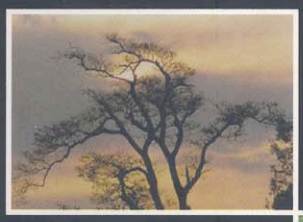
Structure and functioning of the Paraná River and its floodplain

LTER - site 6
(PELD sítio 6)








Angelo Antonio Agostinho
Liliana Rodrigues
Luiz Carlos Gomes
Sidinei Magela Thomaz
Leandro E. Miranda

EDUEM

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Address for correspondence:
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Fish Assemblages in the Upper Paraná River Floodplain

Karla Danielle Gaspar da Luz
Edson Fontes Oliveira
Ana Cristina Petry
Horácio Ferreira Júlio Júnior
Carla Simone Pavanelli
Luiz Carlos Gomes

Abstract

We aimed to characterize the composition of the fish assemblages and identify possible indicator species in the four main biotopes (i.e., rivers, channels, connected lagoons, and disconnected lagoons) of the Upper Paraná River floodplain. Quarterly samples were taken from February 2000 to August 2002. A total of 107 species belonging to 27 families were recorded. Gillnetting captured 91 species whereas seining captured 68. In all, 79 species were captured in rivers, 61 in channels, 74 in connected lagoons, and 91 in disconnected lagoons. Among the species with the highest numerical abundances was *L. platymetopon, A. altiparanae, S. marginatus* and *S. notomelas*. Results of an ordination and the index of indicator species revealed that each biotope in the Upper Paraná River floodplain, except the river, shared a roll of common species. In rivers, however, there was an absence of species with commercial importance. Several species were indicators of biotopes and have fewer ecological restrictions and diverse feeding habits and reproductive strategies. A higher number of indicator species in rivers may be a result of the higher heterogeneity of the species composition among subsystems, mainly between the Paraná River and its tributaries (Baia and Ivinheima Rivers).
Key words: Fish assemblage. Indicator species. Floodplain.

Resumo

A ictiofauna da planície de inundação do alto rio Paraná caracteriza-se pela riqueza de espécies, estando a maioria dessas distribuídas de acordo com suas necessidades e limitações. O presente trabalho teve por objetivos caracterizar a composição ictiofaunística e destacar possíveis espécies indicadoras das quatro principais categorias de biótopos (rios, canais, lagoas conectadas e lagoas desconectadas) a partir das amostragens realizadas no período compreendido entre fev/00 e ago/02. Um total de 107 espécies foi registrado, estando distribuídas em 27 famílias. Do total de espécies capturadas 79 ocorreram nos rios, 61 nos canais, 74 em lagoas conectadas e 91 em lagoas desconectadas, sendo 91 espécies amostradas com redes de espera e 68 com

arrastos. Entre as espécies que mais se destacaram em número de ocorrência entre os biótopos, encontram-se *L. platymetopon, A. altiparanae, S. marginatus* e *S. notomelas*. Os resultados obtidos através da técnica de ordenação e do índice de espécies indicadoras revelaram, com exceção do biótopos rios, que, de uma forma geral, cada biótopo da planície de inundação do alto rio Paraná compartilha um elenco de espécies em comum. Nos rios, entretanto, verificou-se a ausência das principais espécies de importância comercial da planície, sendo consideradas indicadoras desse biótopo um elevado número de espécies com menores restrições ecológicas, e que apresentam elevada diversidade de hábitos alimentares e estratégias reprodutivas. Esse maior número de espécies indicadoras no biótopo rios pode ser atribuído a maior heterogeneidade na composição específica entre os subsistemas, principalmente entre o rio Paraná e seus tributários (rios Baía e Ivinheima), como demonstrado pela análise de ordenação.
Palavras-chave: Ictiofauna. Espécies indicadoras. Planície de inundação.

Introduction

The ichthyofauna of the Upper Paraná River is composed of nearly 600 species (BONETTO, 1986). Surveys conducted in the last years on the stretch between the mouth of the Paranapanema River and Itaipu Reservoir recorded about 170 species (AGOSTINHO; JÚLIO JÚNIOR; GOMES; BINI; AGOSTINHO, 1997), predominantly Characiformes and Siluriformes (BRITSKI, 1992). Fish species are distributed along the transversal axis, direction river main channel - floodplain (disconnected lagoons), inhabiting diverse biotopes, according to their needs and limitations (AGOSTINHO; THOMAZ; MINTE-VERA; WINEMILLER, 2000). Therefore, some species show a strong dependence on flood events. The flood is the main force function working on the Upper Paraná River floodplain, promoting spatial and temporal heterogeneity. Based on a large survey program carried on the Upper Paraná River floodplain, the present study aims to characterize the fish assemblage composition of this region, focusing on variation sources and identifying indicator species for the main categories of biotopes.

Results and Discussion

In the first phase, samples were taken quarterly from February 2000 to November 2001 in 36 sampling stations distributed among four categories of biotopes (rivers, channels, connected and disconnected lagoons) belonging to three subsystems (Paraná, Baia, and Ivinheima). In the second phase, from February to September 2002, samples were taken quarterly in 10 sampling stations, distributed among three biotopes (rivers, connected and disconnected lagoons, selected as representative for the biotopes). Samples were taken by gillnetting in all biotopes and seining in connected and disconnected lagoons, with standardized effort for each sampling gear. Presence/absence data were summarized by a correspondence analysis (CA). The first axis of the CA (CA 1) was retained for interpretation because it accounts for most of the variability

and it is not influenced by the arch effect (GAUCH, Jr., 1982 (reprinted 1986)). The scores of the CA 1 were used in an analysis of variance (ANOVA), tested by 5000 randomizations (Null model; GOTELLI; ENTSMINGER, 2002). Time (years) and space (biotopes and subsystems) were considered sources of variation. Indicator species for each biotope category was assessed based on the abundance and occurrence of a given species considering each sample, as described by Dufrêne and Legendre (1997).

Ichthyofauna surveys identified 107 species, belonging to 27 families, eight orders, and two classes. The species list (Appendix 1) and their taxonomic identification were based on the classification proposed by Britski, Silimon and Lopes (1999). The orders Characiformes (50) and Siluriformes (36) included 80% of the species collected (Table 1) this tendency is also observed in other basins of the Neotropical region (LOWE-MCCONNELL, 1999).

Table 1 - Number of fish species per family for the main biotopes of the Upper Paraná River floodplain (N= total number of species; RIV = rivers; CHA = channels; CL =connected lagoons and DL = disconnected lagoons; * orders).

Family	N	RIV	CHA	CL	DL	Family	N	RIV	CHA	CL	DL
**Myliobatiformes*						**Siluriformes*					
Potamotrygonidae	1		1	1	1	*Doradidae*	5	4	3	1	3
**Characiformes*						*Auchenipteridae*	2	2	2	2	2
Characidae	27	13	10	24	24	*Ageneiosidae*	1	1	1		1
Cynodontidae	1	1	1	1	1	*Pimelodidae*	14	12	7	8	12
Chrenuchidae	1			1	1	*Callichthyidae*	2	2	1	2	2
Parodontidae	2	2	2	1	1	*Loricariidae*	12	12	11	5	8
Prochilodontidae	1	1	1	1	1	**Cyprinodontiformes*					
Curimatidae	4	4	4	4	4	*Poeciliidae*	1				1
Anostomidae	10	10	6	6	8	*Rivulidae*	1			1	
Lebiasinidae	1			1	1	**Perciformes*					
Erythrinidae	3	2	2	3	3	*Sciaenidae*	1	1	1	1	1
**Gymnotiformes*						*Cichlidae*	8	5	6	6	6
Apteronotidae	1				1	**Symbranchiformes*					
Hypopomidae	1			1	1	*Synbranchidae*	1			1	1
Rhamphichthyidae	1	1		1	1	**Pleuronectiformes*					
Gymnotidae	1	1	1	1	1	*Achiridae*	1	1		1	1
Sternopygidae	3	3	2	2	3						

According to biotopes, 79 species were collected in rivers, 61 in channels, 74 in connected lagoons, and 91 in disconnected lagoons. Gillnetting captured 91 species and seining 68. Among the species with highest numerical occurrence were *Loricariichthys platymetopon*, *Astyanax altiparanae*, *Serrasalmus marginatus*, and *Serrapinus notomelas*.

The most represented families were Characidae (27 species), Pimelodidae (14), Loricaridae (12), Anostomidae (10) and Cichlidae (8 species). Characidae, Pimelodidae and Cichlidae are characterized by species with tendency to omnivory. Characidae and Pimelodidae included species in almost all trophic levels, but Anostomidae and Loricariidae included mainly herbivorous and detritivorous species whose food sources are abundant in the floodplain.

Ordination with CA according to sampling gear showed distinct spatial patterns corresponding to the biotopes, and a less pronounced pattern among subsystems (Figure 1). The CA 1 scores of gillnetting samples differed significantly among biotopes [I_{obs}=34.52; P ($I_{obs} \geq I_{exp}$) <0.01] and subsystems [I_{obs}=17.10; P ($I_{obs} \geq I_{exp}$) <0.01] (Figure 1B). The species *Hypostomus* sp., *Leporinus octofasciatus*, *Leporellus vittatus*, *Crenicichla haroldoi*, and *Apareiodon affinis* had higher positive scores and were found only in rivers and channels, specially in the Paraná subsystem. The species *Cichlasoma paranaense*, *Hoplerythrinus unitaeniatus*, *Astronotus ocellatus*, *Potamotrygon motoro*, and *Laetacara* sp. had negative scores and were found mainly in lagoons (Figure 1A and 1B). For seining, assemblages also differed among biotopes [I_{obs}=43.39; P($I_{obs} \geq I_{exp}$)<0.01] and subsystems [I_{obs}=23.95; P ($I_{obs} \geq I_{exp}$) <0.01] (Figure 1D). The species *Iheringichthys labrosus*, *Plagioscion squamosissimus*, *Catathyridium jenynsii*, *Potamotrygon motoro*, *Cichla monoculus* and *Satanoperca pappaterra* had higher positive scores and were captured mainly in connected lagoons of the Paraná subsystem. However, the Gymnotiformes *Eigenmannia virescens*, *Gymnotus* spp., *Sternopygus macrurus*, *Brachyhypopomus* sp., and *Synbranchus marmoratus* had negative scores and occurred mainly in disconnected lagoons in the Baia and Ivinheima subsystems (Figure 1C and D).

Limnological characteristics such as water turbidity conceivably influenced ordination of CA 1. Turbidity was higher in the Baia and Ivinheima subsystems than in the Paraná (THOMAZ; PAGIORO; ROBERTO; PIERINI; PEREIRA; DE FELIPPO; CIMBLERIS; SOARES, 2002). This difference over subsystems is influenced by the presence of several dams in the Paraná River above the study area, which produce a clearing effect on the latter (BARBOSA; PADISÁK; ESPÍNDOLA; BORICS; ROCHA, 1999). Visual predators predominated in the subsystem Paraná, especially in the lagoons directly connected with the main river.

Indicator species indexes (INVAL) are shown in Table 2. The species which had probabilities of type I error less than 5% (P<0.05) resulted from the random Monte Carlo reallocation procedure, assuming the null hypothesis that the INVAL value for a given species *i* within the four biotopes *j* can be found at random (MCCUNE; MEFFORD, 1997).

Considering only the INVAL values greater than 30%, five species can be considered indicator of the environmental conditions dominating the river biotope (i.e., *Leporinus friderici*, *Iheringichthys labrosus*, *Rhaphiodon vulpinus*, *Apareiodon affinis* and *Auchenipterus osteomystax*). None of these species is a large-body migratory species as the ones that dominated the samples in 1986-1988 (i.e., *Salminus maxillosus*, *Prochilodus lineatus*, *Pseudoplatystoma corruscans*, *Paulicea luetkeni*, *Rhinelepis aspera*, *Leporinus obtusidens* and *Leporinus* sp.); (AGOSTINHO; JÚLIO JÚNIOR; GOMES; BINI; AGOSTINHO, 1997). *Schizodon borellii* may be considered indicator of the channel biotope and exhibit an herbivorous-grazer feeding habit (FERRETTI; ANDRIAN; TORRENTE, 1996). This species undergoes short spawning migrations in

lotic environments (AGOSTINHO; JÚLIO JÚNIOR; GOMES; BINI; AGOSTINHO, 1997). *Serrasalmus marginatus*, *Loricariichthys platymetopon*, and *Parauchenipterus galeatus* can be indicators of the connected lagoons biotope. These species are sedentary, exhibit parental care (the two former), and internal fecundation (the latter). For disconnected lagoons, the main indicator species are three insectivorous species (*Astyanax altiparanae*, *Roeboides paranensis*, and *Moenkhausia intermedia*), a bentophagous (*Hoplosternum littorale*), and an herbivorous species (*Leporinus lacustris*) (GASPAR DA LUZ; ABUJANRA; AGOSTINHO; GOMES, 2001).

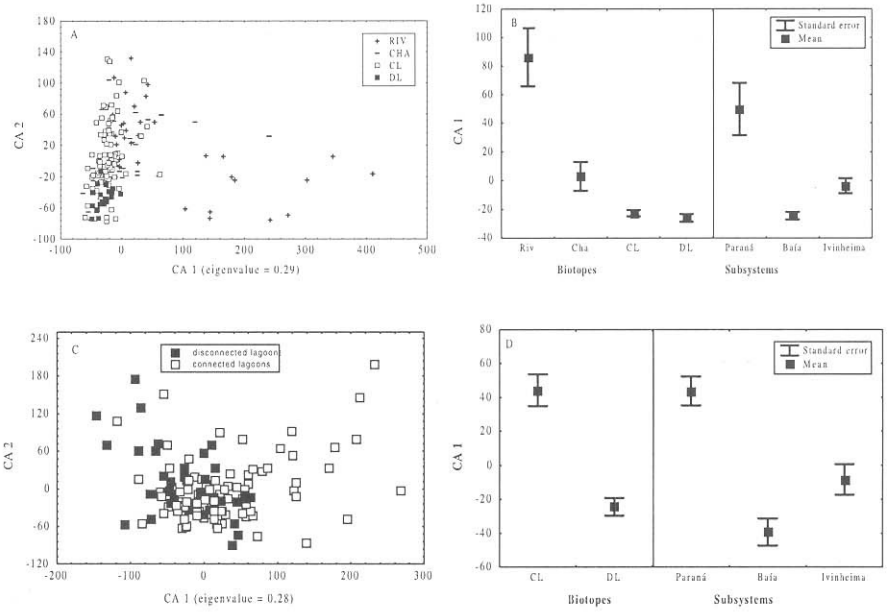

Figure 1 - Ordination of sampling sites on axis 1 and axis 2 (A, C) of the correspondence analysis (CA) and average (± standard error) of the scores on CA axis 1 (B, D), based on the species abundance sampled by gillnetting (A, B) and seining (C, D) from the Upper Paraná River floodplain, during 2000, 2001 and 2002 (see Table 1 for abbreviations).

Results of the ordination and index of indicator species analyses showed that each biotope of the Upper Paraná River floodplain share a common roll of species, with rivers as an exception. In rivers, there was an absence of the commercially important species, and the number of indicator species was high and had fewer ecological restrictions, and great diversity of feeding habits and reproductive strategies.

The greater number of species considered indicator of the river biotope may be attributed to the greater heterogeneity of the species composition among the subsystems, especially in the Paraná River and its tributaries (Baia and Ivinheima Rivers).

Table 2 - Indicator values (INVAL) of the species for the main biotopes (1 = rivers; 2 = channels; 3 = connected lagoons and 4 = disconnected lagoons). P is the probability of type i error, obtained by random Monte Carlo reallocation. Values in bold are the species that can be considered indicator for a given biotope. CV = coefficient of variation of indicator values from randomized groups.

Species	INVAL				P	CV	Species	INVAL				P	CV
	1	2	3	4				1	2	3	4		
L. friderici	**50**	7	1	1	0.000	23.58	*L. vittatus*	**9**	0	0	0	0.006	60.40
I. labrosus	**40**	1	6	0	0.000	25.86	*M. aculeatus*	**8**	0	0	0	0.024	56.00
R. vulpinus	**39**	10	16	0	0.000	17.00	*G. knerii*	**7**	1	0	0	0.034	57.93
A. affinis	**33**	0	0	0	0.000	47.41	*Hypostomus* sp. c	**7**	1	0	0	0.046	60.00
A. osteomystax	**31**	1	27	0	0.007	22.92	*S. borellii*	9	**32**	21	13	0.017	12.26
H. regani	**28**	0	0	0	0.000	44.78	*C. paranaense*	0	**10**	1	4	0.078	41.31
S. insculpta	**26**	6	23	2	0.036	18.99	*S. marginatus*	14	12	**39**	19	0.015	13.72
P. squamosissimus	**26**	0	7	1	0.001	27.30	*P. galeatus*	7	14	**34**	27	0.016	11.62
T. paraguayensis	**25**	3	14	0	0.031	28.93	*L. platymetopon*	17	10	**33**	29	0.013	9.33
Hypostomus spp.	**24**	6	0	0	0.000	36.72	*L. anisitsi*	14	1	**32**	14	0.005	15.54
L. obtusidens	**22**	7	1	5	0.000	25.00	*R. hahni*	4	0	**16**	0	0.009	31.60
C. haroldoi	**21**	0	0	0	0.000	52.57	*A. altiparanae*	11	2	4	**48**	0.000	21.68
Pimelodella sp. 1	**20**	0	0	1	0.000	44.57	*R. paranensis*	12	2	11	**44**	0.000	16.53
A. fasciatus	**20**	0	0	0	0.000	50.53	*M. intermédia*	12	1	5	**34**	0.000	25.39
H. plathyrhynchos	**16**	2	8	3	0.048	24.59	*H. littorale*	1	1	10	**33**	0.001	25.89
H. ancistroides	**15**	0	1	11	0.016	31.67	*L. lacustris*	3	11	17	**31**	0.009	15.67
S. nasutus	**14**	0	0	0	0.000	49.69	*C. modestus*	0	0	3	**22**	0.004	35.82
P. granulosus	**12**	0	3	0	0.046	37.81	*Gymnotus* spp.	1	0	5	**21**	0.001	28.99
P. pirinampu	**12**	0	1	0	0.005	47.25	*E. trilineata*	0	1	2	**19**	0.004	36.49
P. ornatus	**11**	0	0	0	0.005	47.25	*H. edentatus*	4	0	1	**13**	0.028	39.24
S. hilarii	**9**	1	0	0	0.020	52.06	*B. orbignyanus*	0	0	0	**8**	0.022	64.80

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Appendix 1 - List of fish species captured in the upper Paraná River floodplain.

CHONDRICHTHYES
MYLIOBATIFORMES
POTAMOTRYGONIDAE
Potamotrygon motoro (Natterer, 1841)

OSTEICHTHYES
CHARACIFORMES
CHARACIDAE
BRYCONINAE
Brycon orbignyanus (Valenciennes, 1849)
TETRAGONOPTERINAE
Astyanax altiparanae Garutti & Britski, 2000
Astyanax fasciatus (Cuvier, 1819)
Astyanax schubarti Britski, 1964
Bryconamericus stramineus Eigenmann, 1908
Hemigrammus marginatus Ellis, 1911
Hyphessobrycon eques (Steindachner, 1882)
Hyphessobrycon sp.
Moenkhausia intermedia (Eigenmann, 1908)
Moenkhausia sanctaefilomenae (Steindachner, 1907)
APHYOCHARACINAE
Aphyocharax anisitsi Eigenmann & Kennedy, 1903
Aphyocharax sp.
CHEIRODONTINAE
Serrapinnus notomelas (Eigenmann, 1915)
Serrapinnus sp. 1
Serrapinnus sp. 2
Odontostilbe sp.
SALMININAE
Salminus hilarii Valenciennes, 1829
Salminus maxillosus Valenciennes, 1849
CYNOPOTAMINAE
Galeocharax knerii (Steindachner, 1879)
CHARACINAE
Roeboides paranensis Pignalberi, 1975
ACESTRORHYNCHINAE
Acestrorhynchus lacustris (Reinhardt, 1874)
Oligosarcus pintoi Campos, 1945
MYLEINAE
Metynnis cf. *maculatus* (Kner, 1860)
Myloplus tiete (Eigenmann & Norris, 1900)
Piaractus mesopotamicus (Holmberg, 1887)
SERRASALMINAE
Serrasalmus marginatus Valenciennes, 1847
Serrasalmus spilopleura Kner, 1860
CYNODONTIDAE
Rhaphiodon vulpinus Agassiz, 1829
CRENUCHIDAE
CHARACIDIINAE
Characidium aff. *zebra* Eigenmann, 1909
PARODONTIDAE
Apareiodon affinis (Steindachner, 1879)
Parodon nasus Kner, 1859
PROCHILODONTIDAE
Prochilodus lineatus (Valenciennes, 1836)
CURIMATIDAE
Steindachnerina insculpta (Fernández-Yèpez, 1948)
Steindachnerina brevipinna (Eigenmann & Eigenmann, 1889)
Cyphocharax modestus (Fernández-Yèpez, 1948)
Cyphocharax nagelii (Steindachner, 1881)
ANOSTOMIDAE
Leporellus vittatus (Valenciennes, 1849)
Leporinus friderici (Bloch, 1794)
Leporinus sp.
Leporinus lacustris Campos, 1945
Leporinus macrocephalus Garavello & Britski, 1988
Leporinus obtusidens (Valenciennes, 1847)
Leporinus octofasciatus Steindachner, 1917
Schizodon altoparanae Garavello & Britski, 1990
Schizodon borellii (Boulenger, 1900)
Schizodon nasutus Kner, 1859
LEBIASINIDAE
Pyrrhulina australis Eigenmann & Kennedy, 1903
ERYTHRINIDAE
Hoplias aff. *malabaricus* (Bloch, 1794)
Hoplerythrinus unitaeniatus (Spix, 1829)
Erythrinus erythrinus (Schneider, 1801)
GYMNOTIFORMES
RHAMPHICHTHYIDAE
Rhamphichthys hahni (Meiken, 1937)
GYMNOTIDAE
Gymnotus spp.
STERNOPYGIDAE
Sternopygus macrurus (Schneider, 1801)
Eigenmannia trilineata López & Castello, 1966
Eigenmannia virescens (Valenciennes, 1847)
HYPOPOMIDAE
Brachyhypopomus sp.
APTERONOTIDAE
Porotergus ellisi Aramburu, 1957
SILURIFORMES
DORADIDAE
Pterodoras granulosus (Valenciennes, 1833)
Trachydoras paraguayensis (Eigenmann & Ward, 1907)
Doras eigenmanni (Boulenger, 1895)

Platydoras armatulus (Valenciennes, 1840)
Rhinodoras dorbignyi (Kröyer, 1855)
AUCHENIPTERIDAE
Auchenipterus osteomystax (Ribeiro, 1918)
Parauchenipterus galeatus (Linnaeus, 1766)
AGENEIOSIDAE
Ageneiosus valenciennesi Bleeker, 1894
PIMELODIDAE
Iheringichthys labrosus (Kröyer, 1874)
Pimelodella sp. 1
Pimelodella sp. 2
Pimelodus maculatus Lacépède, 1803
Pimelodus ornatus Kner, 1857
Pimelodus blochii Valenciennes, 1840
Pimelodus absconditus Azpelicueta, 1995.
Rhamdia quelen (Quoy & Gaimard, 1824)
Hypophthalmus edentatus Spix, 1829
Hemisorubim platyrhynchos (Valenciennes, 1840)
Pseudoplatystoma corruscans (Agassiz, 1829)
Pseudoplatystoma corruscans x *Pseudoplatystoma fasciatum*
Sorubim cf. *lima* (Schneider, 1801)
Pinirampus pirinampu (Spix, 1829)
CALLICHTHYIDAE
Hoplosternum littorale (Hancok, 1828)
Callichthys callichthys (Linnaeus, 1758)
LORICARIIDAE
PLECOSTOMINAE
Hypostomus ancistroides Ihering, 1911
Hypostomus microstomus Weber, 1987
Hypostomus regani (Ihering, 1905)
Hypostomus spp.
Hypostomus sp. c
Liposarcus anisitsi (Eigenmann & Kennedy, 1903)
Cochliodon cochliodon (Kner, 1854)
LORICARIINAE
Loricariichthys platymetopon Isbrücker & Nijssen, 1979
Loricariichthys rostratus Reis & Pereira, 2000
Rhinelepis aspera Valenciennes, 1840
Loricaria sp.
ANCISTRINAE
Megalancistrus aculeatus (Perugia, 1891)
CYPRINODONTIFORMES
POECILIIDAE
Lebistes reticulatus (Peters, 1859)
RIVULIDAE
Rivulus sp.
PERCIFORMES
SCIAENIDAE
Plagioscion squamosissimus (Heckel, 1840)
CICHLIDAE
Astronotus ocellatus (Agassiz, 1831)
Cichla monoculus Spix, 1831
Cichlasoma paranaense Kullander, 1983
Crenicichla haroldoi Luengo & Britski, 1964
Crenicichla britskii Kullander, 1982
Crenicichla nierderleinii (Holmberg, 1891)
Satanoperca pappaterra (Heckel, 1840)
Laetacara sp.
SYNBRANCHIFORMES
SYNBRANCHIDAE
Synbranchus marmoratus Bloch, 1795
PLEURONECTIFORMES
ACHIRIDAE
Catathyridium jenynsii (Günther, 1862)