Biota Neotropica 16(3): e20150145, 2016
www.scielo.br/bn

biotaneotropica
ISSN 1676-0611 (online edition)
inventory

Headwater stream fish fauna from the Upper Paranapanema River basin

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CETRA M., MATTOX, G.M.T., FERREIRA, F.C., GUINATO, R.B., SILVA, F.V., PEDROSA, M. **Headwater stream fish fauna from the Upper Paranapanema River basin**. Biota Neotropica. 16(3): e20150145. http://dx.doi.org/10.1590/1676-0611-BN-2015-0145

Abstract: The Paraná River basin has about 600 fish species. In the Upper Paraná, 310 fish species were recorded, with 52 species were registered in the streams and headwaters of the Paranapanema River. The aim of this study was to characterize the stream fish communities in the Upper Paranapanema River basin. Samplings were conducted with electrofishing during the dry season in the year of 2014. The collection effort consisted of 30 streams stretches. As a result, 41 species of stream fish were recorded in the Upper Paranapanema River basin, distributed in 26 genera, 11 families and 7 orders. Thirty-nine percent of the species can be considered rare, 41% intermediate and 20% common. We captured approximately eight species by stream stretch and the estimated richness (Schao2) was 40 ± 6 species. Around 40% of the individuals had less than 50 mm in length.
Keywords: *fish communities, estimated richness, rare species.*

CETRA M., MATTOX, G.M.T., FERREIRA, F.C., GUINATO, R.B., SILVA, F.V., PEDROSA, M. **Ictiofauna de riachos das cabeceiras da bacia hidrográfica do Alto Paranapanema**. Biota Neotropica. 16(3): e20150145. http://dx.doi.org/10.1590/1676-0611-BN-2015-0145

Resumo: A bacia hidrográfica do Rio Paraná possui cerca de 600 espécies de peixes. No Alto Rio Paraná, 310 espécies de peixes foram registradas com 52 espécies registradas em riachos do Rio Paranapanema. O objetivo deste estudo foi caracterizar a comunidade de peixes de riachos da bacia do Alto Rio Paranapanema. O levantamento das espécies foi realizado com uso de pesca elétrica durante a estação seca de 2014. As coletas ocorreram em 30 trechos de riachos. Foram capturas 41 espécies distribuídas em 26 gêneros, 11 famílias e 7 ordens. Trinta e nove por cento das espécies podem ser consideradas raras, 41% intermediárias e 20% comuns. Foram capturadas cerca de 8 espécies por trecho de riacho e a riqueza estimada (Schao2) foi 40 ± 6 espécies. Cerca de 40% dos indivíduos possuem comprimento menor que 50 mm.
Palavras-chave: *comunidades de peixes, riqueza estimada, espécies raras.*

Introduction

The Paraná River basin is the second largest in area in the Neotropical region (Agostinho & Júlio Jr. 1999), with about 2.6 million km^2. Older estimates suggest that this basin has nearly 600 fish species (Bonetto 1986). Recently, 310 fish species were recorded in the Upper Paraná (Langeani et al. 2007), which comprises approximately 900,000 km^2 and the portion of this basin in São Paulo State includes 260 species along the Paraná River and its main tributaries, Paranapanema, Tietê and Grande (Oyakawa & Menezes 2011). About 65% of these species were small sized (less than 21 cm), and occurred in streams and headwaters (Langeani et al. 2007). Recent inventories documented a high diversity fish fauna for the Upper Paraná (Casatti et al. 2001, Castro & Casatti 1997, Castro et al. 2003, 2004, 2005, Langeani et al. 2005a b, Fagundes et al. 2015).

As recommended by Casatti et al. (2008), this study intended to perform the following actions:

(i) survey the fish populations in the Upper Paranapanema River basin, which currently presents a knowledge gap;

(ii) study the fish community from streams and headwaters that are especially interesting for sharing species with neighboring basins;

(iii) provide information on the fish populations that can be used in the monitoring of riparian forests restoration projects.

This study aimed to characterize the stream fish communities in the Upper Paranapanema River and supplement the species lists of Castro et al. (2003).

Material and Methods

1. Study area

The Upper Paranapanema River basin is located in the Unidade de Gerenciamento dos Recursos Hídricos [Water Resources Management Unit] (UGRHI 14). This unit presents agriculture activity and population density around 30 inhabitants/km^2. About 15% of the area is covered by native vegetation, and the headwaters are covered by reforested area (*Eucaliptus* spp.) and native forests (CETEC 1999). The headwater streams are in the Serra de Paranapiacaba, at about 1100 m altitude, and are tributaries of the Paranapanema River, which, after running along 500 km, will flow into the Paraná River.

2. Fish Sampling

Fish sampling was conducted from June to November 2014 as the associations between fish assemblage and environmental structure are better described in the dry season (Pinto et al. 2006). Furthermore, it is important to control the effect of sources of temporal variation.

The ichthyofauna sampling was performed with electrofishing between 10h and 16h (License SISBIO 13352-1/IBAMA/MMA). We collected the fish fauna in 30 streams stretches with 70 m. These streams are located in 13 watersheds in the municipalities of Piedade, Pilar do Sul, São Miguel Arcanjo, Capão Bonito, Ribeirão Grande, Guapiara, Apiaí, Ribeirão Branco, Itapeva, Itaberá, Itararé and Sengés (Figure 1, Table 1), covering stretches of 1st to 6th orders (Hydrology ArcGIS software tool).

The wadeable stream stretches have at least one sequence of riffle-run-pool meso-habitats. The organisms collected were fixed for 48h in 4% formalin and then transferred to 70% alcohol. Vouchers of the species collected were deposited in the collection of Laboratório de Ictiologia of the Departamento de Zoologia e Botânica da UNESP - São José do Rio Preto (DZSJRP 20.268 - 20.663) and of Laboratório de Ictiologia de Ribeirão Preto - FFCLRP/USP (LIRP 11826). The specimens were identified according to Castro et al. (2003), Castro & Vari (2004), Vari & Castro (2007), Lucinda (2008), Zawadzki et al. (2008), Lippert et al. (2014) and with the assistance of specialists in some groups.

Results and Discussion

We captured about 7 kg of fish: 1878 individuals, 41 species, 26 genera, 11 families and 7 orders (Table 2). Following the criteria of Teshima et al. (2015), 16 species (39%) can be considered rare, 17 species (41%) are intermediate and 7 species (20%) are common. On average, we captured approximately 8 species by stream stretch and the estimated richness (Schao2) was 40 ± 6 species. Around 40% of individuals had less than 50 mm in length.

The orders Siluriformes and Characiformes represented the majority of the species richness, 44% and 37% respectively, reflecting a well-known pattern recognized for South American rivers (Lowe-McConnell 1999). Twelve species are not on the list of species that occur in the Upper Paraná (Langeani et al. 2007), and 18 are not in the list by Castro et al. (2003) that collected fish in streams of the Paranapanema basin.

Some species have been listed with different names as presented in Castro et al. (2003) and Langeani et al. (2007) (Table 2, with asterisk). This happened because some species that had been recognized as distinct morphotypes were later formally described. This is the case of *Astyanax* sp1 and *Astyanax* sp2 (Castro et al. 2003), later described as *A. bockmanni* and *A. biotae* (Castro & Vari 2004, Vari & Castro 2007). A *Bryconamericus* morphotype with humeral spot was identified only at the genus level (Castro et al. 2003). Langeani et al. (2007) identified a morphotype of *Bryconamericus* with humeral spot as *B. iheringii*, highlightening that this could probably represent a new species. Also, these previous lists included *Phalloceros caudimaculatus* as a single species, but we found herein both species currently recognized in the genus for the Paranapanema basin (see below).

The São Paulo State fish fauna is relatively well known (Langeani et al. 2007, Oyakawa & Menezes 2011). However, there are still many taxa to be better studied and that probably represent new species. It is known, for instance, that *Astyanax scabripinnis* represents a group of species, some of which still undescribed, and further detailed analysis based on larger and more complete sample series may result in the description new species (e.g., Moreira-Filho & Bertollo 1991, Bertaco & Malabarba 2001, Bertaco & Lucena 2006, Fagundes et al. 2015).

Neoplecostomus selenae, *Phalloceros reisi* and *P. harpagos* were described in 2008 but were already cited as new species under description by Langeani et al. (2007). *Otothyropsis biamnicus* was recently described (Calegari et al. 2013) and included in a recent species list of the Upper Paraná (Fagundes et al. 2015).

 http://dx.doi.org/10.1590/1676-0611-BN-2015-0145

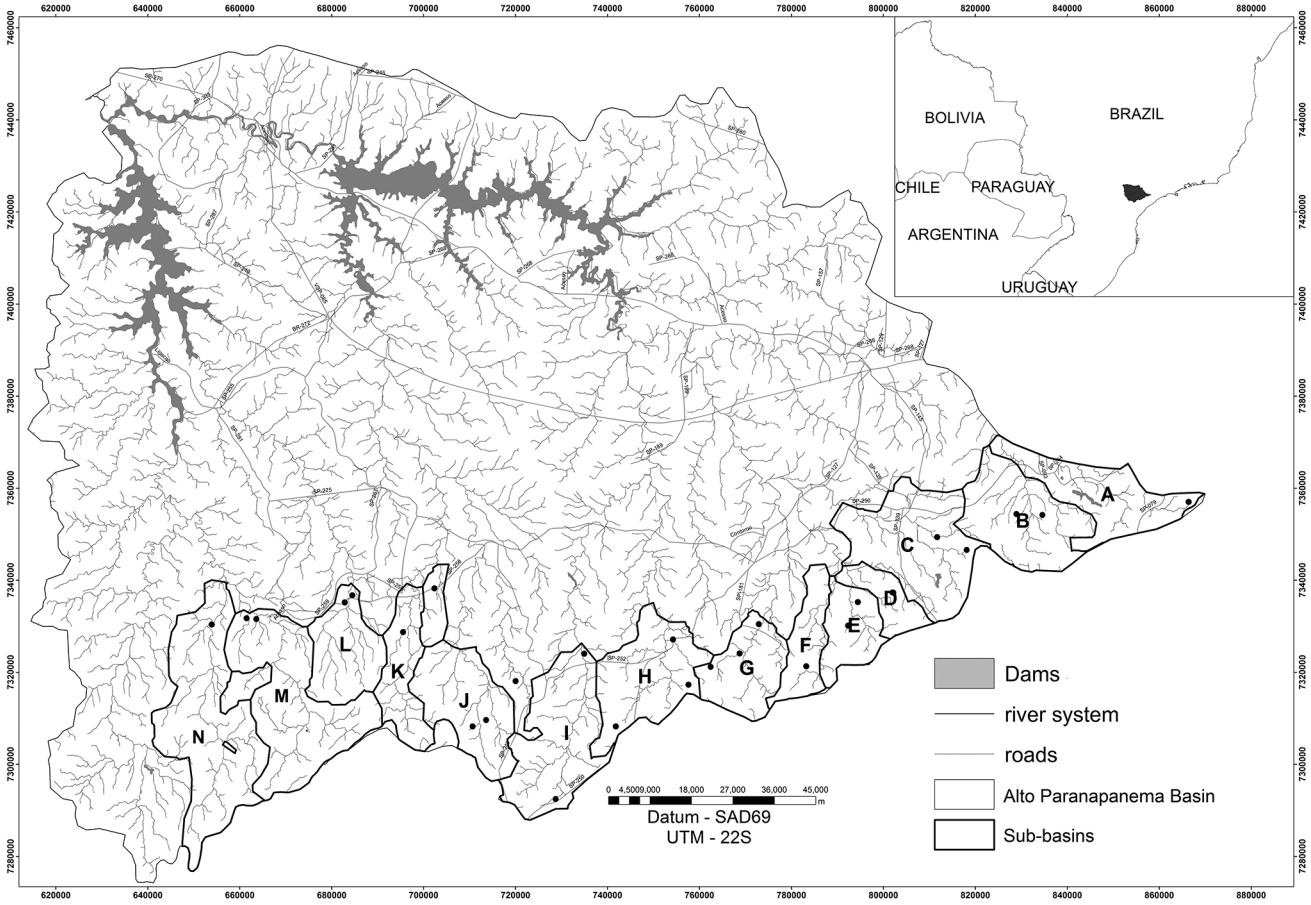

Figure 1. Sub-basins and stretch streams sampled: A (Turvo), B (Pinhal), C (Guarapú), D (Taquaral), E (Guapiara), F (Paranapanema), G (Almas), H (Apiaí-Mirim), I (Apiaí-Guaçu), J (Taquari-Guaçu), K (Pirituba), L (Verde), M (Itararé), N (Jaguaricatu).

Table 1. Geographical information of the stretch streams sampled.

Stretch	Stream	Sub-basin	Zone	X	Y	Municipality
P03	Turvo	Turvo	23	253797	7358842	Piedade
P17	Clarinho	Pinhal	23	223828	7355389	Pilar do Sul
P19	Pinhal	Pinhal	23	217944	7355372	Pilar do Sul
P23	Guarapu	Guarapu	23	207407	7347068	São Miguel Arcanjo
P24	Lageado	Guarapu	23	203595	7342984	São Miguel Arcanjo
APP01	Taquaral	Taquaral	22	802182	7337329	Capão Bonito
APP05	Grande	Taquaral	22	802002	7337026	Capão Bonito
APP04	Cristal	Guapiara	22	795363	7335461	Capão Bonito
APP25	Guapiara	Guapiara	22	790520	7330282	Capão Bonito
APP24	Guapiara tributary	Guapiara	22	790430	7330199	Capão Bonito
APP02	Panema	Paranapanema	22	783224	7321220	Capão Bonito
APP23	Conchas	Paranapanema	22	775540	7323894	Capão Bonito
APP03	Almas	Almas	22	768502	7324070	Ribeirão Grande
APP12	Bateia	Almas	22	762266	7321196	Ribeirão Grande
APP22	Pinheiros	Apiaí-Mirim	22	757668	7317396	Guapiara
APP13	Alegre	Apiaí-Mirim	22	754209	7327285	Guapiara
APP11	São José do Guapiara	Apiaí-Mirim	22	741811	7308275	Guapiara

Continued Table 1.

APP21	Afluente Apiaí Guaçu	Apiaí-Guaçu	22	734904	7324251	Ribeirão Branco
APP10	Apiai-Guaçu	Apiaí-Guaçu	22	728684	7292451	Apiaí
APP14	Taquari-Mirim	Taquari-Guaçu	22	720031	7318116	Ribeirão Branco
APP19	Afluente Taquari1	Taquari-Guaçu	22	713707	7309647	Ribeirão Branco
APP20	Afluente Taquari2	Taquari-Guaçu	22	710646	7308221	Ribeirão Branco
APP06	Papagaio	Pirituba	22	695536	7328740	Itapeva
APP18	Afluente Pirituba	Pirituba	22	702365	7338237	Itapeva
APP15	Da Gurita	Verde	22	684567	7336707	Itaberá
APP08	Verde	Verde	22	682849	7335189	Itararé
APP07	Afluente Verde	Verde	22	682786	7335250	Itararé
APP09	Funil	Itararé	22	663580	7331572	Sengés
APP16	Pelame	Itararé	22	661498	7331784	Sengés
APP17	Afluente Jaguaricatu	Jaguaricatu	22	653926	7330379	Sengés

Table 2. Species sampled in the headwater streams from Upper Paranapanema River basin with respective status. X: species listed in Castro et al. (2003) and/or Langeani et al. (2007). Asterisk indicates species listed with a different name in previous papers.

	Status	**Castro et al. (2003)**	**Langeani et al. (2007)**
Cypriniformes			
Cobitidae			
Misgurnus anguillicaudatus (Cantor, 1842)	rare	-	-
Characiformes			
Characidae			
Astyanax bockmanni Vari & Castro, 2007	common	X*	X*
Astyanax paranae Eigenmann, 1914	intermediate	-	X
Astyanax biotae Castro & Vari, 2004	rare	X*	X
Astyanax scabripinnis (Jenyns, 1842)	common	X	-
Bryconamericus stramineus Eigenmann, 1908	rare	X	X
Bryconamericus aff. *iheringii* (Boulenger, 1887)	rare	-	X
Hyphessobrycon anisitsi (Eigenmann, 1907)	rare	-	X
Oligosarcus paranensis Menezes & Géry, 1983	rare	X	X
Piabina argentea Reinhardt, 1867	intermediate	X	X
Crenuchidae			
Characidium gomesi Travassos, 1956	intermediate	X	X
Characidium schubarti Travassos, 1955	intermediate	-	X
Characidium aff. *zebra* Eigenmann, 1909	intermediate	X	X
Erythrinidae			
Hoplias malabaricus (Bloch, 1794)	intermediate	X	X
Parodontidae			
Apareiodon ibitiensis Campos, 1944	Rare	-	X
Parodon nasus Kner, 1859	Rare	-	X
Gymnotiformes			
Gymnotidae			
Gymnotus sylvius Albert & Fernandes-Matioli, 1999	Rare	X	X
Sternopygidae			
Eigenmannia virescens (Valenciennes, 1836)	Rare	X	X

 http://dx.doi.org/10.1590/1676-0611-BN-2015-0145

Continued Table 2.

Siluriformes			
Heptapteridae			
Cetopsorhamdia iheringi Schubart & Gomes, 1959	Intermediate	X	X
Imparfinis borodini Mees & Cala, 1989	intermediate	-	X
Imparfinis mirini Haseman, 1911	Common	X	X
Phenacorhamdia tenebrosa (Schubart, 1964)	Rare	X	X
Pimelodella avanhandavae Eigenmann, 1917	Common	-	X
Rhamdia quelen (Quoy & Gaimard, 1824)	intermediate	X	X
Loricariidae			
Hypostomus ancistroides (Ihering, 1911)	Common	X	X
Hypostomus nigromaculatus (Schubart, 1964)	intermediate	X	X
Hypostomus sp1	Rare	-	-
Hypostomus sp2	Intermediate	-	-
Neoplecostomus selenae Zawadzki, Pavanelli & Langeani, 2008	Common	-	-
Otothyropsis biamnicus Calegari, Lehmann & Reis, 2013	Rare	-	-
Otothyropsis sp.	Rare	-	-
Rineloricaria pentamaculata Langeani & Araújo, 1994	intermediate	X	X
Trichomycteridae			
Trichomycterus davisi (Haseman, 1911)	intermediate	-	-
Trichomycterus diabolus Bockmann, Casatti & de Pinna, 2004	Rare	-	X
Trichomycterus sp1	intermediate	-	-
Trichomycterus sp2	intermediate	-	-
Cyprinodontiformes			
Poecilidae			
Poecilia vivipara Bloch & Schneider, 1801	Rare	-	X
Phalloceros reisi Lucinda, 2008	Common	*	*
Phalloceros harpagos Lucinda, 2008	intermediate	*	*
Synbranchiformes			
Synbranchidae			
Synbranchus marmoratus Bloch, 1795	intermediate	X	X
Labriformes			
Cichlidae			
Geophagus brasiliensis (Quoy & Gaimard, 1824)	Common	X	X

The species mentioned above were described in the last 10 years, hence discovered in relative recent times. In addition, some taxa could not be identified to species level, probably because they represent new taxa awaiting description. As noted by Langeani et al. (2007), this may be the case of *Hypostomus* sp1, *Hypostomus* sp2, *Trichomycterus* sp1, *Trichomycterus* sp2 and *Othothyropsis* sp, which should contribute to the increase in the species richness from the Upper Paraná.

The exotic species *Misgurnus anguillicaudatus* had been registered in the Iguaçu River basin (Ingenito et al. 2004, Vitule 2009) and was recently captured in preserved streams in the Ribeira de Iguape River basin (Gomes et al. 2011, Cetra et al. 2012). We herein present the first record of this species in the Paranapanema River basin in the São Paulo State.

Among the 41 fish species sampled in the present study, we highlight *Neoplecostomus selenae*, a species listed as vulnerable on the list of endangered species in São Paulo State (Oyakawa et al. 2009). This species was included in that list because it was known solely from the type locality in Ribeirão das Bateias basin, Ribeirão Grande municipality (Zawadzki et al 2008). For the conservation of this species, Oyakawa et al. (2009) suggested habitat protection and scientific research to obtain data on its biology, and inventories to better access the distribution of this species. The results in the present study expanded the area of occurrence of *N. selenae* (Apiaí-Guaçu, Apiaí-Mirim, Guapiara, Itararé, Panema, Taquaral, Taquari-Guaçu and Verde sub-basins) yielding new specimens for further studies.

The present study complemented data on fish populations of the Upper Paraná River basin, specifically of the tributary streams of the Paranapanema River (e.g., Castro et al. 2003, Langeani et al. 2007), representing a considerable increase in the richness in the latter drainage, in addition to a few putative new species. Although the fish fauna of the Paraná River basin is relativelky well known (eg, Langeani et al. 2007, Oyakawa

& Menezes 2011), several areas of this drainage system still remain unexplored and represent gaps in the knowledge of this ichthyofauna.

Acknowledgements

The species identification had the valuable assistance of Bárbara Calegari, Fernanda Martins, Flávio Bockmann, Paulo Lucinda, Veronica Slobodian, who sent appropriate literature and/or examined specimens. This study was financed by FAPESP - Proc. No. 2013/24737-2.

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Received: 03/12/2015
Revised: 01/07/2016
Accepted: 22/07/2016