Check List 8(3): 491-498, 2012

ISSN 1809-127X (available at *www.checklist.org.br*)

Check List
Journal of species lists and distribution

Lists of Species

Fish of the Taiassuí and Benfica river basins, Benevides, Pará (Brazil)

Roberta Dannyele Oliveira Raiol [1*], Wolmar Benjamim Wosiacki [2] and Luciano Fogaça de Assis Montag [1]

1 Universidade Federal do Pará, Instituto de Ciências Biológicas (ICB), Departamento de Ecologia e Zoologia de Vertebrados, Rua Augusto Corrêa, 01, Guamá. CEP 66075-110. Belém, PA, Brazil.
2 Museu Paraense Emílio Goeldi, Campus de Pesquisa, Departamento de Ictiologia. Avenida Perimetral, 1901, Terra-Firme. CEP 66077-530. Belém, PA, Brazil.
* Corresponding author. E-mail: *raiol06@gmail.com*

Abstract: Species inventories are relatively efficient and inexpensive tools for the monitoring of biodiversity, especially in areas that have suffered high rates of deforestation, such as the municipalities located within the "Belém Endemism Center". This region extends from northeastern Pará to northern Maranhão and has a unique flora and fauna, but is threatened by high rates of deforestation and habitat fragmentation since it is included in the so-called "Arc of Deforestation". Benevides is the third most impacted municipality within the metropolitan region of Belém (Pará), after Belém itself and Santa Bárbara, but the biological diversity of its freshwater fish fauna is still unknown. In the present study, 81 fish species belonging to seven orders and 23 families were identified. Characidae and Cichlidae were the families with the largest numbers of species in the Taiassuí and Benfica river basins. Two of the species – *Apistogramma tucurui* and *Hyphessobrycon inconstans* – were recorded in the state for the first time. Based on the composition analysis of the fishes, it is possible to said that the Benevides fish community is relatively well preserved, because it has high diversity of groups.

Introduction

The Neotropical Region harbors the richest freshwater ichthyofauna in the World, with estimates of the total number of species varying from 1800 to 8000 (Malabarba and Reis 1987, Schaefer 1998, respectively). The Amazon Basin accounts for a large proportion of this total, with some 1400 species recorded to date, making this the World's richest hydrographic basin in terms of fish species richness (Goulding 1989, Kullander and Nijssen 1989, Schaffer 1998, Lowe-McConnell 1999, Reis *et al.* 2003, Buckup *et al.* 2007, Arrolho-Silva and Silva 2008). Even so, considerable gaps in our knowledge remain, and Malabarba and Reis (1987) and Reis *et al.* (2003) have estimated that up to 30% or 40% of Amazonian fish species have yet to be described.

Some parts of the Amazon basin have been surveyed relatively intensively, with long-term studies using a variety of sampling techniques that have produced extensive species lists, reflecting the high local diversity. These studies include surveys of the Rio Napo (Equador/Peru/Brazil), which recorded 473 species (Restrepo *et al.* 1991), and the Rio Negro in Brazil, which recorded 450 species (Goulding et al, 1988). Other important inventories include those of the Rio Caquetá-Japurá River in Colombia and Brazil, which returned a total of 241 species (Castro and Arboleda 1988), the Rio Mamoré in Bolivia/Brazil, with 280 species (Lauzane and Loubens 1985), and the Rio Putumayo-Içá (Equador/Brazil), with 100 species (Castro 1994). A number of surveys in Brazil have also produced comprehensive lists of species, such as those of the Rio Tocantins (300 species) (Santos 1984), lower Anapu (208 species), and the savannas of Marajó Island, with 257 species (Barthem *et al.* 1995, Montag *et al.* 2008, 2009). However, most of these surveys are relatively localized, considering the vast dimensions of the Amazon basin, and substantial lacunas in our knowledge of its ichthyofauna still exist, many of which coinciding with the region's largest urban centers (Vieira and Shibatta 2007).

Right-bank tributaries of the Rio Guamá, the Taiassuí and Benfica rivers are among the most important water bodies in the municipality of Benevides, which is located within the metropolitan region of Belém, capital of the Brazilian state of Pará. This region has more than 1.8 million inhabitants, and has lost most of its original forest cover, which has led to intense habitat fragmentation and loss of biodiversity (Dudgeon *et al.* 2006).

The metropolitan region of Belém nevertheless contains a considerable portion of the biodiversity of the Belém Endemism Center, which is located in the extreme eastern portion of the Amazon region, incorporating all the associated biomes east of the Rio Tocantins, including the Amazonian portion of the state of Maranhão. This region is one of the most intensely deforested portions of Brazilian Amazon (Brandon *et al.* 2005); total deforestation in mainland Belém is estimated to be 87.5%, falling to 32.6% on the regional islands (Brandon *et al.* 2005; Almeida and Vieira 2010; Munôz 2010).

Brandon *et al.* (2005) concluded that so-called endemic areas require more studies than other regions, given their relatively large numbers of unique species and differentiated evolutionary history. The indiscriminate use and modification of the natural resources of these regions have severe implications for the conservation of their biodiversity (Almeida and Vieira 2010). Given this situation, this study presents an inventory of the fish species of the Taiassuí and Benfica rivers basins in Benevides, Pará, which may aid in the development of effective conservation and management strategies.

Material sand methods

Benevides (01°21'41" S, 48°14'42" W) is located in the northeast of the Brazilian state of Pará, and has a total area of 188 km². It is characterized by high rates of deforestation, with the loss of the original forest cover exceeding 23% (Brandon *et al.* 2005), and the study area is typical of this pattern, with only 30% of its original vegetation remaining (SEPOF 2006).

The region of Benevides has a humid tropical climate, with a mean temperature of around 26°C and low thermal amplitude, with the highest temperatures, of up to 36°C, being recorded between September and November. The natural vegetation is composed mainly of secondary forest, regenerated from the removal of the original forest cover and in particular the dense forests of the floodplains, which has been replaced for the implantation of subsistence agriculture and cattle ranching, which are the predominant activities in the region.

A total of seven field campaigns were conducted in the Taiassuí River in March, April, May, July, September, and November, 2006, and January, 2007. The specimens collected during these excursions formed the primary database, which was complemented with the specimens captured in December, 2001, and March, 2003, which have been deposited in the collection of the Goeldi Museum in Belém, and are referred to here as secondary data. Fish specimens were collected at four sites, three stretches of the Taiassuí and one of the Benfica River (Figure 1), where four collectors conducted a standard sample of two hours using seine and hand nets with a 5 mm mesh size between opposite knots.

The specimens collected were fixed in 10% formaldehyde solution and subsequently conserved in 70% ethanol. Species were identified through consultation of the available literature (e.g. Burgess 1989, Géry 1977, Goldstein 1973, Menezes 1996, Planquette *et al.* 1996, Keith *et al.* 2000, Kullander 2006, Soares and Pinheiro 2008) and specialists, with the taxonomic status of each species being validated based on the reference works of Reis *et al.* 2003 and Buckup *et al.* 2007. All specimens were subsequently incorporated into the ichthyological collection of the Goeldi Museum (MPEG) in Belém (Appendix 1).

The physical and biotic characteristics of each sampling station were recorded, including the width and depth of the river stretch and transparency with a Secchi disk and the type of riparian vegetation. The collection of fish samples was authorized by IBAMA/Pará, through special license 0096/2005. The efficiency of the inventory was evaluated based on a cumulative species (rarefaction) curve for the species recorded, from which a logistic equation was established. This equation was used to provide projections of the effectiveness of additional sampling effort.

Results and Discussion

Characteristics of the sampling stations

All four sites surveyed in the present study (Figure 2) have been partially dammed for recreational use (as bathing pools) and the construction of homes, which has resulted in some modification of the marginal vegetation due to its withdrawal. The water is 100% transparent at all sites. The mean width of the body of water is 9 m, while depths vary between 0.4 m and 1.0 m (Table 1).

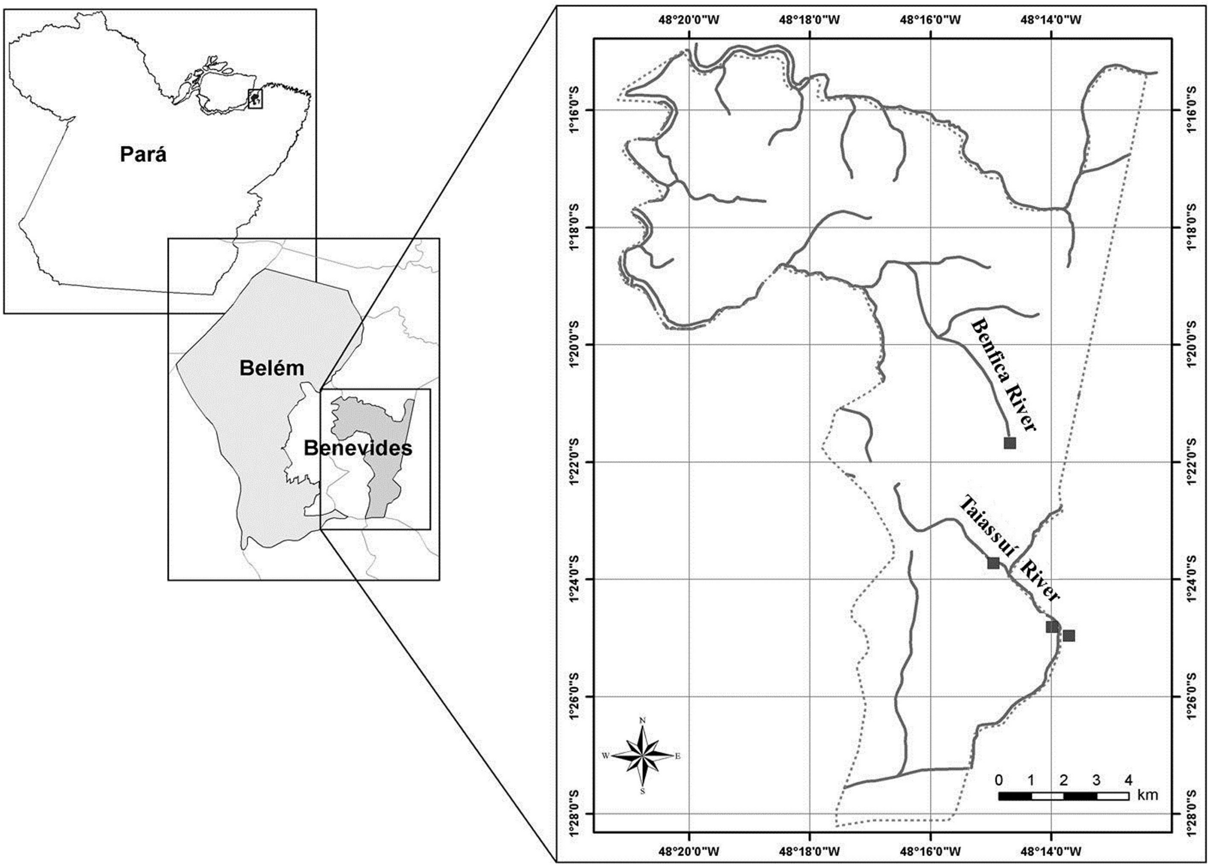

Figure 1. Location of the ichthyological sampling stations on the Taiassuí and Benfica rivers in the municipality of Benevides (Pará), where samples were collected between 2001 and 2007.

Rooted floating vegetation (Nymphaeaceae: *Nymphaea* spp.) and fixed submerged plants (Cabombaceae: *Cabomba* spp.) were found at all four sites, in addition to free-standing macrophytes vegetation typical of habitats that suffer periodic flooding. The substrate was sandy and rocky, with an abundance of clay and leaf debris in some parts.

Ichthyofauna

A total of 5,133 specimens were captured, belonging to seven orders, 23 families, and 81 species (Table 3). Of these species, 33 have been identified taxonomically, while 48 (56.6% of the total) have been assigned to morphospecies, due to the lack of specialized reference material, or in at least some cases, because the specimens probably represent undescribed taxa.

The most diverse order was Characiformes, with seven families and 34 species (42% of the total captured), followed by Perciformes, with two families and 18 species (22% of the total), Siluriformes (eight families, 14 species), Gymnotiformes (three families, 11 species), Cyprinodontiformes (two families, two species). Together, the Beloniformes and Synbranchiformes, both represented by a single species, provided only 1.2% of the specimens captured (Table 2).

The structure of the fish community recorded in the present study was distinct from that typically found in other parts of the Amazon basin, due to the increased participation of the family Cichlidae (Perciformes). This difference may be at least partly accounted for by the anthropogenic impacts observed in the study area, such as the partial damming of the rivers for the creation of bathing pools, the silting up of the river beds and/or the ongoing urbanization of the municipality of Benevides, which is most unplanned (SEPOF 2006), and has resulted in drastic alterations of the aquatic environments of rivers and streams.

Areas in the proximity of rivers are preferred by most

Table 1. Characteristics of the sampling stations in the Taiassuí and Benfica rivers, municipality of Benevides (Pará), in 2006 and 2007.

SITE	COORDINATES		WIDTH (M)	DEPTH (M)	TRANSPARENCY (%)	RIPARIAN VEGETATION
	LATITUDE	LONGITUDE				
Taiassuí 1	1°23'43.7" S	48°14'57.6" W	16	0.4	100	*Nymphaea* spp
Taiassuí 2	1°25'13.0" S	48°14'49.1" W	16	1	100	*Cabomba* spp, *Nymphaea* spp and Macrophytes
Taiassuí 3	1°25'36.9" S	48°14'50.8" W	5	0.5	100	*Cabomba* spp
Benfica 1	1°21'41.0" S	48°14'41.0" W	9	0.5	100	*Cabomba* spp

Figure 2. Sampling stations used for the collection of fish specimens in Benevides, Pará, in 2003, 2006, and 2007: (a) site 1 (Rio Taiassuí); (b) site 2 (Rio Benfica); (c) site 3 (Rio Taiassuí); (d) site 4 (Rio Taiassuí).

residents due to the availability of freshwater and fish, and many commercial installations and holiday homes have also been constructed in close proximity to these water bodies (SEPOF 2006). These processes may be transforming lotic environments into lentic ones, which may favor the occurrence of benthopelagic fish species (Alvarada *et al.* 2005), like most cichlids. The reduced current flow leads to increased deposits of organic material, which may increase the availability of refuges and feeding resources for some fish taxa (Lowe-McConnel 1975).

One other possible explanation for the contrasts in the composition of the fish community of the study area is related to methodological differences and selectivity of the fishing gear employed, in particular, the sampling technique (hand nets and trawls) and timing (9:00-16:00h), which almost certainly favored the capture of diurnal fish, such as cichlids and characids, over those with nocturnal or crepuscular habits, i.e. most siluriforms and gymnotiforms (Lowe-McConnel 1999).

In 2001, 596 specimens were collected, representing 18 families and 43 species/morphospecies, while in 2003, only 155 specimens were captured, including 11 families and 26 species/morphospecies. Twenty of the species recorded in 2003 had not been found in the 2001 samples. The total sample from 2006 consisted of 3821 specimens, representing 20 families and 73 species/morphospecies, of which 11 had not been recorded in 2001/2003. The sample from 2007 consists of 561 specimens, distributed in 12 families and 24 species, seven of which had not been recorded previously (Figure 3). Two of these species – *Apistogramma tucurui* Staeck, 2003 and *Moenkhausia oligolepis* (Günther, 1864) – were recorded from Pará for the first time, given that all previous records were from the upper Rio Tocantins in the Brazilian state of Tocantins.

The rarefaction curve (Figure 3) provided the following equation – *Number of taxa* = 23.42 * ln(*Number of samples*) + 30.058. This indicates that, if the number of samples for the Benevides region were doubled to 18, maintaining the same sampling techniques and effort, the number of species recorded for the study area would increase by approximately 17%. According to Dias (2004), an area can be considered to have been well sampled when the curve approaches stability, indicating that almost all the local species have been collected.

The vast majority of the species 70% (65 species) returned less than 1% of the specimens. This high participation of low abundance species may be explained by the behavioral, dietary, and principally reproductive characteristics of the species (McDonald 2004, Paranhos 2006), given that low fecundity may result in reduced abundance or a restricted distribution. An alternative explanation may be that many of these species undertake mass migrations during part of the year related to shifts in resource abundance and/or breeding patterns (Cunico *et al.* 2002), resulting in their under-representation in the different months during which samples were collected or that this situation reflects some major shift in local conditions, resulting from either natural or anthropogenic pressures (Barrella 2001)

The conservation of the biological diversity of aquatic ecosystems is one of the most important and difficult challenges of the present day (Chernoff *et al.* 1996, Chernoff and Wilink 1999). In the tropics, however, the biodiversity of aquatic ecosystems is poorly-known in comparison with terrestrial systems (Agostinho *et al.* 2005). In addition to the considerable lacunas in the taxonomy and systematics of many species groups, phylogenetic and biogeographic (Machado-Allison and Fink 1996, Mago-Leccia 1978) and ecological patterns (Goulding 1979, Winemiller 1989, Menezes 1996) are generally only poorly understood.

The development of effective measures for the reduction or elimination of environmental impacts (such as mining, canal-digging, damming, development of waterways, and other human occupation) on the biodiversity of aquatic ecosystems will require reliable information on this diversity, or at the very least, an evaluation of their ecological complexity and the life history of their constituent organisms (Chernoff *et al.* 1996, Alves *et al.* 2008).

Castro and Acirfa (1987) concluded that abrupt alterations of the environment may modify the whole structure of the fish community, selecting the species best adapted to the new physical-chemical conditions of the water (Branco 1972). However, such changes could not be evaluated in the present study, given the lack of comparative data from previous years. Obviously, this underlines the importance of the establishment of systematic and continuous monitoring initiatives, not only for the present study area, but also for other hydrographic basins within the Belém Endemism Center. This will provide important data on the diversity, ecology, distribution, and conservation status of species, as well as insights into possible environmental impacts, contributing to the development of effective conservation and management policies.

Table 2. Relative contribution of the different fish orders to the total species richness and abundance recorded between 2001 and 2007 in the Taiassuí and Benfica rivers, Benevides (Pará).

ORDER	Nº. OF SPECIES		Nº. OF SPECIMENS	
Characiformes	34	(41.98%)	4473	(87.14%)
Perciformes	18	(22.22%)	349	(6.80%)
Siluriformes	14	(17.28%)	147	(2.86%)
Gymnotiformes	11	(13.58%)	129	(2.51%)
Beloniformes	1	(1.23%)	22	(0.43%)
Cyprinodontiformes	2	(2.47%)	11	(0.21%)
Synbranchiformes	1	(1.23%)	2	(0.04%)
Total		81		5133

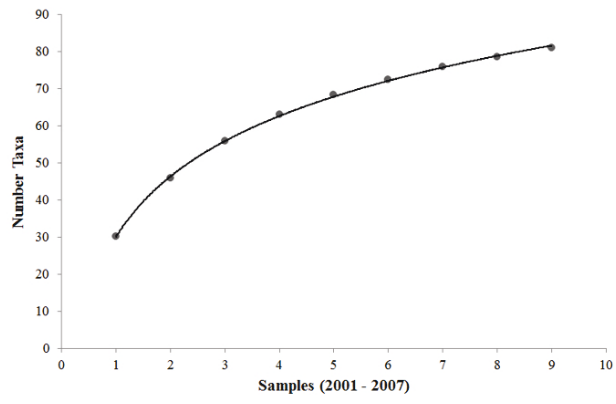

Figure 3. Rarefaction curve for the samples of fish collected between 2001 and 2007 in the Taiassuí and Benfica rivers, Benevides, Pará. Number of taxa = 23.42 * ln(Number of samples) + 30.058.

Table 3. Composition of species found in the Taiassuí and Benfica rivers, based on the occurrence of the species in the years 2001, 2003, 2006 and 2007.

TAXA/AUTHORITY	2001	2003	2006	2007
Beloniformes				
Belonidae				
Potamorrhaphis guianensis (Jardine, 1843)	■		■	
Characiformes				
Erythrinidae				
Erythrinus erythrinus (Agassiz, 1829)			■	
Hoplias malabaricus (Bloch, 1794)	■	■	■	■
Acestrorhynchidae				
Acestrorhynchus falcatus (Bloch, 1794)		■	■	
Characidae				
Bryconops sp.1	■		■	■
Bryconops sp.2			■	
Charax sp.			■	
Hemigrammus belotii (Steindachner, 1882)	■		■	
Hemigrammus cf. *ocellifer*			■	■
Hemigrammus ocellifer (Steindachner, 1882)	■			
Hemigrammus sp.	■			
Hyphessobrycon cf. *inconstans*			■	
Hyphessobrycon heterorhabdus (Ulrey, 1894)		■	■	
Hyphessobrycon inconstans (Eigenmann and Ogle, 1907)			■	
Hyphessobrycon sp.	■	■	■	■
Hyphessobrycon werneri Géry and Uj, 1987	■	■	■	■
Iguanodectes cf. *rachovii*		■	■	■
Iguanodectes rachovii Regan, 1912			■	
Microschemobrycon sp.			■	
Moenkhausia collettii (Steindachner, 1882)	■		■	
Moenkhausia comma Eigenmann, 1908				
Moenkhausia oligolepis (Günther, 1864)	■		■	
Moenkhausia sp.	■	■	■	■
Mylopus sp.			■	
Poptella sp.		■	■	
Crenuchidae				
Aphyocharacidium sp.	■	■	■	■
Crenuchus spilurus Günther, 1863	■	■	■	■
Microcharacidium sp.	■		■	■
Curimatidae				
Curimata sp.1	■		■	
Curimata sp.2			■	
Gasteropelecidae				
Carnegiella strigata (Günther, 1864)	■		■	■
Lebiasinidae				
Copella sp.	■	■	■	
Nannostomus beckfordi Günther, 1872	■		■	
Nannostomus sp.	■	■	■	
Pyrrhulina sp.		■	■	
Cyprinodontiformes				
Poeciliidae				
Poecilia sp.	■			
Rivulidae				
Rivulus sp.	■	■	■	
Gymnotiformes				
Hypopomidae				
Microsternarchus sp.1	■		■	
Microsternarchus sp.2	■	■	■	
Microsternarchus sp.3			■	
Hypopygus sp.1		■	■	■
Hypopygus sp.2	■		■	
Hypopygus sp.3			■	■

Table 3. *Continued.*

TAXA/AUTHORITY	2001	2003	2006	2007
Steatogenys sp.		■	■	
Rhamphichthyidae				
*Gymnorhamphichthys rondoni (*Miranda Ribeiro, 1920)			■	
Gymnorhamphichthys petiti Géry and Vu-tân-Tuê, 1964		■	■	
Sternopygidae				
Eigenmannia sp.1	■		■	
Eigenmannia sp.2			■	
Perciformes				
Cichlidae				
Acaronia nassa (Heckel, 1840)			■	
Aequidens epae Kullander, 1995	■		■	■
Aequidens sp.1	■		■	■
Aequidens sp.2		■		
Apistogramma agassizii (Steindachner, 1875)	■		■	■
Apistogramma sp.	■	■	■	
Apistogramma tucurui Staeck, 2003	■	■	■	
Cichlasoma sp.1			■	
Cichlasoma sp.2			■	
Crenicichla lepidota Heckel, 1840	■	■	■	
Crenicichla notophthalmus Regan, 1913	■			■
Crenicichla regani Ploeg, 1989	■		■	
Heros severus Heckel, 1840			■	
Heros sp.			■	
Mesonauta acora (Castelnau, 1855)	■		■	
Satanoperca jurupari (Heckel, 1840)	■		■	
Satanoperca sp.		■	■	
Polycentridae				
Monocirrhus polyacanthus Heckel, 1840	■		■	■
Siluriformes				
Trichomycteridae				
Ituglanis amazonicus (Steindachner, 1882)			■	
Trichomycterus hasemani (Eigenmanni, 1914)			■	■
Aspredinidae				
Bunocephalus caracoideus (Cope, 1874)	■		■	■
Auchenipteridae				
Tatia sp.			■	■
Cetopsidae				
Helogenes marmoratus Günther, 1863		■	■	
Heptapteridae				
Gladioglanis sp.	■			
Loricariidae				
Ancistrus sp.1	■	■	■	■
Ancistrus sp.2			■	
Farlowella sp.	■	■	■	■
Rineloricaria hasemani Isbrücker and Nijssen, 1979	■		■	
Rineloricaria sp.1			■	
Rineloricaria sp.2			■	
Pseudopimelodidae				
Microglanis sp.			■	
Pseudopimelodus sp.	■		■	
Synbranchiformes				
Synbranchidae				
Synbranchus sp.	■			■
Number of taxa	**43**	**26**	**73**	**24**

Acknowledgments: We are grateful to CNPq for granting the first author with an undergraduate stipend (process number 117018/2006-6), the colleagues who participated in the collection of specimens, Dr. André Netto-Ferreira for the identification of the Lebiasinidae, Dr. Alexandre Cardoso (PUC-RS) for the identification of the Bunocephalinae (Aspredinidae; Siluriformes), Dr. Flávio Lima (MZUSP) for the identification of the Characiformes, Dr. Stephen Ferrari for the translation of the manuscript, and all the other colleagues who contributed directly or indirectly to the success of this study.

Literature Cited

Agostinho A.A, S.M. Thomaz and L.C. Gomes. 2005. Conservação da biodiversidade em águas continentais do Brasil. *Megadiversidade* 1(1): 70-78.

Almeida, A.S and I.C.G. Vieira. 2010. Centro de Endemismo Belém: Status da vegetação remanescente e desafios para a conservação da biodiversidade e restauração ecológica. *Revista de Estudos Universitários* 36(3): 95-111.

Alvarado, L.C.P, M.R. Álvarez, A.M.M. Dix and M. Dix. 2005. *La ictiofauna del Refugio de Vida Silvestre Bocas del Polochic y la cuenca del lago de Izabal: composición, distribución y ecologia*. Guatemala City: Organización de las para la Educación, la Ciencia y la Cultura, Universidad del Valle de Guatemala. 209 p.

Alves, C.B.M, C.G. Leal, M.F.G. de Brito and A.C.A. Santos. 2008. Biodiversidade e Conservação de peixes do Complexo do Espinhaço. *Megadiversidade* 4(12): 177-196.

Arrolho-Silva, S.A and F.R. Silva. 2008. Dieta natural de *Prionobrama filigera* (Cope, 1870) Piabinha em margem alagada do Rio Teles Pires. *Revista de Ciências Agro-ambientais*, *Alta Floresta* 6(1): 57-65.

Barthem, R.B. 1995. Developmental of commercial fisheries in the Amazon Basin and Consequences for fish Stocks and Subsistence Fishing; p. 127-204 *In* M. Clüsenergodt and I.Sachs (ed.). *Brazilian perspectives on sustainable development of the Amazon region.* Paris: Unesco. 330 p.

Barrella, W. 2001. Os peixes como indicadores da qualidade das águas dos rios; p 249-262 *In* N.B. Maia, H.L. Martos and E.W. Barrella (ed.). *Indicadores ambientais: conceitos e aplicações*. São Paulo: EDUC/COMPED/INEP. 285 p.

Buckup, P.A., N.A. Menezes and M.S. Ghazzi. 2007. *Catálogo das espécies de peixes de água doce do Brasil*. Rio Janeiro: Museu Nacional. 195 p.

Brandon, K., A.B. Rylands, G.A.B. Fonseca and J.M.C Silva. 2005. Conservação brasileira: desafios e oportunidades. *Megadiversidade* 1(1): 7-13.

Branco, S.M. 1972. Poluição e Intoxicação de Peixes; p. 45-52 *In* C. Gardin (ed.) *Poluição e Piscicultura*. São Paulo: Faculdade de Saúde Pública da USP e Instituto de Pesca da C.P.R.N. da Secretaria da Agricultura. 216 p.

Burgess, W.E. 1989. *An atlas of freshwater and marine catfishes*. Neptune City, NJ: T.F.H. Publications. 784 p.

Castro, D. 1994. *Los peces del rio Putumayo sector de Puerto Leguízamo* (CAP). Mocoa: Putumayo. 174 p.

Castro, D. and A. Arboleda. 1988. Lista preliminar de peces del rio Caquetá. *Boletín Facultad Biología Marina de la Universidad Jorge T. Lozano* 8: 7-14.

Castro, R.M.C and M.F. Arcifa. 1987. Comunidades de peixes de reservatórios do sul do Brasil. *Revista Brasileira de Biologia* 47 (4): 493-500.

Chernoff, B., R. Barriga, A. Forsyth, R. Foster, B. Leon, A. Machado-Allison, C. Magalhães, N. Menezes, D. Moskovits, H. Hortega and J. Sarmiento. 1996. *Aqua-Rap. Rapid Assessment Program for the Conservation of Aquatic Ecosystems in Latin America*. Washington, DC: Conservation International. 8p+Annex.

Chernoff, B. and K. P.W. Willink. 2000. Ecological and geographical structure in assemblages of freshwater fishes in the Pantanal, Mato Grosso do Sul, Brasil; p. 183-201 *In* P.W. Willink, B. Chernoff, L.E. Alonso, J.R. Montambault and R. Lourival (ed.). *A biological assessment of the aquatic ecosystems of the Pantanal, Mato Grosso do Sul, Brasil*. *RAP Bulletin of Biological Assessment 18.* Washington, DC: Conservation International. 290 p.

Cunico A.M., W.J. Graça, S. Veríssimo and L.M Bini. 2002. Influência do nível hidrológico sobre a assembléia de peixes em lagoa sazonalmente isolada da planície de inundação do alto rio Paraná. *Acta Scientiarum* 24(2): 383-389.

Dias, S.C. 2004. Planejando estudos de diversidade e riqueza: uma abordagem para estudantes de gradução. *Acta Scientiarum* 26(4): 373-379.

Dudgeon, D., A.H. Arthington, M.O. Gessner, Z. Kawabata, D.J. Knowler, C. Lévêque, R.J. Naiman, A. Prieur-Richard, D. Soto, M.L.J. Stiassny and C.A. Sullivan. 2006. Freshwater biodiversity: importance, threats, status and conservation challenges. *Biological Review* 81: 163-182.

Gery, J. 1977. *Characoids of the world*. Neptune City, NJ: T.F.H. Publications. 672 p.

Goldstein, R.J. 1973. *Cichlids of the world*. Neptune City, NJ: T.F.H. Publications. 382 p.

Goulding, M. 1979. *Ecologia da pesca do rio Madeira*. Manaus: Instituto Nacional de Pesquisas da Amazônia/Conselho Nacional de Desenvolvimento Científico e Tecnológico. 172 p.

Goulding, M. 1988. Ecology and Management of Migratory food fishes oh the Amazon Basin; p. 71-85 *In* F. Almeida and C.M. Pringle (ed.). *Tropical Rainforest, Diversity and Conservation*. San Francisco: California Academy of Sciences.

Goulding, M. 1989. *Amazon: the flooded forest*. London: BBC. 208 p.

Keith P., P.-Y. Le Bail and P. Planquette. 2000. *Atlas des poissons d'eau douce de Guyane (tome 2, fascicule I): Batrachoidiformes, Mugiliformes, Beloniformes, Cyprinodontiformes, Synbranchiformes, Perciformes and Tetraodontiformes*. Paris: Collection du Patrimoine Naturel (MNHN/SPN), 43(1): 286 p.

Kullander, S.O. and H. Nijssen. 1989. *The Cichlids of Surinam*. New York: E.J. Brill. 256 p.

Kullander, S.O and C. A. S. Lucena. 2006**.** A review of the species of Crenicichla (Teleostei: Cichlidae) from the Atlantic coastal rivers of southeastern Brazil from Bahia to Rio Grande do Sul States, with descriptions of three new species. *Neotropical Ichthyology* 4 (2): 127-146.

Lauzane, L. and G. Loubens. 1985. *Peces del río Mamoré.* Paris: L'Orstom. 116 p.

Lowe-McConnell, R.H. 1975. *Fish communities in tropical freshwater*. London: Longman Group. 337 p.

Lowe-McConnel, R.H. 1999. *Estudos ecológicos de comunidades de peixes tropicais. Translation by A.E.A.M, Vazzoler, A.A. Agostinho and P.M. Cunnhingham*. São Paulo: EDUSP. 536 p.

Machado-Allison, A. and W. Fink. 1996. *Los peces Caribe de Venezuela: diagnosis, claves y aspectos ecológicos y evolutivos*. Caracas: Universidad Central de Venezuela. 151 p.

Malabarba, L.R. and R.E. Reis. 1987. *Manual de Técnicas para a preparação de Coleções Zoológicas, Peixes.* Campinas: Sociedade Brasileira de Zoologia 36: 14 p.

Mago-Leccia, F.1978. *Los peces de agua dulce del Pais*. Caracas: Cuadernos Lagoven. 35 p.

McDonald, L.L. 2004. Sampling rare populations; p. 11-42 *In* W, Thompson (ed). *Sampling rare and elusive species – concepts, designs and techniques for estimate populations parameters*. Washington: Island Press.

Menezes, N.A. 1996. Methods for assessing freshwater fish diversity; p. 289-295 *In* C.E. de M, Bicudo and N.A, Menezes (ed.) *Biodiversity in Brazil: A first approach*. São Paulo: Conselho Nacional de Desenvolvimento Científico e Tecnológico.

Montag, L.F.A; T.M.S. Freitas; W.B. Wosiacki and R.B. Barthem. 2008. Os peixes da Floresta Nacional de Caxiunã (municípios de Melgaço e Portel, Pará – Brasil). *Boletim Museu Paraense Emílio Goeldi, Ciências Naturais* 3(1): 11-34.

Montag, L.F.A., A.A. Albuquerque, T.M.S. Freitas and R.B. Barthem. 2009. Ictiofauna de campos alagados da Ilha do Marajó, Estado do Pará, Brasil. *Biota Neotropical* 9(3): 241-253

Munôz, S.H. 2010. A importância dos fragmentos urbanos para a conservação da flora e fauna da grande Belém no Estado do Pará. *XVIII Seminário de Iniciação Científica – PIBIC "Formação de recursos humanos e políticas públicas para a Amazônia*". Belém: Museu Paraense Emílio Goeldi. 100 p.

Paranhos, K.M. 2006. *Estimativas populacionais para espécies raras: Mico-leão-preto Leontopithecus chrysopygus (Mikan, 1823) como modelo*. Dissertação de Mestrado em Ecologia e conservação. Curitiba: Universidade Federal do Paraná. 53 p.

Planquette P., P. Keith and P.-Y. Le Bail. 1996. Atlas des poissons d'eau douce de Guyane. *Paris: Collection du Patrimoine Naturel (M.N.H.N/INCRA/C.S.P)* 22(1): 1-429.

Le Bail P.-Y., Keith P. and P. Planquette. 2000. Atlas des poissons d'eau douce de Guyane (tome 2, fascicule II) : Siluriformes. *Paris: Collection du Patrimoine Naturel (MNHN/SPN)* 43(1): 1-307.

Reis, R.E., S.O. Kullander and C.J. Ferraris Jr. 2003. *Check list of the freshwater fishes of South and Central America*. Porto Alegre: EDPUCRS. 729 p.

Restrepo G.M., M.E.T. Tormen and T. Bustamante. 1991. *Frontera amazónica: historia de un problema*. Quito: CEDIME. 100 p.

SEPOF. 2006. *Gerência de Base de Dados Estatísticos do Estado da Secretaria de Planejamento, orçamento e finanças: Estatística Municipal de Benevides*. Belém: Governo do Estado do Pará. 2 p.

Santos, G.M., M. Jégu and B. Mérona. 1984. *Catálogo de peixes comerciais do baixo rio Tocantins: projeto Tucuruí.* Manaus: Eletronorte/CNPq/INPA. 83 p.

Soares, L. M. S and R. F. M. Pinheiro. 2008. A systematic revision of Tatia (Siluriformes: Auchenipteridae: Centromochlinae). *Neotropical Ichthyology* 6 (3): 495 – 542.

Schaefer S. 1998. Conflict and resolution: impact of new taxa on phylogenetic studies of the Neotropical cascudinhos (Siluroidei: Loricariidae); p. 375-400 *In* L.R. Malabarba, R.E. Reis, R.P. Vari, Z.M. Lucena and C.A.S. Lucena (ed.). *Phylogeny and classification of Neotropical fishes*. Porto Alegre: EDUPUCRS.

Vieira, D.B and O.A. Shibatta. 2007. Peixes como indicadores de qualidade ambiental do ribeirão Esperança, município de Londrina, Paraná, Brasil. *Biota Neotropica* 7(1): 57-66.

Winemiller, K.O. 1989. Patterns of variation in life history among South American fishes in seasonal environments. *Oecologia* 81:225-241.

Received: June 2011
Accepted: May 2012
Published online: June 2012
Editorial responsibility: Rubens Pazza

Appendix 1. Voucher specimens.

Beloniformes: *Potamorrhaphis guianensis* (MPEG 10287, 10566, 12033, 12034). **Characiformes**: *Acestrorhynchus falcatus* (MPEG 10285, 10546, 12131, 12601) ; *Aphyocharacidium* sp. (MPEG 10255, 10544, 10545, 10609, 10611, 10610, 11994, 12120, 12489, 12599, 12602, 12606); *Bryconops* sp.1 (MPEG 10229, 10235, 10525, 10539, 10548, 10577, 10579, 10582, 10603, 10604, 10605, 10606, 10607, 10608, 10612, 10613, 10614, 10615, 10616, 10617, 11969, 12487, 12488, 12572, 12597, 12623); *Bryconops* sp.2 (MPEG 10252); *Charax* sp. (MPEG 10278); *Hemigrammus bellotii* (MPEG 10249, 10530, 10538, 10541, 10543, 10594, 10596, 12174, 12490, 12580, 12588, 12598); *Hemigrammus* cf. *ocellifer* (MPEG 10251, 10567, 11999, 12158, 12159, 12466, 12481, 12612); *Hemigrammus ocellifer* (MPEG 12622); *Hemigrammus* sp. (MPEG 12593); *Hyphessobrycon* cf. *inconstans* (MPEG 10238, 10531); *Hyphessobrycon heterorhabdus* (MPEG 10248, 10529, 10569, 10574, 10578, 12129, 12141); *Hyphessobrycon inconstans* (MPEG 10257, 10575); *Hyphessobrycon* sp. (MPEG 10522, 10523, 10533, 10534, 10537, 10542, 11965, 12160, 12173, 12510, 12514, 12603, 12607, 12134); *Hyphessobrycon werneri* (MPEG 10253, 10535, 10547, 10598, 12000, 12119, 12170, 12578, 12584, 12589, 12590); *Iguanodectes* cf. *rachovii* (MPEG 10528); *Iguanodectes rachovii* (MPEG 10256, 10532, 11963, 12138, 12145); *Microshemobrycon* sp. (MPEG 10597); *Moenkhausia collettii* (MPEG 10250, 10568, 10595, 10599); *Moenkhausia comma* (MPEG 10254); *Moenkhausia oligolepis* (MPEG 10576, 10580); *Moenkhausia* sp. (MPEG 10527, 10540) *Mylopus* sp. (MPEG 10243); *Poptella* sp. (MPEG 10581, 10600, 10601); *Crenuchus spilurus* (MPEG 10279, 10536, 10572, 10573, 10602); *Microcharacidium* sp. (MPEG 10262, 10524); *Curimata* sp.1 (MPEG 10237, 10275); *Curimata* sp.2 (MPEG 10521); *Erytrinus Erytrinus* (MPEG 10277); *Hoplias malabaricus* (MPEG 10549, 10583); *Carnegiella strigata* (MPEG 10241, 10546); *Copella* sp. (MPEG 10231); *Nannostomus beckfordi* (MPEG 10247, 10259, 10571, 12581, 12536); *Nannostomus* sp. (MPEG 12126, 12127, 12130, 12132, 12157, 12587, 12608, 12621); *Pyrrhulina* sp. (MPEG 10570, 12128, 12149, 12478, 12613). **Cyprinodontiformes**: *Rivulus* sp. (MPEG 10584, 12125, 12133, 1213910550); *Poecilia* sp. (MEPG 12142). **Gymnotiformes**: *Microstenarchus* sp.1 (MPEG 10562, 10587, 12169, 12515); *Microstenarchus* sp.2 (MPEG 10270, 10273, 10276, 10563, 10564, 10565, 12146, 12148, 12155, 12485); *Microstenarchus* sp.3 (MPEG 10585, 10586); *Hypopygus* sp.1 (MPEG 10246, 10260, 10264, 11996, 12117); *Hypopygus* sp.2 (MPEG 10227, 12484, 12516, 12573); *Hypopygus* sp.3 (MPEG 11988, 12156, 12168, 12483, 12486); *Gymnorhamphichthys rondoni* (MPEG 10234); *Gymnorhamphichthys petiti* (MPEG 12121, 12123, 12150); *Eigenmannia* sp1. (MPEG 10280, 12175); *Eigenmannia* sp.2 (MPEG 10282) *Steatogenys* sp. (MPEG 10266, 10274, 10561, 12122**). Perciformes**: *Acaronia nassa* (MPEG 10230, 10232, MPEG10269, MPEG11927, MPEG11928); *Apistogramma agassizii* (MPEG 10236, 10268, 10552, 10553, 11896, 11897, 11898, 11899, 11950, 12048, 12049, 12479); *Apistogramma tucurui* (MPEG 10244, 11901, 11902, 11903, 11939, 12575); *Apistogramma* sp. (MPEG 10589, 11892, 11893, 11894, 11895, 11940); *Aequidens epae* (MPEG 10261, 10272, 10554, 10588, 10590, 10591, 10592, 11900, 11926, 11990); *Aequidens* sp. 1 (MPEG 10269, 11927, 11928, 11991, 12047); *Aequidens* sp. 2 (MPEG 11938); *Cichlasoma* sp.1 (MPEG 11920); *Cichlasoma* sp.2 (MPEG 11921); *Crenicichla lepidota* (MPEG 10240, 11931, 11937); *Crenicichla notophthalmus* (MPEG 11935, 11936); *Crenicichla regani* (MPEG 10265, 11932, 11933, 11934); *Heros severus* MPEG10281, MPEG11925); *Heros* sp. (MPEG 11960, 11962); *Mesonauta acora* (MPEG 10233, 10551, 11911, 11912); *Satanoperca jurupari* (MPEG 10228, 11930); *Satanoperca* sp. (MPEG 11953, 11929, 12050); *Monocirrhus polyacanthus* (MPEG 10267, 11922, 11923, 11924, 12001, 12511) **Siluriformes**: *Bunocephalus caracoideus* (MPEG 10271, 12512, 11966, 12513); *Tatia* sp. (MPEG 10556, 11998); *Microglanis* sp. (MPEG 13016); *Gladioglanis* sp. (MPEG 12052); *Helogenes marmoratus* (MPEG 10258, 10555, 12054, 12058); *Ancistrus* sp.1(MPEG 10557, 11961, 11989, 11997, 12609, 12610, 12618, 12619, 12620); *Ancistrus* sp.2 (MPEG 10245); *Farlowella* sp. (MPEG 10284, 10560, 12002, 12059, 12060, 12152, 12153, 12154); *Rineloricaria hasemani* (MPEG 10286, 10559, 10593, 12595, 12628, 12630, 12631); *Rineloricaria* sp.1 (MPEG 10558); *Rineloricaria* sp.2 (MPEG 12519, 12629); *Pseudopimelodus* sp. (MPEG 10263, 12056, 12057); *Ituglanis amazonicus* (MPEG 10242); *Trichomycterus hasemani* (MPEG 10556, 11998). **Synbranchiformes**: *Synbranchus marmoratus* (MPEG 11967, 12035).