



## Ichthyofauna of lotic environments in the Ivinhema river basin, upper Paraná river, Mato Grosso do Sul state, Brazil

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**Abstract:** In order to inventory the species richness and fish fauna composition along the Ivinhema river basin, 232 stretches of rivers and streams were sampled from 2000 to 2018, using a rectangular sieve, trawls, gillnets, cast nets, and electrofishing. A total of 141 species was caught in the basin, including seven orders and 35 families. For the recorded species, 42 are from the upper Paraná river, 51 from lower Paraná river, 27 from other basins, two from other continents, and the origin for 19 species are unknown/not reported. Six species are registered for the first time in the upper Paraná river basin: *Astyanax abramis*, *Moenkhausia oligolepis*, *Serrapinnus kriegi*, *Curimatopsis myersi*, *Pyxiloricaria menezesi*, and *Cichlasoma dimerus*. This is the first complete survey of the ichthyofauna in lotic environments along the whole Ivinhema river basin, containing relevant information for comparing studies and serving as reference data that can contribute to the management and implementation of politics for conservation of the basin. This survey also increases 24 species on the list of the most complete inventory in the upper Paraná river published in 2007.

**Keywords:** Fish communities, freshwater, survey.

## Íctiofauna de ambientes lóticos na bacia do rio Ivinhema, alto rio Paraná, Mato Grosso do Sul, Brasil

**Resumo:** Com o objetivo de inventariar a riqueza de espécies e a composição da ictiofauna ao longo da bacia do rio Ivinhema, 232 trechos de rios e riachos foram amostrados de 2000 a 2018, utilizando uma peneira retangular, rede de arrasto, rede de espera, tarrafas e pesca elétrica. Ao todo 141 espécies foram amostradas na bacia, incluindo oito ordens e 35 famílias. Para as espécies registradas, 42 são do alto rio Paraná, 51 do baixo rio Paraná, 27 de outras bacias, duas de outros continentes e para 19 espécies as origens são desconhecidas ou não reportadas. Seis espécies são registradas pela primeira vez na bacia alto rio Paraná: *Astyanax abramis*, *Moenkhausia oligolepis*, *Serrapinnus kriegi*, *Curimatopsis myersi*, *Pyxiloricaria menezesi* e *Cichlasoma dimerus*. Este é o primeiro levantamento da ictiofauna em ambientes lóticos para toda a bacia do rio Ivinhema, contendo informação relevante para estudos comparativos e servindo como dados de referências que podem contribuir para gerenciamento e implementação de políticas para conservação da bacia. Este levantamento também acrescenta 24 espécies na lista do inventário mais completo realizado no alto rio Paraná publicado em 2007.

**Palavras-chave:** Comunidades de peixes, água doce, inventário.

## Introduction

The upper Paraná river basin, with 367 fish species, being 317 described and 50 not formally described (Langeani et al. 2007), is located entirely within the territory of Brazil and extends from the municipalities of Guaira and Mundo Novo, upstream to the ancient waterfall known as Sete Quedas, which is currently submerged by the Itaipu Reservoir, and encompasses 891,000 km<sup>2</sup> or 10.5% of the area of Brazil (Agostinho et al. 2003). This portion of the Paraná river basin is the most studied regarding Brazilian freshwater fish (Agostinho et al. 2007), but for some regions the knowledge is still insufficient. Most of those studies were performed in the Brazilian Southeast (Paraná and São Paulo states) and despite of increasing researches, there have been only a few studies in the Midwest Brazilian (region where upper Paraná is inserted, including Mato Grosso do Sul and Goiás states and Federal District) (Aquino et al. 2009).

In the particular case of the Ivinhema river basin, a tributary practically free of impoundments and located in the western portion of upper Paraná river basin, some studies have been conducted to determine the environmental features that influence fish species in some few headwater streams (Súarez et al. 2007, Súarez & Lima-Junior, 2009), that influence spacial and temporal variation of fish in streams of lower Ivinhema (Súarez 2008a) or the fish richness in streams of the whole Ivinhema basin (Súarez et al. 2011). Fish eggs and larvae distribution related to environmental factors were also studied in the upper Ivinhema and its river tributaries (Nascimento & Nakatani 2006) and fishfauna associated to macrophyte mats were described in the lower Ivinhema (Bulla et al. 2011). In the latter, in Súarez (2008b) and in Súarez & Lima-Junior (2009) a small list of 28, 46 and 64 fish species is presented, respectively, and restricted to the lower Ivinhema river. The richness of 111 fish species was reported in Súarez et al. (2011), but no list of fish species was presented. In the current study, more streams and rivers stretches were sampled and then we described a larger fish richness and composition along the whole Ivinhema river basin, including streams and the main river tributaries.

Given that the upper Paraná river basin is located in a densely populated area that is also one of the most industrialized regions in Brazil (Thomaz et al. 2004), it is not surprising that this area has experienced continuous environmental alteration, that may have a substantial influence on fish communities and their habitats (Bryce et al. 1999, Holt et al. 2006). Therefore, studies describing fish community composition and occurrence in the western part of the upper Paraná river basin are needed, where lotic environments, free from impoundment, still exist. This is particularly important in the state of Mato Grosso do Sul, which has experienced over the last decade great expansion of sugar-cane cultivation and alcohol production (Domingues & Thomaz Junior 2012). Studies, like the present work, would be very important in obtain information useful in the minimization and mitigation of the impacts of anthropic alteration and facilitate management policies for conservation, specifically for the fish fauna.

It is in this context that the present study was conducted, using data from field sampling, with the aim of inventorying the richness and composition of fish species in the Ivinhema river basin.

## Material and Methods

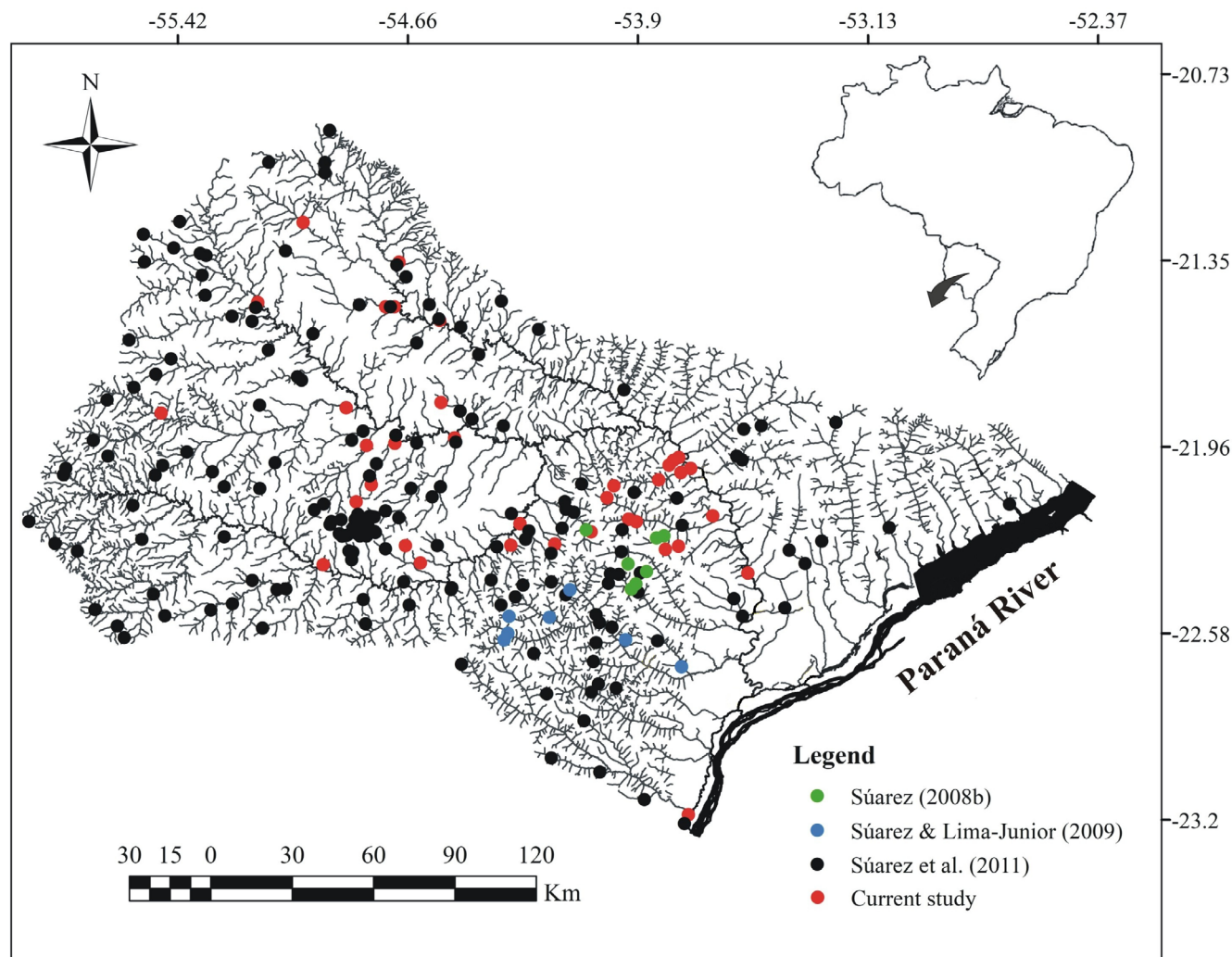
The Ivinhema river is the main tributary of the Paraná river in the western portion of the state of Mato Grosso do Sul. The mouth of this river is in the stretch of the Paraná river below Engenheiro Sérgio Motta dam but above Itaipu hydroelectric dam, which is the only stretch of the Paraná free of impoundments (Agostinho et al. 2000), including the Ivinhema river basin. The headwater is the Dourados river (area = 9,900 km<sup>2</sup>) at 700 m of altitude, with the contribution of other sub-basins including Santa Maria river (area = 2,700 km<sup>2</sup>), Brillhante river (area = 8,878 km<sup>2</sup>), Vacaria river (area = 6,500 km<sup>2</sup>), and the Ivinhema river (18,045 km<sup>2</sup>), forming the Ivinhema river basin, with a total area of 46,023 km<sup>2</sup>. Samplings were performed along 232 stretches of rivers and streams, throughout the Ivinhema river basin from January 2000 to June 2018, being that seven stretches were sampled in Súarez (2008b), seven in Súarez & Lima-Junior (2009), 186 in Súarez (2011) and 32 in the current study (Figure 1).

Fish were sampled from an approximately 100 m extension of each stream: 40 throws of a 1.2 x 0.8 m (2 mm mesh size) rectangular sieve; 10 trawlings (1.5 x 5 m; 2 mm mesh size); 12 hours of exposition to a sequence of 14 gillnets (10 x 1.5 m, with mesh sizes between adjacent knots: 1.5, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0, 10.0 cm) and three cast nets (height 1.5 to 3 m, diameter 3 to 6 m, and mesh sizes between adjacent knots: 1.5, 3.0, 6.0 cm). Also, electrofishing was employed in small streams, with approximately 100-m-long hauls. In rivers, fish were also captured with a series of 14 gillnets and cast nets in each stretch, whereas along the banks of the rivers the rectangular sieve and trawls were used mainly to sample small sized fish.

Fish were anesthetized with Eugenol solution, euthanized and, in the sequence, fixed in 10% formalin and preserved in 70% ethanol. The euthanasia followed all the ethic criterion established by the Universidade Estadual de Mato Grosso do Sul, along the accomplishment of all the projects that originated the current data. The collections of specimens were authorized by the Brazilian Environment Institute (IBAMA), through special license number # 13458-115900-1, issued by SISBIO. Taxonomic identifications followed Graça & Pavanelli (2007) and current taxonomic reviews. Some specimens were deposited in zoological collections: Núcleo de Pesquisas em Limnologia, Ictiologia e Aquicultura da Universidade Estadual de Maringá (NUP/UEM), Museu de Zoologia da Universidade de São Paulo (MZUSP), Museu da Universidade Federal do Rio Grande do Sul (UFRGS), Museu de Zoologia da Universidade Estadual de Londrina (MZUEL) and Coleção de Peixes da Universidade estadual de Mato Grosso do Sul (CPUEMS).

For those species that we were not able to present voucher specimens, we inserted the information of other references that had already reported the occurrence of the species in the Ivinhema river basin or upper Paraná river basin.

After the list was compiled, in order to confirm species names, possible synonyms and their basin of occurrence, we confronted it with information available on 'Check List of the Freshwater Fishes of South and Central America' (Reis et al. 2003), 'Catálogo das Espécies de Peixes de Água Doce do Brasil' (Buckup et al. 2007), 'Catalog of Fishes' (Eschmeyer et al. 2018) and 'Fishbase' (Froese & Pauly 2018).



**Figure 1.** Sampled stretches of rivers and streams that comprise the Ivinhema river basin, in the upper Paraná river basin (between January 2000 and June 2018), Mato Grosso do Sul State, Brazil.

The geographic origin for fish species followed Langeani et al. (2007) as autochthonous (native), natural species from the upper Paraná; allochthonous, species from other Neotropical regions and introduced in the upper Paraná; and exotic, species from other continents. For some species not reported in Langeani et al. (2007), the origin was defined according to reviews for the species or the remarks of Ota et al. (2018).

The fish fauna composition based in size was analyzed through the maximum size of each species (standard length for fish that has caudal fin, total length for fish that has only this information available and for Gymnotiformes or Synbranchiformes, and the total disc length for stingrays). This information were gathered from FishBase or directly measured on the specimen in the case of species is not described, not inserted in the database or the sampled specimen was longer than the reported in the FishBase. The size classes were obtained by Sturges formula ( $K = 1 + 3.32 \log n$ , where  $K$  = number of classes; and,  $n$  = the size sample), which furnishes the number of classes for the total sampling, based on the range of total fish size divided by the number of classes.

## Results

A total of 141 species was caught in this study. From this, eight species are without voucher numbers, but we inserted references that already reported these species in the Ivinhema river basin, and only one species we did not find any reference reporting its occurrence in the basin (Table 1). All species are distributed in 7 orders and 35 families. Characiformes and Siluriformes were the most representative orders with 65 (46.1%) and 50 species (35.5%), respectively, and Characidae and Loricariidae were the most abundant families with 28 (19.8%) and 17 species (12%), respectively. Although four species were identified at genus level, they were considered different species from those that are already described and reported for the upper Paraná basin.

After verification for synonymies and species that were redescribed, our study also contributed to increase the fish inventory furnished by Langeani et al. (2007), since 24 species were not reported on that list, and six of these species are the first reporting (species with asterisk) in the upper Paraná river: *Phalloceros harpagos*,

**Table 1.** Fish species caught between January 2000 and June 2018 in the Ivinhema river basin and its sub-basins (Santa Maria river – S; Dourados river – D; Vacaria river – V; Brilhante river – B; Ivinhema river – I), upper Paraná river basin. Voucher numbers, size (standard length, total length\*, or total disc length\*\* in centimeters) and species origin.

Species	Voucher or Reference	Size (cm)	sub-basin	origin
<b>MYLIOBATIFORMES</b>				
Potamotrygonidae				
<i>Potamotrygon falkneri</i> Castex & Maciel, 1963	Agostinho et al. 1997, Lonardoní et al. 2006, Lacerda et al. 2008	78**	B,I	allochthonous
<i>Potamotrygon motoro</i> (Müller & Henle, 1841)	Agostinho et al. 1997, Lonardoní et al. 2006, Lacerda et al. 2008	50**	B	allochthonous
<b>CHARACIFORMES</b>				
Acestrorhynchidae				
<i>Acestrorhynchus lacustris</i> (Lütken, 1875)	CPUEMS118	27	S,D,V,B,I	autochthonous*
Anostomidae				
<i>Leporellus vittatus</i> (Valenciennes, 1850)	#	30	S,V	autochthonous
<i>Leporinus amblyrhynchus</i> Garavello & Britiski, 1987	CPUEMS18	27.4	I	autochthonous
<i>Leporinus friderici</i> (Bloch, 1794)	NUP9375	40	S,D,V,B,I	autochthonous*
<i>Leporinus lacustris</i> Campos, 1945	NUP9387	20.3	D,B,I	autochthonous
<i>Leporinus octofasciatus</i> Steindachner, 1915	CPUEMS424	31.2	S,I	autochthonous*
<i>Leporinus striatus</i> Kner, 1859	CPUEMS290	25	S,D,V,B	autochthonous
<i>Megaleporinus macrocephalus</i> (Garavello & Britski, 1988)*	CPUEMS754	60	S,V,B,I	allochthonous
<i>Megaleporinus piavussu</i> Britski, Birindelli & Garavello, 2012*	NUP9371	40	D,I	autochthonous*
<i>Megaleporinus obtusidens</i> (Valenciennes, 1837)*	CPUEMS301	39.8	I	autochthonous*
<i>Schizodon borellii</i> (Boulenger, 1900)	CPUEMS705	30	S,D,V,I	autochthonous*
Bryconidae				
<i>Salminus brasiliensis</i> (Cuvier, 1816)	CPUEMS707	100	S,D,V,B,I	autochthonous*
<i>Salminus hilarii</i> Valenciennes, 1850	NUP9374	50	S,D,V,B,I	autochthonous*
Characidae				
<i>Aphyocharax anisitsi</i> Eigenmann & Kennedy, 1903	CPUEMS261	5.5	I	allochthonous
<i>Aphyocharax dentatus</i> Eigenmann & Kennedy 1903	NUP9944	7.2	S,V,I	autochthonous*
<i>Aphyocharax</i> sp.	NUP9361	5.3	S,D,V,B,I	unknown
<i>Astyanax abramis</i> (Jenyns, 1842)	MZUEL14444	14	I	autochthonous
<i>Astyanax biotae</i> Castro & Vari, 2004	CPUEMS537	5.2	---	autochthonous
<i>Astyanax bockmanni</i> Vari & Castro, 2007	Súarez 2008b	6.7	S,D,I	autochthonous*
<i>Astyanax fasciatus</i> (Cuvier, 1819)	CPUEMS116	12	S,D,V,B,I	autochthonous*
<i>Astyanax lacustris</i> (Lütken, 1875)*	NUP9378	10.6	S,D,V,B,I	autochthonous
<i>Astyanax paranae</i> Eigenmann, 1914	CPUEMS523	11.3	D,V,B,I	autochthonous
<i>Galeocharax knerii</i> (Steindachner, 1879)	CPUEMS280	33.1	D,V,B,I	autochthonous
<i>Hyphessobrycon anisitsi</i> (Eigenmann, 1907)	CPUEMS170	6	D,B,I	autochthonous*
<i>Hyphessobrycon eques</i> (Steindachner, 1882)	NUP9314	4	S,D,I	autochthonous*
<i>Knodus moenkhausii</i> (Eigenmann & Kennedy, 1903)	CPUEMS522	4.8	---	allochthonous
<i>Moenkhausia bonita</i> Benine, Castro & Sabino, 2004	NUP9317	4.4	D,I	unknown
<i>Moenkhausia forestii</i> Benine, Mariguela & Oliveira, 2009	NUP9318	3.8	S,D,V,B,I	autochthonous*
<i>Moenkhausia intermedia</i> Eigenmann, 1908	CPUEMS232	8	S,D,B,I	autochthonous*
<i>Moenkhausia oligolepis</i> (Günther, 1864) Glass tetra	CPUEMS531	10	---	unknown
<i>Moenkhausia sanctaefilomenae</i> (Steindachner, 1907)	NUP9936	7	S,D,V,B,I	autochthonous*

Continuation Table 1.

Species	Voucher or Reference	Size (cm)	sub-basin	origin
<i>Oligosarcus pinto</i> Campos, 1945	NUP9315	8.4	S,D,V,B,I	autochthonous
<i>Piabarchus stramineus</i> Eigenmann, 1908*	CPUEMS119	5.6	S,D,V,B,I	autochthonous
<i>Piabina argentea</i> Reinhardt, 1867	NUP9323	7.3	S,D,V,B,I	autochthonous*
<i>Psellogrammus kennedyi</i> (Eigenmann, 1903)	NUP9321	5.9	S,D,V,B,I	autochthonous*
<i>Roeboides descalsvadensis</i> Fowler, 1932	NUP9363	8.9	S,D,V,B,I	allochthonous
<i>Serrapinnus calliurus</i> (Boulenger, 1900)	MZUEL14483	4.4	I	autochthonous*
<i>Serrapinnus heterodon</i> (Eigenmann, 1915)	CPUEMS208	4.1	V,B	autochthonous
<i>Serrapinnus kriegi</i> (Schindler, 1937)	MZUEL14348	2.4	I	unknown
<i>Serrapinnus notomelas</i> (Eigenmann, 1915)	NUP9937	3.6	S,D,V,B,I	autochthonous
<i>Serrapinnus</i> sp.	CPUEMS16	3.2	D,V,B,I	unknown
Crenuchidae				
<i>Characidium gomesi</i> Travassos, 1956	CPUEMS248	6.5	D,V,B,I	autochthonous
<i>Characidium lagosantense</i> Travassos, 1947	CPUEMS257	4.1	I	unknown
<i>Characidium laterale</i> (Boulenger, 1845)	MZUEL14344	3.5	I	autochthonous
<i>Characidium zebra</i> Eigenmann, 1909	NUP9353	7.4	S,D,V,B,I	autochthonous*
Curimatidae				
<i>Curimatopsis myersi</i> Vari, 1982	MZUEL14516	4.4	I	unknown
<i>Cyphocharax modestus</i> (Fernández-Yépez, 1948)	NUP9327	16.2	S,D,V,B,I	autochthonous
<i>Cyphocharax vanderi</i> (Britski, 1980)	MZUEL14496	6.8	I	autochthonous
<i>Steindachnerina brevipinna</i> (Eigenmann & Eigenmann, 1889)	NUP9365	10.9	S,D,V,B,I	allochthonous
<i>Steindachnerina insculpta</i> (Fernández-Yépez, 1948)	NUP9358	10.6	D,V,B,I	autochthonous
Cynodontidae				
<i>Rhaphiodon vulpinus</i> Spix & Agassiz, 1829	Agostinho et al. 1997, Reynalte-Tataje et al. 2011	80	B,I	autochthonous*
Erythrinidae				
<i>Erythrinus erythrinus</i> (Bloch & Schneider, 1801)	CPUEMS542	20	I	allochthonous
<i>Hoplerythrinus unitaeniatus</i> (Agassiz, 1829)	NUP9376	25	D,V,B,I	allochthonous
<i>Hoplias misionera</i> Rosso, Mabragna, González-Castro Delpiani, Avigliano, Schenone, Días de Astarloa, 2016*	MUZEL14495	49	S,D,V,B,I	autochthonous*
Hemiodontidae				
<i>Hemiodus orthonops</i> Eigenmann & Kennedy, 1903	CPUEMS275	25	S,I	allochthonous
Lebiasinidae				
<i>Pyrrhulina australis</i> Eigenmann & Kennedy, 1903	NUP9356	5	S,D,V,B,I	autochthonous*
Parodontidae				
<i>Apareiodon affinis</i> (Steindachner, 1879)	Agostinho et al. 1997	17	D	autochthonous*
<i>Apareiodon ibitiensis</i> Campos, 1944	MZUSP85418	11.3	S,D,B,I	autochthonous
<i>Apareiodon piracicabae</i> (Eigenmann, 1907)	NUP9934	12	S,D	autochthonous
<i>Parodon nasus</i> Kner, 1859	CPUEMS138	12.7	S,D,V,B,I	autochthonous*
Prochilodontidae				
<i>Prochilodus lineatus</i> (Valenciennes, 1836)	CPUEMS595	59.2	S,D,V,B,I	autochthonous*
Serrasalminidae				
<i>Metynnis lippincottianus</i> (Cope, 1870)	NUP9380	14.9	I	unknown
<i>Myloplus tiete</i> (Eigenmann & Norris, 1900)*	NUP9364	16.3	I	autochthonous
<i>Serrasalmus maculatus</i> Kner, 1858	CPUEMS521	20.2	S,D,V,B,I	autochthonous*
<i>Serrasalmus marginatus</i> Valenciennes, 1837	CPUEMS708	27	S,D,B,I	autochthonous

Continuation Table 1.

Species	Voucher or Reference	Size (cm)	sub-basin	origin
<b>GYMNOTIFORMES</b>				
Apteronotidae				
<i>Apteronotus albifrons</i> (Linnaeus, 1766)	NUP9386	50*	D,I	allochthonous
Gymnotidae				
<i>Gymnotus inaequilabiatus</i> (Valenciennes, 1839)	CPUEMS697	60*	D,V,I	allochthonous
<i>Gymnotus omarorum</i> Richer-de-Forges, Crampton & Albert, 2009	MUZEL14328	25.4*	I	unknown
<i>Gymnotus pantanal</i> Fernandes, Albert, Daniel-Silva, Lopes, Crampton & Almeida-Toledo, 2005	MUZEL14486	25.1*	I	autochthonous*
<i>Gymnotus paraguensis</i> Albert & Crampton, 2003	CPUEMS179	24*	D,I	allochthonous
<i>Gymnotus sylvius</i> Albert & Fernandes-Matioli, 1999	NUP9389	36*	S,D,V,B,I	autochthonous*
Hypopomidae				
<i>Brachyhypopomus gauderio</i> Giora & Malabarba, 2009*	NUP9390	18.6*	B,I	allochthonous
Rhamphichthyidae				
<i>Gymnorhamphichthys britskii</i> Carvalho, Ramos & Albert, 2011*	NUP9384	11.5	I	autochthonous*
Sternopygidae				
<i>Eigenmannia trilineata</i> López & Castello, 1966	NUP9381	25*	S,D,B,I	autochthonous*
<i>Eigenmannia virescens</i> (Valenciennes, 1847)	CPUEMS284	35.8*	S,B,I	autochthonous*
<i>Sternopygus macrurus</i> (Bloch & Schneider, 1801)	NUP9388	141*	S,D,B,I	autochthonous*
<b>SILURIFORMES</b>				
Aspredinidae				
<i>Bunocephalus larai</i> Ihering, 1930	NUP9352	5.6	S,B,I	autochthonous
Auchenipteridae				
<i>Auchenipterus osteomystax</i> (Miranda Ribeiro, 1918)	CPUEMS709	27	B,I	autochthonous*
<i>Tatia neivai</i> (Ihering, 1930)	NUP9313	8.2	D,B,I	autochthonous
<i>Trachelyopterus coriaceus</i> Valenciennes, 1840	MZUEL14503	18*	I	unknown
<i>Trachelyopterus galeatus</i> (Linnaeus, 1766)	NUP9377	22	D,V,B,I	autochthonous*
Callichthyidae				
<i>Callichthys callichthys</i> (Linnaeus, 1758)	NUP9359	17	V,B,I	autochthonous*
<i>Corydoras aeneus</i> (Gill, 1858)	NUP9362	7.5	S,D,V,B,I	autochthonous*
<i>Hoplosternum littorale</i> (Hancock, 1828)	NUP9368	15.8	B,I	autochthonous*
<i>Lepthoplosternum pectorale</i> (Boulenger, 1895)	MUZEL14322	6	I	unknown
Cetopsidae				
<i>Cetopsis gobioides</i> Kner, 1858	NUP9367	10.9	B,I	autochthonous*
Clariidae				
<i>Clarias gariepinus</i> (Burchell, 1822)	CPUEMS594	32.9	D,V	exotic
Doradidae				
<i>Ossancora eigenmanni</i> (Boulenger, 1895)	CPUEMS704	15.2	S,I	allochthonous
<i>Platydoras armatulus</i> (Valenciennes, 1840)	Agostinho et al. 1997	43	B	unknown
<i>Pterodoras granulosus</i> (Valenciennes, 1821)	CPUEMS273	60	B,I	allochthonous
<i>Trachydoras paraguayensis</i> (Eigenmann & Ward, 1907)	CPUEMS224	19.2	D,B,I	allochthonous
Heptapteridae				
<i>Cetopsorhamdia iheringi</i> Schubart & Gomes, 1959	NUP9348	11.1	D,V,I	autochthonous
<i>Imparfinis borodini</i> Mees & Cala, 1989	CPUEMS701	15.7	B	autochthonous
<i>Imparfinis mirini</i> Haseman, 1911	NUP9355	8.5	D,B,I	autochthonous
<i>Imparfinis schubarti</i> (Gomes, 1956)	NUP9348	10.6	D,V,I	autochthonous

Continuation Table 1.

Species	Voucher or Reference	Size (cm)	sub-basin	origin
<i>Phenacorhamdia tenebrosa</i> (Schubart, 1964)	MZUSP85419	6.7	S,D,V,B,I	autochthonous
<i>Pimelodella avanhandavae</i> Eigenmann, 1917	NU9372	12.5	S,D,V,B,I	autochthonous
<i>Pimelodella gracilis</i> (Valenciennes, 1835)	NUP9346	18	S,D,V,B,I	autochthonous*
<i>Pimelodella taenioptera</i> Miranda-Ribeiro, 1914	CPUEMS820	12.1	D,V,B	allochthonous
<i>Rhamdia quelen</i> (Quoy & Gaimard, 1824)	MZUEL14499	38.7	D,V,B,I	autochthonous*
<b>Loricariidae</b>				
<i>Ancistrus</i> sp.	NUP9328	11	V,B	unknown
<i>Curculionichthys insperatus</i> Britski & Garavello, 2003*	MZUSP85735	3	S,D,V,B,I	autochthonous
<i>Farlowella hahni</i> Meinken, 1937*	NUP9396	22.5	D,B,I	autochthonous*
<i>Hisonotus francirochai</i> (Ihering, 1928)	MUZEL14355	3.6	I	autochthonous
<i>Hypostomus albopunctatus</i> (Regan, 1908)	CPUEMS268	40	S,V,B	autochthonous
<i>Hypostomus ancistroides</i> (Ihering, 1911)	MUZEL14450	21	S,D,V,B,I	autochthonous
<i>Hypostomus cochliodon</i> Kner, 1854	CPUEMS228	23	S,D,V,B,I	allochthonous
<i>Hypostomus iheringii</i> (Regan, 1908)	NUP9354	11.6	S,D,V,B,I	autochthonous
<i>Hypostomus regani</i> (Ihering, 1905)	CPUEMS712	41	S,D,I	autochthonous
<i>Hypostomus strigaticeps</i> (Regan, 1908)	NUP9340	16	S,D,V,B,I	autochthonous
<i>Loricariichthys platymetopon</i> Isbrücker & Nijssen, 1979	NUPP9338	30	S,D,V,B,I	allochthonous
<i>Otothyropsis marapoama</i> Ribeiro, Carvalho & Melo, 2005	NUP9395	3.6	S,D,I	autochthonous
<i>Otothyropsis polyodon</i> Caleagri, Lehmann A. & Reis, 2013	NUP9392	4.2	S,D,V,B,I	unknown
<i>Pterygoplichthys ambrosetti</i> Eigenmann & Kennedy, 1903	CPUEMS229	39.5	B,I	autochthonous*
<i>Pyxiloricaria menezesi</i> Isbrücker & Nijssen, 1984	NUP9382	14	S,D,V,B,I	unknown
<i>Rineloricaria lanceolata</i> (Günther, 1868)	NUP9336	9.5	S,D,B,I	unknown
<i>Rineloricaria</i> sp.	NUP9342	8.6	S,D,I	unknown
<b>Pimelodidae</b>				
<i>Hemisorubim platyrhynchos</i> (Valenciennes, 1840)	CPUEMS272	52.5	D,V,B,I	autochthonous*
<i>Pimelodus maculatus</i> La Cepède, 1803	CPUEMS281	36	S,D,B,I	autochthonous*
<i>Pimelodus ornatus</i> Kner, 1858	CPUEMS235	38.5	D	allochthonous
<i>Pseudoplatystoma corruscans</i> (Spix & Agassiz, 1829)	Agostinho et al. 1997, Súarez & Lima-Junior 2009, Reynalte-Tataje et al. 2011, Vaini et al. 2016	114	D,V,B,I	autochthonous*
<i>Sorubim lima</i> (Bloch & Schneider, 1801)	CPUEMS713	50.5	B,I	allochthonous
<b>Pseudopimelodidae</b>				
<i>Pseudopimelodus mangurus</i> (Valenciennes, 1835)	Súarez 2008b, Súarez & Lima-Junior 2009	34.5	I	autochthonous*
<b>Scoloplacidae</b>				
<i>Scoloplax empousa</i> Schaefer, Weitzman & Britski, 1989	NUP9347	2	I	unknown
<b>Trichomycteridae</b>				
<i>Paravandellia oxyptera</i> Miranda Ribeiro, 1912	CPUEMS66	2.8	D	autochthonous*
<i>Trichomycterus davisii</i> (Haseman, 1911)*	UFRGS11158	8	D	autochthonous
<b>Cynolebiidae</b>				
<i>Melanorivulus ivinhemensis</i> Volcan, Severo-Neto & Lanes, 2018*	NUP9350	3	D,I	autochthonous
<b>CYPRINODONTIFORMES</b>				
<b>Poeciliidae</b>				
<i>Phalloceros harpagos</i> Lucinda, 2008	NUP9360	3.4	D,B,I	autochthonous*
<i>Poecillia reticulata</i> Peters, 1859	NUP9379	5	D,V,B	allochthonous

Continuation Table 1.

Species	Voucher or Reference	Size (cm)	sub-basin	origin
SYNBRANCHIFORMES				
Synbranchidae				
<i>Synbranchus marmoratus</i> Bloch, 1795	NUP9357	150*	S,D,V,B,I	autochthonous*
CICHLIFORMES				
Cichlidae				
<i>Apistogramma commbrae</i> (Regan, 1906)	CPUEMS133	3.3	I	allochthonous
<i>Astronotus crassipinnis</i> Heckel, 1840	CPUEMS541	24	V,B	allochthonous
<i>Chaetobranchopsis australis</i> Eigenmann & Ward, 1907	NUP9366	12	I	allochthonous
<i>Cichlasoma dimerus</i> (Heckel, 1840)	MZUEL14512	11.7	I	unknown
<i>Cichlasoma paranaense</i> Kullander, 1983	NUP9385	7.8	S,D,V,B,I	autochthonous
<i>Coptodon rendalli</i> (Boulenger, 1897)*	NUP9316	16.6	D,B,I	exotic
<i>Crenicichla britskii</i> Kullander, 1982	MZUSP85416	14.5	S,D,V,B,I	autochthonous
<i>Gymnogeophagus setequedas</i> Reis; Malabarba & Pavanelli, 1992	CPUEMS598	9.8	D	autochthonous*
<i>Laetacara araguaiaae</i> Ottoni & Costa 2009*	MUZEL14324	6	I	allochthonous

<sup>1</sup> Species name with asterisk indicates that the deposit was made with the synonym species and it changed according to the new identification.

<sup>2</sup> Acronym refers to the following collections: Universidade Estadual de Maringá (NUP), Coleção de Peixes - Universidade Estadual Paulista/Campus de São José do Rio Preto (DZSJRP), Museu de Zoologia da Universidade de São Paulo (MZUSP), Museu de Ciências e Tecnologia da PUCRS (MCP), Universidade Federal do Rio Grande do Sul (UFRGS) and Museu de Zoologia da Universidade Estadual de Londrina (MZUEL), Coleção de Peixes da Universidade estadual de Mato Grosso do Sul (CPUEMS).

<sup>3</sup> Autochthonous: species from upper Paraná, asterisk indicates the type locality outside upper Paraná; Allochthonous: species from other Neotropical basins; Exotic: species from other continents and Unknown species no information about on the origin.

<sup>4</sup> Voucher number indicates species deposited by this work; References were used when it was not possible to deposit voucher specimens, but the species was already reported in the Ivinhema river basin; hastag, the only species without deposited specimens in the Ivinhema river basin, but reported by Langeani et al. (2007) in the upper Paraná river basin.

SÚAREZ, Y.R. & LIMA-JÚNIOR, S.E. 2009 Spatial and temporal variation in stream fish assemblages of Guirai River Basin, Upper Paraná Basin. *Biota Neotrop.* 9(1):101-111 <http://www.biotaneotropica.org.br/v9n1/en/abstract?article+bn01709012009> (ultimo acesso em 21/01/2019)

VAINI, J.O., CRISPIM, B.A., SILVA, D.B.S., BENITES, C., RUSSO, M. R. & GRISOLIA, A. B. 2016. Genetic variability of pure *Pseudoplatystoma corruscans* and *Pseudoplatystoma reticulatum* individuals in the Paraná and Paraguay River basins. *Fish. Sci.* 82:605-611.

*Moenkhausia forestii*, *Brachyhypopomus gauderio*, *Laetacara araguaiaae*, *Gymnotus omarorum*, *Gymnorhamphichthys britskii*, *Otothyropsis polyodon*, *Melanorivulus ivinhemensis*, *Astyanax abramis*\*, *Moenkhausia oligolepis*\*, *Serrapinnus kriegi*\*, *Curimatopsis myersi*\*, *Pyxiloricaria menezesi*\*, *Cichlasoma dimerus*\*, *Characidium lagsantense*, *Rineloricaria lanceolata*, *Moenkhausia bonita*, *Metynniss lippincottianus*, *Farlowella hahni*, *Trichomycterus davisi*, *Apistogramma commbrae*, *Chaetobranchopsis australis*, *Psellogrammus kennedyi*, and *Serrapinnus calliurus*. Some species may be visualized in Figure 2.

Regarding to geographic origin, 93 species were autochthonous from the Paraná river (42 from upper Paraná and 51 from lower Paraná), 27 were allochthonous and two were exotics (Table 1). It was not possible to define the origin of 19 species, mainly because nothing is reported about them or because the species are yet to be described.

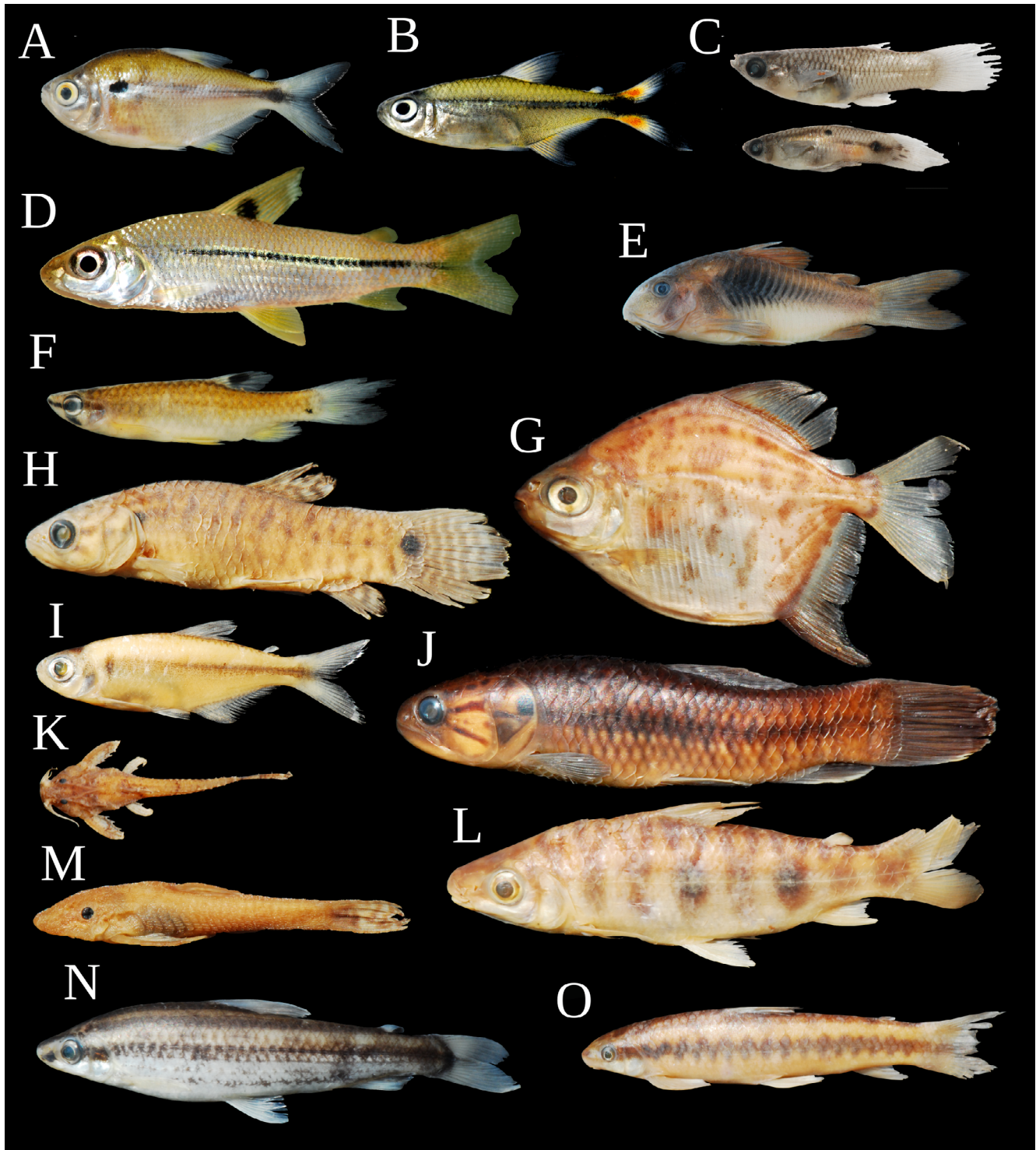
The length of fish species varied from two to 150 cm. Small-sized fish were mostly common (63.8%, 90 species) in size class until 20.7 cm (Figure 3), fish of medium size were in the second size class 39.4 cm (19.9%, 28 species) and the other 16 species (16.3%) were considered large size, above 39.5 cm and until 150 cm.

## Discussion

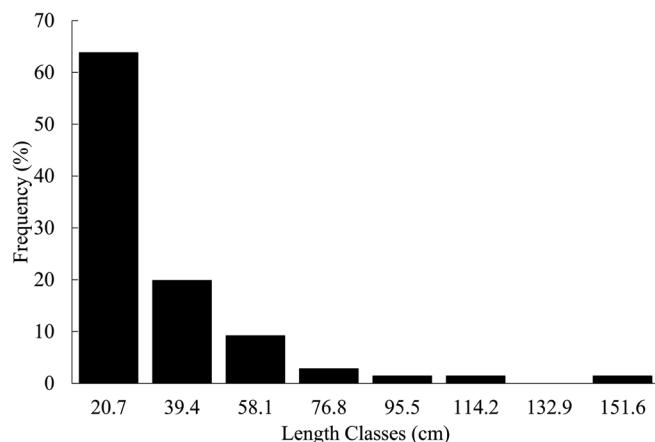
For the upper Paraná river basin it was reported 317 described fish species by Langeani et al. (2007). Although, since it was published this list may be increased, in function of the new descriptions, our study has 117 identified species (35.6%) in common, it can be said that the Ivinhema river basin, covering only 5% of the total area of the upper Paraná, possesses an expressive fish fauna, one third of the species.

From 24 species not reported on the inventory of Langeani et al. (2007), eight were described after the publication: *P. harpagos*, *M. forestii*, *B. gauderio*, *L. araguaiaae*, *G. omarorum*, *G. britskii*, *O. polyodon*, and *Melanorivulus ivinhemensis* (Lucinda 2008, Benine et al. 2009, Giora & Malabarba 2009, Ottoni & Costa 2009, Richerde-Forges et al. 2009, Carvalho et al. 2011, and Calegari et al. 2013, Volcan et al. 2018, respectively). *Phallocerus harpagos*, *M. forestii*, *G. britskii*, *O. polyodon*, and *M. ivinhemensis* were already described with specimens sampled in the upper Paraná river basin. It is noteworthy that *M. ivinhemensis* was described recently and is considered endemic in marginal areas of small first order streams and wetlands in the Ivinhema river (Ota et al. 2018). *Brachyhypopomus gauderio* was described from





**Figure 2.** Representative specimens for some fish species reported in the Ivinhema river basin, in the upper Paraná river basin, Mato Grosso do Sul State, Brazil. A) *Astyanas lacustris*; B) *Hemigrammus marginatus*; C) (Female and male) *Poecilia reticulata*; D) *Steindachnerina brevipinna*; E) *Corydoras aeneus*; F) *Pyrrhulina australis*; G) *Myloplus tiete*; H) *Erythrinus erythrinus*; I) *Knodus moenkhausii*; J) *Hoplerythrinus unitaeniatus*; K) *Scoloplax empousa*; L) *Leporinus octofasciatus*; M) *Otothyropsis polyodon*; N) *Leporinus striatus*; O) *Parodon nasus*.



**Figure 3.** Frequency of fish by size classes along the Ivinhema river basin, upper Paraná river basin, Mato Grosso do Sul State, Brazil.

Paraguay and Uruguay basins and Brazilian southeastern coast (Giora & Malabarba 2009), but according to Ota et al. (2018) this species was identified as *B. cf. pimicaudatus* (Graça & Pavanelli 2007) and its occurrence in the upper Paraná might be associated to introduction as a live bait by anglers. *Laetacara araguaiaiae* was described from the Verde and Araguaia rivers (Otoni & Costa 2009), but as a non-native species, it was reported the upper Paraná floodplain, probably introduced by the aquarium trade (Ota et al. 2018), and now we expanded its occurrence to the river Ivinhema.

For six species, the current study had extended their occurrence to the upper Paraná river: *Astyanax bimaculatus* subgroup was revised by Lucena & Soares (2016) and they re-described *A. abramis* as a valid species from Paraguay, Lower Paraná and La Plata river basin. *Moenkhausia oligolepis* was reported originally only in the Guianas and Amazon river basins, but Benine et al (2009) with a detailed revision of this species reported its occurrence in Paraguay river. For *S. kriegi*, *C. myersi*, *P. menezesi* and *C. dimerus* and the other above-mentioned species, there was not found any report for these six species in the upper Paraná, thus these are the first reports.

Ten species not reported in Langeani et al. (2007) had their taxonomic status revised or occurrence extended. *Characidium lagosantense* was re-described and reported in the Mogi-Guaçu river by Silveira (2008). The taxonomic revision of *Rineloricaria* species was carried out in the Paraguay river (Vera-Alcaráz et al. 2012), but *R. lanceolata* occurrence was also recorded in the Ivinhema river in 2011 and reported by Froehlich et al. (2017). *Moenkhausia bonita* was described in 2004 in the Paraguay river (Benine et al. 2004), but its occurrence in the Ivinhema river was registered in 2006 and reported by Froehlich et al. (2017) and Ota et al. (2018). *Metynnis lippincottianus* was reported in the Ivinhema river by Suárez (2011) and Froehlich et al. (2017). It is interesting to point out that *M. lippincottianus* was not reported by Langeani et al. (2007) and it was adverted that it had been identified in the upper Paraná as *M. maculatus* (Graça & Pavanelli 2007). However, as an original Amazonian fish, two populations of this species were reported in two tributary streams of Ilha Solteira dam, suggesting these populations were installed locally (Froehlich et al. 2017) and now our study reported this species in many streams in the Ivinhema river. Its occurrence can be associated with the releasing of specimens for restocking or with the aquarium trade (Ota 2015).

*Farlowella hahni*, despite not being reported by Langeani et al. (2007), it was reported in the upper Paraná by Graça & Pavanelli (2007) as *F. amazonum*, but Ota et al. (2018) comparing the characters, described for the genus by Retzer & Page (1996), decided that the species would match more with the description of *F. hahni*. This species was reported before in the lower Paraná river and its occurrence in the upper portion can be associated to the inundation of the Sete Quedas Falls after the filling of Itaipu Reservoir (Ota et al. 2018). *Trichomycterus davisi*, first identified as *Trichomycterus* sp. (Graça & Pavanelli 2007), has now been assigned as *T. davisi* belonging to a species complex (Ota et al. 2018). *Apistogramma commbrae* and *C. australis* may have been introduced accidentally by aquarists or even after the construction of the Itaipu dam, since these species originally occurred only in the lower Paraná river and were firstly reported in the upper Paraná (Ivinhema river) by Suárez et al. (2011). *Psellogrammus kennedyi*, also reported for this latest author, and *S. calliurus* are considered a not-native species in the upper Paraná and had their occurrence associated with the function of a fish ladder that connects downstream portion (lower Paraná) to upstream portion (upper Paraná) in the Itaipu Dam (Ota et al. 2018).

Whereas Langeani et al. (2007) estimated at least 50 more species to be described, our inventory shows that the true richness of the Ivinhema river basin may be even greater insofar as specific identification was not possible for four species (four species at genus level). According to taxonomists, we probably have four new species: *Serrapinnus* sp., *Ancistrus* sp., and *Rineloricaria* sp. (personal communication). Thus, even without considering other species with uncertain taxonomic definitions, 2.8% of the sampled species are poorly or completely unknown to science.

The greater representation of the orders Characiformes and Siluriformes is a frequent pattern in Neotropical waters (Castro et al. 2004). Both orders accounted for 81.6% of the sampled species, which is consistent with that found by Langeani et al. (2007). This pattern is not surprising since both orders are the most representative of South America freshwater fish (Lowe-McConnell 1999). On the other hand, the greater representation of the families Characidae and Loricariidae reflects a recurrent pattern in Brazilian continental waters (Reis et al. 2003, Buckup et al. 2007).

Although the majority of fish reported in the Ivinhema river basin was autochthonous (29.8%) in the upper Paraná and autochthonous in the lower Paraná (36.2%), summing 66%, there was a substantial occurrence of allochthonous species (20%). The two exotic species recorded (1.4%), *Clarias gariepinus* and *Coptodon rendalli*, were clearly introduced into the basin through pisciculture (Langeani et al. 2007). This is the first report of *C. gariepinus* in the Dourados and Vacaria rivers, expanding the knowledge about their occurrence in tributaries of upper Paraná, which is considered to be highly adaptable and capable of negatively affecting the native fish fauna (Alves et al. 1999). During sampling, local fishermen and riverine communities reported that this species is frequently caught in these sub-basins and in abundance in the Dourados river.

Even though we do not have knowledge about the origin of 13.5% of the species, a point that is very concerning in this inventory is that only 29.8% of species may be considered native from the upper Paraná, the remaining fishes (56.7%) are from the lower Paraná, other basins or other continents. When the subject is homogenization and species

invasion, it is important to consider not only allochthonous and exotic species. Introduced species from different parts of the basin may be more problematic than species from other basins or continents (Vitule 2009). In Paraná river, even the species that overcame the barrier from the lower to the upper parts, because of the impoundment caused by Itaipu Dam, may cause some troubles for upper communities, such as pointed by Taylor et al. (1984): hybridization, genetic losses, trophic alterations, parasites or diseases introduction. Those alterations in local communities may result in extinction of native species, biodiversity losses or biota homogenization (Vitule 2009).

The streams of the present study exhibited greater species richness (112) than streams of other works in upper Paraná, such as Castro et al. (2003, 2004), Gubiani et al. (2006) e Gomiero & Braga (2006), which reported 52, 64, 62 and 48 species, respectively. In spite of these researches have used different methodologies and our samples were carried out in more stretches and in a greater area, consequently reflecting on difference catch effort and species richness, the rivers of the Paraná river basin in the state of São Paulo have experienced the influence of a series of impoundments for hydroelectric reservoirs, a process that affects sub-basin connections, thereby preventing recolonization and, thus, influencing species richness. On the other hand, the Ivinhema river basin, in the western portion of the upper Paraná, does not contain significant impoundments, with only two small hydropower plants in the upper portion of the Dourados river (São João I and II), or any other barriers, thus maintaining the potential for greater connectivity among streams, facilitating species flux and even recolonization by species from the Paraná river floodplain.

The most common species sampled were *Astyanax lacustris*, *Serrapinnus notomelas*, *Piabarchus stramineus*, and *Hypostomus ancistroides*. These small-sized species have great feeding plasticity and are known for their capacity to adapt to and colonize different water bodies. These species were reported throughout the Ivinhema river basin and are widely distributed in the upper Paraná river (Castro et al. 2004, Gubiani et al. 2006, Teresa & Casatti 2010, Viana et al. 2013).

A wide range of standard length was registered for the sampled fish (2 to 150 cm), however, it was evidenced that the fish fauna of Ivinhema river Basin is composed basically of small-sized species, about 63.8% smaller than 20.7 cm. Despite of a greater number of samples in streams, and this may influence in a higher richness of small-sized fish (Castro 1999, Castro et al. 2003, 2004, Couto & Aquino 2011), this may be considered a pattern for the basin, because the large-sized species were sampled mainly below the intermediate altitude (430m) and in larger rivers, in areas located in tributaries such as Dourados, Brilhante and Ivinhema rivers. Moreover, 65% of 310 species analyzed in the upper Paraná river were small-sized ( $\leq 20.8$  cm) (Langeagni et al., 2007) and 50% of South-American freshwater fish are small-sized (Castro 1999). According to this last work, this pattern may be a result of the high hydrological variability in streams; we believe that this pattern act more intensively structuring fish assemblages locally, where the water levels may vary between rainy and dry periods until five meters (personal observation), selecting generalist and resilient small-sized fish that are more prone to establish in these areas.

In conclusion, the current study is particularly significant because it helps reduce the lack of information on fish communities of an ecosystem that has been kept relatively free from dams and

impoundments, from its headwaters to its confluence with the Paraná river basin. These data are also important for understanding the distribution of fish among sub-basins, adding new species records for the Ivinhema river basin, and the upper Paraná basin as a whole, serving as reference data for each region and contributing to the management, decision-making, and implementation of politics to conserve the basin as a whole. Furthermore, these data should prove useful as a reference for monitoring the fish fauna of the basin, which has experienced great alterations to its landscapes over the last decade due to the expansion of sugarcane crops and also may be suffering some pressure by a high percentage of non-native species in the upper Paraná.

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## Author Contributions

Wagner Vicentin: Substantial contribution in the concept and design of the study; contribution to data collection; Contribution to data analysis and interpretation; Contribution to manuscript preparation; Contribution to critical revision, adding intellectual content.

Fabiane Silva Ferreira: Substantial contribution in the concept and design of the study; contribution to data collection; Contribution to data analysis and interpretation; Contribution to manuscript preparation; Contribution to critical revision, adding intellectual content.

Yzel Rondon Suárez: Substantial contribution in the concept and design of the study; contribution to data collection; Contribution to data analysis and interpretation; Contribution to manuscript preparation; Contribution to critical revision, adding intellectual content.

## Conflicts of interest

The authors declare that they have no conflict of interest related to the publication of this manuscript.

## References

- AGOSTINHO, A.A., GOMES, L.C. & PELICICE, F.M. 2007. Ecologia e manejo de recursos pesqueiros em reservatórios do Brasil. EDUEM, Maringá.
- AGOSTINHO, A.A., GOMES, L.C., SUZUKI, H.I. & JÚLIO 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.). World Bank, Vitoria, p.19-89.
- AGOSTINHO, A.A., JÚLIO-JÚNIOR, H.F., GOMES, L.C., BINI, L.M. & AGOSTINHO, C.S. 1997. Composição, abundância e distribuição espaço-temporal da ictiofauna. In A planície de inundação do alto rio Paraná: aspectos físicos, biológicos e socioeconômicos (A.E.A.M. Vazzoler, A.A. Agostinho & N.S. Hahn, eds.). EDUEM, Maringá, p.179-208.
- AGOSTINHO, A.A., THOMAZ, S.M., MINTE-VERA, C.V. & WINEMILLER, K.O. 2000. Biodiversity in the high Paraná river floodplain. In Biodiversity in wetlands: assessment, function and conservation. (B. Gopal, W.J. Junk & J.A. Davis, eds.). Backhuys Publishers, Leiden, p. 89-118.
- ALVES, C.B.M., VONO, V. & VIEIRA, F. 1999. Presence of the walking catfish *Clarias gariepinus* (Burchell) (Siluriformes, Clariidae) in Minas Gerais state hydrographic basins, Brazil. Rev. Bras. Zool. 16(1):259-263.
- AQUINO, P.P.U., SCHNEIDER, M., MARTINS-SILVA, M.J., PADOVESI-FONSECA, C., ARAKAWA, H.B. & CAVALCANTI, D.R. 2009. Ictiofauna dos córregos do Parque Nacional de Brasília, bacia do Alto Rio Paraná, Distrito Federal, Brasil Central. Biota Neotrop. 9(1): 217-230 <http://www.biotaneotropica.org.br/v9n1/pt/abstract?inventory+bn02809012009> (last access in 20/02/2014).
- BENINE, R.C., CASTRO, R.M.C. & SABINO, J. 2004. *Moenkhausia bonita*: A new small characin fish from the Rio Paraguay basin, southwestern Brazil (Characiformes: Characidae). Copeia. 4(1):68-73.
- BENINE, R.C., MARIGUELA, T.C. & OLIVEIRA, C. 2009. New species of *Moenkhausia* Eigenmann, 1903 (Characiformes: Characidae) with comments on the *Moenkhausia oligolepis* species complex. Neotrop. Ichthyol. 7(2):161-168.
- BRYCE, S.A., LARSEN, D.P., HUGHES, R.M. & KAUFMANN, P.R. 1999. Assessing relative risks to aquatic ecosystems: a mid-Appalachian case study. J. Am. Water Resour. As. 35(1):23-36.
- BUCKUP, P.A., MENEZES, N.A. & GHAZZI, M.S. 2007. Catálogo das espécies de peixes de água doce do Brasil. Museu Nacional, Rio de Janeiro.
- BULLA, C.K., GOMES, L.C., MIRANDA, L.E. & AGOSTINHO, A.A. 2011. The ichthyofauna of drifting macrophyte mats in the Ivinheima River, Upper Paraná River Basin, Brazil. Neotrop. Ichthyol. 9(2):403-409.
- CALEGARI, B.B., LEHMANN, P.A. & REIS, R.E. 2013. Two new species of cascudinhos of the genus *Otothyropsis* (Siluriformes: Hypoptopomatinae) from the rio Paraná basin, Brazil. Zootaxa. 3619(2):130-144.
- CARVALHO, T.P., RAMOS C.S. & ALBERT J.S. 2011. A new species of *Gymnorhamphichthys* (Gymnotiformes: Rhamphichthyidae) from the Paraná-Paraguay basin. Copeia, 2011(3): 400-406
- CASTRO, R.M.C. 1999. Evolução da ictiofauna de riachos sul-americanos: padrões gerais e possíveis processos causais. In Ecologia de peixes de riachos (E.P. Caramaschi, R. Mazzoni & P.R. Peres-Neto, eds.). PPGE-UFRJ, Rio de Janeiro, p.139-155.
- CASTRO, R.M.C., CASATTI, L., SANTOS, H.F., FERREIRA, K.M., RIBEIRO, A.C., BENINE, R.C., DARDIS, G.Z.P., MELO, A.L.A., STOPLIGLIA, R., ABREU, T.X., BOCKMANN, F.A., CARVALHO, M., GIBRAN, F.Z. & LIMA, F.C.T. 2003. Estrutura e composição da ictiofauna de riachos do Rio Paranapanema, Sudeste e Sul do Brasil. Biota Neotrop. 3(1): 1-14 <http://www.biotaneotropica.org.br/v3n1/pt/abstract?article+BN01703012003> (last access in 20/12/2013).
- CASTRO, R.M.C., CASATTI, L., SANTOS, H.F., MELO, A.L.A., MARTINS, L.S.F., FERREIRA, K.M., GIBRAN, F.Z., BENINE, R.C., CARVALHO, M., RIBEIRO, A.C., ABREU, T.X., BOCKMANN, F.A., PELIÇÃO, G.Z., STOPLIGLIA, R. & LANGEANI, F. 2004. Estrutura e composição da ictiofauna de riachos da bacia do Rio Grande no estado de São Paulo, sudeste do Brasil. Biota Neotrop. 4(1): 1-39 <http://www.biotaneotropica.org.br/v4n1/pt/download?article+BN01704012004> (last access in 20/12/2013).
- COUTO, T.B.A. & AQUINO, P.D.P.U. 2011. Structure and integrity of fish assemblages in streams associated to conservation units in Central Brazil. Neotrop. Ichthyol. 9(2):445-454.
- DOMINGUES, T.A. & THOMAZ JUNIOR, A. 2012. A territorialização da cana-de-açúcar no Mato Grosso do Sul. Cad. Prudentino Geogr. 34(1):138-160.
- ESCHMEYER, W.N., FRICKE, R. & VAN DER LAAN, R. (Eds). 2018. Catalog of Fishes: Genera, Species, Reference <http://researcharchive.calacademy.org/research/ichthyology/catalog/fishcatmain.asp>. Electronic version (last access in 31/05/2018)
- FISHBASE. <http://www.fishbase.org/home.htm> (last access in 15/12/2017)
- FROELICH, O., CARVALHO, M., SABINO, J., SÚAREZ, Y.R. & VILELA, M.J.A. 2017. Checklist da ictiofauna do Estado de Mato Grosso do Sul, Brasil. Iheringia, Sér. Zool. 107(supl.):e2017151.
- FROESE, R. & PAULY, D. (Eds). 2018. FishBase. World Wide Web electronic publication. <http://www.fishbase.org>, version (02/2018). (last access in 31/05/2018)
- GIORA, J. & MALABARBA, L.R. 2009. *Brachyhypopomus gauderio*, new species, a new example of underestimated species diversity of electric fishes in the southern South America (Gymnotiforme, Hypopomidae). Zootaxa. 2093:60-68.
- GOMIERO, L.M. & BRAGA, F.M.S. 2006. Ichthyofauna diversity in a protected area in the state of São Paulo, southeastern Brazil. Braz. J. Biol. 66(1):75-83.
- GRAÇA, W.J. & PAVANELLI, C.S. 2007. Peixes da planície de inundação do Alto Rio Paraná e áreas adjacentes. EDUEM, Maringá.
- GUBIANI, E.A., HOLZBACH, A.J., BAUMGARTNER, G., NETO, L.B.R. & BERGMANN, F. 2006. Fish, Piquiri River, Upper Paraná River Basin, Paraná State, Brazil. Check List 2(3):9-14.
- HOLT, T.V., MURPHY, D.M. & CHAPMAN, L. 2006. Local and landscape predictors of fish-assemblage characteristics in the Great Swamp, New York. Northeast. Nat. 13(3):353-374.
- LACERDA, A.C.F., TAKEMOTO, R.M. & PAVANELLI, G. C. 2008. Digenea, Nematoda, Cestoda, and Acanthocephala, parasites in Potamotrygonidae (Chondrichthyes) from the upper Paraná River floodplain, states of Paraná and Mato Grosso do Sul, Brazil. Check List, 4(2):115-122.
- 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> (last access in 18/02/2013)
- LONARDONI, A.P., GOULART, E., OLIVEIRA, E.F. & ABELHA, M. 2006. Hábitos alimentares e sobreposição trófica das raízes *Potamotrygon falkneri* e *Potamotrygon motoro* (Chondrichthyes: Potamotrygonidae) na planície alagável do alto rio Paraná; Brasil. Acta Sci. Bio. Sci. 28(3):195-202
- LOWE-MCCONNELL, R.H. 1999. Estudos ecológicos de comunidades de peixes tropicais. EDUSP, São Paulo.
- LUCENA, C.A.S. & SOARES, H.G. 2016. Review of species of the *Astyanax bimaculatus* "caudal peduncle spot" subgroup *sensu* Garutti & Langeani (Characiformes, Characidae) from the rio La Plata and rio São Francisco drainages and coastal systems of southern Brazil and Uruguay. Zootaxa. 4072(1):101-125
- LUCINDA, P.H.F. 2008. Systematics and biogeography of the genus *Phallocoeres* Eigenmann, 1907 (Cyprinodontiformes: Poeciliidae: Poeciliinae), with the description of twenty-one new species. Neotrop. Ichthyol. 6(2):113-158.
- NASCIMENTO, F.L. & NAKATANI, K. 2006. Relações entre fatores ambientais e a distribuição de ovos e larvas de peixes na sub-bacia do rio Ivinheima, Estado de Mato Grosso do Sul, Brasil. Acta Sci. Bio. Sci. 28(2):117-122.
- OTA, R.P. 2015. Revisão taxonômica e análise filogenética das espécies do gênero *Metynnis* Cope, 1878 (Characiformes: Serrasalminidae). Tese de doutorado, Instituto Nacional de Pesquisas da Amazônia, Manaus, AM.
- OTA, R.R., DEPRÁ, G.D., WEFERSON JÚNIO DA GRAÇA, W.J. & PAVANELLI, C.S. 2018. Peixes da planície de inundação do alto rio Paraná e áreas adjacentes: revised, annotated and updated. Neotrop. Ichthyol. 16(2): e170094.

- OTTONI, F.P. & COSTA, W.J.E.M. 2009. Description of a new species of *Laetacara* Kullander, 1986 from central Brazil and re-description of *Laetacara dorsigera* (Heckel, 1840) (Labroidae: Cichlidae: Cichlasomatinae). *Vertebr. Zool.* 59(1): 41-48.
- REIS, R.E., KULLANDER, S.O. & FERRARIS JUNIOR, C.J. 2003. Check list of the freshwater fishes of South and Central America. EDPUCRS, Porto Alegre.
- RETZER, M.E. & PAGE, L.M. 1996. Systematics of the stick catfishes, *Farlowella* Eigenmann & Eigenmann (Pisces, Loricariidae). *Proc. Acad. Nat. Sci. Philadelphia.* 147:33-88.
- REYNALTE-TATAJE, D.A., NAKATANI, K., FERNANDES, R., AGOSTINHO, A.A., BIALETZKI, A. 2011. Temporal distribution of ichthyoplankton in the Ivinhema River (Mato Grosso do Sul State/Brazil): influence of environmental variables. *Neotrop. Ichthyol.* 9(2):427-436.
- RICHER-DE-FORGES, M.M., CRAMPTON, W.G.R. & ALBERT, J.S. 2009. A new species of *Gymnotus* (Gymnotiformes, Gymnotidae) from Uruguay: description of a model species in neurophysiological research. *Copeia.* 2009(3): 538-544.
- 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. M.S. Dissertation, Universidade Estadual Paulista, São José do Rio Preto.
- SÚAREZ, Y.R. 2008a. Spatial and temporal variation in fish species diversity and composition in streams of Ivinhema River Basin, Upper Paraná River. *Biota Neotrop.* 8(3):197-204 <http://www.biotaneotropica.org.br/v8n3/en/abstract?article+bn02308032008> (last access in 22/12/2017)
- SÚAREZ, Y.R. 2008b. Fish, Lower Ivinhema River Basin streams, state of Mato Grosso do Sul, Brazil. *Check List* 4(3): 226-231.
- SÚAREZ, Y.R. & LIMA-JÚNIOR S.E. 2009 Spatial and temporal variation in stream fish assemblages of Guirai River basin, upper Paraná Basin. *Biota Neotrop.* 9(1):102-111. <http://www.biotaneotropica.org.br/v9n1/en/abstract?article+bn01709012009>. (last access in 31/05/2018)
- SÚAREZ, Y.R., SOUZA, M.M., FERREIRA, F.S., PEREIRA, M.J., SILVA, E.A., XIMENES, L.Q.L., AZEVEDO, L.G., MARTINS, O.C. & LIMA JÚNIOR, S.E. 2011. Patterns of species richness and composition of fish assemblages in streams of the Ivinhema River Basin, Upper Paraná River. *Acta Limnol. Bras.* 23(2):177-188.
- SÚAREZ, Y.R., VALÉRIO, S.B., TONDATO, K.K., XIMENES, L.Q.L. & FELIPE, T.R.A. 2007. Determinantes ambientais da ocorrência de espécies de peixes em riachos de cabeceira da bacia do rio Ivinhema, alto rio Paraná. *Acta Sci. Bio. Sci.* 29(2):145-150.
- TAYLOR, J.N., COURTENAY, W.R.Jr., McCANN, J.A. 1984. Known impacts of exotic fishes in the continental United States. In *Distribution, biology, and management of exotic fishes* (W.R. Courtenay Jr. & J.R. Stauffer, eds.). Johns Hopkins University Press, Baltimore, p. 322-373.
- TERESA, F.B. & CASATTI, L. 2010. Importância da vegetação ripária em região intensamente desmatada no sudeste do Brasil: um estudo com peixes de riacho. *Panam. J. Aquat. Sci.* 5(3):444-453.
- THOMAZ, S.M., AGOSTINHO, A.A. & HAHN, NS. 2004. The Upper Paraná river and its Floodplain: physical aspects, ecology and conservation. Backhuys Publishers, Leiden.
- VERA-ALCARAZ, H.S., PAVANELLI, C.S. & ZAWADZKI, C.H. 2012. Taxonomic revision of the *Rineloricaria* species (Siluriformes: Loricariidae) from the Paraguay River basin. *Neotrop. Ichthyol.* 10(2):285-311.
- VAINI, J.O., CRISPIM, B.A., SILVA, D.B.S., BENITES, C., RUSSO, M. R. & GRISOLIA, A. B. 2016. Genetic variability of pure *Pseudoplatystoma corruscans* and *Pseudoplatystoma reticulatum* individuals in the Paraná and Paraguay River basins. *Fish. Sci.* 82:605-611.
- VIANA, L.F., SÚAREZ, Y.R. & LIMA-JÚNIOR, S.E. 2013. Influence of environmental integrity on the feeding biology of *Astyanax altiparanae* Garutti & Britski 2000 in the Ivinhema river basin. *Acta Sci. Bio. Sci.* 35(4):541-548.
- VITULE, J.R.S. 2009. Introduction of fishes in Brazilian continental ecosystems: Review, comments and suggestions for actions against the almost invisible enemy. *Neotrop. Biol. Cons.* 4(2):111-122.
- VOLCAN, V.M., SEVERO-NETO, F. & LANÉS, L.E.K. 2018. Unrecognized biodiversity in a world's hotspot: three new species of *Melanorivulus* (Cyprinodontiformes: Rivulidae) from tributaries of the right bank of the Rio Paraná basin, Brazilian Cerrado. *Zoosyst. Evol.* 94(2):263-280.

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