

Fish fauna of the Pandeiros River, a region of environmental protection for fish species in Minas Gerais state, Brazil

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Abstract: The Area of Environmental Protection of the Pandeiros River is the largest unit for sustainable use in Minas Gerais state, Brazil. The Pandeiros Wetland in the lower part of this river is considered a nursery for most migratory fish species of the São Francisco River and it is currently threatened by the introduced peacock-bass *Cichla piquiti* (Kullander & Ferreira, 2006). In this study, a list of fish species from the Pandeiros River was developed and compared with data for populations from other regions in the São Francisco basin. The presence of a new species record for the São Francisco River basin in the Pandeiros, and the particular local biotic and abiotic conditions of that river, support its recognition as an important conservation unit within the basin.

Key words: Neotropical ichthyology, Pandeiros River, São Francisco River, species inventory

INTRODUCTION

The São Francisco River is 2,780 km long and drains 450 municipalities of seven Brazilian states (Franco de Camargo and Petrere 2001). The headwaters of the Pandeiros River, an important tributary of the middle São Francisco River, are in northern Minas Gerais state, Brazil. This river is 145 km long and its flow rate ranges from 8 m³/s in the dry season to 24 m³/s in the rainy season. The tributaries of the Pandeiros River are the Pindaíbal I and II, São Pedro, Alegre, and Mandins rivers on the left bank and the Catolé, Borrachudo, Macaúbas, and São Domingos rivers on the right bank. The area where the Pandeiros River reaches the São Francisco River is known as the Pandeiros Wetland (Lopes *et al.* 2010).

The Area of Environmental Protection of the Pandeiros River (AEP-Pandeiros) was established by State Law No.11.901 in 1995. It encompasses 393,060 hectares and is the largest unit for sustainable use in Minas Gerais state. AEP-Pandeiros covers the entire basin of the Pandeiros River in the municipalities of Januária, Bonito de Minas, and Cônego Marinho (Lopes *et al.* 2010). This AEP has global conservation relevance because freshwater ecosystems are the most threatened biodiversity hotspots (Strayer and Dudgeon 2010). The objective of the AEP-Pandeiros is to protect the Pandeiros Wetland and the

biological diversity in the surrounding area for development and reproduction of native fish species. Wetlands are home to large assemblages of species (Gibbs 2000), and the Pandeiros Wetland, with an area of 3,000 ha in the dry season to 5,000 ha in the wet season, is considered to be the nursery of most migratory fishes of the São Francisco Basin (Godinho and Godinho 2003). The ecotone of the AEP-Pandeiros contains three vegetation types (savannah is the predominant vegetation, but Caatinga and dry forest are also present), which increases local diversity and provides suitable conditions for species that require large habitat ranges. The area, therefore, is a priority for conservation (Kark *et al.* 2007), as established by the Atlas of Biodiversity Conservation of Minas Gerais state (Drummond *et al.* 2005). Although the local fauna is poorly studied, 315 bird species were listed in this conservation unit (Lopes *et al.* 2010). The fish fauna of the Pandeiros River is less well known than that of the Velhas River (Alves and Pompeu 2001) and the Três Marias Dam (Britski *et al.* 1986), both in the São Francisco River basin.

The decline of fish fauna at a global scale can be attributed to factors such as habitat alteration, water extraction, pollution, commercial exploitation, and the introduction of exotic species (Paiva *et al.* 2006; Barros *et al.* 2012), but their cumulative effects are less predictable. Lists of species are one of the tools used to establish priorities for conservation (Jowett and Richardson 2003; Raghavan *et al.* 2008) and to guide use of financial resources for biodiversity management (Grammont and Cuarón 2006).

In this study, an inventory of the Pandeiros River fishes was undertaken and compared with other fish assemblages from the São Francisco basin region. The results underscore the importance of the AEP-Pandeiros for conservation of fish species of the São Francisco River basin.

MATERIALS AND METHODS

Collecting permit SISBIO14975-1 was provided by the Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio); this authorization is valid for the collection, transport, and sacrifice of an unlimited number of specimens of all fish taxa from Pandeiros River basin. Four field campaigns were conducted: two in the dry season (July)

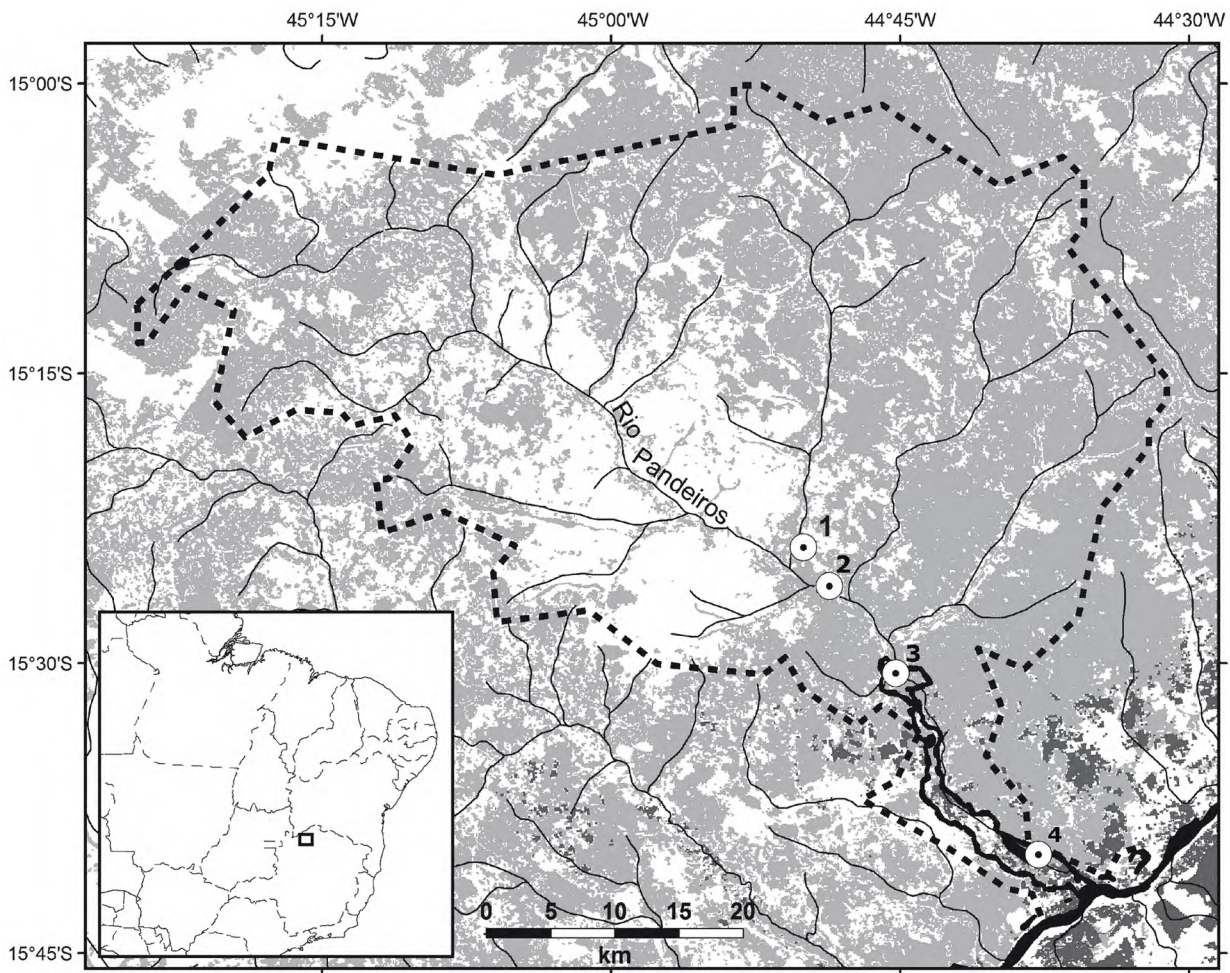


Figure 1. Environmental Protection Area of the Pandeiros River is indicated by the dotted line. Sampling sites as follows: (1) Catolé Stream; (2) bridge over the Pandeiros River; (3) Pandeiros Resort, and (4) Pandeiros Wetland. Map from Lopes *et al.* (2010) and modified.

and two in the rainy season (February and December) of 2008 and 2009. Fish were caught with trolling nets, seines, fishing rods, and mesh nets (mesh sizes 3, 4, 5, 7, 8, 10, 12, 14 mm between opposite knots) from dusk to dawn in different habitats in the basin. The two sites upstream of the three waterfalls of the Pandeiros River were Catolé Stream, a tributary of the Pandeiros River at the Santa Maria da Vereda Farm (15°24'43"S, 044°50'32"W), and at the bridge over the Pandeiros River (15°26'27.0"S, 044°49'19.2"W). Collections downstream of the three waterfalls were made at the Pandeiros Resort (15°26'48.7"S, 044°49'32.0"W) and the Pandeiros Wetland in Três Irmãs Farm (15°40'01.8"S, 044°37'99.3"W) (Figure 1). Tissue samples from captured specimens were deposited in the public tissue collection of the Laboratory of Molecular Systematics at the Universidade Federal de Viçosa (UFV) in Viçosa, Minas Gerais state, Brazil, which is an authorized depository of the Brazilian Genetic Heritage (Ministério do Meio Ambiente, decision no 23 of 24 April 2003). Voucher specimens were fixed in 10% formalin, stored in 70% alcohol, and deposited in the ichthyological collection of the João Moojen Zoology Museum at the UFV, the ichthyological collection of the Universidade Federal do Rio Grande do Sul (UFRGS), and the ichthyological collection of the Pontifícia Universidade Católica do Rio Grande do Sul (PUCRS). Fish specimens were identified following specialized literature (*e.g.*, Britski

et al. 1986; Alves and Pompeu, 2010, and original species descriptions), with taxonomic classification following Eschmeyer (2013). Prior to preservation, specimens captured alive were anaesthetized and euthanized with clove oil following Inoue *et al.* (2003).

RESULTS

Forty-four fish species were identified in the Pandeiros River basin (Table 1), including the large piscivorous catfish, *Pseudoplatystoma corruscans*, and the minute *Planaltina* sp. (Figure 2). Sixteen species were collected upstream of the three waterfalls of the Pandeiros River and nine of them occurred only in this region: *Acestrorhynchus lacustris*, *Mylius altipinnis*, *Characidium* aff. *zebra*, *Hoplias intermedius*, *Pimelodella* cf. *lateristriga*, *Corydoras multimaculatus*, *Harttia longipinna*, *Planaltina* sp. and *Trichomycterus* sp. On the other hand, *Trachelyopterus galeatus*, *Pterygoplichtys etentaculatus*, *Salminus franciscanus*, *Prochilodus argenteus*, *Pimelodus maculatus*, *Leporinus reinhardtii*, *Brycon orthotania*, *Pseudoplatystoma corruscans*, and *Leporinus elongatus* were only recorded downstream of the three waterfalls. *Bryconops affinis*, *Bryconamericus stramineus* and *Piabina argentea* were only recorded at the beach of the Pandeiros Resort. *Hoplosternum littorale* and *Cichla piquiti*, which are non-natives to the São Francisco River basin, were captured in the Pandeiros Wetland.

Table 1. Fish species collected and place of capture in the Environmental Protection Area Pandeiros.

ORDER/Family/Species	TSC*	Sampling sites [†]				Vouchers [‡]
		CS	BP	PR	PW	
CHARACIFORMES/Characidae						
<i>Astyanax lacustris</i> (Lütken, 1875)	41		16	25		MZUFV3624; UFRGS10086
<i>Astyanax fasciatus</i> (Cuvier, 1819)	15		8	7		UFRGS10090
<i>Astyanax rivularis</i> (Lütken, 1875)	15		5	10		MZUFV4301
<i>Bryconamericus stramineus</i> Eigenmann, 1908	31			31		MZUFV3621; UFRGS10087; UFRGS10154
<i>Bryconops affinis</i> (Günther, 1864)	22			22		MZUFV3628; MZUFV4253
<i>Moenkhausia sanctaeflorenae</i> (Steindachner, 1907)	23		6	17		MZUFV4303
<i>Piabina argentea</i> Reinhardt, 1867	51			51		UFRGS10155; UFRGS10088
<i>Planaltina</i> sp.	5	5				UFRGS10158
CHARACIFORMES/Serrasalminidae						
<i>Myleus micans</i> (Lütken, 1875)	57		14	18	25	MZUFV3627; MZUFV3731; MZUFV4249
<i>Myleus altipinnis</i> (Valenciennes, 1850)	1		1			UFRGS10152
<i>Pygocentrus piraya</i> (Cuvier, 1819)	14				14	MZUFV3656; MZUFV3764
<i>Serrasalmus brandtii</i> (Lütken, 1875)	17				17	MZUFV3654; MZUFV3765
CHARACIFORMES/Bryconidae						
<i>Brycon orthotaenia</i> Günther, 1864	8				8	MZUFV4219
<i>Salminus franciscanus</i> (Lima & Britski, 2007)	24			6	18	MZUFV3658; MZUFV3780
CHARACIFORMES/Acestrorhynchidae						
<i>Acestrorhynchus lacustris</i> (Lütken, 1875)	6	2	4			MZUFV3735
CHARACIFORMES/Anostomidae						
<i>Leporellus vittatus</i> (Valenciennes, 1850)	3			3		MZUFV4304
<i>Leporinus piau</i> Fowler, 1941	12			5	7	UFRGS10410;
<i>Leporinus reinhardti</i> Lütken, 1875	13			4	9	MZUFV4305
<i>Leporinus taeniatus</i> Lütken, 1875	9			43	6	MZUFV3626; MZUFV3736; UFRGS10409
<i>Leporinus elongatus</i> Valenciennes, 1850	3				3	UFRGS10412
<i>Schizodon knerii</i> (Steindachner, 1875)	21				21	UFRGS10413
CHARACIFORMES/Curimatidae						
<i>Curimatella lepidura</i> (Eigenmann & Eigenmann, 1889)	11				11	MZUFV4302
<i>Steindachnerina elegans</i> (Steindachner, 1874)	13			13		UFRGS10156;
CHARACIFORMES/Prochilodontidae						
<i>Prochilodus argenteus</i> (Spix & Agassiz 1829)	27			6	21	MZUFV3657; MZUFV3781; UFRGS10411
CHARACIFORMES/Parodontidae						
<i>Parodon hilarii</i> Reinhardt, 1866	7			7		UFRGS10157
CHARACIFORMES/Erythrinidae						
<i>Hoplias intermedius</i> (Günther, 1864)	16		16			MZUFV3734
<i>Hoplias malabaricus</i> (Bloch 1794)	22				22	MZUFV3659; MZUFV3762
<i>Hoplerythrinus unitaeniatus</i> (Spix & Agassiz, 1829)	3				3	MZUFV3655
CHARACIFORMES/Crenuchidae						
<i>Characidium</i> aff. <i>zebra</i> Eigenmann, 1909	4	2	2			UFRGS10159; UFRGS10151
SILURIFORMES/Sternopygidae						
<i>Eigenmannia virescens</i> (Valenciennes, 1836)	2			2		MZUFV4306
SILURIFORMES/Auchenipteridae						
<i>Trachelyopterus galeatus</i> (Linnaeus, 1776)	3			1	2	MZUFV4310
SILURIFORMES/Pimelodidae						
<i>Pseudoplatystoma coruscans</i> (Spix & Agassiz, 1829)	2				2	MZUFV4307
<i>Pimelodus maculatus</i> Lacepède, 1803	3			2	1	MZUFV3766
SILURIFORMES/Loricariidae						
<i>Hypostomus lima</i> (Lütken, 1874)	24		8	16		MZUFV3738; MCP44315
<i>Hypostomus francisci</i> (Lütken, 1874)	5		3	2		MZUFV3737; UFRGS10149
<i>Pterygoplichthys etentaculatus</i> (Spix & Agassiz, 1829)	14			3	11	MZUFV3660
<i>Harttia longipinna</i> Langeani, Oyakawa & Montoya-Burgos, 2001	3		3			MCP44316
SILURIFORMES/Callichthyidae						
<i>Hoplosternum littorale</i> (Hancock, 1828)	18				18	MZUFV3767
<i>Corydoras multimaculatus</i> Steindachner, 1907	5		5			MZUFV3733
SILURIFORMES/Heptapteridae						
<i>Pimelodella</i> cf. <i>lateristriga</i> (Lichtenstein, 1823)	2		2			UFRGS10153
SILURIFORMES/Trichomycteridae						
<i>Trichomycterus</i> sp.	1		1			MZUFV4308
LABRIFORMES/ Cichlidae						
<i>Cichla piquiti</i> (Kullander & Ferreira, 2006)	1				1	MZUFV3763
<i>Cichlasoma sanctifranciscense</i> Kullander, 1983	1				1	UFRGS10407
<i>Australoheros</i> cf. <i>facetus</i> (Jenyns, 1842)	3				3	MZUFV4309
Total of species (n = 44)		3	15	22	22	

* TSC: total number of specimens captured

† Sampling sites: CS – Catolé Stream, BP – bridge over of the Pandeiros River, PR – Pandeiros Resort, PW – Pandeiros Wetland).

‡ Voucher collections: MZUFV – Coleção de Peixes, Museu de Zoologia João Moojen, Universidade Federal de Viçosa.

UFRGS – Coleção de Peixes, Universidade Federal do Rio Grande do Sul

MCP – Coleção de Peixes, MCP-Peixes, Pontifícia Universidade Católica do Rio Grande do Sul.

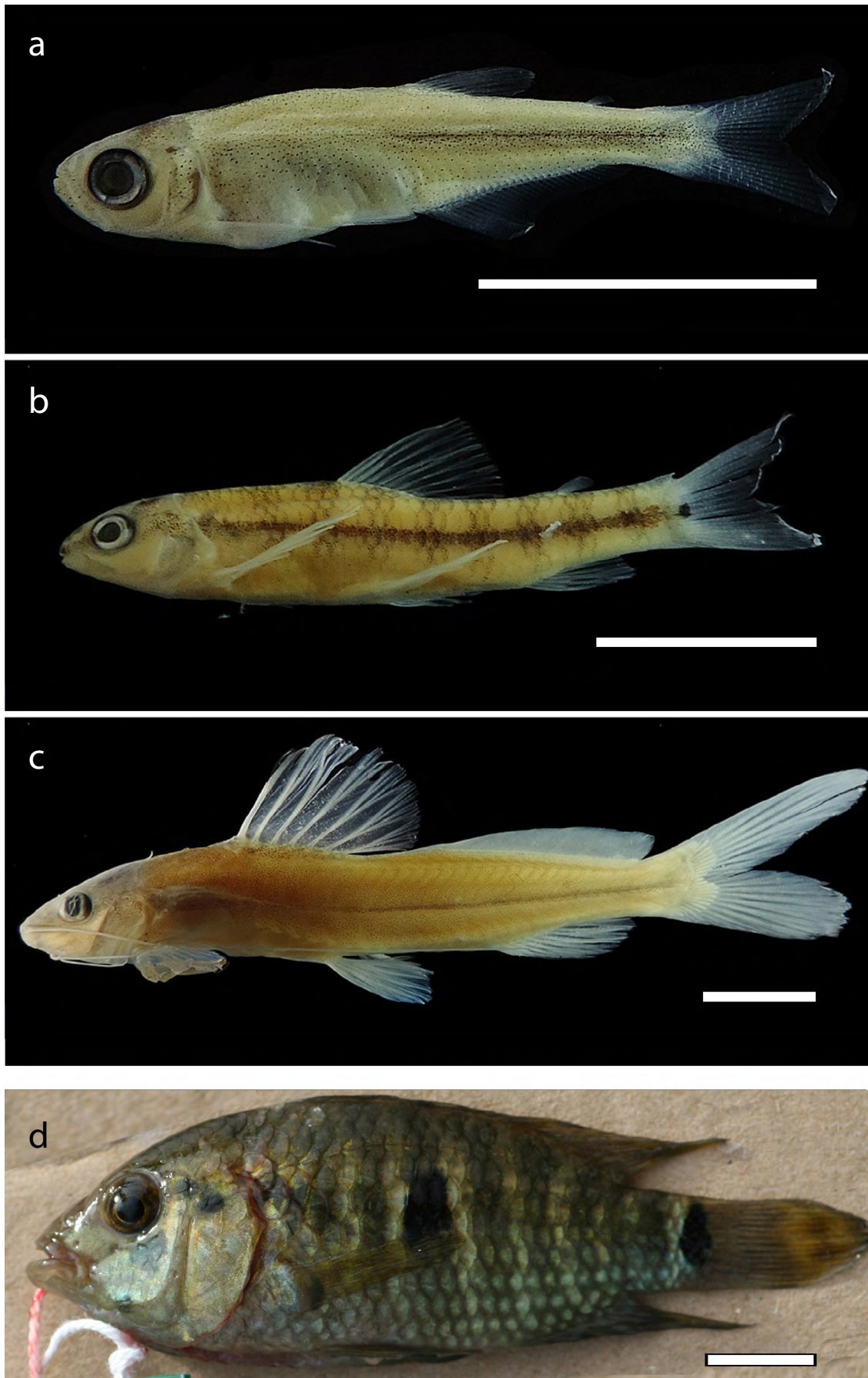


Figure 2. Fish species undescribed and/or with uncertainly taxonomic identification collected on Pandeiros River Basin. *Planaltina* sp. (a), *Characidium* aff. *zebra* (b) and *Pimelodella* cf. *lateristriga* (c) pictures taken after fixation in 10% formalin and stored in 70% alcohol. *Australoheros* cf. *facetus* (d) picture taken with specimen alive. Bar = 1 cm.

DISCUSSION

Nearly one-fifth of all cited species for the São Francisco River basin occur in the AEP-Pandeiros. Twenty-five of them were found in the Velhas River (Alves and Pompeu 2001), 28 in the Três Marias Dam region (Britski *et al.* 1986), 21 in marginal lakes of the São Francisco River in the municipalities of Jaíba, and Itacarambi (Minas Gerais) (Pompeu and Godinho 2003), 19 in the Juramento River (Silva *et al.* 2006), and 13 in Itapeçerica River (Domingos *et al.* 2013). This pattern indicates that the fishes of the Pandeiros River are widely distributed in the São Francisco River basin. However, the presence of the near-threatened species *Pseudoplatystoma corruscans*, included in the list of endangered species in Minas Gerais state (Vieira *et al.* 2008), underscores the importance of the AEP-Pandeiros as environmental protection region for the conservation of the ichthyofauna of the São Francisco basin. The relevance of the AEP-Pandeiros also applies to small-sized, poorly known species: the occurrence of *Planaltina* sp. in the Pandeiros River for example, represents the first record of this genus in the São Francisco River basin. Currently, only three species of this genus have been described: *Planaltina myersi* from the Corumbá River (a tributary of the Paranaíba River), and *Planaltina glandipedis* and *Planaltina britskii* from tributaries of the Grande and Tietê rivers, all tributaries of the Upper Paraná River (Menezes *et al.* 2003). Based on a bibliographic review undertaken for this study, and including *Planaltina* sp., the number of known freshwater fish species in the basin is 233 (Britski *et al.* 1986; Malabarba and Weitzman 1999, 2000; Alves and Pompeu 2001; Lütken 2001; Reis *et al.* 2003; Pompeu and Godinho 2003; Costa 2005, 2006, 2013, 2014; Silva *et al.* 2006; Costa and Brasil 2006; Bockmann and Castro 2010; Nielsen *et al.* 2010; Costa and Amorim 2011; Costa *et al.* 2012; Ottoni 2012; Lehmann and Reis 2012; Bichuette and Rizzato 2012).

Of the sixteen species collected upstream of the three waterfalls, *Myleus altipinnis*, *Characidium* aff. *zebra*, *Hoplias intermedius*, *Pimelodella* cf. *lateristriga*, *Corydoras multimaculatus*, *Harttia longipinna*, *Planaltina* sp. and *Trichomycterus* sp. were not found anywhere else. This suggests their preference for water rapids which are characteristic of this river section. According to reports from locals, *Acestrorhynchus lacustris*, another species recorded only in this part of the river, was recently stocked in the upper Pandeiros River. This species has generalist piscivorous habits (Hahn *et al.* 2000), which may impact natural fish populations upstream. The lack of sampling of the migratory species *Brycon orthotaenia*, *Pimelodus maculatus*, *Pseudoplatystoma corruscans*, *Salminus franciscanus*, *Leporinus elongatus*, and *Prochilodus argenteus* upstream of the three waterfalls suggests that these constitute a barrier for some species of the fish fauna of the Pandeiros River. The occurrence of *Trachelyopterus galeatus*, *Pterygoplichtys etentaculatus*, and the migratory fishes *S. franciscanus*, *P. argenteus*, *P. maculatus* and *Leporinus reinhardtii* in the Pandeiros Wetland and the Pandeiros Resort are likely due to the physical continuity without waterfalls. In the Pandeiros Wetland and the Pandeiros Resort it was possible to see schools of *P. argenteus* closely followed by *S. franciscanus*, which is an efficient predator in lotic environments (Rodríguez-Olarte and Taphorn 2006). The migration of fishes in the São Francisco River basin occurs with greater intensity from October to January,

probably due to the greater water volume in the river, higher temperature, and longer days. *Salminus franciscanus*, *P. argenteus*, *P. maculatus*, *L. reinhardtii*, *L. elongatus*, *B. orthotaenia*, and *P. corruscans* ascend the river channel and reproduce in the tributaries (Godinho and Godinho 2003). In a mark and recapture study of *P. argenteus*, 10% of the specimens were recaptured 800 km upstream 85 days after release (Sato and Godinho 2003), thus demonstrating the great migratory capacity of this species.

Bryconops affinis was collected in all campaigns immediately downstream of the lower waterfall. Juveniles of this species apparently prey on *Bryconamericus stramineus* and *Piabina argentea* juveniles, which were observed in the shallow, clear water along the beach of Pandeiros Resort. *Bryconamericus* species are omnivorous, may reach 10 cm in length, live in diverse environments, and are an important food item for larger fishes (Lima *et al.* 2003).

The presence of the invasive species *Hoplosternun littorale* and *Cichla piquiti* in the AEP-Pandeiros may affect native biodiversity due to competition for resources (*H. littorale*) or predation (*C. piquiti*) (Duncan and Williams 2002). Fish communities of native species have declined in parts of the São Francisco River basin in association with exotic species introduction. For example, populations of small fishes such as *Astyanax lacustris*, *Curimatella lepidura*, and *Triporthus guentheri* are declining, whereas non-native species have increased their populations in the Três Marias Dam (Sato and Godinho 2003).

The wetland formed by the Pandeiros River can be considered a nursery for migratory fish species of the São Francisco River. High temperatures and large amounts of nutrients, macrophytes, phytoplankton, and zooplankton are present in the Pandeiros River. These are favorable biotic conditions for the reproduction of fish species, and they provide food sources for fish larvae of the São Francisco River. Thus, the Pandeiros River helps maintain temporal processes and biodiversity in this basin (Ward and Tockner 2001).

The diversity of fish of the Pandeiros River and local biotic conditions (ecotone regions) are consistent that AEP-Pandeiros is an important conservation unit for the ichthyofauna of the São Francisco River basin, in Brazil.

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