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Ichthyofauna of urban streams in the western region of Paraná State, Brazil

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Abstract: The western region of Paraná State is drained by the Paraná River Basin, which has several streams. Many headwaters streams are located in urban or rural areas and undergo several impacts, such as chemical alterations, deforestation, habitat disruption, and biological invasions. The present study presents a species list of fish from three streams of different municipalities, with different degrees of urbanization and regimes of land use, aiming at inventorying the fish species that occur in these particular environments. Sampling was carried out quarterly from June 2010 to March 2011 using electrofishing. We captured 25 species of 20 genera, 13 families, and six orders, among which we found two non-native and one migratory fish species. The species list presented here contributes to build a database on fish species distribution patterns in altered environments, and to set the ground for future actions of biodiversity management and conservation.

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Introduction

The western region of Paraná State has 50 municipalities that comprise an area of approximately 23 million km² (11.5% of the area of the State), has an estimated population of 1,083 million inhabitants, and is subdivided in three microregions: Foz do Iguaçu, Cascavel, and Toledo (FUNDETEC 1995). The region's climate is subtropical, predominantly super-humid, and has purple latosol with deep layers of good fertility and well-drained soil, which make the region favorable to agriculture.

Several streams compose the vast hydrographic network of the region, which is inserted in the Paraná River basin, comprising the drainages of the rivers Iguaçu, Piquiri, and Paraná III (SUDERHSA 1997). Due to their geomorphological characteristics and relationships with hydrography, these sub-basins have high ecological importance (SUDERHSA 1997; IPARDES 2010).

In this context, rivers and streams of this region stand out as aquatic ecosystems strongly affected by an increase in environmental degradation resulting from human activities. The increase in population density, which increases the load of domestic and industrial wastewater, the growth in agricultural and urban areas, habitat loss, species introduction, and hydroelectric dam construction, (Dudgeon *et al*. 2006; Moya *et al*. 2011) are among the main human actions responsible for changes in the environmental conditions of these natural ecosystems.

Landscapes composed of a mosaic of rural and urban areas affect low-order streams (1st, 2nd, 3rd orders, Strahler 1957) in terms of their physical, chemical, and biological characteristics (Gubiani *et al*. 2010). Alterations in stream flow discharge, including changes in hydrological processes (with network waterproofing), are common characteristics of human-modified streams, resulting in a decrease in soil percolation and an increase in superficial discharge (Dunne and Leopold 1978). As a consequence, changes in channel stability and morphology and increases in wastewater discharge are expected, which are reflected in ecological aspects, such as changes in species distributions (Maloney and Weller 2010; Alexandre *et al*. 2010; Cunico *et al.* 2012), decreases in species richness, and dominance of tolerant species to environmental degradation (Paul and Meyer 2001; Meyer *et al.* 2005).

Although in recent years there has been a significant increase in the studies of the ichthyofauna in tropical streams the knowledge is less extensive than that of temperate areas (Winemiller *et al.* 2008). In Brazilian inland waters, especially in urban stream, the estimates of the fish diversity are still imprecise due to the lack of complete inventories (Agostinho *et al*. 2008). First-order streams are abundant and unique components of a river network, they showing high biological diversity and are important for maintenance of the biological integrity of entire ecosystem (Meyer et al. 2007). List of species contributes to build a database on species distribution patterns in altered environments, and to set the ground for future actions of biodiversity management and conservation

In the present study, we sampled ichthtyofauna in three first-order streams affected by urban activities, aiming at inventorying the fish species that occur in these particular environments.

Materials and Methods

Study area

The study was carried out in first-order streams of Paraná River basin, with different levels of human occupation in their surroundings, located in the western region of the state of Paraná, southern Brazil. We sampled the Jequitibá Stream, located in the municipality of Palotina, tributary of the Piquiri River; the São Francisco Stream, located in the municipality of Cascavel; and the Pinheirinho Stream, located in the municipality of Toledo. The last two streams are tributaries of the Paraná III drainage (Figure 1; Table 1).

Sampling

Sampling was carried out quarterly, from June 2010 to March 2011 along stream gradient (headwater, middle, and mouth) (Figure 1). We sampled fish with an electrofishing equipment composed of two electrified dip nets (cathode and anode), supplied by a portable alternate current generator (HONDA, 2.5 kW, 220 V, ranging from 400 to 600 V at the exit; 3-4 A). At each reach, we made three successive captures from downstream to upstream, lasting 30-min each, and following Esteves and Lobón-Cerviá (2001). The species were euthanized with a benzocaine overdose (250 mg/l), following the guidelines of the American Veterinary Medical Association (2013), and posterior fixed in formaldehyde 4. The collect of fish was permitted by Instituto Ambiental do Paraná (IAP#755/2008). In the laboratory, the species was identified following Graça and Pavanelli (2007), measured, and weighted. Later, some individuals were preserved in alcohol 70% and deposited in the ichthyological collection of Nupelia (Núcleo de Pesquisas em Limnologia, Ictiologia e Aquicultura), at the Universidade Estadual de Maringá, Brazil.

Data analysis

To assess sampling efficiency, we used richness estimators based on abundance: Chao 1 (Chao 1987) and ACE (Abundance-based Coverage Estimator, Lee and Chao 1994). We generated a species accumulation curve, expressed by the number of samples taken, which assesses the efficiency of fish sampling (Chao 2005). Calculations were made in the software Estimates 9.0 (Colwell 2013).

Results

We captured 12,687 individuals of 25 species, 19 genera, 13 families, and six orders (Table 2). The most predominant orders were Characiformes (40%), with five families and ten species, followed by Siluriformes (28%), with four families and seven species.

In the Jequitibá Stream we recorded the highest species richness (19 species) with the exclusive occurrence of *Prochilodus lineatus*, *Bryconamericus* aff. *iheringii*, *Serrapinnus notomelas*, *Callichthys callichthys*, *Imparfinis mirini*, and *Pimelodella gracilis*. In the Pinheirinho Stream, we captured 17 species; among them *Characidium* aff. *zebra*, *Heptapterus mustelinus*, and *Gymnotus pantanal* were exclusive. In the São Francisco Stream we recorded the lowest richness (13 species), where only *Geophagus brasiliensis* was an exclusive species. Nine species were common to the three streams and two (*Poecilia reticulata* and *Oreochromis niloticus*) are non-native species (Table 2).

The most abundant species differed between streams. In the Jequitibá Stream *Astyanax altiparanae* was the most abundant species (77%); no other species had a relative abundance above than 4%. In the Pinheirinho Stream the most abundant species were *Astyanax* aff. *paranae* (70%) and *Phalloceros harpagos* (11%). In the São Francisco

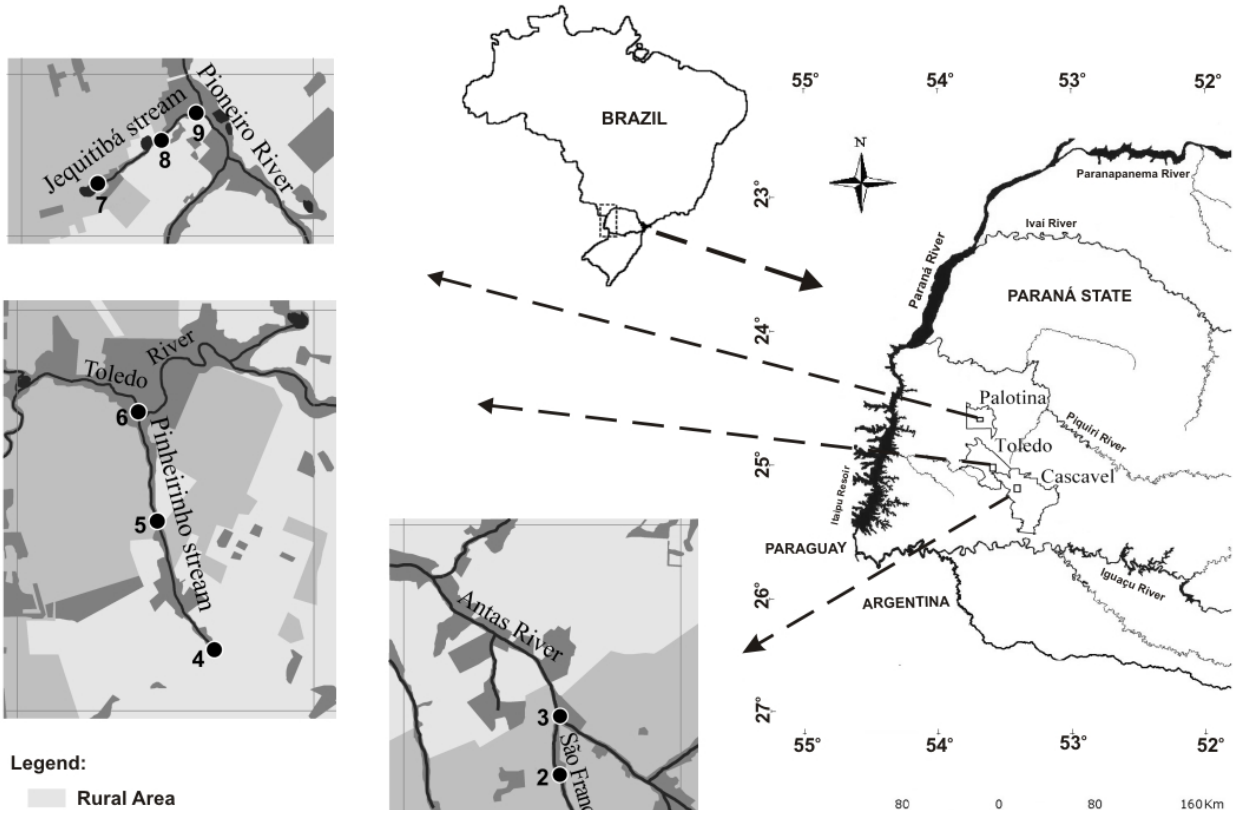

Figure 1. Sampling sites in three streams located in the cities of Palotina, Toledo, and Cascavel, state of Paraná, southern Brazil.

Table 1. General characteristics of the streams sampled in the Paraná State, southern Brazil. Sampling sites: headwater (1), middle (2), and mouth (3).

STREAM	URBANIZATION (%)	RIVER BASIN	SITES	COORDINATES		AVERAGE DEPTH (M)	AVERAGE WIDTH (M)	OBSERVATIONS
				LONGITUDE (W)	LATITUDE (S)			
São Francisco	100	Paraná III	1 2 3	53°28′08″ 53°28′16″ 53°28′17″	24°56′46″ 24°56′19″ 24°55′55″	0.12 0.58 0.13	1.80 3.46 2.90	Reduced or absent riparian vegetation, with sparse trees, predominance of grasses in some stretches; predominant human occupation in the surroundings; erosion on the margins. Partially sandy substrate. Predominance of rapids.
Pinheirinho	61.2	Paraná III	4 5 6	53º 42′33″ 53º 42′48″ 53º 42′55″	24°45′23″ 24°44′46″ 24°44′05″	0.16 0.61 0.20	1.94 2.07 3.00	Reduced riparian vegetation in most stretches, with sparse trees. Predominance of agricultural areas close to the spring and urban areas in the other sampling sites. Erosion on the margins. Partially sandy substrate. Reaches of rapids with some backwater regions.
Jequitibá	64.7	Piquiri	7 8 9	53°49′42″ 53°49′28″ 53°49′15″	24°17′13″ 24°17′02″ 24°16′54″	0.15 0.14 0.20	1.94 2.24 2.60	Reduced riparian vegetation in most stretches, with sparse trees. Predominant urban occupation in the surroundings. Erosion on the margins. Partially sandy substrate. Few sites of rapids and dominance of ponds.

Stream the most abundant species were *Phalloceros harpagos* (63%) and *Poecilia reticulata* (33%).

The species accumulation curve did not stabilize for the Jequitibá Stream (richness estimators: ACE = 25.2 species and Chao 1 = 22.0 species; Figure 2). For the Pinheirinho and São Francisco Streams the richness estimators suggested good sampling efficiency, with estimated richness values very close to the observed values (Figure 2).

Discussion

High dominance of environmental degradation tolerant or non-native species highlights the potential influence of urbanization on the species composition of the fish assemblages that occur in the study area. Meyer *et al.* (2005) named ″urban stream syndrome″ a set of impacts common to these environments, and highlighted for fish assemblages a biodiversity decrease, with an increase in the abundance of tolerant species to environmental degradation. Similar patterns have been observed in Brazilian urban streams (Perin *et al.* 2007; Cunico *et al.* 2009; Gubiani *et al.* 2010; Daga *et al.* 2012; Domingos *et al.* 2013).

The dominance of the species *Astyanax altiparanae* in the Jequitibá Stream and the dominance of *Astyanax* aff. *paranae* in the Pinheirinho Stream highlight the plasticity of these species in the occupation of habitats, especially modified by human activities. Species of the genus *Astyanax* are common in streams of the Upper Paraná River Basin (Penczak *et al*. 1994; Castro and Casatti 1997; Pavanelli and Caramaschi 1997; Castro *et al.* 2003, 2004, 2005; Cionek *et al*. 2012), but the broad trophic range and the high reproductive plasticity of species of *Astyanax* (Casatti *et al*. 2001; Castro *et al*. 2004; Ferreira *et al*. 2012) provide them with capacity to efficiently explore altered environments.

The high capture rate of *A.* aff. *paranae* observed in Pinheirinho Stream occurred in reaches close to the headwaters, with a decrease in the middle reaches and mouth (pers. commun.), corroborate observations of Furlan *et al*. (2013) observed in an urban stream in the upper Tietê River basin. Gubiani *et al*. (2010) also registered higher catch of these same species in urban streams of the upper Paraná River basin.

Similarly, species of the family Poecilidae, such as *Phalloceros harpagos* and *Poecilia reticulata*, which are abundant in the São Francisco Stream, are known for colonizing environments altered by urbanization (Cunico *et al*. 2006, Gubiani *et al*. 2010, Daga *et al.* 2012). Lemes and Garutti (2002) reported the permanence of the species *Poecilia reticulata* in a stream of the Upper Paraná River Basin even after a burned oil spill, evidencing its broad plasticity in face of drastic environmental change.

In addition to the occurrence and abundance of tolerant species to environmental degradation, urban streams are customarily impacted by the invasion of non-native species (Vieira and Shibatta 2007, Cunico *et al*. 2009). The species *Poecilia reticulata* and *Oreochromis niloticus*, which come from Venezuela (Lucinda 2003) and Africa (Coward and Bromage 2000), respectively, have been broadly introduced in aquatic ecosystems by home aquarists and fish farming and are nominated within the ″100 worst invasive alien species″ list (e.g. Lowe et al. 2000, Cambray 2003). The non-native species recorded in the present study are the same found by Cunico *et al*. (2006) in urban streams of Maringá and by Gubiani *et al*. (2010) in streams of Toledo, state of Paraná.

Hence, the species list presented here contributes to build a database on species distribution patterns in altered environments by urbanization, and to set the ground for future actions of biodiversity management and conservation.

Table 2. List of fish species and abundances in urban streams of western of Paraná State. JEQ: Jequitibá stream; PIN: Pinheirinho stream; SFR: São Francisco stream.

TAXA	VULGAR NAME	JEQ	PIN	SFR	ABUNDANCE TOTAL	VOUCHER
CHARACIFORMES						
Prochilodontidae						
Prochilodus lineatus (Valenciennes, 1837)	curimbatá	10	0	0	10	NUP 14606
Crenuchidae						
Characidium aff. *zebra* Eigenmann, 1909	mocinha	0	2	0	2	NUP 14609
Characidae						
Astyanax altiparanae Garutti & Britski, 2000	tambiú	871	131	0	1002	NUP 14598
Astyanax aff. *fasciatus* (Cuvier, 1819)	lambari-rabo-vermelho	1	128	2	131	NUP 8548
Astyanax aff. *paranae* Eigenmann, 1914	lambari	15	1650	267	1932	NUP 14600; NUP 14599
Bryconamericus aff. *iheringii* (Boulenger, 1887)	lambari	7	0	0	7	NUP 14917
Cheirodontidae						
Serrapinnus notomelas (Eigenmann, 1915)	pequira	6	0	0	6	NUP 14596
Erythrinidae						
Hoplias sp.1	traíra	1	4	1	6	NUP 8528
Hoplias sp.2	traíra	7	1	2	10	NUP 8510
Hoplias sp.3	traíra	2	4	0	6	NUP 8509
SILURIFORMES						
Trichomycteridae						
Trichomycterus sp.	candiru	0	112	20	132	NUP 14591
Callichthydae						
Callichthys callichthys (Linnaeus, 1758)	camboja	3	0	0	3	NUP 14594
Loricariidae						
Hypostominae						
Hypostomus ancistroides (Ihering, 1911)	cascudo	39	4	89	132	NUP 14611
Heptapteridae						
Imparfinis mirini Haseman, 1911	bagrinho	6	0	0	6	NUP 14592
Heptapterus mustelinus (Valenciennes, 1835)	bagre-pedra	0	19	0	19	NUP 8547
Pimelodella gracilis (Valenciennes, 1835)	mandi-mole	17	0	0	17	NUP 14590
Rhamdia quelen (Quoy & Gaimard, 1824)	jundiá	41	0	7	48	NUP 14603; NUP 14616
GYMNOTIFORMES						
Gymnotidae						
Gymnotus pantanal Fernandes *et al.* 2005	tuvira	0	3	0	3	NUP 9290
Gymnotus sylvius Albert & Fernandes-Matioli, 1999	tuvira	11	8	2	21	NUP 14593; NUP 14602
SYNBRANCHIFORMES						
Synbranchidae						
Synbranchus marmoratus Bloch, 1795	muçum	20	9	2	31	NUP 14605
CYPRINODONTIFORMES						
Poecilidae						
Phalloceros harpagos Lucinda, 2008	guaru	1	262	5788	6051	NUP 14614
Poecilia reticulata Peters, 1859	guaru	0	19	3037	3056	NUP 14615
PERCIFORMES						
Cichlidae						
Cichlasoma paranaense Kullander, 1983	carazinho	1	2	1	4	NUP 14597; NUP 14608
Geophagus brasiliensis (Quoy & Gaimard, 1824	cará	0	0	10	10	NUP 14610
Oreochromis niloticus (Linnaeus, 1758)	tilápia	40	2	0	42	NUP 8544
Total number		**1099**	**2360**	**9228**	**12687**	
Richness		**19**	**17**	**13**		

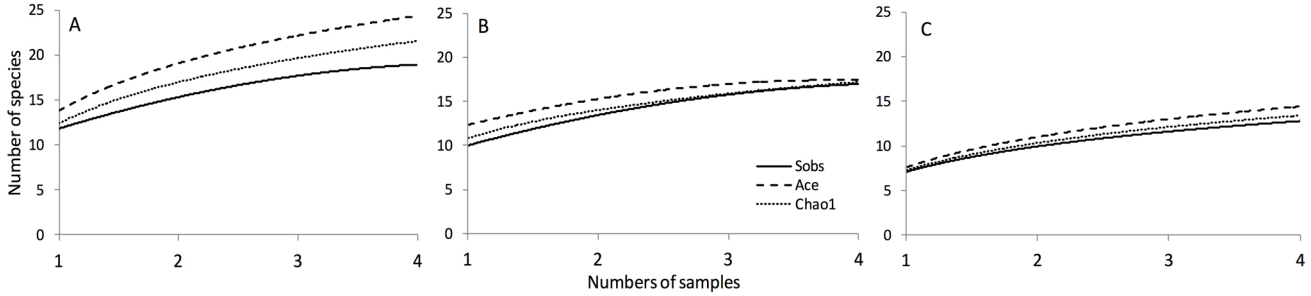

Figure 2. Species accumulation curves (Sobs) and richness estimators ACE and Chao 1 for the sampling performed from June 2010 to March 2011 in the streams Jequitibá (A), Pinheirinho (B), and São Francisco (C) in urban areas of western Paraná State, southern Brazil.

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