parque Estadual de Amaporã) at Northwestern Paraná State were inventoried. Additionally, information about the streams is provided while they are still under protection, so they can be used as monitoring tools and knowledge source for environmental research of impacted first order streams.

MATERIALS AND METHODS

This survey was carried out at three first order streams: Conceição (22°35'15.0"S 52°53'29.0"W), Scherer (22°36'06.7" S 52°53'02.0" W) and Jurema (23°04'53.0" S 52°47'38.3" W) (Figure 1). The first two streams are located at the Estação Ecológica do Caiuá, in Diamante do Norte municipality, Paraná State, and draining to the Paranapanema River sub-basin. The third is situated at the Parque Estadual de Amaporã, in Amaporã municipality, Paraná State, draining to the Ivaí River sub-basin. They all belong to the upper Paraná River basin, drain through Arenito Caiuá formation, under Floresta Estacional Semi-Decidual domains, in Northwestern Paraná, Brazil (Figure 2). Sampling authorizations are: Instituto Ambiental do Paraná - nº 72/2008 and Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis - nº 12621-1.

Fishes were collected, quarterly, between June 2008 and June 2009, using electric fishing technique according to Penczak (1981) procedures, with three consecutive efforts, comprising nine sections of 40 m (three in each stream), with the sampling area blocked. The specimens were anesthetized using benzocaine hydrochloride and fixed in formaldehyde 10%. The species were identified according

to Graça and Pavanelli (2007), Lucinda (2008) and Costa (2011), and voucher specimens (preserved in alcohol 70%) are deposited in the Coleção Ictiológica of Núcleo de Pesquisas em Limnologia, Ictiologia e Aquicultura of Universidade Estadual de Maringá (available at <http://peixe.nupelia.uem.br>) (Table 1). Fish nomenclature was according to Reis *et al.* (2003).

RESULTS AND DISCUSSION

A total of 2,557 specimens were collected, representing six orders, nine families and 10 species (Table 1). Species richness can be naturally low in headwater streams (Allan and Castillo 2007), due to its small size and reduced mobility presented by small fishes (Castro 1999; Braga and Andrade 2005; Agostinho *et al.* 2007). This could also be related to the fact that Conceição and Scherer streams discharge into Paranapanema river, right beneath Rosana reservoir and Jurema stream is dammed up, in its final



FIGURE 1. First order streams of the upper Paraná River basin. (Top-left): Conceição; (Top-right) Scherer and (Down) Jurema.

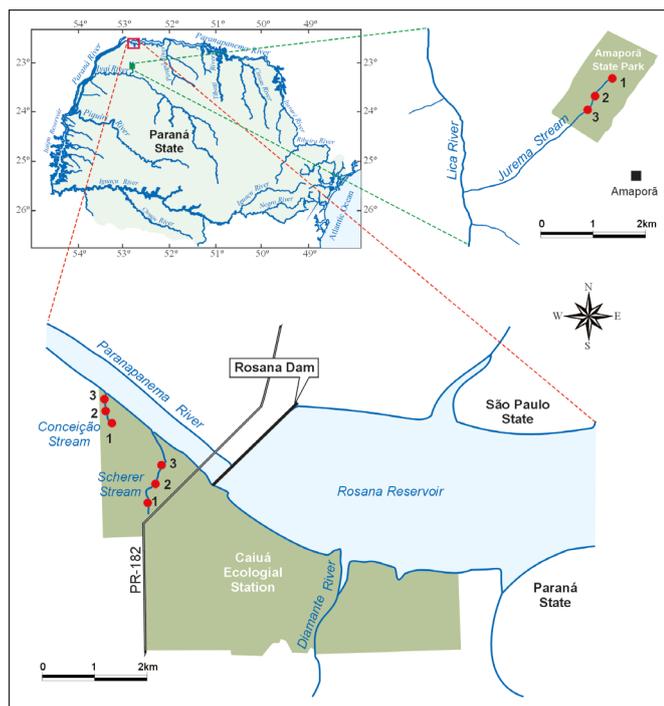


FIGURE 2. Location of the stretches sampled in Conceição and Scherer streams (Caiuá Ecological Station) and Jurema stream (Amaporá State Park). The numbers represent the sample sections in all streams.

stretch, to attend the local population recreation (inside the park), which could represent barriers to small sized species dispersion.

Of all species, four were collected in Conceição stream (1,372 specimens): *Phalloceros harpagos* (82.6%), *Melanorivulus apiamici* (17%), *Gymnotus inaequilabiatus* (0.2%) and *Synbranchus marmoratus* (0.2%). In Scherer stream we also collected four species (359 specimens): *Gymnotus inaequilabiatus* (45.7%), *Astyanax altiparanae* (44.8%), *Characidium aff. zebra* (6.7%) and *Crenicichla britskii* (2.8%). Jurema stream presented five species, with a total of 826 specimens, as follows: *Astyanax aff. paranae* (42.8%), *P. harpagos* (36.9%), *Trichomycterus sp.* (18.3%), *Callichthys callichthys* (0.7%) and *G. inaequilabiatus* (0.4%). *Phalloceros harpagos* occurred in both Conceição and Jurema streams, while *Gymnotus inaequilabiatus* occurred in Conceição and Scherer streams. Both species are characterized by their generalist behavior and ability to survive into a wide variety of environmental conditions (Campos-da-Paz, 2003; Wolff *et al.* 2007), favoring their presence in more than one stream.

The predominant species were represented by Characiformes, representing 30% of captured species, followed by Siluriformes and Cyprinodontiformes (both 20%). Gymnotiformes, Perciformes and Synbranchiformes were all represented by only one species (10% each) (Figure 3). This pattern, with Characiformes and Siluriformes along the most species rich orders match the Neotropical pattern (Lowe-McConnell 1999). Considering all the collected species, the most abundant were *Phalloceros harpagos* (44%) from Conceição, *Astyanax aff. paranae* (14%) and *P. harpagos* (12%) from Jurema, and *Melanorivulus apiamici* (9%) from Conceição stream. The representativeness of Cyprinodontiformes appears to be a constant in first order streams, as found by Casatti (2004; 2005), Araújo *et al.* (2011) and Cetra *et al.* (2012) in streams of the upper Paraná River basin.

The high dominance of *P. harpagos* can be related to a variety of feeding habits (Casatti *et al.* 2009; Rocha *et al.* 2009) and constant reproduction (Wolff *et al.* 2007). This species present a preference for pools with medium water column deep and mud substrata (Mazzoni *et al.* 2011), and in this research, groups of adult specimens were always visualized swimming, while juveniles could be seen in macrophyte banks. *Melanorivulus apiamici* was commonly identified as *Rivulus apiamici*, however, Costa (2011) in his phylogenetical study within Rivulinae, restricted the occurrence of *Rivulus* only to Cuba rivers, and considered *Melanorivulus*, previously recognized as a *Rivulus* subgenus, as a valid genus. It is distributed along Paraná River basin, and tends to seek for macrophytes as shelter (Bulla *et al.* 2011). *Crenicichla britskii* is geographically distributed in Southern Brazil, in the upper Paraná River basin (Kullander 2003a), and according to Casatti (2005) prefers marginal pools in association to riparian vegetation roots submerged. *Astyanax aff. paranae* and *A. altiparanae* are geographically distributed in Southern Brazil, in the upper Paraná River basin (Lima *et al.* 2003), present a diversified diet and can be classified as herbivorous (Rocha *et al.* 2009), insectivorous (Rolla *et al.* 2009) and omnivorous (Casatti *et al.* 2009), reflecting their ability to explore different microhabitats (Casatti *et al.* 2003).

Some species are recognized to have similar feeding habits in different streams and usually are nominated specialists. In this study are represented by *C. aff. zebra* and *Trichomycterus* sp. both classified as insectivorous (Esteves and Lobón-Cerviá 2001; Esteves et al. 2008; Casatti et al. 2009). *Characidium* aff. *zebra* is distributed in the Amazon and Essequibo River basins (Buckup 2003) and their expanded fins allows the maintenance of their position and resistance to faster flowing waters, inhabiting especially rapids along the stream (Aranha et al. 2000). According to Campos-da-Paz (2003), *G. inaequilabiatus* is distributed especially into Paraguay River basin and lower Paraná basin, species of the genera are usually nocturnal predators with territorial behavior. The distribution of *Synbranchus marmoratus* covers North, Central and South America, from Mexico to Northern Argentina (Kullander 2003b). This species explores sites next to riparian vegetation (Aranha et al. 1998) and are characterized as burrowers (Kullander 2003b). *Callichthys callichthys* occurs in most Cis-Andean South American River drainages (Reis 2003), tend to occur in headwaters (Pavanelli and Caramaschi 2003), and according to Reis (2003) are obligatory air-breathers. These species can be classified as insectivorous, carnivorous and omnivorous, respectively (Casatti et al. 2009).

Regarding the reproductive period, the highest catch of mature individuals of all species occurred from September to December, coinciding with the period of higher temperature and rainfall. We highlight the occurrence of mature individuals of *P. harpagos* during all the sampling period, with reproductive peak between September and December (Zanatta et al. in press). According to Gomiero

and Braga (2007), the same species that have prolonged reproductive period can have reproductive peaks that coincide with favorable environmental conditions to reproduction.

The studied streams are located in Conservation Units (CU), and the preserved riparian vegetation provides pristine habitats for aquatic organisms. The influence of agricultural practices that take place in the surroundings of the CU's were not notice in the nutrients concentrations (phosphorus and nitrogen), that were considered normal (pers. obs.) and matched those registered by other authors in streams from the upper Paraná River basin (Ferreira and Casatti 2006). On the other hand, the increase of runoff during rain periods around the edges and the interior of the CU, with visual formation of ravines in the soil, along with constant visitation of students from the school close by the CU, and the channel flow interference inflicted by anthropogenic constructions were considered the most evident influences of adjacent practices. The maintenance of quality environments depends on the monitoring of these CU's regarding visitors and the management of adjacent practices to avoid major physical impacts upon these streams, even though they still maintain preserved characteristics.

This inventory is, therefore, important because it provides valuable information about the species composition of preserved first order stream ichthyofauna. *Trichomycterus* sp. can represent an undescribed species to science, yet to be described for the upper Paraná River basin, which emphasizes the necessity of protection of these small streams.

TABLE 1. Fish captured in three first order streams of the upper Paraná River basin, Northwestern of Paraná, between June 2008 and June 2009. Species were classified according to Reis et al. (2003). Voucher specimens are housed at Coleção Ictiológica do Núcleo de Pesquisas em Limnologia, Ictiologia e Aquicultura, Universidade Estadual de Maringá. ^Φ Conceição stream; [‡] Jurema stream; * Scherer stream.

CLASSIFICATION	VOUCHER	SPECIES ABUNDANCE
CHARACIFORMES		
Characidae		
<i>Astyanax altiparanae</i> Garutti and Britski, 2000	NUP 6068 (2 ex.)	161
<i>Astyanax</i> aff. <i>paranae</i> Eigenmann, 1914	NUP 6067 (12 ex.), 6070 (4 ex.), 6447 (3 ex.), 6451 (1 ex.)	354
Crenuchidae		
<i>Characidium</i> aff. <i>zebra</i> Eigenmann, 1909	NUP 6071 (2 ex.)	24
SILURIFORMES		
Trichomycteridae		
<i>Trichomycterus</i> sp.	NUP 6069 (3 ex.), 6449 (1 ex.)	151
Callichthyidae		
<i>Callichthys callichthys</i> (Linnaeus, 1758)	NUP 6122 (1 ex.)	6
GYMNOTIFORMES		
Gymnotidae		
^{Φ*} <i>Gymnotus inaequilabiatus</i> (Valenciennes, 1839)	NUP 7607 (1 ex.)	^Φ 3 *3
CYPRINODONTIFORMES		
Poeciliidae		
^{Φ‡} <i>Phalloceros harpagos</i> Lucinda, 2008	^Φ NUP 6074 (3 ex.), 6463 (5 ex.), 12430 (15 ex.) [‡] NUP 6453 (2 ex.), 6455 (2 ex.)	^Φ 1133 [‡] 305
Rivulidae		
<i>Melanorivulus apimici</i> (Costa, 1989)	NUP 6060 (7 ex.), 6075 (3 ex.)	233
PERCIFORMES		
Cichlidae		
<i>Crenicichla britskii</i> Kullander, 1982	NUP 6072 (1 ex.), 7604 (1 ex.)	10
SYNBRANCHIFORMES		
Synbranchidae		
<i>Synbranchus marmoratus</i> Bloch, 1795	NUP 6073 (1 ex.), 7601 (1 ex.)	3

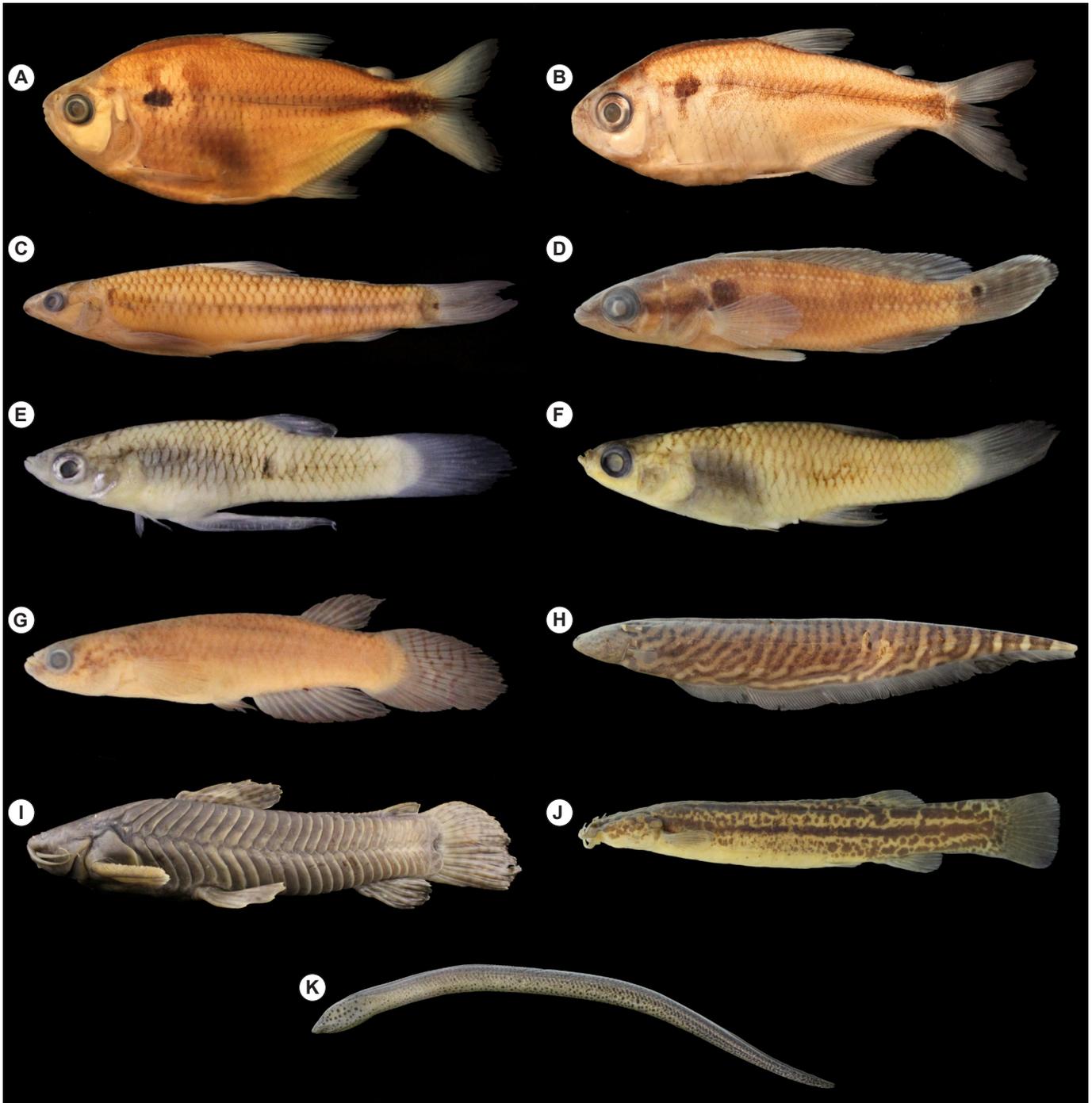


FIGURE 3. Fishes found in first order streams of the upper Paraná River basin; **A)** *Astyanax altiparanae*, NUP 7302, 61.5 mm SL, **B)** *Astyanax* aff. *paranae*, NUP 6451, 43.2 mm SL, **C)** *Characidium* aff. *zebra*, NUP 6071, 53.2 mm SL, **D)** *Crenicichla britskii*, NUP 7604, 36.7 mm SL, **E)** *Phalloceros harpagos*, male, NUP 12430, 20.5 mm SL, **F)** *Phalloceros harpagos*, female, NUP 6074, 28.3 mm SL, **G)** *Melanorivulus apiamici*, NUP 6060, 30 mm SL, **H)** *Gymnotus inaequilabiatus*, NUP 7607, 104.8 mm TL, **I)** *Callichthys callichthys*, NUP 6122, 71.3 mm SL, **J)** *Trichomycterus* sp., NUP 6069, 53.7 mm SL, **K)** *Synbranchus marmoratus*, NUP 13261, 182.5 mm TL. (Photographs by Luiz Fernando Tencatt).

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