

Ichthyofauna of the Ribeirão Frutal and tributaries, upper Rio Paraná basin, Minas Gerais, Southeastern Brazil

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Abstract: The Ribeirão Frutal basin is located within the upper Rio Paraná system, in the Frutal municipality, Minas Gerais State, Southeastern Brazil. Until now, there was no complete ichthyological survey published for this small basin. Therefore, here we provided a list of fish species from the Ribeirão Frutal and some of its tributaries. We found 31 species of fishes representing five orders and ten families. We identify a likely undescribed and five non-native species in the Frutal basin. Lastly, we recommend new surveys of fishes in small hydrographic basins within upper Rio Paraná system.

Keywords: Ichthyology, inventory, Neotropical region, Rio Grande, survey.

Ictiofauna do Ribeirão Frutal e afluentes, bacia do alto Rio Paraná, Minas Gerais, Sudeste do Brasil

Resumo: A bacia do Ribeirão Frutal está localizada no sistema do alto Rio Paraná, no município de Frutal, Estado de Minas Gerais, Sudeste do Brasil. Até o momento, não existe publicação de um levantamento ictiológico completo para essa bacia. Portanto, aqui fornecemos uma lista das espécies de peixes do Ribeirão Frutal e alguns de seus tributários. Nós encontramos 31 espécies de peixes representando cinco ordens e 10 famílias. Identificamos uma provável espécie não descrita e cinco não nativas na bacia do Frutal. Por fim, recomendamos novos levantamentos de peixes em pequenas bacias hidrográficas do sistema do alto Rio Paraná.

Palavras-chave: Ictiologia, inventário, levantamento, região Neotropical, Rio Grande.

Introduction

Ichthyological surveys, also referred to in scientific literature as inventories (e.g., Giongo et al. 2011; Vidotto-Magnoni et al. 2015), are performed in order to assess the biodiversity of a stream, river or lake (Silveira et al. 2010). Consequently, these studies may result in new discoveries (e.g., undescribed species) and can be implemented as the basis for conservation actions (e.g., Castro et al. 2004, Serra et al. 2007, Raiol et al. 2012, Ohara & Loeb 2016, Silva-Oliveira et al. 2016, Melo et al. 2016, Ferreira et al. 2017).

The Ribeirão Frutal basin is a tributary of the Rio Grande, in the upper Rio Paraná system, Minas Gerais State (*Triângulo Mineiro*), Brazil. This small basin (with just over 120 Km²) (Machado & Audino 2017) has been impacted by several anthropogenic disturbances (see Machado & Audino 2017; and Brito et al. 2017 and references therein). Recently, a truck leaked a substantial volume of hydrochloric acid into

one of its tributaries, the Vertente Grande, killing a large number of its aquatic organisms (Azevedo-Santos & Coelho, pers. obs.). Another threat, for instance, is the advancement of the urban area of the Frutal municipality, which may compromise the water quality of the lower Ribeirão Frutal. Despite being located in a relatively well-populated region, there has been no comprehensive survey of its fish fauna until now. In order to understand the ichthyofauna from this small basin facing numerous threats due to anthropogenic development, we here provided a survey of fish species that occur in the Ribeirão Frutal and some of its tributaries.

Material and methods

Samplings were carried April, May, August, and October 2017, using handnets (mesh of 1.5 mm), a small trawl (mesh of 1.5 mm), and gill nets (10 and 20 mm between opposite nodes). Collections involved

the efforts of two researchers during daytime and, when possible, in the evening. A total of 10 localities were sampled in the Ribeirão Frutal basin (Figure 1-2; Table 1). Immediately after removal from wild, individuals of several species were photographed alive in an aquarium. Vouchers were euthanized in anesthetic (i.e., benzocaine), fixed in 10% formalin, transferred to 70% alcohol and subsequently deposited in Brazilian collections: LBP (Laboratório de Biologia de Peixes, Botucatu, Botucatu, SP, Brazil); NUP (Coleção Ictiológica do Núcleo de Pesquisas em Limnologia, Ictiologia e Aquicultura, Universidade Estadual de Maringá, Maringá, PR, Brazil); and UNT (Coleção de Peixes do Laboratório de Ictiologia Sistemática da Universidade Federal do Tocantins, Porto Nacional, TO, Brazil). Identifications were carried out using published literature and, when possible, with the help of a specialist in each group (see Acknowledgements section). All collections for this study were performed with permission of IBAMA (SISBIO - Number 58612-1).

Results

Samples resulted in 765 individuals distributed in five orders, ten families, and 31 fish species (Table 2). Among families, Characidae was the most represented, followed by Cichlidae, and Loricariidae (Figure 3). Site four (S4) presented the highest species-richness, with 16 species (Table 3). At site nine (S9), a small tributary entering the Ribeirão Frutal near its confluence with the Rio Grande, we recorded one likely undescribed species (i.e., *Satanoperca* sp.; Figure 4j). Finally, we found five fish species believed to be non-native to the Ribeirão Frutal basin: *Cichla* cf. *piquiti* Kullander & Ferreira 2006, *Knodus moenkhausii* (Eigenmann & Kennedy 1903), *Metynnis lippincottianus* (Cope 1870), *Oreochromis niloticus* (Linnaeus 1758), and *Poecilia reticulata* Peters 1859.

Discussion

Most species found in our survey (about 87.1 %) were recorded by Langeani et al. (2007) for the upper Rio Paraná basin. However, these authors do not provide the distribution of species within the basin (see Langeani et al. 2007). Therefore, we contribute to the knowledge of the distribution of species into the Ribeirão Frutal basin, in the upper Rio Paraná system.

Recently, Santos et al. (2017) provided a list of species from two regions of the lower rio Preto, Rio Grande basin, in the upper Paraná system; relatively near the Ribeirão Frutal basin. These authors found representatives of the order Characiformes, Gymnotiformes, Cyprinodontiformes, Perciformes (=Cichliformes herein), Siluriformes, and Synbranchiformes (see Santos et al. 2017 for more details). In this work, we did not find any representatives of Gymnotiformes. As species of this order occur in the Rio Grande basin (Santos et al. 2017; see also Castro et al. 2004), it is possible that species of this order also occur at the present study location, but were merely not sampled.

Langeani et al. (2007) showed that Characidae and Loricariidae, in general, are the two most species-rich families of the upper Rio Paraná basin. In addition, several ichthyofaunal surveys (e.g., Pavanelli et al. 2007, Smith et al. 2007, Oliveira et al. 2009, Fagundes et al. 2015, Hoffmann et al. 2015, Cardoso et al. 2016, Frota et al. 2016, Santos et al. 2017) show this pattern in tributaries of the basin. However, in our work Cichlidae was the second most represented family (Fig. 3); probably due to the presence of two non-native species of this family (i.e., *Cichla* cf. *piquiti* and *Oreochromis niloticus*).

Satanoperca sp. (Fig. 4j) is probably the undescribed species previously mentioned by Ota (2013). According to Ota (2013), this species occurs in the Tocantins/Araguaia and upper Rio Paraná basins, but there is no certainty as to whether or not it is native to the upper Paraná basin. On the other hand, *Astyanax* sp. is very similar to

Table 1. Sampled localities in the Ribeirão Frutal basin, upper Rio Paraná system, Brazil.

Site	Coordinates	Remarks
S1	20° 0'14.97"S, 48°55'33.76"W	A tributary of left side of the Ribeirão Frutal; known as "Córrego do Jaó". It presents sections with riparian vegetation. A stretch upstream is dammed and forms a small reservoir. Near to the tributary there is an expansion of the urban perimeter.
S2	19°56'13.50"S, 48°56'56.50"W	Site in the upper portion of main channel of the Ribeirão Frutal.
S3	20°00'36.1"S, 48°56'39.3"W	A small tributary of right side of the Ribeirão Frutal. Unknown name.
S4	20°00'19.9"S, 48°56'37.2"W	Site in the middle portion of main channel of the Ribeirão Frutal. Region subject to the expansion of the urban perimeter.
S5	20°03'50.2"S, 48°56'49.6"W	Lower portion of left tributary of the Ribeirão Frutal; known as "Córrego do Marianinho". Its headwater is the target of the expansion of the urban perimeter.
S6	20°01'13.25"S, 48°56'25.08"W	A tributary of left side of the Ribeirão Frutal; known as "Vertente Grande". This tributary has much of its course within the urban perimeter (with sections channeled by cement). There are evidences that the tributary receives domestic effluents.
S7	19°55'41.5"S, 48°56'07.5"W	Headwater of the Ribeirão Frutal. Portions with presence of riparian vegetation and lotic habitats in which the water flows on rocky substratum.
S8	19°55'52.0"S, 48°56'05.1"W	The first tributary of the Ribeirão Frutal, left side. Unknown name.
S9	20°06'11.6"S, 48°57'32.2"W	Left side tributary of the Ribeirão Frutal. Unknown name. Probably one of the most heavily impacted tributaries with dams (forming small reservoirs) in different stretches. We observed the cultivation of oranges near to the affluent.
S10	20°04'25.3"S, 48°57'02.4"W	Left side tributary of the Ribeirão Frutal; known as "Córrego do Sal".

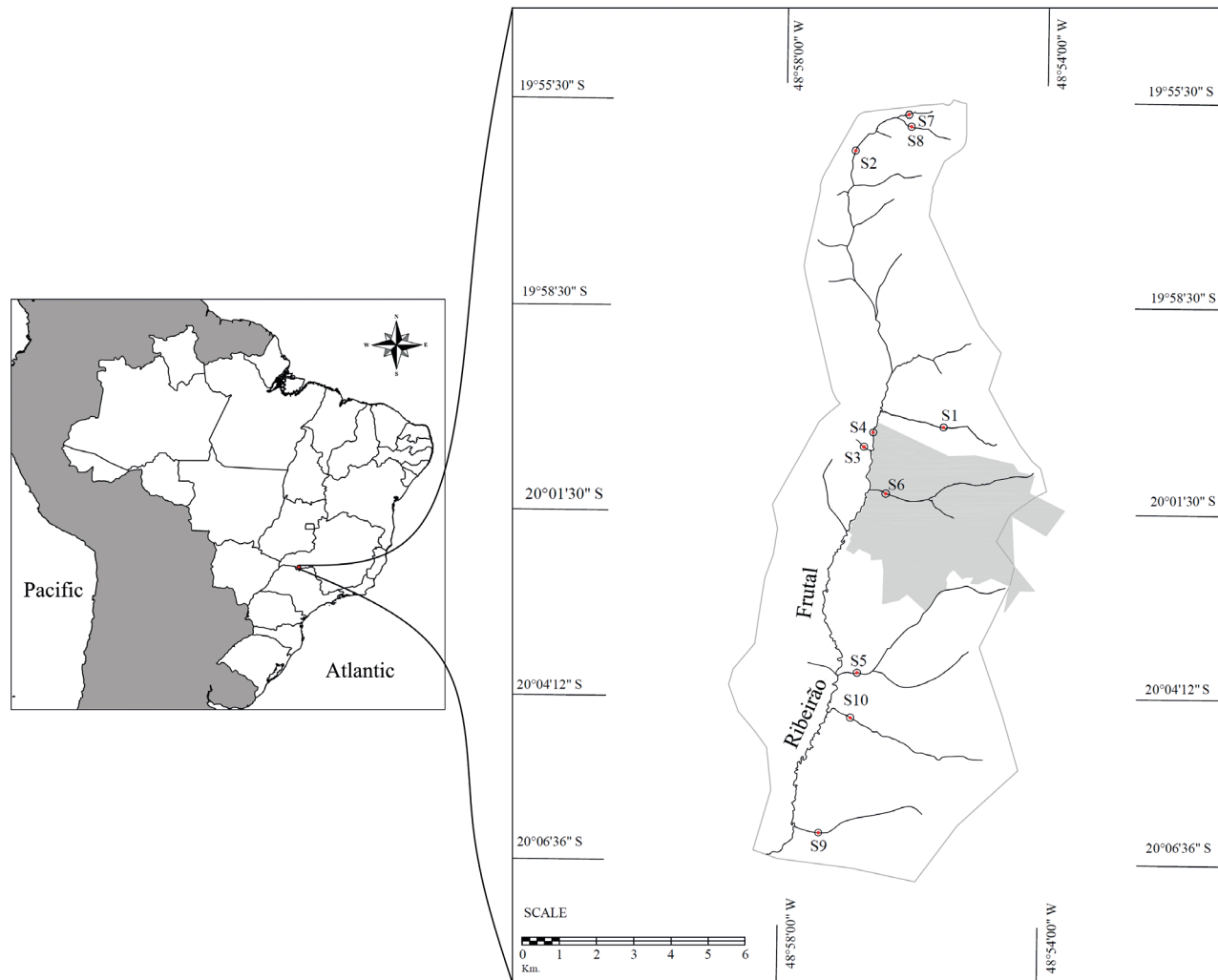


Figure 1. Map showing the Ribeirão Frutal basin with the sites sampled in the basin, upper Rio Paraná system, Brazil. Shaded area represents the urban perimeter of the Frutal municipality.

A. paranae Eigenmann, 1914. In addition, the species collected seems to have two morphotypes in the body shape. Only with further analysis, preferably including osteological and molecular data, can we be certain of its specific identification.

We found a total of five non-native species in Ribeirão Frutal basin: *Oreochromis niloticus*, native to the Afrotropical region (Welcomme 1988), *Poecilia reticulata*, described based on material from “Caracas” (Peters 1859, p. 412), in Venezuela, *Metynnis lippincottianus* and *C. cf. piquiti*, both native to the Amazon basin (Jégu 2003, Kullander & Ferreira 2006), and *Knodus moenkhausii*, which is not native to the upper Rio Paraná basin according to Langeani et al. (2007). *Hyphessobrycon eques* was found only in two tributaries of the Ribeirão Frutal basin (see Tab. 3). Castro et al. (2004) were not certain whether this species was native to the Rio Grande. With no evidence to suggest recent introduction of this species to the Ribeirão Frutal, we will tentatively

consider it to be native. All of the five aforementioned non-native species seem to be fully-established and reproducing at the collecting sites in Ribeirão Frutal basin.

Numerous small basins of the upper Rio Paraná system have been impacted by anthropogenic activities (e.g., Santos et al. 2017, this work). Therefore, modern and comprehensive ichthyological surveys are needed to effectively document the fish fauna of these small tributary basins. Obviously, together with these surveys, measures to avoid or minimize negative impacts to these environments should be adopted. For the Ribeirão Frutal basin, in particular, we recommended three first actions: (i) management of the non-native fish species mentioned here and initiatives to avoid new introductions (e.g., Azevedo-Santos et al. 2015); (ii) avoid urban sprawl over the basin; and (iii) remove the dams (i.e., small reservoirs) in the headwater streams of the basin.



Figure 2. Photos showing stretches of each sampling site (S1 to S10) from the Ribeirão Frutal basin, upper Rio Paraná system, Brazil.

Table 2. Fish species collected in the Ribeirão Frutal basin, upper Rio Paraná system, Brazil. Classifications follow Eschmeyer and Fong (2018)

Species	Voucher
CHARACIFORMES	
Crenuchidae	
<i>Characidium zebra</i> Eigenmann, 1909 ¹	LBP 24213
Parodontidae	
<i>Apareiodon ibitiensis</i> Campos, 1944 ¹	LBP 24406; LBP 24989
<i>Parodon nasus</i> Kner, 1859 ¹	LBP 23623; LBP 24412; LBP 24415; LBP 24429; LBP 24988
Serrasalmididae	
<i>Metynnys lippincottianus</i> (Cope, 1870)*	NUP 19142; LBP 24996
Characidae	
<i>Astyanax bockmanni</i> Vari & Castro 2007 ¹	LBP 25000
<i>Astyanax lacustris</i> (Lütken, 1875) ¹	LBP 23611; LBP 23616; LBP 24225
<i>Astyanax</i> sp.	NUP 19125; LBP 23609; NUP 19139; NUP 19131; NUP 19140; LBP 24402; LBP 24419; LBP 24420; LBP 24990; LBP 24995
<i>Bryconamericus turiuba</i> Langeani, Lucena, Pedrini & Tarelho-Pereira, 2005 ¹	NUP 19128; NUP 19134; LBP 24404; LBP 24407; LBP 24986
<i>Hyphessobrycon eques</i> (Steindachner, 1882) ¹	LBP 23604; LBP 24423; LBP 24980
<i>Knodus moenkhausii</i> (Eigenmann & Kennedy, 1903) ^{1,*}	NUP 19129; NUP 19132; NUP 19136; LBP 24217; NUP 19144; LBP 24403; LBP 24411; LBP 24425; LBP 24428; LBP 24982; LBP 24987; LBP 24999; LBP 25001
<i>Moenkhausia</i> cf. <i>intermedia</i> Eigenmann, 1908 ¹	LBP 23606
<i>Oligosarcus pintoii</i> Campos, 1945 ¹	LBP 23603; LBP 23675; LBP 23618
<i>Piabina argentea</i> Reinhardt, 1867 ¹	LBP 23612; LBP 24405; LBP 24413
<i>Serrapinnus notomelas</i> (Eigenmann, 1915) ¹	LBP 23607
SILURIFORMES	
Heptapteridae	
<i>Cetopsorhamdia iheringi</i> Schubart & Gomes, 1959 ¹	LBP 24408
<i>Imparfinis borodini</i> Mees & Cala, 1989 ¹	LBP 24410
<i>Rhamdia quelen</i> (Quoy & Gaimard, 1824) ¹	LBP 23622; LBP 24417; LBP 24983
Callichthyidae	
<i>Aspidoras fuscoguttatus</i> Nijssen & Isbrücker, 1976 ¹	NUP 19124; NUP 19127; NUP 19133; NUP 19137; LBP 23677; NUP 19138; LBP 24339; LBP 24401; LBP 24414; LBP 24418; LBP 24991
Loricariidae	
<i>Hypostomus ancistroides</i> (Ihering, 1911) ¹	NUP 19126; NUP 19130; NUP 19135; NUP 19141; LBP 23676; LBP 24215; LBP 24219; LBP 24223; LBP 24340; LBP 24424; LBP 24984; LBP 24998
<i>Hypostomus</i> cf. <i>iheringii</i> (Regan, 1908) ¹	LBP 24218; LBP 24993; LBP 25002
<i>Hypostomus nigromaculatus</i> (Schubart, 1964) ¹	LBP 23608; LBP 24220; LBP 24409; LBP 24427; LBP 24985
<i>Hypostomus</i> cf. <i>topavae</i> (Godoy, 1969) ¹	LBP 24416
SYNBRANCHIFORMES	
Synbranchidae	
<i>Synbranchus marmoratus</i> Bloch, 1795 ¹	LBP 25003
CICHLIFORMES	
Cichlidae	
<i>Cichla</i> cf. <i>piquiti</i> Kullander & Ferreira, 2006 ^{1,*}	LBP 23619
<i>Cichlasoma paranaense</i> Kullander, 1983 ¹	LBP 23605; LBP 23620; LBP 24979; LBP 24997
<i>Crenicichla britskii</i> Kullander, 1982 ¹	LBP 23617; LBP 24421
<i>Geophagus brasiliensis</i> (Quoy & Gaimard, 1824) ¹	LBP 23610; LBP 23674; LBP 23621; LBP 24422
<i>Oreochromis niloticus</i> (Linnaeus, 1758) ^{1,2,*}	LBP 23614; LBP 24222
<i>Satanoperca</i> sp.	NUP 19143; LBP 25426
CYPRINODONTIFORMES	
Poeciliidae	
<i>Phalloceros harpagos</i> Lucinda, 2008	UNT 016907; UNT 016908; UNT 016909; UNT 016910; UNT016911; LBP 24214; LBP 24216; LBP 24224; LBP 24981
<i>Poecilia reticulata</i> Peters, 1859 ^{1,2,*}	LBP 23613; LBP 23615; LBP 24221; LBP 24226; LBP 24992; LBP 24994

¹ Species recorded by Langeani et al. (2007) for the upper Rio Paraná basin. ² Species recorded (without voucher) by Azevedo-Santos & Coelho (2017) for the Vertente Grande, Ribeirão Frutal basin. * Non-native species in the Ribeirão Frutal basin.

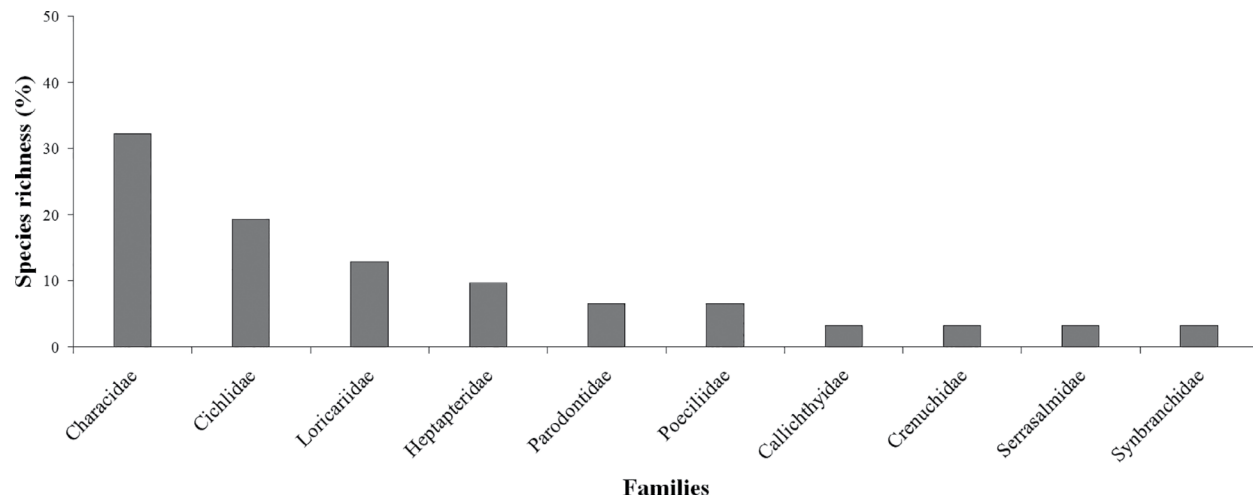


Figure 3. Species richness (%) of each fish family collected in Ribeirão Frutal basin, upper Rio Paraná system, Brazil.

Table 3. Species collected (X) in each site (S1 to S10) of the Ribeirão Frutal basin, upper Rio Paraná system, Brazil.

Species	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
<i>Apareiodon ibitiensis</i>				X						
<i>Aspidoras fuscoguttatus</i>	X	X		X	X	X	X			
<i>Astyanax bockmanni</i>										X
<i>Astyanax lacustris</i>				X					X	
<i>Astyanax</i> sp.	X	X	X	X			X	X		
<i>Bryconamericus turiuba</i>		X		X						
<i>Cetopsorhamdia iheringi</i>				X						
<i>Characidium zebra</i>	X									
<i>Cichla</i> cf. <i>piquiti</i>									X	
<i>Cichlasoma paranaense</i>			X						X	
<i>Crenicichla britskii</i>									X	
<i>Geophagus brasiliensis</i>				X		X			X	
<i>Hyphessobrycon eques</i>			X						X	
<i>Hypostomus ancistroides</i>	X	X		X	X	X			X	
<i>Hypostomus</i> cf. <i>iheringii</i>					X					X
<i>Hypostomus nigromaculatus</i>				X	X					X
<i>Hypostomus</i> cf. <i>topavae</i>						X				
<i>Imparfinis borodini</i>				X						
<i>Knodus moenkhausii</i>		X	X	X	X				X	X
<i>Metynnis lippincottianus</i>									X	
<i>Moenkhausia</i> cf. <i>intermedia</i>			X							
<i>Oligosarcus pintoii</i>			X			X			X	
<i>Oreochromis niloticus</i>						X				
<i>Parodon nasus</i>				X	X					X
<i>Phalloceros harpagos</i>		X	X	X	X			X		X
<i>Piabina argentea</i>		X		X						
<i>Poecilia reticulata</i>				X	X	X				X
<i>Rhamdia quelen</i>				X		X				X
<i>Satanoperca</i> sp.									X	
<i>Serrapinnus notomelas</i>			X							
<i>Synbranchus marmoratus</i>										X
Species richness	4	7	8	16	8	8	2	2	11	9

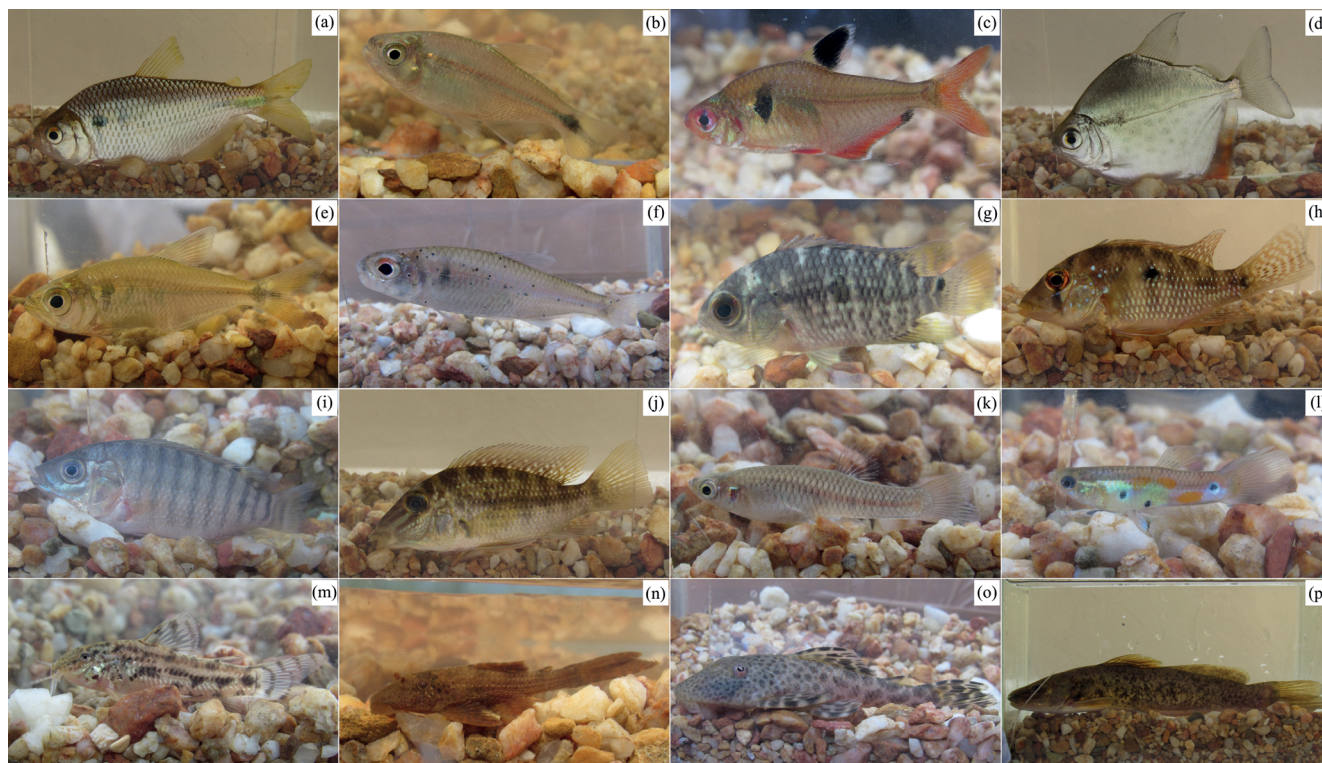


Figure 4. Live specimens representing several of the species collected in Ribeirão Frutal basin: (a) *Astyanax lacustris*, LBP 23616; (b) *Astyanax* sp., NUP 19125; (c) *Hyphessobrycon eques*, LBP 23604; (d) *Metynnis lippincottianus*, NUP 19142; (e) *Oligosarcus pintoii*, LBP 23603; (f) *Piabina argentea*, LBP 23612; (g) *Cichlasoma paranaense*, LBP 23605; (h) *Geophagus brasiliensis*, LBP 23621; (i) *Oreochromis niloticus*, LBP 23614; (j) *Satanoperca* sp., NUP 19143; (k) *Phalloceros harpagos*, UNT 016907; (l) *Poecilia reticulata*, LBP 23615; (m) *Aspidoras fuscoguttatus*, NUP 19127; (n) *Hypostomus ancistroides*, NUP 19130; (o) *Hypostomus nigromaculatus*, LBP 23608; (p) *Rhamdia quelen*, LBP 23622.

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Authors' Contributions

Valter M. Azevedo-Santos formulated the idea. Valter M. Azevedo-Santos and Paula N. Coelho performed the field work including collection of all the specimens. All authors collaborated with the identification, data analysis, and writing of the manuscript.

Conflicts of Interest

We, the authors, declare that we have no conflicts of interest related to the publication of this article.

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