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inventory

Ichthyofauna of the "Cachoeira de São Roberto" and fishes of lower Preto River, upper Paraná River basin, Brazil

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Abstract: Rheophilic environments typically houses fish species with specific ecological requirements. Thus, the suppression of these environments can lead to damaging impacts to local and regional fauna. In this work the ichthyofauna of the "Cachoeira de São Roberto" was inventoried, with a historical review of fish collected in the lower Preto River basin. The sampling sites included two reaches (named R1 and R2): R1 in the "Cachoeira de São Roberto" and R2 refers to two km upstream. The fishes were sampled bimonthly during one year (April 2013 to February 2014) using small and dip nets. Voucher specimens were catalogued in the Fish Collection of "Departamento de Zoologia e Botânica do Instituto de Biociências, Letras e Ciências Exatas, Universidade Estadual Paulista 'Júlio de Mesquita Filho', câmpus de São José do Rio Preto, SP" (DZSJRP). Historical records from lower Preto River basin were composed by fish species sampled downstream of spillway of the dam in the municipality of São José do Rio Preto, SP, using the database of fish collection of DZSJRP. The ichthyofauna of the sampled reaches was composed by 53 species, distributed in 16 families and seven orders. The greatest richness was found in the upstream site (R2) with the presence of *Aphyocheirodon hemigrammus* and *Myleus tiete*, two Brazilian threatened fish species. Chao index suggested the occurrence of 64 species for the inventoried reaches. Considering all portion of lower Preto River basin, including historical records, 69 species were found, four of these species have not described yet. The present study highlights the importance of inventories in rheophilic environments, which usually includes sensitive, threatened, and species with restricted distribution. Besides that, inventories can provide technical data to support decisions about potential environmental impacts helping with the management and conservation of fish fauna.

Keywords: *diversity, rheophilic environment, Small Hydroelectric Plants, threatened species.*

Ictiofauna da Cachoeira de São Roberto e peixes do baixo rio Preto, bacia do alto rio Paraná, Brasil

Resumo: Ambientes reofílicos normalmente abrigam espécies de peixes com exigências ecológicas. Assim, a supressão desses ambientes pode levar a impactos danosos à fauna local e regional. Neste trabalho inventariou-se a ictiofauna da Cachoeira de São Roberto, com uma revisão histórica dos peixes coletados na bacia do baixo rio Preto. Os locais amostrados incluíram dois trechos (nomeados R1 e R2): R1 na área da Cachoeira de São Roberto e R2, dois km a montante de R1. As coletas ocorreram bimestralmente durante um ano (abril de 2013 a fevereiro de 2014), utilizando puçá e arrasto. Os peixes coligidos foram depositados na Coleção de Peixes do Departamento de Zoologia e Botânica do Instituto de Biociências, Letras e Ciências Exatas, Universidade Estadual Paulista "Júlio de Mesquita Filho", câmpus de São José do Rio Preto, SP (DZSJRP). Registros históricos da bacia do baixo rio Preto foram representados pelas espécies de peixes coletadas a jusante do vertedouro da represa municipal de São José do Rio Preto, SP depositados na coleção DZSJRP. A ictiofauna nos trechos inventariados (R1 e R2) foi representada por 53 espécies, distribuídas em 16 famílias e sete ordens. A maior riqueza foi encontrada no R2, com registro de *Aphyocheirodon hemigrammus* e *Myleus tiete*, duas espécies da ictiofauna brasileira ameaçadas de extinção. Estimativas de diversidade (Chao index) sugeriram a ocorrência de 64 espécies nos trechos inventariados. Considerando toda porção da bacia do baixo rio Preto, incluindo os registros históricos, registrou-se 69 espécies, quatro delas ainda não descritas formalmente. O presente estudo ressalta a importância de inventários em áreas reofílicas, que normalmente inclui espécies sensíveis, ameaçadas e com distribuição restrita. Além disso, inventários podem fornecer dados técnicos para subsidiar decisões sobre impactos ambientais auxiliando a gestão e conservação da fauna de peixes.

Palavras-chave: *diversidade, ambiente reofílico, Pequenas Centrais Hidrelétricas, espécies ameaçadas.*

Introduction

The Northwest of São Paulo State, Brazil, shows few riffle or waterfall areas, most of them not completely inventoried. Some of these areas have been target and submerged by hydroelectric plants (Agostinho et al. 2007, Júlio Junior et al. 2009). "Salto do Ferrador" (in municipality of Icém, SP) and "Cachoeira dos Índios" (in municipality of Ouroeste, SP) are two examples of these waterfalls situated in the Grande River and replaced by "Marimbondo" and "Água Vermelha" hydroelectric plants, respectively. In addition to the hydroelectric plants in the principal rivers of the region (*e.g.* Tietê and Grande rivers), Small Hydroelectric Plants (SHPs) have been employed in tributaries of these drainages (Agostinho et al. 2007). Recently, two riffle areas were target by this kind of project: "Cachoeira do Talhadão", in the Turvo River, Duplo Céu District, municipality of Palestina, SP, and in the confluence of Preto and Turvo Rivers near to "Cachoeira de São Roberto", lower Preto River basin, municipality of Pontes Gestal, SP (HABTEC 2010).

Riffle areas with rocky substrates and high water velocity are important to the maintenance of a specific biota (Garavello & Garavello 2004). The suppression and/or simplification of these areas by dam-buildings is undeniably associated to biological homogenization of aquatic ecosystems (Rahel 2002, Agostinho et al. 2008). Environmental homogenization can lead to the increase of generalist species and decrease of specialist species (Hoeinghaus et al. 2009). Moreover, conversion of lotic to lentic environment can favor species with preference to lentic waters, specially non-native Cichlidae [e.g. *Coptodon rendalli* (Boulenger), *Oreochromis niloticus* (Linnaeus), *Cichla* spp.] found in the upper Paraná River basin (Langeani et al. 2007).The "Cachoeira de São Roberto", a recreation riffle area, was target by a Small Hydroelectric Plant project without a previous or appropriate ichthyofaunistic inventory. The dam-building adjacent to this area could suppress this riffle environment and jeopardize fish fauna in the lower Preto River. Due to the lack of knowledge about the ichthyofauna and the possibility of SHP's building in this area, the aims of this study were to inventory the fish fauna of "Cachoeira de São Roberto" and to regain the fish historical records of the lower Preto River, Northwest of São Paulo State.

Material and Methods

The Preto River is one of the most important rivers of Northwest of São Paulo State; its source is in the municipality of Cedral, SP and it runs across nearly 25 km until the urban area of São José do Rio Preto, SP, where it becomes highly modified by stream flow channelization, impoundments, and lack of riparian forest (ComiteTG 2009). There are two dams and in the end of the second, the river has a spillway with *circa* four meters. After that, it runs for approximately 150 km until its confluence with the Turvo River, in municipality of Pontes Gestal, SP, Grande River drainage in the upper Paraná River basin.

The Northwest of São Paulo State has only 4% of its native vegetation, which has been replaced by agricultural crops since the beginning of the XIX century (Nalon et al. 2008). One of the remaining native riparian forest along Preto River is on the "Cachoeira de São Roberto", a tourist and recreational area with a series of small riffles situated approximately five km from its mouth, in the municipality of Pontes Gestal, SP. The area shows a tropical semi-humid climate, with temperature around 24ºC and pluviosity around 1,418 mm annual (PMPONTESGESTAL 2015).

Two sites in the lower Preto River basin were sampled (Figure 1): Reach 1 (R1), "Cachoeira de São Roberto" located approximately five km upstream from its mouth into the Turvo River (20°11'S 49°41'W), which is characterized by high water velocity with some declivity, substrate composed primarily by slab and basaltic boulders, besides the presence of sparse riparian forest composed by few trees (width of the riparian strip is approximately 10 m from each bank); Reach 2 (R2), located almost two km upstream from R1 (river distance), near to the mouth of the Botelho Stream (20°11'S 49º41'W). It is characterized by lower water velocity than R1, sandy substrate with some pebbles, and marginal vegetation composed mainly by grasses (Poaceae) (Figure 2). These two different reaches (R1 and R2) were selected aiming to know the ichthyofauna that could be affected by the Small Hydroelectric Plant.

Sampling was conducted bimonthly during one year (April 2013 to February 2014) in both reaches. A total of six sample collections were made, three in the dry season (April to August) (the period of low rainfall, 307 mm precipitation) and three in the wet season (October to February) (a period of high rainfall, 605 mm total). Pluviometric data was obtained by "Coordenadoria de Assistência Técnica Integral (CATI)" from the municipality of Votuporanga, SP.

Fishes were sampled using a small net (2.0 x 0.95 m, 2 mm mesh size) and a dip net (0.8 x 0.4 m, 2 mm mesh size). Standardized sampling effort (involving three people) was performed for two hours over approximately 150 m in each reach. Fishes were fixed in 10% formalin for 72 hours and after transferred to 70% alcohol to final preservation. Specimens were identified and vouchered at the fish collection of the "Departamento de Zoologia e Botânica do Instituto de Biociências, Letras e Ciências Exatas, Universidade Estadual Paulista 'Júlio de Mesquita Filho', câmpus de São José do Rio Preto, SP" (DZSJRP) (Figures 3, 4).

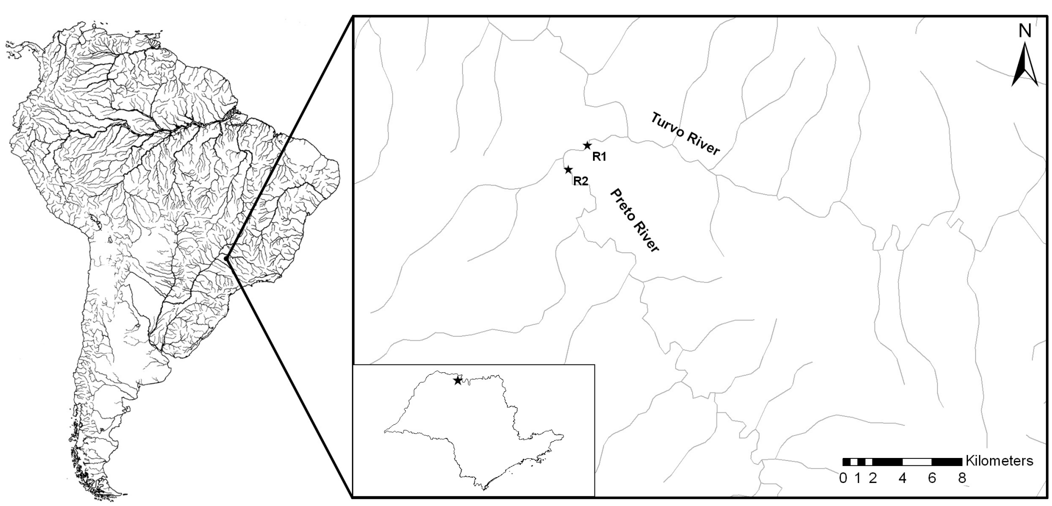

Figure 1. Location of the two reaches (R1 and R2) in the lower Preto River in the Northwest of São Paulo State, Brazil. Modified from Zeni et al. (2015).

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Figure 2. Reaches sampled in the lower Preto River: a) Riffles area of the "Cachoeira de São Roberto" (R1); b) Run area, near Botelho Stream (R2). Modified from Zeni et al. (2015).

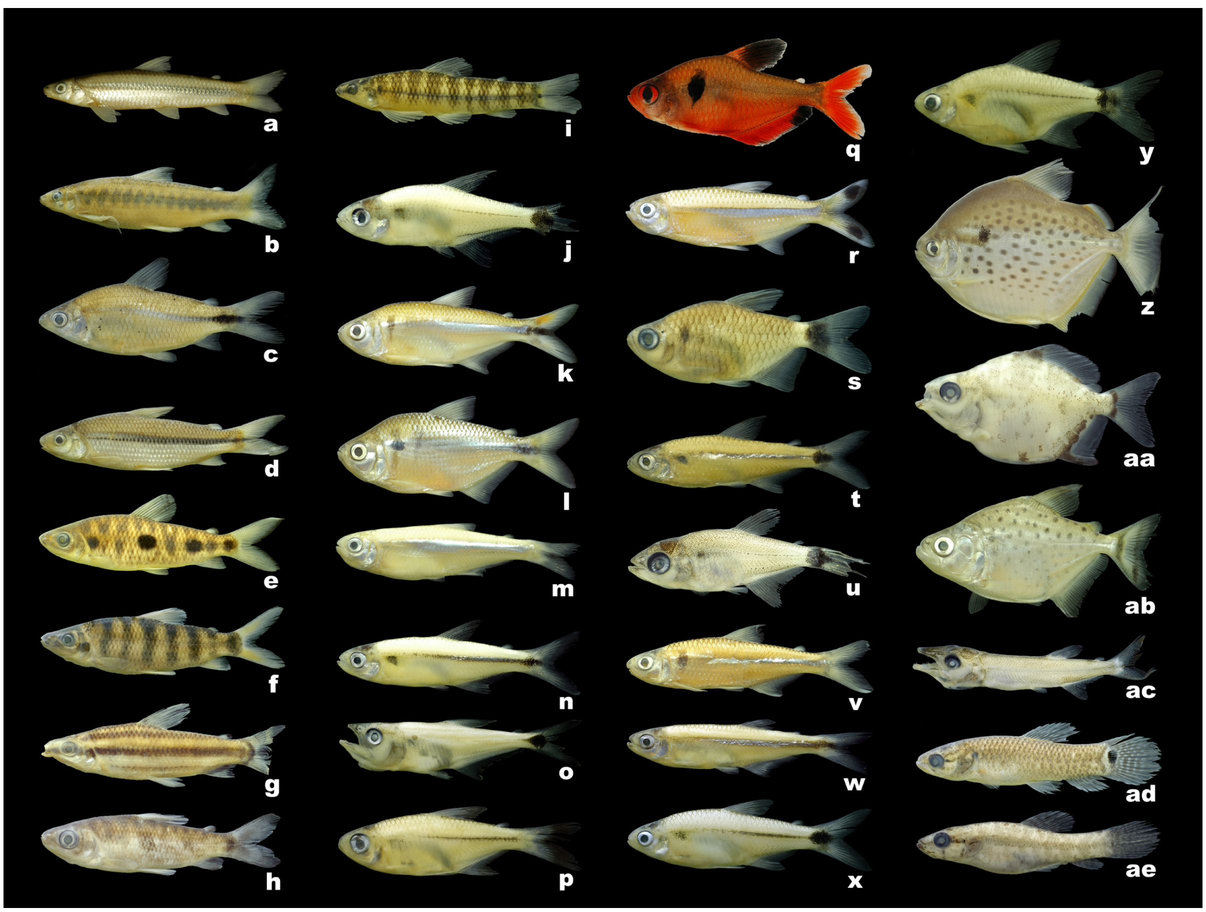

Figure 3. Fishes from the sampled areas of the lower Preto River. Characiformes. a) *Apareiodon affinis*, DZSJRP 19519, 62.6 mm SL; b) *Parodon nasus*, DZSJRP 19516, 74.5 mm SL; c) *Cyphocharax modestus*, DZSJRP 19541, 56.8 mm SL; d) *Steindachnerina insculpta*, DZSJRP 19501, 84.7 mm SL; e) *Leporinus friderici*, DZSJRP 19496, 81.9 mm SL; f) *Leporinus octofasciatus*, DZSJRP 19499, 72.2 mm SL; g) *Leporinus striatus*, DZSJRP 19543, 41.1 mm SL; h) *Megaleporinus macrocephalus*, DZSJRP 19500, 61.2 mm SL; i) *Characidium* cf. *zebra*, DZSJRP 19507, 46.4 mm SL; j) *Aphyocheirodon hemigrammus*, DZSJRP 19542, 22.0 mm SL; k) *Astyanax fasciatus*, DZSJRP 19511, 68.0 mm SL; l) *Astyanax lacustris*, DZSJRP 19517, 60.8 mm SL; m) *Bryconamericus stramineus*, 19518, 41.0 mm SL; n) '*Cheirodon*' *stenodon*, DZSJRP, 19512, 26.3 mm SL; o) *Galeocharax gulo*, DZSJRP 19530, 29.8 mm SL; p) *Hemigrammus marginatus*, DZSJRP 19525, 27.6 mm SL; q) *Hyphessobrycon eques*, DZSJRP 17694, 28.3 mm SL; r) *Moenkhausia intermedia*, DZSJRP 19508, 60.4 mm SL; s) *Moenkhausia* cf. *sanctaefilomenae*, DZSJRP 19539, 29.2 mm SL; t) *Odontostilbe* sp., DZSJRP 19495, 29.2 mm SL; u) *Oligosarcus pintoi*, DZSJRP 19533, 15.5 mm SL; v) *Piabina argentea*, DZSJRP 19494, 43.2 mm SL; w) *Planaltina britskii*, DZSJRP 19498, 31.5 mm SL; x) *Serrapinnus heterodon*, DZSJRP 19523, 30.7 mm SL; y) *Serrapinnus notomelas*, DZSJRP 19527, 28.1 mm SL; z) *Metynnis lippincottianus*, DZSJRP 19509, 99.1 mm SL; aa) *Myleus tiete*, DZSJRP 19526, 23.7 mm SL; ab) *Serrasalmus maculatus*, DZSJRP 19515, 42.5 mm SL; ac) *Acestrorhynchus lacustris*, DZSJRP 19532, 23.9 mm SL; ad) *Erythrinus erythrinus*, DZSJRP 19535, 31.0 mm SL; ae) *Hoplias* cf. *malabaricus*, DZSJRP 19522, 28.4 mm SL.

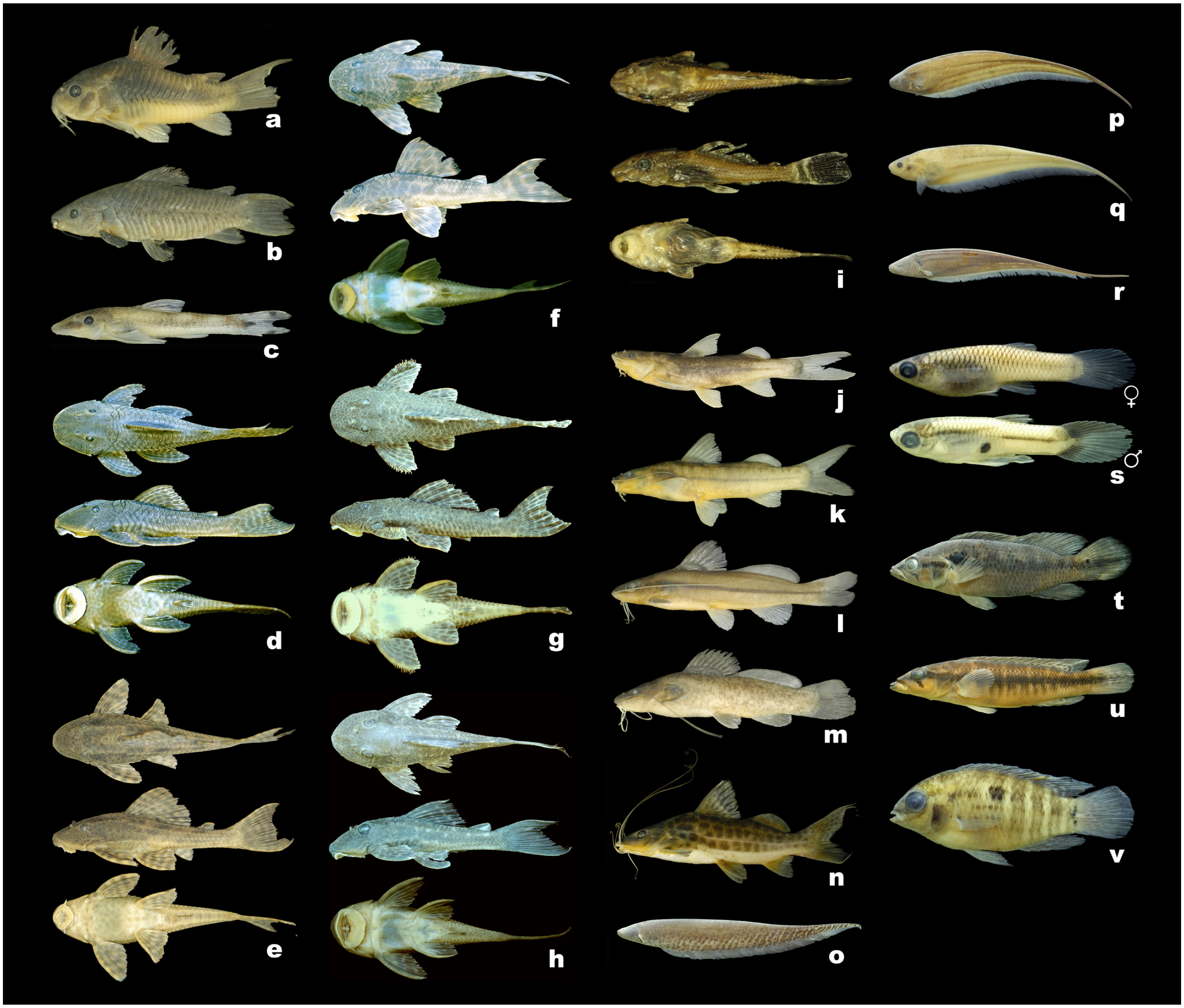

Figure 4. Fishes from the sampled areas of the lower Preto River. Siluriformes: a) *Corydoras aeneus*, DZSJRP 19524, 38.3 mm SL; b) *Hoplosternum littorale*, DZSJRP 19537, 96.4 mm SL; c) *Curculionichthys insperatus*, DZSJRP 19513, 25.7 mm SL; d) *Hypostomus albopunctatus*, DZSJRP 19502, 123.6 mm SL, dorsal, lateral, and ventral views; e) *Hypostomus ancistroides*, DZSJRP 19536, 93.5 mm SL, dorsal, lateral, and ventral views; f) *Hypostomus* cf. *iheringii*, DZSJRP 19510, 82.5 mm SL, dorsal, lateral, and ventral views; g) *Hypostomus nigromaculatus*, DZSJRP 19521, 83.6 mm SL, dorsal, lateral, and ventral views; h) *Hypostomus strigaticeps*, DZSJRP 19520, 64.2 mm SL, dorsal, lateral, and ventral views; i) *Pterygoplichthys ambrosettii*, DZSJRP 19534, 29.3 mm SL, dorsal, lateral, and ventral views; j) *Cetopsorhamdia iheringi*, DZSJRP 19514, 52.5 mm SL; k) *Imparfinis schubarti*, DZSJRP 19504, 73.0 mm SL; l) *Pimelodella avanhandavae*, DZSJRP 19505, 73.1 mm SL; m) *Rhamdia* cf. *quelen*, DZSJRP 19506, 70.9 mm SL; n) *Pimelodus maculatus*, DZSJRP 19503, 145.0 mm SL. Gymnotiformes: o) *Gymnotus sylvius*, DZSJRP 19529, 149.7 mm SL; p) *Eigenmannia guairaca*, DZSJRP 19546, 175.0 mm SL; q) *Eigenmannia virescens*, DZSJRP 19540, 115.0 mm SL; r) *Sternopygus macrurus*, DZSJRP 19544, 157.0 mm SL. Cyprinodontiformes: s) *Poecilia reticulata*, DZSJRP 19538, female 16.4 mm SL and male 13.2 mm SL. Perciformes: t) *Crenicichla britskii*, DZSJRP 19545, 88.1 mm SL; u) *Crenicichla jaguarensis*, DZSJRP 19497, 75.0 mm SL; v) *Laetacara araguaiae*, DZSJRP 19528, 32.9 mm SL.

Species abundance in R1 and R2 reaches was grouped and randomized as a function of the sampling effort, i.e., the number of sampling events (12 events, six from R1 and six from R2), to generate an accumulation curve. The Chao 1 index (with 100 permutations), which is a function of the ratio of the number of species with only one specimen in a sample (*singletons*) by the number of species with two specimens (*doubletons*) was used to estimate fish richness in the area (R1 plus R2).

Historical records from lower Preto River basin were composed by fish species sampled downstream of spillway of the dam in the municipality of São José do Rio Preto, SP, using the database of fish collection of DZSJRP. These data were compiled to the fish checklist of lower Preto River, excluding its abundances (Table 1).

Results

A total of 3,662 individuals were recorded in the sampling for both reaches, belonged to 53 species, 16 families, and seven orders. Characiformes represented the richest order, with 58.5% of the sampled species, followed

Table 1. Fishes of the lower Preto River basin: abundance (N) of the fish species (Orders and Families) in each reach (R1 and R2). Fish classification to families follows Reis et al. (2003), except to Serrasalmidae, according to Calcagnotto et al. (2005). * indicates threatened species; hyphen (-) indicates absence of quantitative data because are occurrence of species according to historical records.

Species	Reach 1	Reach 2
	N	N
CHARACIFORMES		
Parodontidae		
Apareiodon affinis (Steindachner, 1879)	14	0
Parodon nasus Kner, 1859	2	0
Curimatidae		
Cyphocharax modestus (Fernández-Yépez,1948)	0	5
Cyphocharax vanderi (Britski, 1980)	-	-
Steindachnerina insculpta (Fernández-Yépez, 1948)	2	6
Anostomidae		
Leporellus vittatus (Valenciennes, 1850)	-	-
Leporinus friderici (Bloch, 1794)	7	1
Leporinus lacustris Campos, 1945	-	-
Leporinus paranensis Garavello & Britski, 1987	-	-
Leporinus octofasciatus Steindachner, 1915	2	0
Leporinus striatus Kner, 1858	0	1
Megaleporinus macrocephalus (Garavello & Britski, 1988)	1	0
Schizodon altoparanae Garavello & Britski, 1990	-	-
Crenuchidae		
Characidium cf. *zebra* Eigenmann, 1909	25	16
Characidium sp.	-	-
Characidae		
Aphyocharax dentatus Eigenmann & Kennedy, 1903	-	-
Aphyocheirodon hemigrammus Eigenmann, 1915*	0	1
Astyanax fasciatus (Cuvier, 1819)	280	12
Astyanax lacustris (Lütken, 1875)	26	13
Bryconamericus stramineus Eigenmann, 1908	860	3
'*Cheirodon*' *stenodon* Eigenmann, 1915	10	58
Galeocharax gulo (Cope, 1870)	0	1
Hemigrammus marginatus Ellis, 1911	0	6
Hyphessobrycon eques (Steindachner, 1882)	0	1561
Moenkhausia intermedia Eigenmann, 1908	18	14
Moenkhausia cf. *sanctaefilomenae* (Steindachner, 1907)	0	3
Odontostilbe sp.	4	20
Oligosarcus pintoi Campos, 1945	0	2
Piabina argentea Reinhardt, 1867	30	26
Planaltina britskii Menezes, Weitzman & Burns, 2003	85	5
Serrapinnus heterodon (Eigenmann, 1915)	8	37
Serrapinnus notomelas (Eigenmann, 1915)	1	87
Serrapinnus sp.	-	-
Triportheus nematurus (Kner, 1858)	-	-
Serrasalmidae		
Metynnis lippincottianus (Cope, 1870)	1	0
Myleus tiete (Eigenmann & Norris, 1900)*	0	1
Serrasalmus maculatus Kner, 1858	1	5
Acestrorhynchidae		
Acestrorhynchus lacustris (Lütken, 1875)	0	4
Erythrinidae		
Erythrinus erythrinus (Bloch & Schneider, 1801)	0	1
Hoplias cf. *malabaricus* (Bloch, 1794)	0	3
SILURIFORMES		
Callichthyidae		
Corydoras aeneus (Gill, 1858)	0	1
Hoplosternum littorale (Hancock, 1828)	0	3

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Table 1. Continued...

Species	Reach 1	Reach 2
	N	N
Loricariidae		
Curculionichthys insperatus (Britski & Garavello, 2003)	1	0
Hypostomus albopunctatus (Regan, 1908)	25	0
Hypostomus ancistroides (Ihering, 1911)	58	49
Hypostomus cf. *iheringii* (Regan, 1908)	58	3
Hypostomus margaritifer (Regan, 1908)	-	-
Hypostomus nigromaculatus (Schubart, 1964)	47	0
Hypostomus paulinus (Ihering, 1905)	-	-
Hypostomus strigaticeps (Regan, 1908)	1	0
Pterygoplichthys ambrosettii (Holmberg, 1893)	0	10
Heptapteridae		
Cetopsorhamdia iheringi Schubart & Gomes, 1959	5	0
Imparfinis schubarti (Gomes, 1956)	5	0
Pimelodella avanhandavae Eigenmann, 1917	4	5
Rhamdia cf. *quelen* (Quoy & Gaimard, 1824)	4	2
Pimelodidae		
Pimelodus maculatus Lacepède, 1803	1	0
GYMNOTIFORMES		
Gymnotidae		
Gymnotus sylvius Albert & Fernandes-Matioli, 1999	23	41
Sternopygidae		
Eigenmannia guairaca Peixoto, Dutra & Wosiacki, 2015	0	15
Eigenmannia virescens (Valenciennes, 1836)	3	3
Sternopygus macrurus (Bloch & Schneider, 1801)	0	4
CYPRINODONTIFORMES		
Poeciliidae		
Poecilia reticulata Peters, 1859	1	11
SYNBRANCHIFORMES		
Synbranchidae		
Synbranchus cf. *marmoratus* Bloch, 1795	-	-
PERCIFORMES		
Cichlidae		
Cichlasoma paranaense Kullander, 1983	-	-
Coptodon rendalli (Boulenger, 1897)	-	-
Crenicichla britskii Kullander, 1982	1	5
Crenicichla jaguarensis Haseman, 1911	1	2
Laetacara araguaiae Ottoni & Costa, 2009	0	1
Oreochromis niloticus (Linnaeus, 1758)	-	-
Satanoperca sp.	-	-

by Siluriformes (26.4%), Gymnotiformes (7.5%), Perciformes (5.7%), and Cyprinodontiformes (1.9%). The most representative families were Characidae, with 16 species, followed by Loricariidae, with seven species. Anostomidae and Heptapteridae were both represented by four species each, whereas Cichlidae, Serrasalmidae, and Sternopygidae presented three species; Callichthyidae, Curimatidae, Erythrinidae, and Parodontidae, two species and the other five families (Acestrorhynchidae, Crenuchidae, Gymnotidae, Pimelodidae, and Poeciliidae) were represented only by one species each (Table 1).

Fish abundance was higher in R2 (2,047 individuals) than in R1 (1,615 individuals). *Astyanax fasciatus* (Cuvier), *Bryconamericus stramineus* Eigenmann (*sensu* Eigenmann 1908), and *Planaltina britskii* Menezes, Weitzman & Burns were the most abundant species in the R1 ("Cachoeira de São Roberto"), while *Hyphessobrycon eques* (Steindachner), *Serrapinnus notomelas* (Eigenmann), and '*Cheirodon*' *stenodon* Eigenmann were the most abundant ones in the R2.

Twenty-two species were common to both reaches (Table 1). However, each reach showed unique species: R1 presented 13 species found only in this reach and among these species, *Hypostomus* cf. *iheringii* (Regan) and *H. nigromaculatus* (Schubart) were the most abundant ones, with 58 and 47 individuals, respectively. In R2, 18 species were exclusive, where *Hyphessobrycon eques* was the most abundant (1,561 individuals), followed by *Eigenmannia guairaca* Peixoto, Dutra & Wosiacki, with 15 individuals. Twelve species were represented by only one individual (Table 1). *Aphyocheirodon hemigrammus* Eigenmann and *Myleus tiete* (Eigenmann & Norris), both recorded in R2, are categorized as threatened species for Brazil and São Paulo State (Agostinho et al. 2003, Oyakawa et al. 2009, ICMBio 2015).

The estimated richness of the sampled reaches was 65 species (±8). This result was supported by the species accumulation curve, which was increasing without reaching an asymptote (Figure 5).

In addition to the current sampled ichthyofauna (53 species), 16 additional species were added to this inventory by the historical records in the lower Preto River basin (downstream of spillway in municipality of the São José do Rio Preto, SP) (Figure 6). The origin of ichthyofauna in the lower Preto River was predominantly by native species (88.4%) with eight non-native

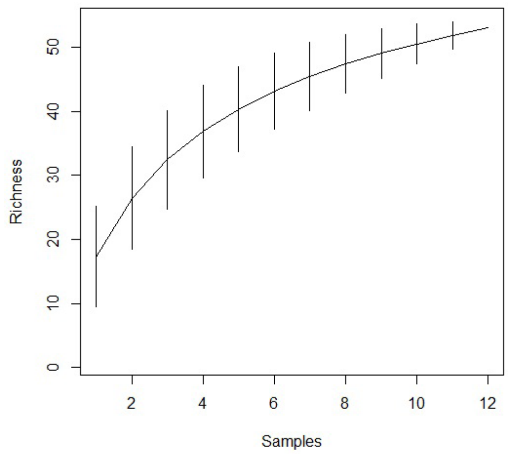

Figure 5. Species accumulation curve based on sampling efforts in the two reaches.

species [*Coptodon rendalli*, *Erythrinus erythrinus* (Bloch & Schneider), *Laetacara araguaiae* Ottoni & Costa, *Megaleporinus macrocephalus (Garavello & Britski)*, *Metynnis lippincottianus* (Cope), *Oreochromis niloticus, Poecilia reticulata* Peters and *Triportheus nematurus* (Kner)]. According to Ota (2013), it is not possible to affirm that *Satanoperca* sp. is a native or introduced species in the upper Paraná River basin. Only four species could not be identified at the species level because they probably are species not described: *Characidium* sp. (cf. Silveira, 2008), *Odontostilbe* sp. (cf. Bührnheim, 2006), *Satanoperca* sp. (cf. Ota, 2013), and *Serrapinnus* sp. (F. Jerep, *pers. comm.*).

Discussion

Higher abundance of Characiformes and Siluriformes in the lower Preto River basin, upper Paraná River basin was already expected, since they are commonly found in the Neotropical region (Britski 1992, Lowe-McConnell 1999, Reis et al. 2003, 2016, Eschmeyer et al. 2016).

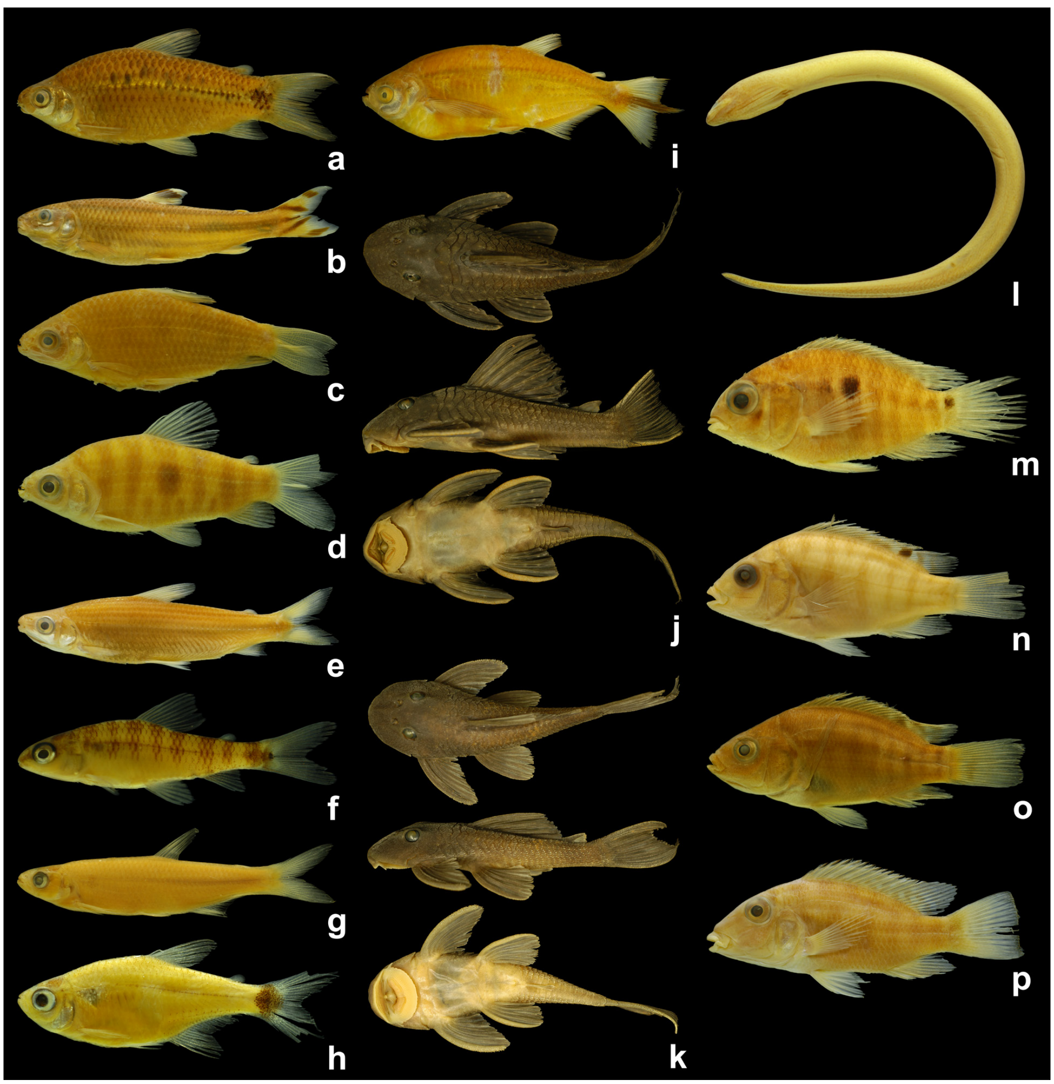

Figure 6. Additional fishes from the lower Preto River, catalogued at the fishes collection (DZSJRP). Characiformes: a) *Cyphocharax vanderi*, DZSJRP 4820, 73.4 mm SL; b) *Leporellus vittatus*, DZSJRP 3678, 159.0 mm SL; c) *Leporinus lacustris*, DZSJRP 8, 75.4 mm SL; d) *Leporinus paranensis*, DZSJRP 2197, 47.2 mm SL; e) *Schizodon altoparanae*, DZSJRP 2853, 93.7 mm SL; f) *Characidium* sp., DZSJRP 18356, 17.9 mm SL; g) *Aphyocharax dentatus*, DZSJRP 3751, 47.8 mm SL; h) *Serrapinnus* sp., DZSJRP 19244, 21.8 mm SL; i) *Triportheus nematurus*, DZSJRP 621, 117.9 mm SL. Siluriformes: j) *Hypostomus margaritifer*, DZSJRP 17721, 131.0 mm SL; k) *Hypostomus paulinus*, DZSJRP 17719, 59.1 mm SL. Synbranchiformes: l) *Synbranchus* cf. *marmoratus*, DZSJRP 1705, 129.0 mm SL. Perciformes: m) *Cichlasoma paranaense*, DZSJRP 1747, 27.5 mm SL; n) *Coptodon rendalli*, DZSJRP 2011, 25.3 mm SL; o) *Oreochromis niloticus*, DZSJRP 18370, 28.9 mm SL; p) *Satanoperca* sp., DZSJRP 18384, 38.0 mm SL.

The richness recorded in the sampled area (53 species) was similar to others studies performed in the Northwest of São Paulo State (Garutti 1988, Casatti et al. 2009, Ferreira & Casatti 2012), although these studies had been performed in streams using different methodologies. In addition to the 53 sampled species, 16 species were regained from historical records, comprising a total of 69 species to the lower Preto River. These data are, probably, underestimated, due to the fact they are the first ones for the area.

The higher abundance of *Astyanax fasciatus*, *Bryconamericus stramineus*, and *Planaltina britskii* in R1 than in R2 is, probably, because these species are drift feeders (Casatti & Castro 1998) that can obtain the maximum food intake at sites with an uninterrupted and lotic water flow. Nonetheless, Parodontidae and *Hypostomus* spp. were also more abundant in this reach. These species have low body depth, ventral mouth, and pectoral fins used to deflect high water flow and cling to the rocky substrate (Garavello & Garavello 2004), the predominant substrate type in riffle areas like R1. In R2, where grasses were present in the river bank, the highest abundance was assigned to *H. eques* and *S. notomelas*. The presence of grass in the river bank can provide an increase of food resources availability, such as aquatic insects, often associated with marginal grasses (Ceneviva-Bastos & Casatti 2014, Zeni & Casatti 2014). Moreover, this condition can be important to the establishment and growth of *Aphyocheirodon hemigrammus* and *Myleus tiete*, threatened species in Brazil, since grasses leaves and roots can be used as refuges from predators, acting as a nursery for large-bodied species (Araújo & Garutti 2003). In fact, the juvenile specimen of *Myleus tiete* (23.8 mm SL) recorded in this study was sampled in R2. According to Zeni et al. (2015), juvenile specimens from others species [*Acestrorhynchus lacustris* (Lütken), *Erythrinus erythrinus*, *Galeocharax gulo* (Cope), *Hoplias* cf. *malabaricus* (Bloch), and *Pterygoplichthys ambrosettii* (Holmberg)] were found associated to this area during reproductive period.

Myleus tiete is a migratory fish and, currently, considered as an endangered species (EN) (ICMBio 2015), since few and small populations are geographically fragmented and isolated, specially due to the numerous dam-buildings in the drainages of upper Paraná River basin. Modification of lotic to lentic system can jeopardize this migratory species by preventing the life cycle to be completed, since some stages can occur only in lotic environments. Furthermore, the suppression of riparian vegetation mainly caused by agriculture practices can directly affect *M. tiete* feeding habits as well as *A. hemigrammus*. *Aphyocheirodon hemigrammus* occurs, preferentially, in lentic and floodplain environments and it has been considered vulnerable to extinction (VU) (ICMBio 2015), mainly due meso- and microhabitat homogenization associated to siltation, which has been decreasing this species' population. Although both species can be found in different habitats (lotic and lentic environment), in the lower Preto River they were found only in the lentic reach (R2). As a conclusion, this type of environment can be important to the occurrence of lentic-adapted species, as *A. hemigrammus*, and juvenile of rheophilic species, as *M. tiete*.

Large rheophilic fishes previously reported from the "Cachoeira de São Roberto", such as *Megaleporinus obtusidens* (Valenciennes) ('piapara'), *Brycon* sp. ('piracanjuba'), and *Salminus brasiliensis* (Cuvier) ('dourado') (Borges 2007) were not found during more than one year of sampling. The absence of these species, even juvenile specimens, may be due to the failure in the sampled methods used in this study or result of the human impacts on the Preto River. Land use changes, removal of riparian vegetation, physical habitat homogenization due to the invasion of grass from pastures, organic pollution, and more recently, dam-building in the urban sections of the river, and the presence of non-native species can affect the occurrence of large rheophilic species (Agostinho et al. 2005). Besides these species, local fishermen have recognized *Prochilodus lineatus* (Valenciennes) ('corimba') and *Salminus hilarii* Valenciennes ('tabarana') in the area, but not recorded in this study.

Among the species found in the lower Preto River basin, most of them were common for the "Unidade de Gerenciamento de Recursos Hídricos (UGRH) da bacia do Turvo-Grande" (cf. Garutti 1988, Lemes & Garutti 2002, Andrade 2003, Casatti et al. 2009, Rocha et al. 2009), with exception of *Aphyocheirodon hemigrammus* and *Myleus tiete*. Besides the threatened species, four undescribed species were recorded (*Characidium* sp., *Odontostilbe* sp., *Satanoperca* sp. and *Serrapinnus* sp.). This condition enhances the high diversity of the upper Paraná River basin (Langeani et al. 2007; Carvalho & Langeani 2013) and reinforces the importance of the Preto River basin to shelter new and endangered species.

The occurrence of fishes in the lower Preto River comprised 11.6% of non-native species introduced in the upper Paraná River from different vias (Langeani et al. 2007, Azevedo-Santos et al. 2015). Pisciculture and aquarism are probable the principal causes of fish introduction observed in the lower Preto River basin and in others Brazilian river basins (Alves et al. 2007, Vitule 2009; Azevedo-Santos et al. 2015). *Megaleporinus macrocephalus*, *Coptodon rendalli,* and *Oreochromis niloticus* were both introduced by pisciculture (Langeani et al. 2007), whereas *Laetacara araguaiae* was probably introduced via upper rio Araguaia basin (*pers. obs*.), and *Poecilia reticulata* could had been introduced by aquarism or mosquito control (Deacon et al. 2011). *Erythrinus erythrinus* was probable introduced by sport fishing, whereas *Triportheus nematurus* was probably distributed in the upper Paraná after the Itaipu dam construction (Langeani et al. 2007). *Metynnis lippincottianus* had probably been accidentally introduced in the upper Paraná River basin (Ota 2015).

In the historical records in the lower Preto River basin there are three non-native species (*Triportheus nematurus*, *Oreochromis niloticus*, and *Coptodon rendalli*), whereas two of them are Perciformes. Cichlidae was one of the most diverse families in these records and maybe this was caused by their association with lentic environment, since the sampling site of these records was marginal lagoons of the Preto River, near the District of Macaúbas, municipality of Mirassolândia, SP. Perciformes has showed high occurrence in the upper Paraná River basin through natural (Langeani et al. 2007) and artificial environments, as the dam in the upper portion of the Preto River, in São José do Rio Preto, SP (Andrade 2003).

Dam-building could have affected lower Preto River if the SHPs projects in Turvo River had been approved. Physical homogenization caused by dam-building and the introduction of non-native species are synergistic processes responsible for biotic homogenization of communities (Rahel 2002). Fortunately, these projects were denied by the "Companhia Ambiental do Estado de São Paulo" (CETESB), as long as the alterations caused by them are environmentally impracticable by jeopardizing hydrological flow and leading to the suppression of more than 60% of the remaining forest fragments. The final decision of CETESB (2012) concluded that "Cachoeira de São Roberto" is situated in the future reservoir area, being affected by changes in water dynamic of the Preto River. In fact, dam-building change lotic into lentic environment and this can affect species with specific adaptations to survive in high flow environments and not only decreasing native species richness (Agostinho et al. 2007, Agostinho et al. 2008, Winemiller et al. 2016), but also increasing the abundance of non-native species (Hoeinghaus et al. 2009). Thus, the suppression of "Cachoeira de São Roberto" would affect the occurrence and abundance of several native species, such as *Hypostomus* spp., Parodontidae, and rheophilic species, as *Myleus tiete*, that could not resist to habitat alterations, besides increase the occurrence of non-native species, such *O. niloticus* and *C. rendalli*. In this context, ichthyofaunistic inventory is important not only to know fish richness, which can include new and threatened species, but also to guide and/or support management and conservation of aquatic systems, mainly in those areas target by dam-building.

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References

AGOSTINHO, A.A., GOMES, L.C., SUZUKI, H.I. & JULIO JUNIOR, H.F. 2003. Migratory Fishes of the Upper Paraná River Basin, Brazil. In Migratory fishes of South America: biology, fisheries and conservation status (J. Carolsfeld, B. Harvey, C. Ross & A. Baer, eds.). The International Bank for Reconstruction and Development/The World Bank, Washington, p. 19-98.

AGOSTINHO, A.A., THOMAZ, S.M. & GOMES, L.C. 2005. Conservação da biodiversidade em águas continentais do Brasil. Megadiversidade 1(1): 70-78.

AGOSTINHO, A.A., GOMES, L.C. & PELICICE, F.M. 2007. Ecologia e manejo de recursos pesqueiros em reservatórios do Brasil. Maringá, PR, Eduem, 501p.

AGOSTINHO, A.A., PELICICE, F.M. & GOMES, L.C. 2008. Dams and the fish fauna of the Neotropical region: impacts and management related to diversity and fisheries. Braz. J. Biol. 68(4): 1119-1132.

ALVES, C.B.M., VIEIRA, F., MAGALHÃES, A.L.B. & BRITO, M.F.G. 2007. Impacts of non- native fish species in Minas Gerais, Brazil: present situation and propects. In Ecological and Genetic Implications of Aquaculture Activities (T.M. Bert, ed.). Springer, Dordrecht, Zuid-Holland, Netherland, p. 291-314.

ANDRADE, V.X.L. de. 2003. Ictiofauna da Represa Municipal de São José do Rio Preto, SP, rio Preto, afluente do rio Turvo, drenagem do rio Grande: Diversidade e Reprodução. Dissertação de Mestrado, Universidade Estadual Paulista "Júlio de Mesquita Filho", Jaboticabal.

ARAÚJO, R.B. & GARUTTI, V. 2003. Ecology of a stream from upper Paraná River basin inhabited by *Aspidoras fuscoguttatus* Nijssen & Isbruücker, 1976 (Siluriformes, Callichthyidae). Braz. J. Biol. 63(3): 363-372.

AZEVEDO-SANTOS, V.M., PELICICE, F.M., LIMA-JUNIOR, D.P., MAGALHÃES, A.L.B., ORSI, M.L., VITULE, J.R.S. & AGOSTINHO, A.A. 2015. How to avoid fish introductions in Brazil: education and information as alternatives. Nat. Conservação 13: 123-132.

BORGES, M.A. 2007. João Borges: Terras, Gentes e o Desbravamento do Noroeste Paulista. São José do Rio Preto, SP, Inteligência Ativa Editora, 270p.

BRITSKI, H.A. 1992. Conhecimento atual das relações filogenéticas de peixes neotropicais. In Situação atual e perspectivas da ictiologia no Brasil (A.A. Agostinho & E. Benedito-Cecílio, eds.). Documentos do IX Encontro Brasileiro de Ictiologia, Editora da Universidade Estadual de Maringá, Maringá, p. 43-57.

BÜHRNHEIM, C.M. 2006. Sistemática de *Odontostilbe* Cope. 1870 com a proposição de uma nova tribo Odontostilbini e redefinição dos gêneros *incertae sedis* de Cheirodontinae (Ostariophysi: Characiformes: Characidae). Tese de Doutorado, Pontifícia Universidade Católica do Rio Grande do Sul, Porto Alegre, RS.

CALCAGNOTTO, D., SCHAEFER, S.A. & DESALLE, R. 2005. Relationships among characiform fishes inferred from analysis of nuclear and mitochondrial gene sequences. Mol. Phylogenet. Evol. 36(2005): 135-153.

CASATTI, L. & CASTRO, R.M.C. 1998. A fish community of the São Francisco River headwaters riffles, southeastern Brazil. Ichthyol. Explor. Freshw. 9(3): 229-242.

CASATTI, L., FERREIRA, C.P. & CARVALHO, F.R. 2009. Grass-dominated stream sites exhibit low fish species diversity and guppies dominance: an assessment on two tropical pasture river basins. Hydrobiologia 632: 273-283.

CENEVIVA-BASTOS, M. & CASATTI, L. 2014. Shading effects on community composition and food web structure of a deforested pasture stream: Evidences from a field experiment in Brazil. Limnologica 46(1): 9-21.

CETESB. Companhia Ambiental do Estado de São Paulo. 2012. Parecer técnico nº 024/12/IE http://www.cetesb.sp.gov.br/noticia/382,Noticia (Access 02 Jul 2014).

COMITETG. Comitê da Bacia Hidrográfica do Turvo/Grande. 2009. Plano ambiental para a bacia de contribuição da represa de abastecimento de São José do Rio Preto.

DEACON, A.E., RAMNARINE, I.W. & MAGURRAN, A.E. 2011. How reproductive ecology contributes to the spread of a globally invasive fish. Plos One 6(9): 1-8.

EIGENMANN, C.H. 1908. Preliminary descriptions of new genera and species of tetragonopterid characins (Zoölogical Results of the Thayer Brazilian expedition.). Bulletin of the Museum of Comparative Zoology 52(6): 91-106.

ESCHMEYER, W. N., FRICKE, R. & VAN DER LAAN, R. (eds.). 2016. Catalog of Fishes: Genera, Species, References. http://researcharchive.calacademy.org/research/ichthyology/catalog/fishcatmain.asp (Access 05 Apr 2016).

FERREIRA, C.P. & CASATTI, L. 2012. Ictiofauna associada a fragmentos florestais da região noroeste do estado de São Paulo. In Fauna e flora de fragmentos florestais remanescentes da região noroeste do estado de São Paulo (O. Necchi Júnior, ed.). Holos Editora, Ribeirão Preto, p. 197-210.

GARAVELLO, J.C. & GARAVELLO, J.P. 2004. Spatial distribution and interaction of four species of the catfish genus *Hypostomus* Lacépède with bottom of Rio São Francisco, Canindé do São Francisco, Sergipe, Brazil (Pisces, Loricariidae, Hypostominae). Braz. J. Biol. 64(3): 591-598.

GARUTTI, V. 1988. Distribuição longitudinal da ictiofauna em um córrego da região noroeste do Estado de São Paulo, bacia do rio Paraná. Braz. J. Biol., Rio de Janeiro, 48(4): 747-759.

HABTEC ENGENHARIA AMBIENTAL LTDA. 2010. RIMA - Relatório de impacto ambiental. Pequenas Centrais Hidrelétricas de Talhado e Foz do Preto. Departamento de Avaliação Ambiental de Empreendimentos - IE.

HOEINGHAUS, D.J., AGOSTINHO, A.A., GOMES, L.C., PELICICE, F.M., OKADA, E.K., LATINI, J.D., KASHIWAQUI, E.A.L. & WINEMILLER, K.O. 2009. Effects of river impoundment on ecosystem services of large tropical rivers: embodied energy and market value of artisanal fisheries. Conserv. Biol. 23(5): 1222-1231.

ICMBio. Instituto Chico Mendes de Conservação da Biodiversidade. 2015. Lista de espécies ameaçadas. http://www.icmbio.gov.br/portal/biodiversidade/fauna-brasileira/lista-de-especies.html?option=com_icmbio_fauna_brasileira&task=listaEspecie (Access 25 Mar 2015). 709-718.

JULIO JUNIOR, H.F., TOS, C.D., AGOSTINHO, A.A. & PAVANELLI, C.S. 2009. A massive invasion of fish species after eliminating a natural barrier in the upper rio Paraná basin. Neotrop. Ichthyol. 7(4): 709-718.

LANGEANI, F., CASTRO, R.M.C., OYAKAWA, O.T., SHIBATTA, O.A., PAVANELLI, C.S. & CASATTI, L. 2007. Diversidade da ictiofauna do Alto rio Paraná: composição atual e perspectivas futuras. Biota Neotrop. 7(3): 181-197 http://www.biotaneotropica.org.br/v7n3/pt/abstract?article+bn03407032007 (Access 12 Jun 2014).

LEMES, E.M. & GARUTTI, V. 2002. Ecologia da ictiofauna de um córrego de cabeceira da bacia do alto rio Paraná, Brasil. Iheringia, Ser. Zool. 92(3): 69-78.

LOWE-MCCONNELL, R.H. 1999. Estudos ecológicos de comunidades de peixes tropicais. Editora da Universidade de São Paulo, São Paulo, Brasil.

NALON, M.A., MATTOS, I.F.A. & FRANCO, G.A.D.C. 2008. Meio físico e aspectos da fragmentação da vegetação. In Diretrizes para a restauração da biodiversidade no Estado de São Paulo (R.R. Rodrigues & V.L.R. Bononi, orgs.). Instituto de Botânica, Imprensa Oficial, São Paulo, p. 14-21.

OTA, R.R. 2013. Revisão taxonômica de *Satanoperca* Günther, 1862 (Perciformes, Cichlidae), com a descrição de três espécies novas. Dissertação de Mestrado, Universidade Estadual de Maringá, Maringá, PR.

OTA, R.P. 2015. Revisão taxonômica e filogenia morfológica de *Metynnis* Cope, 1878 (Characiformes: Serrasalmidae). Tese de Doutorado, Instituto Nacional de Pesquisas da Amazônia, Manaus, AM.

OYAKAWA, O.T., MENEZES, N.A., SHIBATTA, O. A., LIMA, F.C.T., LANGEANI, F., PAVANELLI, C.S., NIELSEN, D.T.B. & HILSDORF, A.W.S. 2009. Peixes de água doce. In Fauna ameaçada de extinção no Estado de São Paulo: Vertebrados (P.M. Bressan, M.C.M. Kierulff & A.M. - Sugieda, eds.). Fundação Parque Zoológico de São Paulo, Secretaria do Meio Ambiente, São Paulo, p. 350-424.

PMPONTESGESTAL. http://www.pontesgestal.sp.gov.br/a-cidade/historia.html (Access 09 Nov 2015).

RAHEL, F.J. 2002. Homogenization of freshwater faunas. Ann. Rev. Ecol. Syst. 33(1): 291-315.

REIS, R.E., KULLANDER, S.O. & FERRARIS-JR, C.J. 2003. Check list of the freshwater fishes of South and Central America. Porto Alegre, Editora PUCRS, 729p.

REIS, R.E., ALBERT, J.S., DI DARIO, F., MINCARONE, M.M., PETRY, P. & ROCHA, L.A. 2016. Fish biodiversity and conservation in South America. J. Fish. Biol. 89(1): 12-47.

ROCHA, F.C., CASATTI, L., CARVALHO, F.R. & SILVA, A.M. 2009. Fish assemblages in stream stretches occupied by cattail (Typhaceae, Angiospermae) stands in Southeast Brazil. Neotrop. Ichthyol. 7(2): 241-250.

SILVEIRA, L.G.G. 2008. Revisão taxonômica de *Characidium lagosantense* Travassos, 1947 (Crenuchidae: Characiformes: Ostariophysi), com descrição de uma nova espécie para o alto rio Paraná. Dissertação de Mestrado, Universidade Estadual Paulista "Júlio de Mesquita Filho", São José do Rio Preto, SP.

VITULE, J.R.S. 2009. Introdução de peixes em ecossistemas continentais brasileiros: revisão, comentários e sugestões de ações contra o inimigo quase invisível. Neotrop. Biol. Conserv. 4(2): 111-122.

WINEMILLER, K.O., MCINTYRE, P.B., CASTELLO, L., FLUET-CHOUINARD, E., GIARRIZZO, T., NAM, S., BAIRD, I.G., DARWALL, W., LUJAN, N.K., HARRISON, I., STIASSNY, M.L.J., SILVANO, R.A.M., FITZGERALD, D.B., PELICICE, F.M., AGOSTINHO, A.A., GOMES, L.C., ALBERT, J.S., BARAN, E., PETRERE Jr., M., ZARFL, C., MULLIGAN, M., SULLIVAN, J.P., ARANTES, C.C., SOUSA, L.M., KONING, A.A., HOEINGHAUS, D.J., SABAJ, M., LUNDBERG, J.G., ARMBRUSTER, J., THIEME, M.L., PETRY, P., ZUANON, J., TORRENTE-VILARA, G., SNOEKS, J., OU, C., RAINBOTH, W., PAVANELLI, C.S., AKAMA, A., van SOESBERGEN, A. & SÁENZ, L. 2016. Balancing hydropower and biodiversity in the Amazon, Congo and Mekong. Science 351(6269): 128-129.

ZENI, J.O. & CASATTI, L. 2014. The influence of habitat homogenization on the trophic structure of fish fauna in tropical streams. Hydrobiologia 726(1): 259-270.

ZENI, J.O., SANTOS, A.C. & CARVALHO, F.R. 2015. Contribution of different mesohabitats to the maintenance of fish richness and diversity in the lower Preto River. Acta Sci. Biol. Sci. 37(3): 301-308.

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