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Lists of Species

Fishes (Osteichthyes: Actinopterygii) from the Pirapó River drainage, upper Paraná River basin, Paraná state, Brazil

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Abstract: In this study we conducted an ichthyofaunistic survey in the Pirapó River drainage, upper Paraná River basin, based on voucher specimens deposited in the Coleção Ictiológica do Nupélia/UEM. We reported a total of six orders, 23 families, and 76 species, in which four of them were classified as allochthonous and two as exotics. Twenty-eight percent of these species were recorded only for tributaries, whereas the commercially important migratory species, Dourado - *Salminus brasiliensis* (Cuvier, 1816), was recorded in the main channel, indicating that the Pirapó River, still free from impoundments, may be one of the last rivers in the upper Paraná River basin that can be used to protect migratory fish species.

Introduction

The Pirapó River is one of the main tributaries of the Paranapanema River, in the upper Paraná River basin (Maack 2002). Since colonization of the northern region of Paraná state, the Pirapó River drainage has suffered severe environmental changes, mainly from an increase in agricultural activities and urban growth (Passos 2007).

Cunico *et al.* (2012) verified a series of urbanization effects on fish assemblages in some Pirapó River tributaries, such as a decrease in species richness and an increase in density of non-native fish species. Hoffmann *et al*. (2005) suggested 10 hydroelectric power plants along the Paranapanema River may contribute to changes in fish assemblage structure across its entire watershed, even for those tributaries still free from impoundments, as the Pirapó River.

These findings reveal a need for investigations into the species diversity of the Pirapó River drainage. Therefore, the aim of this study was to present a fish species inventory for this water basin, in order to provide information for further works on ichthyofaunistic organization, as well as to support conservation plans to preserve the physical and biotic integrity of the Pirapó River and its surrounding areas.

Materials and Methods

Study site

The state of Paraná is subdivided in two major drainage basins, and the Serra do Mar is the main watershed. Those rivers from the smaller hydrographic complex (Eastern basin; 14,674 km^2) flow directly into the Atlantic Ocean through the Ribeira de Iguape River valley, whereas those from the greater hydrographic complex (186,321 km^2) remain inland and as part of the Paraná River basin. The Pirapó River (22°30' S, 52°15' W; 23°30' S, 51°15' W), with a drainage area of approximately 5,000 km^2, is located in the northern region of Paraná state, upper Paraná River basin (Figure 1A). From its source in Apucarana city, to its mouth, on the Paranapanema River, the Pirapó River flows 168 km in a humid subtropical region characterized by hot summers, Cfa (h) (Maack 2002). The average annual temperature is 16-20°C, with January being the warmest and rainiest month, and July the coldest and driest month. The average annual rainfall indices are >1,000 mm (Passos 2007).

Data Collection

The species list was elaborated from voucher species deposited in the Coleção Ictiológica do Núcleo de Pesquisas em Limnologia Ictiologia e Aquicultura - Nupélia, Universidade Estadual de Maringá - UEM, *http://peixe.nupelia.uem.br/*. These species were collected by the authors (Pirapó River channel and Bandeirantes do Norte River, Figure 1A) and cited in previous works (Cunico *et al*. 2009, Figure 1B), from 10 small headwater streams:

Pirapó River channel and Bandeirantes do Norte River - Fieldworks were carried out at six sampling sites: five in the Pirapó River channel and one in its main tributary, the Bandeirantes do Norte River (Figure 1A). Physical and chemical variables were measured at these same sites (Table 1). Fishes were sampled (one collect in each sampling site) in September, 2004, under license granted by the Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis - IBAMA, to Nupélia/UEM (004/2001, Process 02017.000586/01/08). Fish were collected by gillnets (mesh sizes 2.4, 3, 4, 5, 6, 7, 8, 9, 10, 12, and 14 mm), trammel nets (6 and 8 mm), cast nets (2.4, 4, and 6 mm), sweep nets (covering 10 m), and electro-fishing (used in 15-minute intervals during daylight

in shallows and structured areas of the river channel). Installation, inspection, and removal of fishing equipment at each sampling site occurred at 16:00h, 22:00h, and 08:00h, respectively. Sampled fishes were anaesthetized with benzocaine hydrochloride (dissolved in water, 100ml/15L), fixed in 10% formalin, and preserved in 70° GL alcohol. In the laboratory, fishes were identified according to Graça and Pavanelli (2007).

Data Analysis

We determined the species richness and the contribution of each order and family to fish assemblage. Fish species were classified according to their origin, where **(i) autochthonous** originated from the upper Paraná River basin, **(ii) allochthonous** described in other Neotropical basin and introduced in the upper Paraná River basin, without any evidence that might indicate its natural occurrence and **(iii) exotic** originated from other continents (Graça and Pavanelli 2007; Langeani *et al.* 2007; Júlio Júnior *et al*. 2009).

Results and Discussion

We reported a total of six orders, 23 families, and 76 species, in which 43% of them were Siluriformes and

Table 1. Average value of physical and chemical variables at each sampling site. * Minimum and maximum depth. Equipment employed: measuring rope (width), measuring rope and anchor (depth), flowmeter General Oceanics TM (current), mercury thermometer INCOTERM (air temperature), Multifunction YSI mod. 550-A (water temperature and dissolved O2), pHmeter DIGIMED mod. DM-2 (pH), conductivity meter DIGIMED mod. DM-3 (conductivity).

VARIABLES	SITE 1	SITE 2	SITE 3	SITE 4	SITE 5	SITE 6
Width (m)	8.5	23.0	24.2	41.0	46.5	21.0
Depth (m)*	0.60-1.25	0.20-1.85	0.25-2.30	0.15-2.90	0.30-4.90	0.20-1.40
Current (m/s)	0.17	0.47	0.45	0.52	0.45	0.57
Air temp. (ºC)	18.73	17.76	19.30	18.30	16.77	16.00
Water temp. (ºC)	18.40	17.48	18.30	18.8	19.42	18.80
Secchi (m)	1.20	0.69	0.67	0.42	0.60	0.47
Dissolved O_2 (mg/L)	7.62	8.19	7.08	7.69	7.54	8.18
pH	7.19	8.39	6.54	6.27	6.33	6.38
Conductivity (µS/cm)	103.00	114.12	130.30	99.90	91.95	111.90

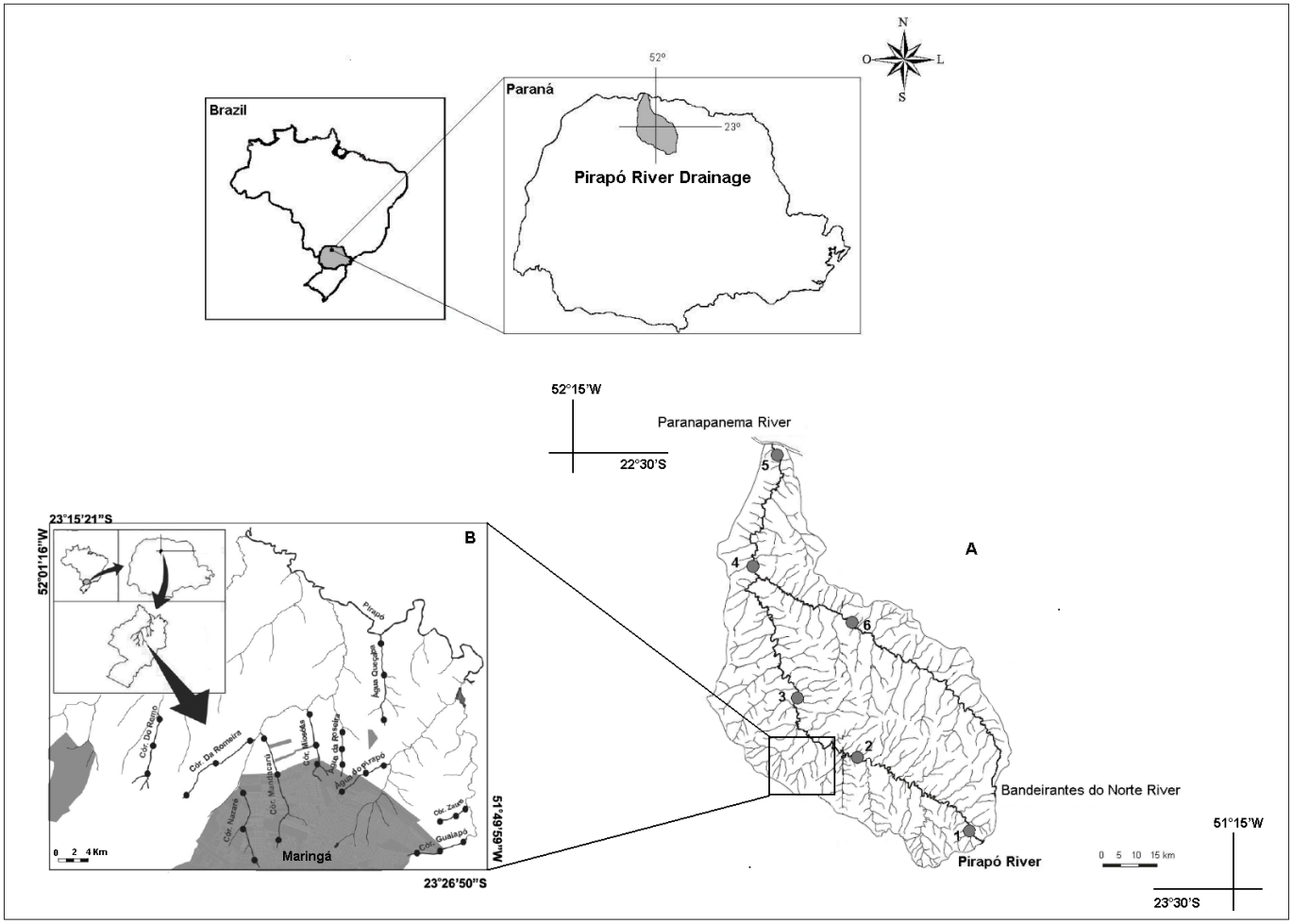

Figure 1. (A) Pirapó River drainage and its location in the Paraná state, Brazil. Numbers correspond to the sampling sites: Site 1 (23°26'59" S, 51°33'27,5" W), Site 2 (23°19'36,9" S, 51°50'41,9" W), Site 3 (23°11'26,2" S, 51°58'16,7" W), Site 4 (22°51'24" S, 52°04'37,7" W), Site 5 (22°36'56,5" S, 51°59'46,2" W), Site 6 (22°58'41,9 S, 51°49'55,4",W); (B) Location of the headwater streams in the Pirapó River drainage and its sampling sites (modified from Cunico *et al.* 2009).

35% Characiformes (Table 2; Figure 2). These results are similar to other rivers in the upper Paraná River basin, where most species are distributed in both orders (Langeani *et al.* 2007). Loricariidae and Characidae were the most representative families, with 15 (19.8%) and 11 (14.5%) species, respectively. Such families were distributed throughout the three subsystems (Table 2). On the other hand, Heptapteridae, with seven recorded species, typically occurred in the headwater streams. These fishes have body forms that provide them a great efficiency in the capture of terrestrial insects deposited among rocks of riffles or in marginal backwater zones of these streams (Pagotto *et al*. 2011).

Three species were restricted to the Bandeirantes do Norte River and 18 to the small headwater streams - *i.e.* 28% of the species richness from the Pirapó River drainage are restricted to its tributaries. Furthermore, seven species from these subsystems do not have a described specific epithet (Table 2). According to Cunico *et al*. (2009) these fishes are probably non-described species. These findings reveal the importance of such tributaries to the biodiversity, as well as they confirm that further researches are needed to best understand the ichthyofaunistic structure of the Pirapó River drainage.

In the Pirapó River channel were recorded 54 fish species, in which 27 were exclusive for this system, including some of the larger species, such as *Salminus brasiliensis*, the dourado, a large migratory fish species severely affected by hydroelectric dams (Agostinho *et al*. 2008). This finding shows why the Pirapó River may have notable significance in the upper Paraná River basin, which has been overly affected by dams (Agostinho *et al*. 2007). In this case, the Pirapó River, still free from barriers to fish migration, may be one of the last rivers in the upper Paraná River basin that can be used to protect species that use lotic habitats to breed and survive. We, therefore, support Hoffmann *et al.* (2005), who highlighted the importance in preserving lotic habitats in watersheds largely dominated by dams.

Regarding species origin, fish assemblage from the Pirapó River drainage is typically composed of native species (Table 2). Only *Steindachnerina brevipinna* (Eigenmann and Eigenmann, 1889), *Erythrinus erythrinus* (Bloch and Schneider, 1801), *Poecilia reticulata* Peters, 1859, and *Xiphophorus hellerii* Heckel, 1848 are classified as allochthonous species. Of these, the first one has spread throughout the upper Paraná River basin after construction of the Itaipu Hydroelectric Power Plant (Júlio Júnior *et al*. 2009), whereas the occurrence of *E. erythrinus* (from Guianas, Orinoco and Amazon basins) is probably related to its use as live bait by fisheries (Graça and Pavanelli 2007). *Poecilia reticulata* and *Xiphophorus hellerii* originated from Venezuela and Mexico, respectively, had probably been carried by aquarists or introduced for controlling insects' larvae (Lucinda 2003). In addition, we also recorded the exotics, *Oreochromis niloticus* (Linnaeus, 1758) and *Tilapia rendalli* (Boulenger, 1897), which occurrence is probably related to the escape from fish ponds (Graça and Pavanelli 2007). This anthropogenic interference and the occurrence of non-native species were first recorded by Cunico *et al.* (2009), who inventoried fish assemblages from some Pirapó River tributaries. They found environmental changes likely created ecosystem susceptibility to invasion by non-native species (especially *P. reticulata*) that are adapted to environmental degradation. The Pirapó River and its tributaries, run through a heavily impacted area in the state of Paraná, where original forest has been replaced by either monoculture crops or urbanization (Maack 2002).

Although this contribution improves the fish knowledge of the Pirapó River drainage, other samplings are needed to best represent its total fish richness, so as to produce a more complete and consistent diagnosis. We recommend permanent monitoring of the ecosystem because species richness may be subject to temporal changes promoted by the anthropogenic intervention. In addition, the presence of migratory fish highlights the importance in preserving the Pirapó River free from dams.

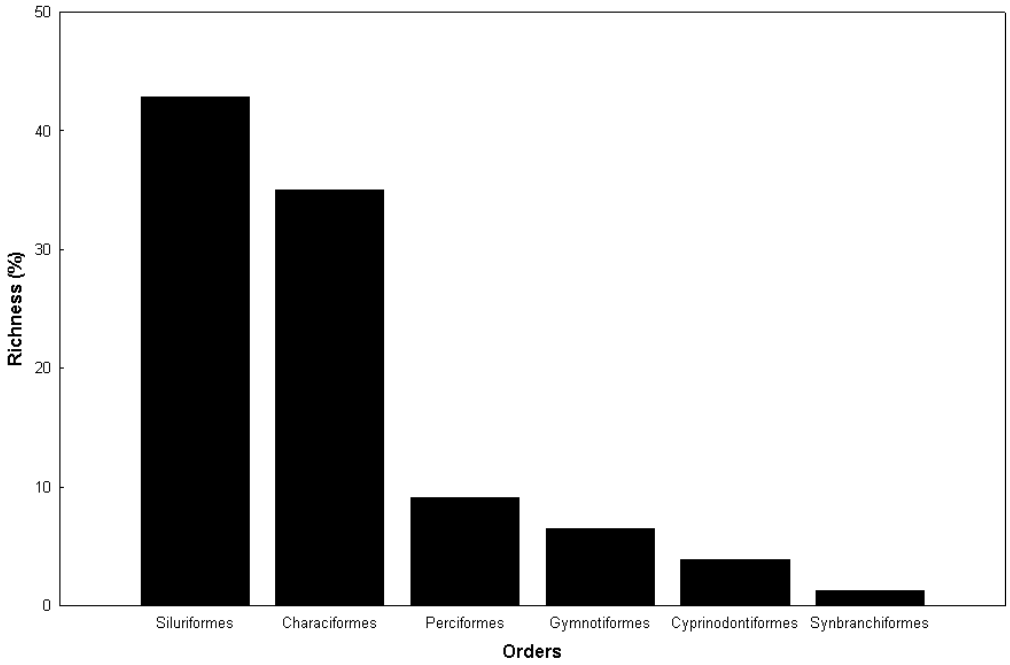

Figure 2. Species richness by order.

Table 2. List of fish species from the Pirapó River drainage. Systematic positions were based on Nelson (2006) for orders and Siluriformes families, Mirande (2010) for Characidae and Serrasalmidae, Oliveira et al. (2011) for Bryconidae, and Reis et al. (2003) for Parodontidae, Curimatidae, Anostomidae, Crenuchidae, Erythrinidae, Gymnotidae, Sternopygidae, Apteronotidae, Poeciliidae, Synbranchidae and Cichlidae. Subsystems: Pirapó River channel (P), Bandeirantes do Norte River (B) and small headwater streams (S). Origin: Autochthonous (Aut), Allochthonous (All) and Exotic (Exo) species. Vouchers specimens: Number of testimony lots, number of specimens in each lot, and range of standard length (SL) or total length (TL) in millimeters.

SYSTEMATIC POSITION	SUBSYSTEMS	ORIGIN	VOUCHER SPECIMENS
OSTEICHTHYES			
CHARACIFORMES			
Parodontidae			
Apareiodon ibitiensis Campos, 1944	P/B/S	Aut	NUP 3827 (2 ex. 82.00-97.00 SL), NUP 3871 (1 ex. 78.00 SL), NUP 5605 (1 ex. 79.00 SL)
Apareiodon piracicabae (Eigenmann, 1907)	S	Aut	NUP 5760 (1 ex. 32.9 SL)
Apareiodon sp.	S	Aut	NUP 6026 (41 ex. 40.20-55.32 SL)
Parodon nasus Kner, 1859	P	Aut	NUP 3870 (1 ex. 99.00 SL)
Curimatidae			
Cyphocharax modestus (Fernandez-Yépez, 1948)	P	Aut	NUP 3780 (1 ex. 132.00 SL)
Steindachnerina brevipinna (Eigenmann and Eigenmann, 1889)	P	All	NUP 3838 (8 ex. 53.00-118.00 SL)
Steindachnerina insculpta (Fernandez-Yépez, 1948)	P	Aut	NUP 3841 (2 ex. 136.00-137.00 SL)
Anostomidae			
Leporinus amblyrhynchus Garavello and Britski, 1987	P	Aut	NUP 3837 (1 ex. 206.14 SL)
Leporinus friderici (Bloch, 1794)	P	Aut	NUP 3865 (2 ex. 145.12-200.00 SL)
Schizodon nasutus Kner, 1858	P	Aut	NUP 3836 (1 ex. 257.8 SL)
Crenuchidae			
Characidium aff. *zebra* Eigenmann, 1909	P/S	Aut	NUP 3763 (1 ex. 41.00 SL), NUP 5555 (5 ex. 34.00-60.95 SL)
Serrasalmidae			
Serrasalmus maculatus Kner, 1858	P	Aut	NUP 3867 (1 ex. 48.00 SL)
Characidae			
Astyanax altiparanae Garutti and Britski, 2000	P/S	Aut	NUP 3840 (4 ex. 56.00-131.10 SL), NUP 6013 (10 ex. 62.38-87.04)
Astyanax bockmanni Vari and Castro, 2007	P/B/S	Aut	NUP 3781 (7 ex. 37.00-71.15 SL), NUP 3830 (1 ex. 62.01 SL), NUP 5626 (5 ex. 47.09-62.13 SL)
Astyanax aff. *fasciatus* (Cuvier, 1819)	P/S	Aut	NUP 3849 (1ex. 47.15 SL), NUP 5580 (8 ex. 28.55-48.70 SL)
Astyanax aff. *paranae* Eigenmann, 1914	P/S	Aut	NUP 3876 (8 ex. 62.00-105.40 SL), NUP 6033 (3 ex. 64.81-73.17 SL)
Bryconamericus stramineus Eigenmann, 1908	P/S	Aut	NUP 3845 (25 ex. 27.44-45.45 SL), NUP 5765 (3 ex. 54.38-61.77 SL)
Galeocharax knerii (Steindachner, 1879)	P	Aut	NUP 3868 (3 ex. 80.00-85.00 SL)
Hemigrammus marginatus Ellis, 1911	P	Aut	NUP 3898 (3 ex. 24.87-28.76 SL)
Oligosarcus paranensis Menezes and Géry, 1983	P	Aut	NUP 3872 (6 ex. 104.00-132.00 SL)
Piabina argentea Reinhardt, 1867	P/B	Aut	NUP 3828 (2 ex. 68.97-71.90 SL), NUP 3896 (9 ex. 35.46-58.82 SL)
Piabina sp.	S	Aut	NUP 5578 (5 ex. 51.20-61.0 SL)
Serrapinnus notomelas (Eigenmann, 1915)	P/S	Aut	NUP 3856 (7 ex. 20.33-32.07 SL), NUP 6025 (5 ex. 27.67-30.67 SL)
Bryconidae			
Salminus brasiliensis (Cuvier, 1816)	P	Aut	NUP 3863 (1 ex. 210.00 SL)
Erythrinidae			
Erythrinus erythrinus (Bloch and Schneider, 1801)	S	All	NUP 6032 (1 ex. 120.40 SL)
Hoplias intermedius (Günther, 1864)	P	Aut	NUP 3881 (1 ex. 220.00 SL)
Hoplias aff. *malabaricus* (Bloch, 1794)	P/B/S	Aut	NUP 3829 (2 ex. 203.00-235.00 SL), NUP 3833 (4 ex. 65.00-222.00 SL), NUP 6042 (1 ex. 205.40 SL)
SILURIFORMES			
Cetopsidae			
Cetopsis gobioides (Kner, 1858)	B	Aut	NUP 3826 (2 ex. 63.96-75.00 SL)
Aspredinidae			
Bunocephalus cf. *larai* Ihering, 1930	P	Aut	NUP 3880 (6 ex. 48.50-57.40 SL)
Trichomycteridae			
Trichomycterus diabolus Bockmann, Casatti and de Pinna, 2004	S	Aut	NUP 5579 (2 ex. 46.00-72.70 SL)

Table 2. ***Continued.***

SYSTEMATIC POSITION	SUBSYSTEMS	ORIGIN	VOUCHER SPECIMENS
Callichthyidae			
Callichthys callichthys (Linnaeus, 1758)	P/S	Aut	NUP 3853 (1 ex. 67.72 SL), NUP 5633 (1 ex. 65.60 SL)
Corydoras aeneus (Gill, 1858)	P/S	Aut	NUP 3834 (8 ex. 31.13-43.35 SL), NUP 5559 (10 ex. 32.56-39.45 SL)
Hoplosternum littorale (Hancock, 1828)	P	Aut	NUP 3839 (1 ex. 145.00 SL)
Loricariidae			
Hisonotus sp.	S	Aut	NUP 3950 (14 ex. 30.70-38.45 SL)
Hypostomus ancistroides (Ihering, 1911)	P/S	Aut	NUP 3765 (30 ex. 77.00-166.00 SL), NUP 6047 (8 ex. 51.50-142.20 SL)
Hypostomus hermanni (Ihering, 1905)	P/B	Aut	NUP 3996 (10 ex. 45.00-150.00 SL), NUP 3998 (3 ex. 49.00-103.00 SL)
Hypostomus cf. *iheringi* (Regan, 1908)	P/B	Aut	NUP 3760 (1 ex. 100.00 SL), NUP 4002 (3 ex. 58.00-97.00 SL)
Hypostomus cf. *nigromaculatus* (Schubart, 1964)	P/B/S	Aut	NUP 3993 (11 ex. 46.12-97.00 SL), NUP 3994 (1 ex. 81.00 SL), NUP 5561 (2 ex. 50.00-62.27 SL)
Hypostomus paulinus (Ihering, 1905)	P	Aut	NUP 3992 (4 ex. 90.00-127.00 SL)
Hypostomus regani (Ihering, 1905)	B	Aut	NUP 4010 (2 ex. 183.00-205.00 SL)
Hypostomus cf. *strigaticeps* (Regan, 1908)	P/B/S	Aut	NUP 3999 (5 ex. 54.75-165.00 SL), NUP 4004 (16 ex. 84.00-201.00 SL), NUP 5283 (3 ex. 39.23-117.58 SL)
Hypostomus cf. *topavae* (Godoy, 1969)	P	Aut	NUP 4003 (8 ex. 96.15-124.73 SL)
Hypostomus sp.	P/S	Aut	NUP 4000 (1 ex. 101.00 SL), NUP 5759 (3 ex. 34.9-84.70 SL)
Neoplecostomus yapo	S	Aut	NUP 5577 (1 ex. 46.67 SL)
Proloricaria prolixa (Isbrücker and Nijssen, 1978)	P/B	Aut	NUP 10426 (3 ex. 94.40-148.34 SL), NUP 10615 (3 ex. 159.45-254-34 SL)
Proloricaria sp.	P	Aut	NUP 10425 (4 ex. 112.11-176.22)
Rineloricaria aff. *latirostris* (Boulenger, 1900)	P/B	Aut	NUP 3997 (4 ex. 55.38-104.00 SL), NUP 4011 (3 ex. 83.00-106.00 SL)
Rineloricaria sp.	S	Aut	NUP 5761 (2 ex. 45.50-54.6 SL)
Pseudopimelodidae			
Pseudopimelodus sp.	P	Aut	NUP 3844 (2 ex. 42.00-44.00 SL)
Heptapteridae			
Cetopsorhamdia iheringi Schubart and Gomes, 1959	S	Aut	NUP 5556 (5 ex. 31.90-66.48 SL)
Imparfinis mirini Haseman, 1911	S	Aut	NUP 5628 (11 ex. 33.84-67.85 SL)
Imparfinis borodini Mees and Cala, 1989	P/S	Aut	NUP 3878 (1 ex. 94.67 SL), NUP 6010 (1 ex. 101.70 SL)
Phenacorhamdia tenebrosa (Schubart, 1964)	S	Aut	NUP 5607 (8 ex. 31.7-70.00 SL)
Pimelodella avanhandavae Eigenmann, 1917	S	Aut	NUP 5632 (1 ex. 80.39 SL)
Pimelodella gracilis (Valenciennes, 1835)	P	Aut	NUP 3883 (6 ex. 75.00-101.00 SL)
Rhamdia quelen (Quoy and Gaimard, 1824)	P/S	Aut	NUP 3798 (2 ex. 98.00-114.00 SL), NUP 6048 (20 ex. 31.20-107.70 SL)
Auchenipteridae			
Tatia neivai (Ihering, 1930)	P	Aut	NUP 3799 (2 ex. 47.48-63.29 SL)
Pimelodidae			
Iheringichthys labrosus (Lütken, 1874)	P	Aut	NUP 3862 (1 ex. 163.00 SL)
Pimelodus microstoma Steindachner, 1877	P/B	Aut	NUP 3793 (4 ex. 150.00-208.00 SL), NUP 3825 (2 ex. 89.00-113.00 SL)
Pimelodus maculatus La Cepède, 1803	P	Aut	NUP 3795 (3 ex. 230.00-260.00 SL)
GYMNOTIFORMES			
Gymnotidae			
Gymnotus inaequilabiatus (Valenciennes, 1839)	P/B/S	Aut	NUP 3796 (29 ex. 117.45-280.00 TL), NUP 3831 (4 ex. 105-165 TL), NUP 6043 (6 ex. 58.30-201.90 TL)
Gymnotus sylvius Albert and Fernandes-Matioli, 1999	P	Aut	NUP 3850 (1 ex. 206.00 TL)
Gymnotus sp.	S	Aut	NUP 6044 (2 ex. 120.00-173.58 TL)
Sternopygidae			
Sternopygus macrurus (Bloch and Schneider, 1801)	S	Aut	NUP 3859 (3 ex. 300.00-319.00 TL)
Apteronotidae			
Apteronotus cf. caudimaculosus Santana, 2003	P/B	Aut	NUP 3832 (1 ex. 193.00 TL), NUP 3854 (2 ex. 229.00-305.00 TL)

Table 2. ***Continued.***

SYSTEMATIC POSITION	SUBSYSTEMS	ORIGIN	VOUCHER SPECIMENS
CYPRINODONTIFORMES			
Poeciliidae			
Phalloceros harpagos Lucinda, 2008	P	Aut	NUP 3848 (1 ex. 18.67 SL)
Poecilia reticulata Peters, 1859	S	All	NUP 3452 (15 ex. 17.30-32.90 SL)
Xiphophorus hellerii Heckel, 1848	S	All	NUP 6030 (3 ex. 49.2-53.50 SL)
SYNBRANCHIFORMES			
Synbranchidae			
Synbranchus marmoratus Bloch, 1795	S	Aut	NUP 6041 (2 ex. 350.5-414.80 TL)
PERCIFORMES			
Cichlidae			
Cichlasoma paranaense Kullander, 1983	P	Aut	NUP 3858 (2 ex. 44.39-49.70 SL)
Crenicichla britskii Kullander, 1982	P/B/S	Aut	NUP 3784 (12 ex. 54.14-91.12 SL), NUP 3835 (12 ex. 47.66-85.30 SL), NUP 6003 (1 ex. 108.78 SL)
Crenicichla haroldoi Luengo and Britski, 1974	P	Aut	NUP 3864 (2 ex. 75.90-139.70 SL)
Crenicichla niederleinii (Holmberg, 1891)	S	Aut	NUP 10718 (1 ex. 91.91 SL)
Geophagus brasiliensis (Quoy and Gaimard, 1824)	P/S	Aut	NUP 3895 (8 ex. 32.34-164.00 SL), NUP 6002 (2 ex. 70.90-70.95 SL)
Oreochromis niloticus (Linnaeus, 1758)	P/S	Exo	NUP 3794 (2 ex. 85.00-224.00 SL), NUP 5316 (4 ex. 30.34-37.67 SL)
Tilapia rendalli (Boulenger, 1897)	B	Exo	NUP 3892 (1 ex. 223.00 SL)

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