

Checklist of freshwater ichthyofauna from coastal streams of Juréia-Itatins reserve, southeastern Brazil

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ABSTRACT: The Juréia-Itatins Ecological Station (JIES) is one of the few protected areas in the state of São Paulo, which harbor a significant portion of the Atlantic forest. Although there is high diversity and endemism of fish species in this region, knowledge of the ichthyofauna in JIES is incipient. A total of 4,809 specimens belonging to six orders, 15 families and 31 species were captured during April 2009 to February 2010, using electrofishing, gillnets and traps. The family Characidae was predominant, mainly due to the abundance of freshwater species such as *Astyanax ribeirae*, *Mimagoniates microlepis*, and *Hollandichthys multifasciatus*. Although the estuarine regions were rarely sampled in this study, six brackish water species were captured. In this study, nine species previously unknown from JIES were discovered. Five endangered fish species, endemic to the Atlantic forest, occur at JIES, thus the presence of protected areas, as a conservation measure, is particularly relevant.

INTRODUCTION

The freshwater fish fauna of the Neotropical region is one of the richest in the world and includes 6,025 species (Reis *et al.* 2003) of the 32,000 that are recognized (Eschmeyer 2011). Brazil encompasses the majority of this diversity, and despite the recent increase in discoveries and descriptions of new species, it is still far from being completely known. Recent estimates suggest that 2,587 species occur in Brazil (Buckup *et al.* 2007) and 393 occur in the state of São Paulo (Oyakawa and Menezes 2011).

Four main hydrographic systems are recognized in the state of São Paulo: upper Paraná River basin, Paraíba do Sul River basin, Ribeira de Iguape River basin, and the “coastal basin” in which a set of small independent coastal drainages that flow directly into the Atlantic Ocean are included (Oyakawa and Menezes 2011). The knowledge of the ichthyofauna from the Ribeira de Iguape basin and coastal drainages in the state of São Paulo is still unsatisfactory, considering the enormous diversity of species in this region (Bizerril 1994; 1995; Ribeiro 2006; Menezes *et al.* 2007; Abilhoa *et al.* 2011; Oyakawa and Menezes 2011).

The still incomplete knowledge of the ichthyofauna in the streams of the Atlantic forest is concerning (Menezes *et al.* 2007) because of the extremely threatened nature of the biome, especially due to deforestation caused by human pressure (Ribeiro *et al.* 2009). The Juréia-Itatins Ecological Station (JIES), where this study was carried out, is one of the few protected areas in the state of São Paulo, which harbor a significant portion of this biome. In spite of the high diversity and endemism of the freshwater fish species in this region of the Atlantic forest, knowledge of the ichthyofauna from JIES can still be considered incipient.

In this study, a list of the freshwater ichthyofauna of the coastal streams from JIES is provided expecting to contribute to the knowledge of species distribution, which can be useful for better management and conservation of

the fish fauna of the Atlantic forest biome.

MATERIALS AND METHODS

Study site

JIES is a reserve located on the south coast of the state of São Paulo (24°18'–24°32' S, 47°00'–47°30' W) (Figure 1). The area of JIES is approximately 80,000 ha and covers the municipalities of Iguape, Peruíbe, Miracatu, and Itariri. In this region, the climate is classified as humid subtropical, and without a dry season. The warmer and wetter season occurs from October to April, and a less pronounced rainy season occurs from May to September. The average annual rainfall and temperature are 2,277 mm and 21.4°C, respectively (Marques and Duleba 2004). The main river in the JIES is Una do Prelado, a lowland and medium-sized river which runs parallel to the sea shore surrounding the Jureia mountain range (Por 1986, 2004), but several smaller streams that drain directly into the sea, as the selected ones in the present study, are also present.

Data collection

Thirty sites were sampled (Table 1, Figure 2). Four samplings from April 2009 to February 2010 were conducted quarterly at S1-S19 sites. Sites S20-S30 were additionally sampled once to increase sampling coverage.

Electrofishing, gillnets (meshes 1.5, 2.0, 2.5, 3.0, 3.5 cm between adjacent knots), and traps, were used to catch fishes depending on the characteristics of each environment (Table 1). Electrofishing gear was used depending on field conditions in stretches of 50 m, consisting in one passage of the equipment. The electrofisher used at sampled sites with easy access consisted of a rectifier current (connected to two dip nets) powered by a gasoline-driven generator. A backpack electrofisher was used at sampled sites without easy access and was also connected to two dip nets. The voltage used was 500 V (direct current). The dip nets were handled by two people walking slowly upstream in the

opposite direction to the stream flow to the 50 m upper limit. Gillnets and traps were set in the afternoon and removed in the morning of the following day.

Fishes were euthanized with benzocaina, fixed in 10% formalin, and then kept in 70% alcohol prior to analysis. Specimens were weighted (g). Specialists were consulted to identify the fish species. Voucher specimens of freshwater species are deposited in the fish collection of “Departamento de Zoologia e Botânica, UNESP, São José do Rio Preto (SP)” (DZSJRP 13234-13258), and estuarine species are deposited in the fish collection of “Museu de Zoologia da Universidade de São Paulo” (MZUSP 110173-110180). Collection permits were issued under IBAMA/ICMBio (15744) and COTEC (260108-000.197/0 2008). For each species, spell checks, authorships and dates of publication were in accordance with Eschmeyer (2011).

RESULTS AND DISCUSSION

A total of 4,809 specimens belonging to six orders, 15 families and 31 species of fish (25 freshwater species, and six brackish species) were captured during fieldwork (Table 2, Figure 3). The orders Characiformes and Siluriformes were predominant, but Characiformes was the most representative in terms of species richness, number of individuals, and biomass (Figure 4). The family Characidae was predominant (Figure 5), mainly due to the abundance of *Astyanax ribeirae*, *Mimagoniates microlepis*, and *Hollandichthys multifasciatus*. The freshwater fish fauna in the sampled streams in JIES is similar to other Brazilian

coastal basins, with the predominance of Characiformes and/or Siluriformes (Sabino and Castro 1990; Mazzoni and Lobón-Cerviá 2000; Esteves and Lobón-Cerviá 2001; Uieda and Uieda 2001; Gerhard *et al.* 2004; Serra *et al.* 2007; Ferreira and Petrere Jr. 2009; Guimarães *et al.* 2010; Mattox and Iglesias 2010), and confirms with what is expected in freshwater environments included in the studied region (Lévêque *et al.* 2008). The representation of the Characidae species was also expected, since this family is one of the most species-rich in the Neotropical region (Reis *et al.* 2003).

Considering only freshwater fish species from JIES, Sabino and Silva (2004) and Oyakawa *et al.* (2006) listed 35 and 34 species, respectively (Table 3). The difference between the species richness previously found with respect to that reported in the current study (25 species) is probably related to the degree of isolation of many streams. According to Winemiller *et al.* (2008), larger drainages tend to exhibit higher species richness (local and regional). Sabino and Silva (2004) and Oyakawa *et al.* (2006) sampled the Espirado River which is directly inserted into a larger river system (tributary of the Una da Aldeia River which flows into the Ribeira de Iguape River), instead of the low-order streams sampled in the present study and, therefore, those authors found a greater species richness than us. Nevertheless, this study added nine species, including the freshwater species *Pseudotothyris obtusa*, *Scleromystax macropterus*, *Characidium lauroi*, *Hyphessobrycon griemi*, *Hyphessobrycon reticulatus*, *Rivulus santensis*, and the

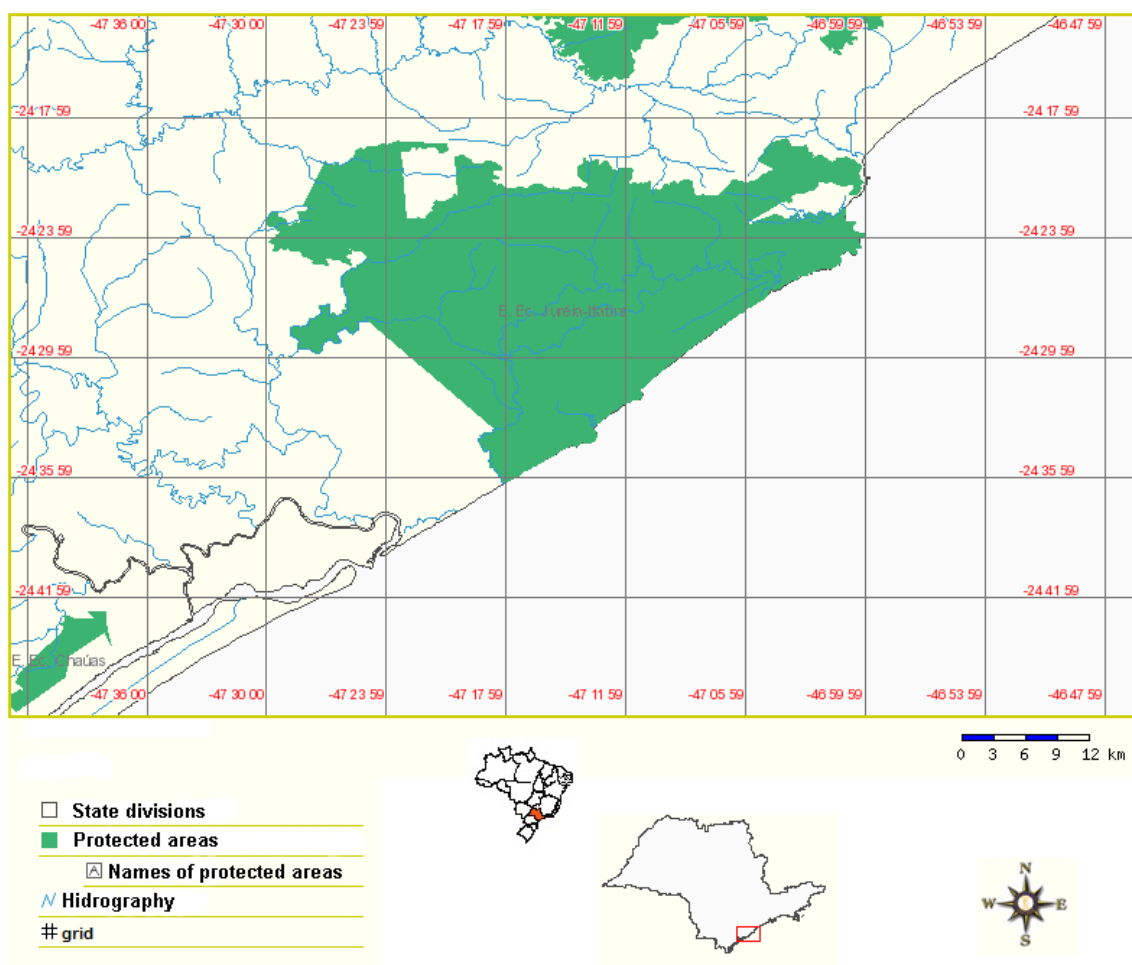


FIGURE 1. Location of Juréia-Itatins Ecological Station in the State of São Paulo, southeastern Brazil.

TABLE 1. Location of sampling sites and sampling methods used to catch fish species at Juréia-Itatins Ecological Station, between April 2009 and February 2010. All sites were located within coastal basin.

SITES	STREAMS	COORDINATES	SAMPLING METHODS
1	Ribeirão das Antas	24°21'26.90" S, 47°02'15.60" W	Backpack electrofisher and two traps
2		24°21'37.00" S, 47°02'15.20" W	Electrofisher
3		24°21'43.28" S, 47°02'15.34" W	Electrofisher, gillnets and two traps
4	Ribeirão Tetequera	24°23'18.00" S, 47°05'53.70" W	Backpack electrofisher and two traps
5		24°23'25.70" S, 47°05'49.30" W	Electrofisher
6		24°23'00.20" S, 47°04'50.30" W	Electrofisher, gillnets and two traps
7	Ribeirão Grajaúna	24°31'03.10" S, 47°12'48.90" W	Backpack electrofisher and two traps
8		24°31'08.10" S, 47°12'42.90" W	Backpack electrofisher
9		24°31'17.30" S, 47°12'04.40" W	Backpack electrofisher and two traps
10	Unnamed stream	24°32'18.80" S, 47°12'46.40" W	Backpack electrofisher and two traps
11		24°32'23.00" S, 47°12'44.90" W	Backpack electrofisher
12		24°32'30.00" S, 47°12'39.60" W	Electrofisher and two traps
13	Rio Verde	24°32'52.60" S, 47°14'37.20" W	Backpack electrofisher and two traps
14		24°32'52.10" S, 47°14'17.50" W	Backpack electrofisher
15		24°32'54.10" S, 47°14'04.50" W	Electrofisher, gillnets and two traps
16	Unnamed stream	24°33'05.50" S, 47°13'55.70" W	Backpack electrofisher and two traps
17		24°33'02.50" S, 47°13'55.90" W	Backpack electrofisher
18		24°32'59.47" S, 47°13'57.97" W	Backpack electrofisher and two traps
19	Rio Preto	24°31'17.30" S, 47°12'04.40" W	Backpack electrofisher and two traps
20	Rio Sabão	24°31'25.90" S, 47°11'52.00" W	Gillnets and two traps
21	Ribeirão da Ponte Alta	24°31'19.10" S, 47°12'02.50" W	Gillnets and two traps
22	Unnamed stream	24°33'02.06" S, 47°14'04.95" W	Backpack electrofisher and two traps
23		24°33'00.93" S, 47°14'04.12" W	Backpack electrofisher
24		24°32'59.05" S, 47°14'02.63" W	Backpack electrofisher and two traps
25	Cachoeira do Salto	24°32'41.46" S, 47°13'50.49" W	Four traps
26	Ribeirão Tetequera	24°23'23.10" S, 47°05'58.80" W	Backpack electrofisher
27	Rio Paícaúna	24°28'39.58" S, 47°07'43.30" W	Gillnets and two traps
28	Ribeirão Boguçá	24°28'54.71" S, 47°13'02.05" W	Backpack electrofisher
29	Rio Perequê	24°22'32.40" S, 47°03'59.19" W	Backpack electrofisher
30	Rio Itinguçú	24°24'02.77" S, 47°07'11.54" W	Backpack electrofisher

brackish-water species *Ctenogobius shufeldti*, *Dormitator maculatus*, *Eleotris pisonis*, which were not previously recorded at JIES.

The ichthyofauna from JIES surveyed to date (see Table 3) shares several fish species with Ribeira de Iguape (44 species) and coastal basin (25 species), but few species with upper Paraná (14 species) and Paraíba do Sul (13 species), considering only freshwater fish species registered in the four main drainages in the state of São Paulo (upper Paraná, Paraíba do Sul, Ribeira de Iguape, and the coastal basin) by Oyakawa and Menezes (2011). Ichthyofauna sharing among coastal rivers and adjacent basins is expected (Serra *et al.* 2007). Furthermore, 21 species are endemic to Atlantic forest streams (see Table 3). The high geographic isolation among freshwater systems usually results in high endemism (Castro 1999), and the high rate of species endemism in coastal drainages in these forests (Bizerril 1994; Backup 1999; Ribeiro 2006), was confirmed in this study and others (e.g. Esteves and Lobón-Cerviá 2001; Abilhoa and Bastos 2009; Mattox and Iglesias 2010; Nogueira *et al.* 2010).

The endemism can increase the vulnerability of species to human impact (Nogueira *et al.* 2010). Sixty-six of the 391 fish species that occur in the state of São Paulo are under threat of extinction and of these, 19 occur in Ribeira de Iguape River basin and 14 in coastal drainages (Oyakawa *et al.* 2009). In JIES, five threatened species have been recorded to date (see Table 3). The Serra do Mar is embedded in a densely populated region of Brazil, where the Atlantic forest is under strong anthropogenic pressure, mainly at *restinga* forest. The remaining fragments are located in areas legally protected by conservation units, such as JIES. Since fish of this region represent a significant portion of the ichthyofauna of this biome (Oyakawa *et al.* 2006), the creation of new protected areas as a conservation measure, such as the *Restinga de Bertioaga* State Park recently created, is particularly relevant.

Although the estuarine regions were rarely sampled in this study, six brackish-water species were captured: *Genidens genidens*, *Centropomus parallelus*, *Eleotris pisonis*, *Dormitator maculatus*, *Awaous tajasica*, and *Ctenogobius shufeldti*. Coastal streams can be influenced by the sea in estuarine areas that are subject to a tidal influence (Por 1986), thus the presence of estuarine fish in the lower reaches of some freshwater streams in JIES was expected. Leung and Camargo (2005) stated that most of these species are euryhaline and therefore would not have difficulties when entering rivers with low salinity, and probably this dependence with estuarine environments is related to their catadromous or amphidromous conditions. In addition, the occurrence of marine-estuarine species in coastal streams decreases as the distance from the estuary increases (Leung and Camargo 2005). Nevertheless, *A. tajasica* was found in distant reaches with little or no marine influence in two streams at JIES, as recorded by Uieda and Uieda (2001), Sabino and Silva (2004), and Guimarães *et al.* (2010) in other Brazilian coastal streams.

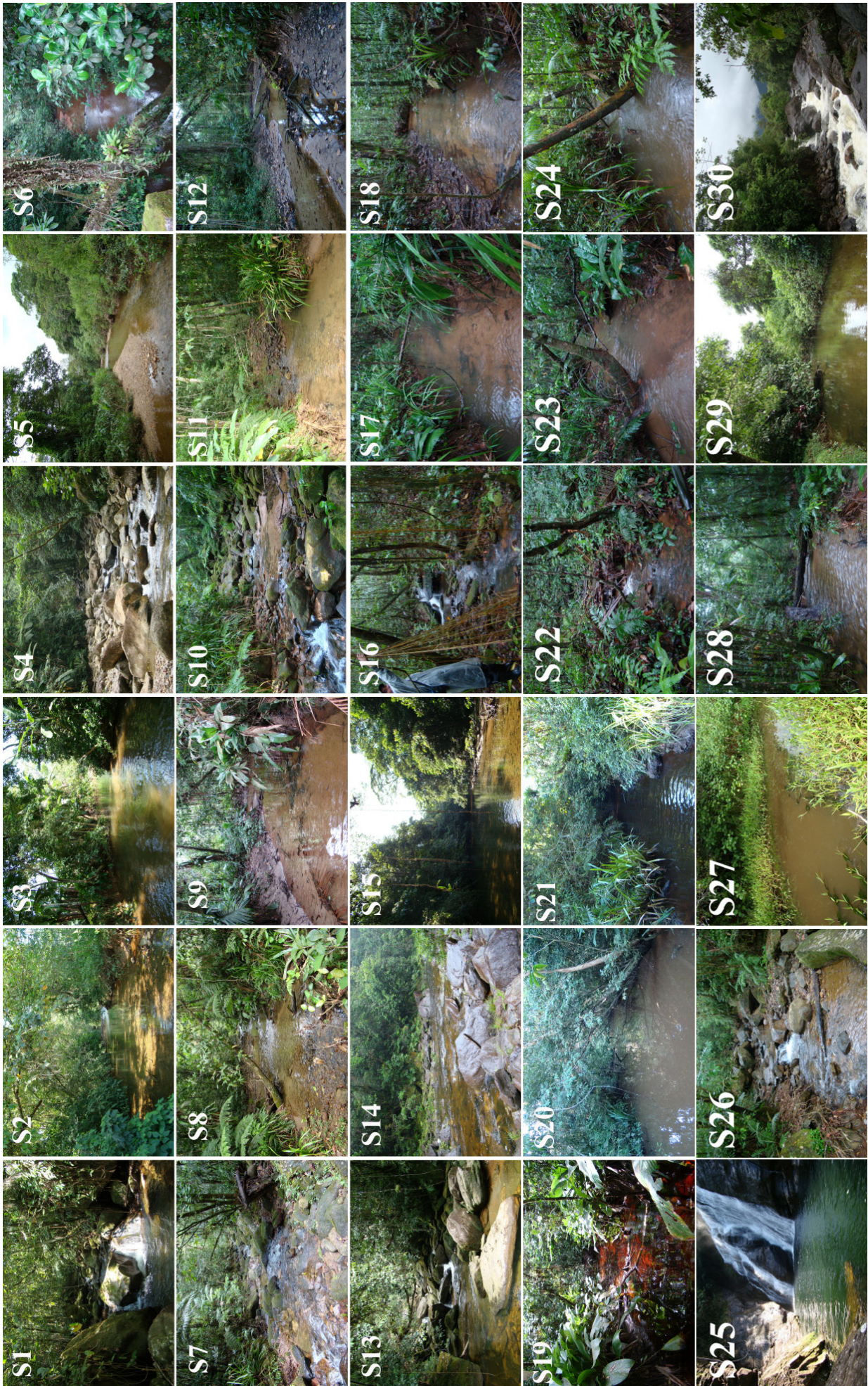


FIGURE 2. Partial view of sample sites located at Juréia-Itatins Ecological Station, southeastern Brazil. See Table 1 for sample codes.

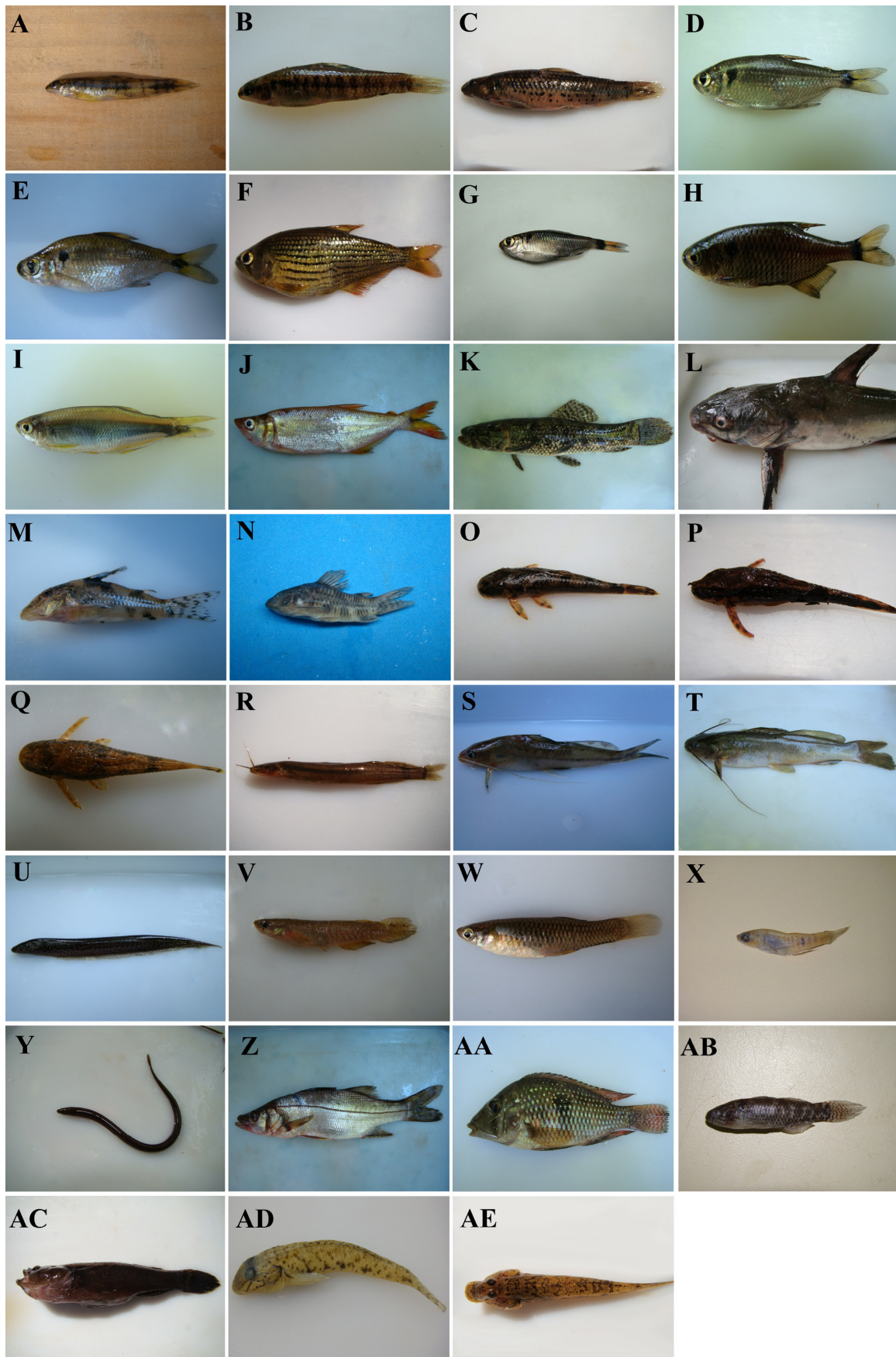


FIGURE 3. Fish fauna sampled in Juréia-Itatins Ecological Station, between April 2009 and February 2010. Total length is shown after each species. A) *Characidium lauroi* 40 mm, B) *Characidium cf. pterostictum* 40 mm, C) *Characidium cf. schubarti* 64 mm, D) *Astyanax ribeirae* 49 mm, E) *Deuterodon iguape* 75 mm, F) *Hollandichthys multifasciatus* 88 mm, G) *Hyphessobrycon griemi* 28 mm, H) *Hyphessobrycon reticulatus* 48 mm, I) *Mimagoniates microlepis* 36 mm, J) *Oligosarcus hepsetus* 180 mm, K) *Hoplias malabaricus* 264 mm, L) *Genidens genidens* 328 mm, M) *Scleromystax barbatus* 58 mm, N) *Scleromystax macropterus* 48 mm, O) *Kronichthys heylandi* 44 mm, P) *Pseudotothyris obtusa* 28 mm, Q) *Schizolecis guntheri* 39 mm, R) *Acentronichthys leptos* 89 mm, S) *Pimelodella transitoria* 78 mm, T) *Rhamdia quelen* 216 mm, U) *Gymnotus pantherinus* 200 mm, V) *Atlantirivulus santensis* 41 mm, W) *Phalloceros reisi* 34 mm, X) *Phalloptychus januaris* 23 mm, Y) *Synbranchus marmoratus* 270 mm, Z) *Centropomus parallelus* 270 mm, AA) *Geophagus brasiliensis* 62 mm, AB) *Dormitator maculatus* 69 mm, AC) *Eleotris pisonis* 107 mm, AD) *Awaous tajasica* 41 mm, and AE) *Ctenogobius shufeldti* 50 mm. Photos: Cristina da Silva Gonçalves.

TABLE 2. List of fish species captured in freshwater streams of Juréia-Itatins Ecological Station, between April 2009 and February 2010. *Brackish-water fish species.

TAXA	SAMPLING SITES																																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30						
CHARACIFORMES																																				
Crenuchidae																																				
<i>Characidium lauroi</i> Travassos, 1949	x	x	x	x	x	x	x	x	x		x								x	x	x															
<i>Characidium cf. pterostictum</i> Gomes, 1947																																				
<i>Characidium cf. schubarti</i> Travassos, 1955	x																																			
Characidae																																				
<i>Astyanax ribeirae</i> Eigenmann, 1911	x	x	x	x	x	x	x	x																												
<i>Deuterodon iguape</i> Eigenmann, 1907																																				
<i>Hollandichthys multifasciatus</i> (Eigenmann and Norris, 1900)	x																																			
<i>Hyphessobrycon griemi</i> Hoedeman, 1957																																				
<i>Hyphessobrycon reticulatus</i> Ellis, 1911																																				
<i>Mimagoniatales microlepis</i> (Steindachner, 1877)	x	x																																		
<i>Oligosarcus hepsetus</i> (Cuvier, 1829)																																				
Erythrinidae																																				
<i>Hoplias malabaricus</i> (Bloch, 1794)	x	x																																		
SILURIFORMES																																				
Ariidae																																				
<i>Genidens genidens</i> (Cuvier, 1829)*																																				
Callichthyidae																																				
<i>Scleromystax barbatus</i> (Quoy and Gaimard, 1824)																																				
<i>Scleromystax macropterus</i> (Regan, 1913)																																				
Loricariidae																																				
<i>Kronichthys heylandi</i> (Boulenger, 1900)																																				
<i>Pseudotothyris obtusa</i> (Miranda Ribeiro, 1911)																																				
<i>Schizolecis guntheri</i> (Miranda Ribeiro, 1918)																																				
Heptapteridae																																				
<i>Acentronichthys leptos</i> Eigenmann and Eigenmann, 1889	x	x																																		
<i>Pimelodella transitoria</i> Miranda Ribeiro, 1907																																				
<i>Rhamdia quelen</i> (Quoy and Gaimard, 1824)	x	x																																		
GYMNOTIFORMES																																				
Gymnotidae																																				
<i>Gymnotus pantherinus</i> (Steindachner, 1908)																																				
CYPRINODONTIFORMES																																				
Rivulidae																																				
<i>Atlantirivulus santensis</i> Köhler, 1906																																				
Poeciliidae																																				
<i>Phalloceros reisi</i> Lucinda, 2008	x	x																																		
<i>Phalloptychus januarius</i> (Hensel, 1868)	x																																			

TABLE 3. CONTINUED.

SPECIES	Sabino and Silva (2004)	Oyakawa et al. (2006)	Present study	Oyakawa and Menezes (2011)
Curimatidae				
<i>Glyphocharax santacatarinae</i> ¹	x			R, C
Erythrinidae				
<i>Hoplias lacerdae</i> ^{1,2}	x			R
<i>Hoplias malabaricus</i>		x	x	R, C, UP, PS
SILURIFORMES				
Ariidae				
<i>Genidens genidens</i> ³	x		x	
Auchenipteridae				
<i>Glanidium</i> sp.	x			
Gallichthyidae				
<i>Scleromystax barbatus</i> ¹	x	x	x	R, C, PS
<i>Scleromystax macropterus</i> ^{1,2}		x	x	R, C
<i>Scleromystax prionotos</i> ^{1,2}		x		R, C
Heptapteridae				
<i>Acentronichthys leptos</i> ¹	x	x	x	R, C
<i>Pimelodella transitoria</i> ¹		x	x	R
<i>Pimelodella</i> sp.	x			
<i>Rhamdia quelen</i>	x	x	x	R, C, UP, PS
<i>Rhamdioglanis frenatus</i> ¹	x			C
<i>Rhamdioglanis transfaciatus</i> ¹		x		R
Loricariidae				
<i>Ancistrus multispinis</i> ¹ (<i>Ancistrus</i> sp.)	x	x		R
<i>Harttia kronei</i> ¹	x			R
<i>Hisonotus leucofrenatus</i> ¹		x		R
<i>Hypostomus</i> sp.	x			
<i>Kronichthys heylandi</i> ¹	x		x	C
<i>Kronichthys lacerta</i> ¹		x		R
<i>Kronichthys subteres</i> ¹		x		R
<i>LampIELLA gibbosa</i> ¹	x			R
<i>Otocinclus affinis</i> ¹		x		R
<i>Parotocinclus maculicauda</i> ¹		x		R, C
<i>Pseudotothyris obtusa</i> ¹			x	R, C
<i>Rineloricaria cf. lima</i>	x			R, PS
<i>Rineloricaria</i> sp.				
<i>Schizolecis guntheri</i> ¹	x	x	x	R, C
Pimelodidae				
<i>Pimelodus</i> sp.	x			
Pseudopimelodidae				
<i>Microglanis</i> sp.	x			

TABLE 3. CONTINUED.

SPECIES	Sabino and Silva (2004)	Oyakawa et al. (2006)	Present study	Oyakawa and Menezes (2011)
Trichomycteridae				
<i>Trichomycterus zonatus</i> ¹		x		R, C
<i>Microcambeva ribeirae</i> ¹		x		R
<i>Microcambeva</i> sp.	x			
GYMNOTIFORMES				
Hypopomidae				
<i>Brachyhypopomus jureiae</i> ^{1,2}		x		C
Gymnotidae				
<i>Gymnotus carapo</i>		x		R, UP, PS
<i>Gymnotus pantherinus</i> ¹	x	x	x	R, C, UP, PS
CYPRINODONTIFORMES				
Poeciliidae				
<i>Phalloceros reisi</i> (<i>P. caudimaculatus</i>) ¹	x	x	x	R, C, UP
<i>Phalloptychus januarius</i> (<i>Phalloptychus</i> sp.) ¹	x		x	C
Rivulidae				
<i>Atlantirivulus santensis</i> ¹			x	R, C, UP
SYBRANCHIFORMES				
Synbranchidae				
<i>Synbranchus marmoratus</i> (<i>Synbranchus</i> sp.)	x		x	R, UP, PS
PERCIFORMES				
Carangidae				
<i>Caranx hippos</i> ³	x			
<i>Caranx latus</i> ³	x			
Centropomidae				
<i>Centropomus parallelus</i> ³	x		x	
Cichlidae				
<i>Australoheros ribeirae</i> ("Cichlasoma" facetum) ¹	x			R
<i>Crenicichla iguapima</i> (<i>Crenicichla lacustris</i> , <i>Crenicichla</i> sp.) ¹	x	x		R
<i>Geophagus brasiliensis</i>	x		x	C, UP, PS
<i>Geophagus iporangensis</i> ¹			x	R
Eleotriidae				
<i>Dormitator maculatus</i> ³			x	
<i>Eleotris pisonis</i> ³			x	
Gobiidae				
<i>Awaous tajasca</i> ³	x		x	
<i>Bathygobius soporator</i> ³	x			
<i>Ctenogobius shufeldti</i> ³			x	
Sciaenidae				
<i>Bardiella ronchus</i> ³	x			
<i>Micropogonias furnieri</i> ³	x			

TABLE 3. CONTINUED.

SPECIES	Sabino and Silva (2004)	Oyakawa et al. (2006)	Present study	Oyakawa and Menezes (2011)
SYNGNATIFORMES				
Syngnathidae				
<i>Microphis</i> sp. ³	x			
<i>Syngnathus</i> sp. ³	x			
MUGILIFORMES				
Mugilidae				
<i>Mugil curema</i> ³	x			
Total	46	34	31	
Freshwater species	35	34	25	
Brackish water species	11	0	6	
Endemic species	23	29	21	
Threatened species	2	3	1	

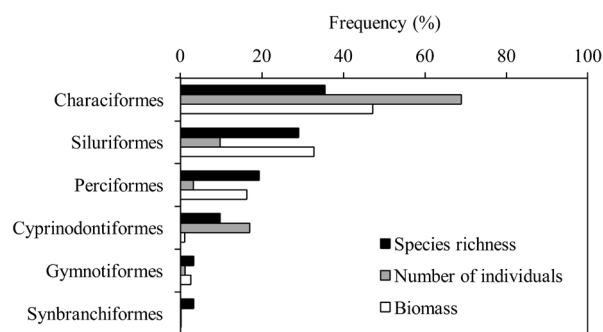


FIGURE 4. Species richness, number of individuals and biomass, according to fish orders sampled in freshwater streams of Juréia-Itatins Ecological Station.

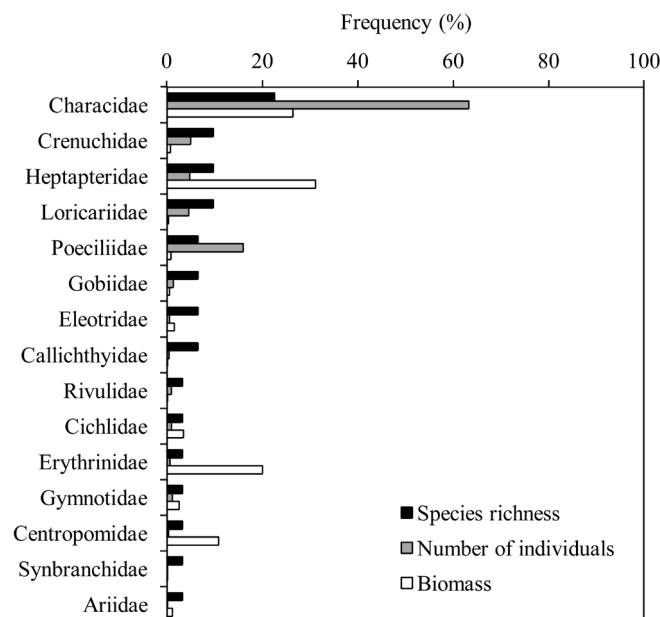


FIGURE 5. Species richness, number of individuals and biomass, according to fish families sampled in freshwater streams of Juréia-Itatins Ecological Station.

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