Biota Neotropica
ISSN: 1676-0611
cjoly@unicamp.br
Instituto Virtual da Biodiversidade
Brasil

Lustosa Costa, Silvia Yasmin; de Lucena Barbosa, José Etham; Gomes Viana, Leandro; Anselmo Ramos, Telton Pedro
Composition of the ichthyofauna in Brazilian semiarid reservoirs
Biota Neotropica, vol. 17, núm. 3, 2017, pp. 1-11
Instituto Virtual da Biodiversidade
Campinas, Brasil

Biota Neotropica 17(3): e20170334, 2017

biotaneotropica
ISSN 1676-0611 (online edition)
article

Composition of the ichthyofauna in Brazilian semiarid reservoirs

Silvia Yasmin Lustosa Costa[1], José Etham de Lucena Barbosa[1], Leandro Gomes Viana[1] & Telton Pedro Anselmo Ramos[2,3*]

[1]Departamento de Ciências Biológicas e da Saúde, Universidade Estadual da Paraiba, Campina Grande, PB, Brazil
[2]Departamento de Botânica, Ecologia e Zoologia, Universidade Federal do Rio Grande do Norte, Natal, RN, Brazil
[3]Departamento de Sistemática e Ecologia, Universidade Federal da Paraíba, João Pessoa, PB, Brazil
**Corresponding author: Telton Pedro Anselmo Ramos, e-mail: telton@gmail.com*

COSTA, S.Y.L., VIANA, L.G., BARBOSA, J. E. L., RAMOS, T.P.A. **Composition of the ichthyofauna in Brazilian semiarid reservoirs**. Biota Neotropica. 17(3): e20170334. http://dx.doi.org/10.1590/1676-0611-BN-2017-0334

Abstract: The scale of impact that the São Francisco River transposition project will have on the drainage basins ichthyofauna is still unclear, however, changes in the fish community diversity and abundance is probable. Surveys and registries of the fish fauna within key systems of the catchment basins are priority actions for the conservation of the aquatic diversity. This study conducted a taxonomic survey of the Epitácio Pessoa (Boqueirão municipality) and Argemiro de Figueiredo (Itatuba municipality), reservoirs ichthyofauna, both belonging to the Paraíba do Norte River basin, important socioeconomic and environmental systems for the transposition project. Monthly sampling was carried out between October/2014 to September/2015 in the upstream and downstream zones of the reservoirs. The specimens were collected using dip nets, drag nets, and sieves, and placed on ice in the field. Later in the laboratory, they were transferred to 10% formaldehyde and then preserved in 70% alcohol. A total of 2,328 specimens were collected representing five orders, 14 families, and 31 species in both systems. At the upstream zones 2057 specimens were collected representing 17 species, and at the downstream zones 271 specimens were collected representing 24 species. Of the 31 species recorded, 13 species are endemic to watersheds that drain rivers from the Brazilian semi-arid region, and seven species (*Apareiodon davisi*, *Characidium bimaculatum*, *Hypostomus pusarum*, *Parotocinclus jumbo*, *P. spilosoma*, *Pimelodella enochi*, and *Prochilodus brevis*) are endemic to the Mid-Northeastern Caatinga Ecoregion (MNCE). Among the latter, *Parotocinclus spilosoma* and *Pimelodella enochi* are endemic to the Paraíba do Norte River. *Apareiodon davisi* is classified as Endangered according to the current published Brazil's official list of endangered species of fish and aquatic invertebrates. This pre-transposition ichthyofaunistic survey will serve as a basis for future post-transposition analyzes, considering this action will change the scope of the ecosystems diversity.

Keywords: *Endemism, Paraíba, Basins Transposition.*

Composição da ictiofauna em reservatórios do semiárido brasileiro

***Resumo*:** A dimensão do impacto que a transposição do rio São Francisco provocará na ictiofauna das bacias receptoras ainda é imprecisa, entretanto, é provável que haja alterações na riqueza e abundância da comunidade de peixes. Levantamentos e registros prévios da fauna íctica em sistemas chaves das bacias receptoras são ações prioritárias para a conservação da diversidade aquática. Este estudo realizou o levantamento taxonômico da ictiofauna dos reservatórios Epitácio Pessoa (município de Boqueirão), e Argemiro de Figueiredo (município Itatuba), ambos pertencentes a bacia hidrográfica do rio Paraíba do Norte, estado da Paraíba, importantes sistemas sócioeconômicos e ambientais para o projeto da transposição. Assim, foram realizadas amostragens mensais de Outubro/2014 a Setembro/2015 nas zonas lacustres e a jusante dos reservatórios. Os espécimes foram coletados com redes de espera, tarrafa, arrasto, peneiras e puçás, em seguida acondicionados em gelo no campo, posteriormente no laboratório, transferidos para o formol a 10% e conservados em álcool 70%. Foram coletados um total de 2328 espécimes distribuídas em 31 espécies, 14 famílias e cinco ordens nos dois sistemas. Nas zonas lacustres foram coletados 2057 espécimes distribuídos em 17 espécies e nas áreas a jusantes foram coletados 271 indivíduos, distribuídos em 24 espécies. Das 31 espécies registradas, 13 são endêmicas das bacias hidrográficas que drenam rios do semiárido brasileiro, destas, sete (*Apareiodon davisi*, *Characidium bimaculatum*, *Hypostomus pusarum*, *Parotocinclus jumbo*, *P. spilosoma, Pimelodella enochi* e *Prochilodus brevis*) são endêmicas do Nordeste Médio Oriental. Dentre estas últimas, *P. spilosoma e P. enochi* são endêmicas do rio Paraíba do Norte. *Apareiodon davisi* é classificada como Em Perigo de acordo com a atual lista oficial de espécies ameaçadas de peixes e invertebrados aquáticos no Brasil. Este levantamento ictiofaunístico pré-transposição servirá de base para análises futuras pós-transposição, considerando que esta ação acarretará mudanças no âmbito de diversidade dos ecossistemas em questão.

Palavras-chave: *Endemismo, Paraíba, Transposição de bacias.*

Introduction

Approximately 5,160 freshwater fish species are described from South America, representing 20 orders, 69 families, and 739 genera (Reis et al. 2016). Brazil covers majority of the Neotropical region, and its ichthyofauna consists of more than 3,000 freshwater species (Reis et al. 2016). According to Buckup et al. 2007, the number of freshwater fish species described in Brazil has increased significantly in recent years, with an annual growth greater than 20%, an average never yet recorded. However, the knowledge about the Brazilian ichthyofaunistic diversity is focused within certain regions, with the Northeast region displaying the lowest volume of published studies and a limited number of researchers (Rosa & Menezes 1996, Langeani et al. 2009, Ramos et al. 2014).

The lack of accurate knowledge related to systematics and distribution of fish taxa within Northeast Brazil is one of the main aspects limiting the ichthyofaunistic diversity evaluation and fish biogeographic determination of this region (Rosa et al. 2003, Ramos et al. 2014). However, in recent decades the number of research articles related to the ichthyofauna diversity of Brazilian semi-arid region has increased (Ramos et al. 2005, Novaes et al. 2013, Sánchez-Botero et al. 2013, Gurgel-Lourenço et al. 2013, Silva et al. 2014, Ramos et al. 2014, Silva et al. 2015, Gurgel-Lourenço et al. 2015).

In Brazil, approximately 12% of its territory is classified as being semi-arid with a population of about 23 million inhabitants (INSA 2015). Thus, the aquatic ecosystems are fundamental to the survival of local communities, taking into account that the construction of dams was primarily intended to increase water storage capacity for the urban network (Maltchik 1996, Rebouças et al. 2006, Medeiros et al. 2010).

Currently, Northeast region of Brazil is undergoing the process of channel construction that will transport water from the largest hydrographic basin in the region, the São Francisco River basin, to the basins of the Mid-Northeastern Caatinga Ecoregion - MNCE (ecoregion composed of hydrographic basins located between the São Francisco and Parnaíba basins - Rosa et al. 2003), among which is the Paraíba do Norte River basin. The Paraíba do Norte River watershed is the third largest of this ecoregion. In order to contribute to the knowledge of this systems ichthyofauna prior to the commencement of the transposition project, an ichthyofauna survey was undertaken focusing on two large reservoirs of the Paraíba do Norte River basin, the Epitácio Pessoa and the Argemiro de Figueiredo reservoirs, and their respective downstream areas.

Material and Methods

1. Study area

The study was carried out in the Epitácio Pessoa (Boqueirão) and Argemiro de Figueiredo (Acauã) reservoirs and their respective downstream areas. These reservoirs are situated in the Paraíba do Norte River basin, in Paraíba State (Figures 1 and 2). The Paraíba do Norte River is about 360 km in length, rising above a thousand meters elevation in the Serra de Jabitacá in Monteiro municipality, and flows into the Atlantic Ocean in Cabedelo

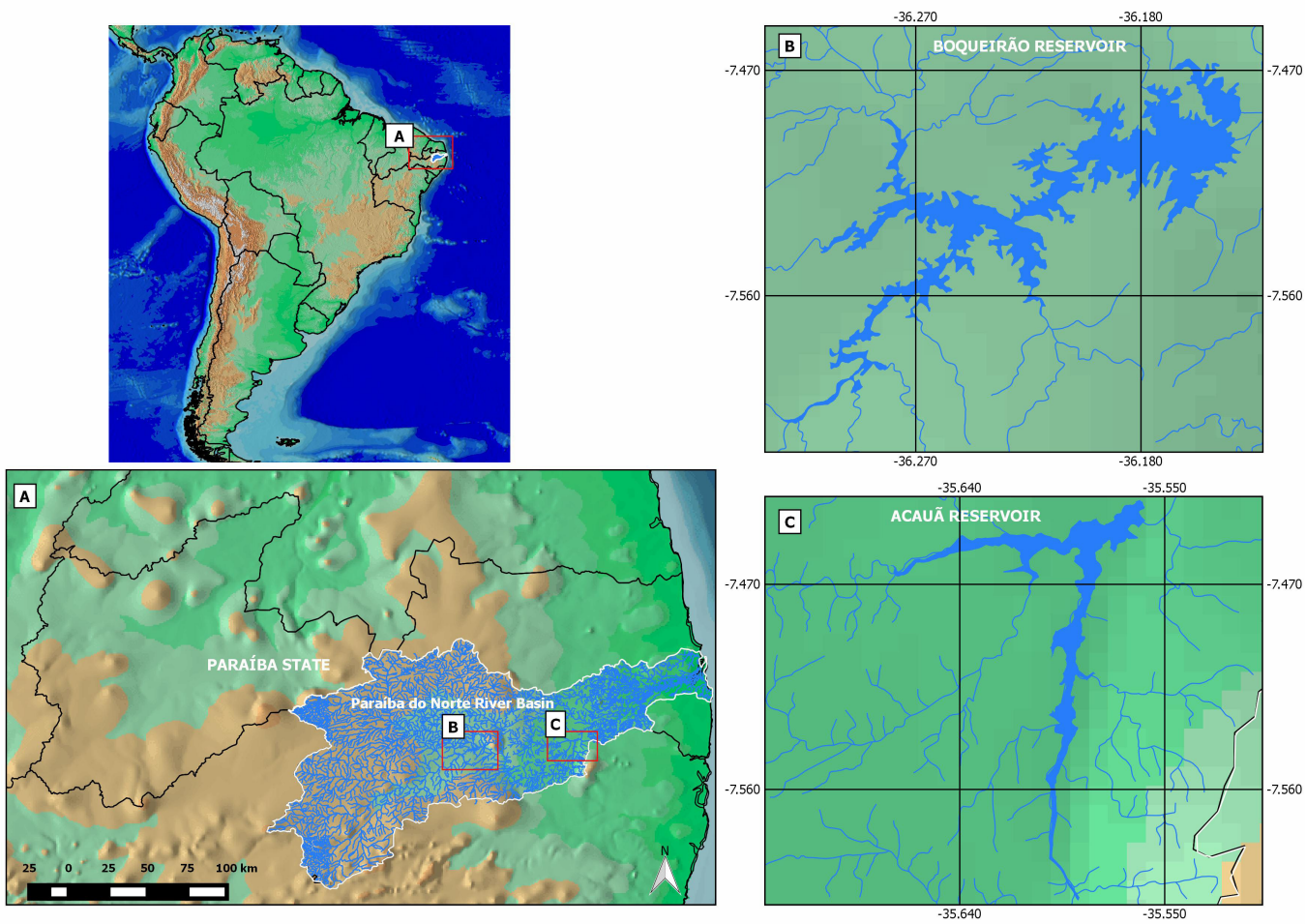

Figure 1. Map of Paraíba do Norte River basin (A): Boqueirão (B) and Acauã (C) reservoirs.

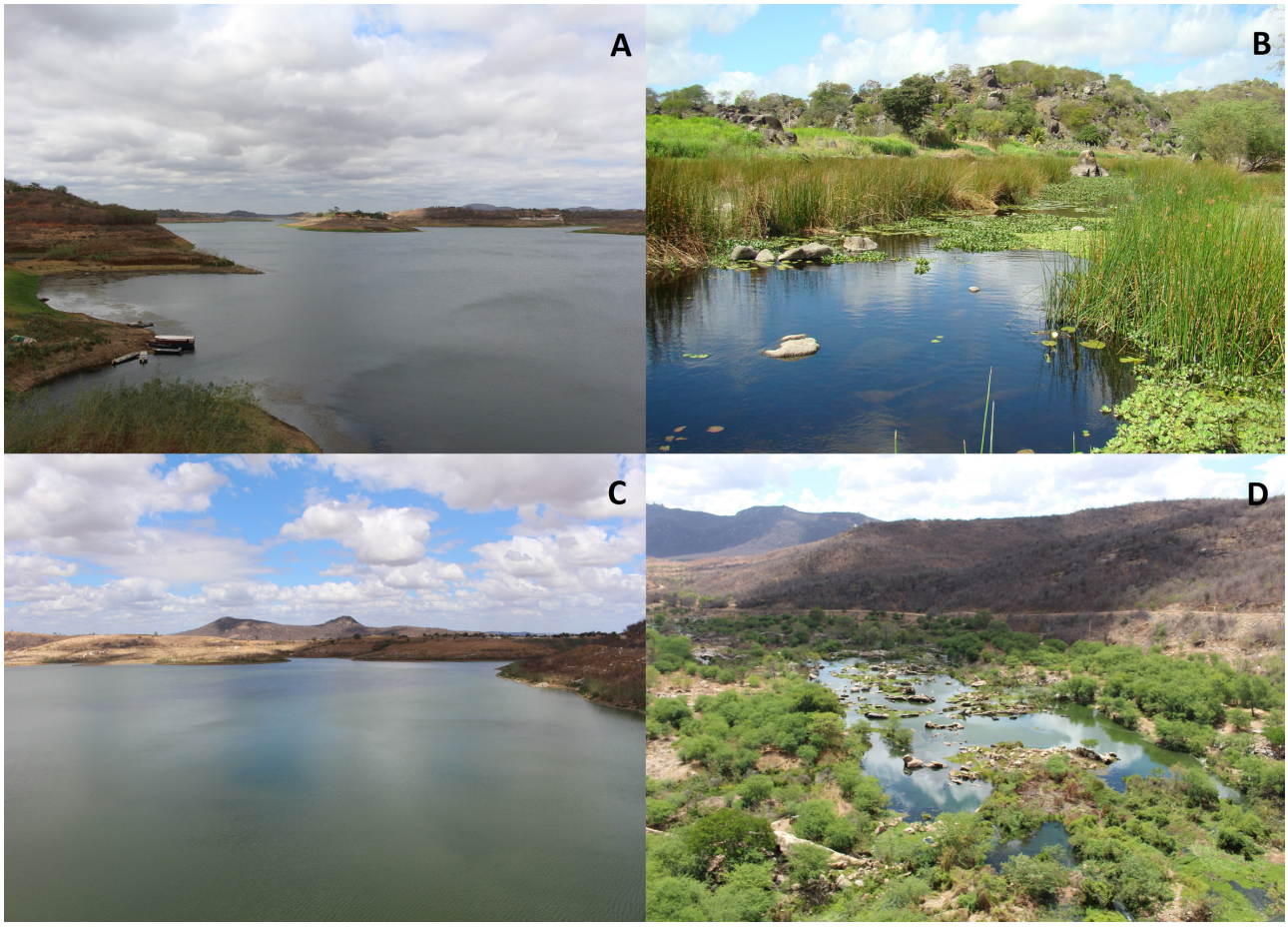

Figure 2. Epitácio Pessoa Reservoir (A) and its downstream area (B), Argemiro de Figueiredo Reservoir (C) and its downstream area (D).

municipality. The basin comprises an area of 20,071.83 km^2, making it the second largest in Paraíba State. It has five main reservoirs, among them are the Epitácio Pessoa and Argemiro de Figueiredo (Paraíba 2007).

The Epitácio Pessoa reservoir (7°29'20'' S and 36º17'3" W), popularly known as Boqueirão, is located in the upper basin at Boqueirão municipality in the northeastern semi-arid region. It is the largest and main reservoir of the Paraíba do Norte River basin with a maximum capacity of 411,686.287m^3 and covering an area of about 14,000 km^2, supplying water to 26 municipalities in Paraíba State. Its main uses are human supply (approximately 600,000 people), animal husbandry and irrigation (Silva 1987, AESA 2015).

The Argemiro de Figueiredo reservoir, commonly known as Acauã, is located in the middle course of the Paraíba do Norte River between the geographical coordinates 7º36'51'' S and 35º33'01'' W in Itatuba municipality, supplying several cities as well as irrigation, water for livestock, and aquaculture. This reservoir has an area of 1,725 hectares with a 253,144,247 m^3 of accumulation capacity (SEMARH 2006).

2. Sampling

Sampling in the Epitácio Pessoa and Argemiro de Figueiredo Reservoirs was conducted monthly for one year, between October/2014 and September/2015. In addition, the downstream ebbing (environments that usually have a lotic regime) areas of the reservoirs were also sampled. In Argemiro de Figueiredo reservoir, the specimens were collected using a trawl net (20 m long, 2 m high and 10 mm mesh), cast net (2.4 m high, and 12 mm mesh) and gill nets (10 m long and 35, 45 and 55 mm meshes). Epitácio Pessoa specimens were collected by means of gill nets only. Gill nets were set at dusk and retrieved at dawn, having a soaking time of 12 hours in each of the sampled environments. Additional sampling methods were used when sampling downstream of the two reservoirs, including the use of sieves, grips and a trawl net (4 m long, 2 m high, and 5 mm mesh). Specimens collected in the reservoirs were placed on ice and taken to the Universidade Estadual da Paraíba (UEPB). Majority of the material was used for feeding studies, and the remaining specimens together with the material collected from the downstream areas were treated according to the scientific curatorial standards, by fixing the specimens in formaldehyde for two to eight days, then transferring them to a 70° GL ethyl alcohol solution, and labeling and sorting specimens into lots according to Malabarba & Reis (1987).

Specimen sampling and identifications were carried out at the Laboratório de Ecologia Aquática da Universidade Estadual da Paraíba (LEAQ/UEPB), Laboratório de Sistemática e Morfologia de Peixes da Universidade Federal da Paraíba (LASEP/UFPB) and Laboratório de Ictiologia Sistemática e Evolutiva da Universidade Federal do Rio Grande do Norte (LISE/UFRN). After identification, specimens were deposited in the Ichthyological collections at the UFPB (29 lots) and UFRN (two lots).

Meristic and morphometric data involved in the identification process were obtained according to Hubbs & Lagler (2006). Species identification was performed according to specialized literature (e.g., Kullander 1983, Britski et al. 1984, Vari 1989, Castro & Vari 2004, Ramos 2012). Taxonomic classification and endemism of species followed Eschmeyer et al. (2017) and Rosa et al. (2003), respectively.

3. Data analysis

Species occurrence was analyzed according to occurrence frequency (FO in percentage) of the species against evaluation criteria for values: Very common (FO > 70%); Common (FO between 50% and 70%); Uncommon (FO between 10% and 50%) and Rare (FO < 10%).

To evaluate abundance of each species, total number of species captured was considered and relative abundance of each species was obtained by dividing the number of individuals captured from each species by total number of specimens.

Results

A total of 2,057 specimens were collected in the Epitácio Pessoa and Argemiro de Figueiredo Reservoirs, representing freshwater fish from three orders, 10 families, 16 genera, and 17 species (Table 1). In the Argemiro de

Table 1. List of fish species recognized in Argemiro Figueiredo (AF) and Epitácio Pessoa (EP) reservoirs and their respective downstream areas (DAF) and (DEP), Paraíba do Norte River basin, Northeastern Brazil with their respective names. Endemic: endemism in Caatinga biome; Allochthonous: introduced from other regions; Autochthonous: native to the region; Exotic: introduced from other countries.

Taxon	Popular name	Origin	AF	EP	DAF	DEP	Voucher
CHARACIFORMES							
Crenuchidae							
Characidium bimaculatum Fowler, 1941	"Filhote de traíra"	Endemic			X		UFPB-10631
Erythrinidae							
Hoplias cf. *malabaricus* (Bloch, 1794)	"Traíra"	Autochthonous	X	X	X	X	UFPB-10604
Parodontidae							
Apareiodon davisi Fowler, 1941	"Piau"	Endemic	X			X	UFPB-10601
Anostomidae							
Leporinus piau Fowler, 1941	"Piau"	Endemic	X	X	X	X	UFPB -10606
Curimatidae							
Psectrogaster rhomboides Eigenmann & Eigenmann, 1889	"Cumatã"	Endemic					UFPB-10607
Steindachnerina notonota (Miranda Ribeiro, 1937)	"Piaba"	Endemic			X	X	UFPB-10616
Prochilodontidae							
Prochilodus brevis Steindachner, 1875	"Curimatã"	Endemic	X	X	X	X	UFPB - 10608
Triportheidae							
Triportheus signatus (Garman, 1890)	"Sardinha"	Endemic	X	X	X	X	UFPB-10600
Characidae							
Astyanax aff. *bimaculatus* (Linnaeus, 1758)	"Piaba"	Autochthonous	X	X	X	X	UFPB -10603
Astyanax aff. *fasciatus* (Cuvier, 1819)	"Piaba"	Autochthonous	X	X	X		UFPB-10635
Compsura heterura Eigenmann, 1915	"Piaba"	Autochthonous			X		UFPB-10627
Hemigrammus rodwayi Durbin, 1909	"Piaba"	Autochthonous			X		UFPB-10632
Hemigrammus marginatus Ellis, 1911	"Piaba"	Autochthonous			X		UFPB-10630
Serrapinnus heterodon (Eigenmann, 1915)	"Piaba"	Autochthonous			X		UFPB-10634
Hyphessobrycon parvellus Ellis, 1911	"Piaba"	Autochthonous			X		UFPB-10633
SILURIFORMES							
Heptapteridae							
Pimelodella enochi Fowler, 1941	"Cascudo"	Endemic			X	X	UFRN-0443
Rhamdia quelen (Quoy & Gaimard, 1824)	"Jundiá"	Autochthonous			X		UFPB-10625
Loricariidae							
Hypostomus pusarum (Starks, 1913)	"Cascudo"	Endemic	X	X		X	UFPB-10602
Parotocinclus jumbo Britski & Garavello, 2002	"Cascudinho"	Endemic			X		UFPB-10628
Parotocinclus spilosoma (Fowler, 1941)	"Cascudinho"	Endemic				X	UFRN-0731
CYPRINODONTIFORMES							
Poeciliidae							
Poecilia reticulata Peters, 1859	"Barrigudinho"	Allochthonous			X		UFPB-10629
Poecilia vivipara Bloch & Schneider, 1801	"Barrigudinho"	Autochthonous			X	X	UFPB-10626
SYNBRANCHIFORMES							
Synbranchidae							
Synbranchus aff. *marmoratus* Bloch, 1795	"Mussum"	Autochthonous			X		UFPB-10623
PERCIFORMES							
Sciaenidae							
Plagioscion squamosissimus (Heckel, 1840)	"Pescada"	Allochthonous	X	X			UFPB-9983
Cichlidae							
Astronotus ocellatus (Agassiz, 1831)	"Óscar"	Allochthonous		X			UFPB-10605
Cichla ocellaris Bloch & Schneider 1801	"Tucunaré"	Allochthonous		X			UFPB-10609
Cichlasoma orientale Kullander, 1983	"Corró preto"	Endemic			X	X	UFPB-9951
Crenicichla menezesi (Ploeg, 1991)	"Quatro-olho"	Endemic	X	X	X	X	UFPB-9980
Geophagus brasiliensis (Boulenger, 1897)	"Acará"	Autochthonous	X	X	X	X	UFPB-9952
Oreochromis niloticus (Linnaeus, 1758)	"Tilápia-do-Nilo"	Exotic	X	X			UFPB-9985
Coptodon rendalli (Boulenger, 1897)	"Tilápia"	Exotic	X	X			UFPB-2883

Figueiredo Reservoir a total of 1,482 specimens were collected, representing 13 species and in the Epitácio Pessoa reservoir a total of 575 specimens were collected, belonging to 16 species. Of the 17 species recorded, 12 species were common to both reservoirs, one species, *Apareiodon davisi*, was recorded only in the Argemiro Figueiredo Reservoir, and four species in the Epitácio Pessoa Reservoir: *Astronotus ocellatus*, *Cichlasoma orientale*, *Cichla ocellaris*, and *Psectrogaster rhomboides*.

Characiformes and Perciformes showed the highest species richness in the reservoir ichthyofauna, both with eight species (47.1%) of the 17 species registered. However, five species of the order Perciformes were introduced: *Astronotus ocellatus*, *Cichla ocellaris*, *Oreochromis niloticus*, *Coptodon rendalli*, and *Plagioscion squamosissimus*. Species from the order Characiformes were distributed within seven families and seven genera, and those species from the order Perciformes were distributed within two families and eight genera. The order Siluriformes, within the reservoirs, was represented by only one species (*Hypostomus pusarum*).

Cichlidae was family with the highest species richness in the Epitácio Pessoa and Argemiro Figueiredo Reservoirs, representing 41,1% with seven species. However, this family comprised only three species (17.7%) when allochthonous and exotic species are removed from this account, this is also the case of the Characidae family. *Oreochromis niloticus* (exotic species) was most abundant species, representing a total of with 473 (23%) specimens collected, and *Plagioscion squamosissimus* (allochthonous species) was second most abundant species, representing a total of 430 (21%) collected specimens. *Astyanax* aff. *bimaculatus* was the most abundant among the native species, representing a total of 189 (9%) collected specimens, followed by *Geophagus brasiliensis* with a total of 172 (8%) collected specimens. Cichlidae and Sciaenidae were the families with highest relative abundance values, comprising 45% and 21%, respectively, of all sampling of the two reservoirs. It is important to note that Sciaenidae family was represented by only one species, *Plagioscion squamosissimus*. Other families had a relative abundance percentage below 10%. Perciformes was the most abundant order in the Epitácio Pessoa and Argemiro de Figueiredo Reservoirs, representing a total of 1,372 (67%) collected specimens, followed by Characiformes with a total of 598 (29%) specimens and Siluriformes with a total of 87 (4%) specimens.

Analysis of frequency of occurrence (FO%) in the Argemiro de Figueiredo reservoir showed that six species were classified as "Very Common", four species as "Common", two species as "Uncommon" and one species as "Rare" (Table 2). For the Epitácio Pessoa Reservoir, five species were classified as "Very Common", six species as "Common", four species as "Uncommon" and a single species as "Rare" (Table 2).

In the lotic portion of the river downstream from Argemiro de Figueiredo and Epitácio Pessoa reservoirs, 271 specimens were collected and represented 24 species, 20 genera, 11 families, and five freshwater fish orders (Table 1). Additional species were recorded through downstream sampling but these were not recognized within the reservoirs. In the area downstream of Epitácio Pessoa Reservoir, 12 species were recorded in which five species were not collected in the reservoir: *Apareiodon davisi*, *Steindachnerina notonota*, *Parotocinclus spilosoma*, *Pimelodella enochi*, and *Poecilia vivipara*. In the area downstream of Argemiro de Figueiredo Reservoir, 20 species were recorded in which 11 species were not collected in the reservoir: *Characidium bimaculatum*, *Compsura heterura*, *Hyphessobrycon* cf. *parvellus*, *Hemigrammus marginatus*, *Hemigrammus rodwayi*, *Parotocinclus jumbo*, *Poecilia reticulata*, *Rhamdia quelen*, *Serrapinnus heterodon*, *Steindachnerina notonota*, and *Synbranchus* aff. *marmoratus*. In these two downstream areas, 12 families were recognized but seven of these families bear only one species.

A total of 31 species were collected in Argemiro Figueiredo and Epitácio Pessoa Reservoirs and their downstream areas, distributed within 27 genera, 14 families, and five orders (Table 1). Characiformes was the order with the largest species richness, comprising 15 species within 13 genera and eight families, and representing 48% of recorded species (Figure 3A). Perciformes was the second richest order with eight species recognized within eight genera and two families, and representing 26% of recorded species. Characidae and Cichlidae were families with the highest number of species, both with seven species representing 23% of species sampled, followed by Loricariidae with three (10%) species (Figure 3B).

Discussion

The dams built in the intermittent rivers of Brazilian Northeast region serve as a refuge for freshwater fishes during drought periods. The number of species (17) recorded in the two reservoirs in our study is in accordance to other reservoirs in the region. Gurgel-Lourenço et al. (2013) also listed 17 species from Paulo Sarasate and Edson Queiroz Reservoirs, both located

Table 2. Occurrence Frequency Classification (F.O.%) for species from Epitácio Pessoa (EP) and Argemiro de Figueiredo (AF) Reservoirs.

Species	EP			AF		
	N	FO (%)	Classification	N2	FO (%)	Classification
Hoplias cf. *malabaricus*	45	100	Very common	9	50	Common
Astronotus ocellatus	34	91,6	Very common	-	-	-
Cichla ocellaris	53	83,3	Very common	-	-	-
Prochilodus brevis	52	83,3	Very common	2	8,33	Rare
Geophagus brasiliensis	52	75	Very common	120	83,3	Very common
Leporinus piau	54	66,6	Common	6	41,6	Uncommon
Psectrogaster romboides	19	66,6	Common	-	-	-
Hypostomus pusarum	63	58,3	Common	24	50	Common
Triportheus signatus	58	58,3	Common	29	83,3	Very common
Cichlasoma orientale	19	50	Common	-	-	-
Crenicichla menezesi	11	50	Common	149	100	Very common
Oreochromis niloticus	67	41,6	Uncommon	406	100	Very common
Astyanax aff. *bimaculatus*	34	25	Uncommon	155	50	Common
Plagioscion squamosissimus	8	25	Uncommon	422	100	Very common
Coptodon rendalli	5	25	Uncommon	23	50	Common
Astyanax aff. *fasciatus*	1	8,3	Rare	30	16,6	Uncommon
Apareiodon davisi	-	-	-	104	75	Very common

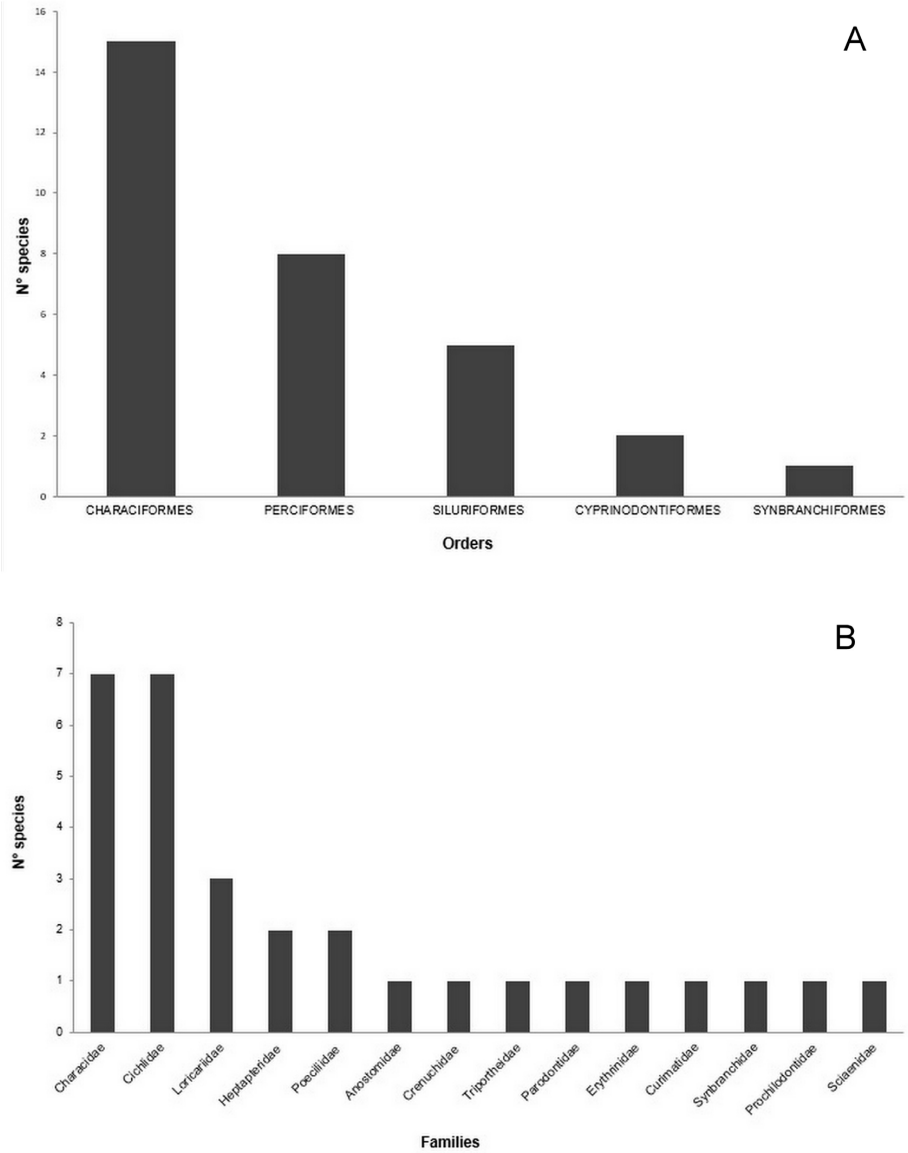

Figure 3. Fish species richness by Order (A) and Family (B) collected in Argemiro Figueiredo and Epitácio Pessoa reservoirs and their respective downstream areas.

in Ceará State. Sánchez-Botero et al. (2013) recognized 9 species by conducting monthly samplings for a period of six months in Santo Anastácio Reservoir at Ceará State. Silva-Filho et al. (2011) recorded 14 species in Duas Unas reservoir, review at Jaboatão River basin, Pernambuco State. Marinho et al. (2006) recognized seven species in Namorados (municipality of São João do Cariri) and Soledade (Soledade municipality) reservoirs at Paraíba do Norte River basin, which are under the hydrographic domain of Taperoá sub-basin. Montenegro et al. (2012) listed 11 species for Taperoá II reservoir, located in Taperoá municipality at Paraíba do Norte River basin. Our study supports a much higher number of species when compared to these previous studies in the same basins.

Characiformes and Siluriformes generally present the greatest species richness Neotropical regions (Lowe-McConnel 1987, Reis et al. 2003), as well as in Brazil (Buckup et al. 2007). The proportional richness of the order Characiformes has been a natural tendency of ichthyofauna basins under influence of the Caatinga biome (Ramos et al. 2005, Silva et al. 2014, Ramos et al. 2014, Silva et al. 2015). The Characidae family, one of the richest families in this study, generally has the greatest richness in fish diversity in Northeast Brazil (Ramos et al. 2005, Paiva et al. 2014, Silva et al. 2014, Ramos et al. 2014, Silva et al. 2015). Rosa et al. (2003) observed that Characidae was the most diversified family (50 species) when studied the diversity of Caatinga ichthyofauna. Most of its species are associated to inland waters of Brazil (Britski 1972).

However, order Perciformes displays higher species diversity than the order Siluriformes when it comes to reservoirs (Marinho et al. 2006, Montenegro et al. 2012, Sánchez-Botero et al. 2013, Gurgel-Lourenço et al. 2015). The higher species diversity of the order Perciformes in the semiarid reservoirs can be correlated to the lentic habit of Caatinga reservoirs, to which Cichlidae species, the most diverse family within the order, are well adapted (Kullander 2003, Langeani et al. 2007). Whereas species of the order Siluriformes are adapted to running water (lotic) environments (Nelson 2006). Epitácio Pessoa and Argemiro de Figueiredo Reservoirs as well as other Caatinga reservoirs are lentic environments that are more suitable for the predominance of cichlids. Most of the exotic species within the Caatinga rivers belong to the Cichlidae family, as pointed out in our results previously that noticed five out of eight Cichlidae species were introduced in these two reservoirs.

Oreochromis niloticus, popularly known as "Nile tilapia", is an exotic species that is well established in the Brazilian semiarid region and the most abundant species recorded in Epitácio Pessoa and Argemiro de Figueiredo Reservoirs. This species feeds mainly on phytoplankton and zooplankton, and it has great trophic plasticity and it is highly tolerant to environmental variations (Gurgel & Fernando 1994, Starling et al. 2002, Attayde et al. 2007). The abundance of *Oreochromis niloticus* is related to breeding in tanks from Argemiro Figueiredo Reservoir where 406 out of 473 specimens were collected. In addition to competition for food resources, mostly zooplankton, this species may affect other species through changes in habitat quality. Omnivorous filter-feeding fish such as tilapia tend to increase total phytoplankton biomass through predation on zooplankton and nutrient recycling (Drenner et al. 1996, Attayde et al. 2007).

Plagioscion squamosissimus, the second most abundant species, was introduced in reservoirs in Northeast Brazil during the early 1950s by Departamento Nacional de Obras Contra a Seca (DNOCS). However, fisheries were only productive from 1970s onwards (Fontenele & Peixoto 1978, Sato & Godinho 1999). Introduction of exotic species is considered to be one of the major reasons for biodiversity loss and the second major cause of animal extinction (Fontana et al. 2003, Ziller & Zalba 2007). Exotic fish may act as predators, competitors or even disseminate pathogenic organisms (Reis et al. 2003).

Astyanax aff. *bimaculatus* is a native species, is the third most abundant representative in the two reservoirs, along with other small Characidae species, popularly known as "piabas" in Northeastern Brazil, that is generally the most abundant group in the region (Ramos 2012, Paiva et al. 2014, Silva et al. 2014). These species are not valuable for fisheries purposes due to their relatively small size (Ramos 2012). However, these species are of importance as a food source for carnivorous species (Câmara et al. 1991). The relative low frequency of "piabas" in these reservoirs, and particularly in Epitácio Pessoa reservoir, when compared to *Oreochromis niloticus* and *Plagioscion squamosissimus* may be related to the abundance of *Cichla ocellaris* and *Hoplias* cf. *malabaricus*. The latter two species, such as *P. squamosissimus,* are considered top predators that have piscivorous habits and feed on small whole fishes such as "piabas" when adults (Goldstein 1973, Lowe-McConnell 1975, Peixoto 1982, Lowe-McConnell 1987, Resende et al. 1996, Almeida et al. 1997, Bennemann & Shibatta, 2002.).

Apareiodon davisi, one of the most representative species in our survey, was collected in Argemiro de Figueiredo Reservoir only, and registered during most of the sampling period. Species of the genus *Apareiodon* are generally found in habitats characterized by flowing water with high oxygen concentrations and rocky substrates, typical of lotic environments. Most of its species are found in rapids, and scrape rock-adhered algae off rocks as their food source (Pavanelli 2006). However, *A. davisi* was one of the six most abundant species from Argemiro de Figueiredo Reservoir, which leads us to infer that a population of this species is adapted to lentic conditions that are distinctive of this reservoir.

Apareiodon davisi is endemic to the Mid-Northeastern Caatinga ecoregion and it was described from specimens collected in drainages of Jaguaribe, Piranhas-Açu, and Paraíba do Norte rivers by Rodolfo Von Ihering during the decade of 1930 in Ceará and Paraíba States (Fowler, 1941). *Apareiodon davisi* is the only threatened species among those herein recognized, according to the criteria from the Brazil's official list of endangered species of fish and aquatic invertebrates (Brasil, 2014), due to the following aspects: 1) recent records detected reduction of population size. In the decades of 1940 and 1950, samples of *A. davisi* were abundant (around 100 specimens collected). However, recent expeditions have shown a decrease in the number of collected specimens (less than 10 specimens). Additionally, a single specimen has been recently collected in the type locality of *A. davisi* (b iv), in the North Paraíba River basin, with few additional specimens collected in recent years; 2) continuous decline of habitat quality (b iii). The locations in which *A. davisi* has been registered have suffered anthropogenic impacts such as deforestation due to expansions of sugar cane farming and extensive livestock, erosion, and river siltation. In addition, the main basins where this species is recognized are characterized by an intermittent regime and will receive water from the San Francisco River transposition. The consequences of changes in the hydrological regime (intermittent to perennial) are unknown to *A. davisi*. 3) severe fragmentation of its populations (a). Uninterrupted dams contribute to population fragmentation in the basins where *A. davisi* are registered. Population regressions were not yet quantified for this species, but occupation area (AOO) together with current records of this species were calculated as 93,9 Km^2 (B2), which categorize *A. davisi* as "endangered (EN)", according to B2 ab (iii,iv) criteria (Brasil, 2014).

Characiformes and Siluriformes, and the families Characidae, Loricariidae, and Cichlidae in the downstream area of Epitácio Pessoa and Argemiro de Figueiredo reservoirs were the most representative groups, which is in agreement with other studies from Northeast Brazil such as those by Ramos et al. (2005), Silva et al. (2014), Ramos et al. (2014), Silva et al. (2015). These results, however, differed regarding ichthyofauna within the reservoirs, as mentioned above.

Poecilia reticulata is the only species considered as introduced into the region that was not recorded within the two reservoirs among 24 species recognized in the downstream area of Argemiro de Figueiredo and Epitácio Pessoa Reservoirs. This is a small and well-disseminated species in Northeast Brazil, commonly used for aquarium trading and as pest control (Ramos 2012).

Two new occurrences were recorded from Paraíba do Norte River basin: *Hemigrammus rodwayi* Durbin, 1909, previously known from Guyana, Suriname, French Guiana Rivers and the Amazon basin; and *Hyphessobrycon* cf. *parvellus* Ellis, 1911 known from the coastal drainage of Bahia State, Brazil (Reis et al. 2003, Buckup et al. 2007). The occurrence of *Hemigrammus rodwayi* in the Brazilian Northeast is considered natural due to environmental similarities between the ichthyofauna of these regions as mentioned in Agassiz & Agassiz (1938) and Paiva (1978). *Hyphessobrycon* cf. *parvellus* was previously recorded from São Francisco River basin and its distribution is now extended to the MNCE. Both *Hemigrammus rodwayi* and *Hyphessobrycon* cf. *parvellus* were collected in several coastal rivers of Northeastern Brazil (Telton Ramos, personal communication).

Six species out of 31 species recorded in the present study were introduced, and 25 autochthonous species (Figures 4 and 5) in which 13 species (52%) are endemic to the basins that drain Caatinga biome. Six species (*Apareiodon davisi*, *Characidium bimaculatum*, *Hypostomus pusarum*, *Parotocinclus jumbo*, *P. spilosoma* and *Pimelodella enochi*) are endemic to the MNCE. *Parotocinclus spilosoma* and *Pimelodella enochi* are endemic to Paraíba do Norte River drainage, to which the water bodies of the studied regions belong (Reis et al. 2003, Rosa et al. 2003, Buckup et al. 2007). Studies on the biology of these endemic species that address adaptations in intermittent rivers such as Paraíba do Norte River are unknown, which makes it difficult to predict environmental impacts that changes in the hydrological regime may cause to them after the river transposition. However, special heterogeneity created from different hydrological phases and environmental variables (characteristics from the intermittent rivers) are important factors in the maintenance of a rich and mutable ichthyofauna as it decreases the comprehensive pattern of species dominance. Formation of pools of a variety of sizes and shapes in riverbeds increase fish resilience after flooding as many species use them as a habitat for reproduction (Medeiros & Maltchick 2001, Barbosa et al. 2012).

According to Maltchik (1999), fish diversity in rivers of the semi-arid region shows an inverse relationship with the hydrological stability, meaning that rivers of greater hydrological stability with minimal seasonal variability have lower rates of biological diversity than rivers with a more instable

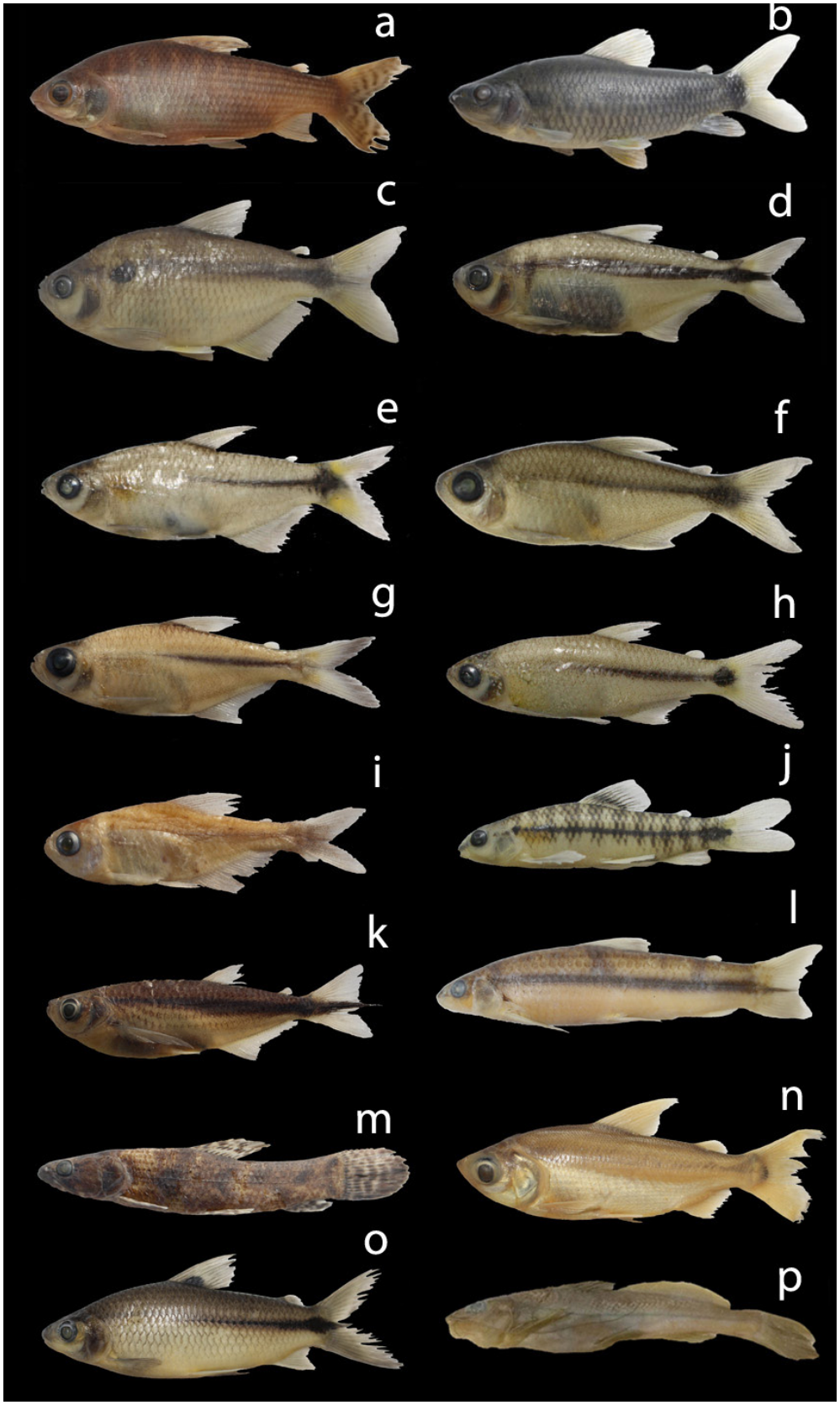

Figure 4. Fishes from the sampled areas of the Argemiro Figueiredo and Epitácio Pessoa reservoirs and their respective downstream areas. a) *Prochilodus brevis*, 120.5 mm SL; b) *Leporinus piau*, 101.2 mm SL; c) *Astyanax* aff. *bimaculatus*, 62.1 mm SL; d) *Astyanax* aff. *fasciatus*, 66.7 mm SL; e) *Compsura heterura*, 38.4 mm SL; f) *Hemigrammus rodwayi*, 26.2 mm SL; g) *Hemigrammus marginatus*, 34.7 mm SL; h) *Serrapinnus heterodon*, 35.2 mm SL; i) *Hyphessobrycon parvellus*, 21.4 mm SL; j) *Characidium bimaculatum*, 30.3 mm SL; k) *Triportheus signatus*, 84.5 mm SL; l) *Apareiodon davisi*, 75.4 mm SL; m) *Hoplias* cf. *malabaricus*, 92.7 mm SL; n) *Psectrogaster rhomboides*, 140.5 mm SL; o) *Steindachnerina notonota*, 96.5 mm SL; p) *Pimelodella enochi*, 175.3 mm SL.

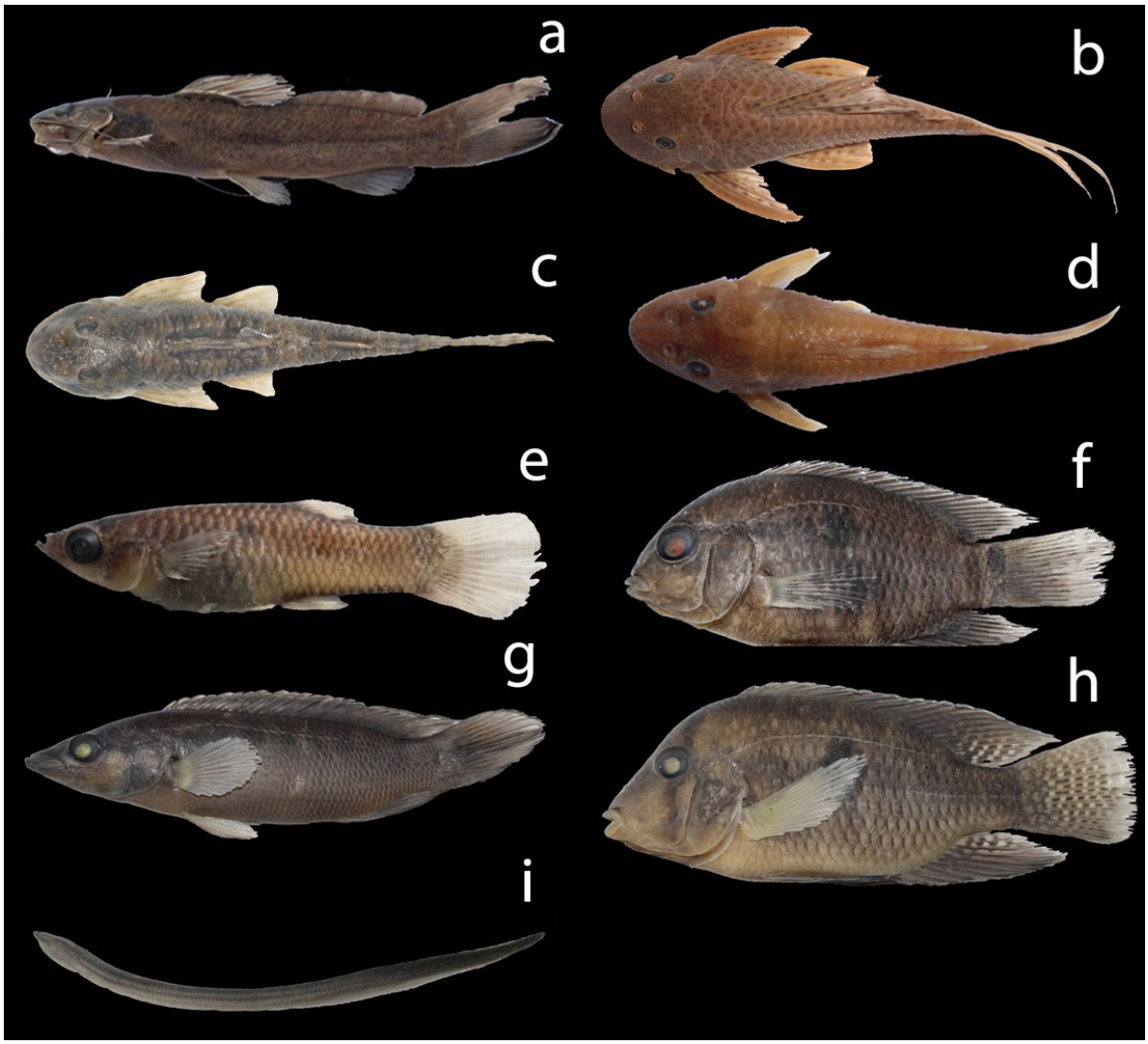

Figure 5. Fishes from the sampled areas of the Argemiro Figueiredo and Epitácio Pessoa reservoirs and their respective downstream areas. a) *Rhamdia quelen*, 129.1 mm SL; b) *Hypostomus pusarum*, 124.5 mm SL; c) *Parotocinclus jumbo*, 53.6 mm SL; d) *Parotocinclus spilosoma*, 38.1 mm SL; e) *Poecilia vivipara*, 27.1 mm SL; f) *Cichlasoma orientale*, 74.3 mm SL; g) *Crenicichla menezesi*, 89.7 mm SL; h) *Geophagus brasiliensis*, 118.4 mm SL; i) *Synbranchus* aff. *marmoratus*., 170.5 mm SL.

hydrology. The author further states that this pattern may be explained by the presence of dominant species in rivers of greatest hydrological stability.

The Northeast region of Brazil is currently undergoing a water transposition process, in which waters of São Francisco River basin, which is characterized by a perennial regime, will be artificially connected to the four largest basins of the MNCE that have an intermittent regime. In addition to Paraíba do Norte basin, the watersheds of the Apodi-Mossoró (Rio Grande do Norte), Jaguaribe (Ceará) and Piranhas-Açu Rivers (Paraíba and Rio Grande do Norte) will also receive water from São Francisco River basin through two main channels (Pittock et al. 2009). The transposition of water from the São Francisco basin to MNCE basins may cause changes in species composition, structure and dynamics of these ecosystem fish communities. Taxonomic studies such as the current study are crucial for comparative reevaluation post-transposition. The study of the ichthyofauna of Argemiro de Figueiredo and Epitácio Pessoa Reservoirs and their downstream areas improved the knowledge of fish diversity from Paraíba do Norte River basin, reinforcing subsidies for environmental protection and conservation of its watersheds. Understanding the local ichthyofauna and their ecosystems is essential for assessing future impacts caused by the transposition of São Francisco River as an example of direct anthropic action as well as by introducing exotic species.

Acknowledgements

We thank all members of Laboratório de Ecologia Aquática from Universidade Estadual da Paraíba (UEPB), especially Patricia Cruz for helping with field work.

Author Contributions

All authors contributed by collecting specimens, and writing this manuscript. SYLC and TPAR identified the species.

Conflicts of interest

The authors declare that have no conflict of interest related to the publication of this manuscript.

References

AESA. http://site2.aesa.pb.gov.br/aesa/volumesAcudesdomestodo=preparaUltimosVolumesPorMunicipio (the last access in 04/12/2015).

AGASSIZ, L. & AGASSIZ, E.C. 1938. Viagem ao Brasil: 1865-1866. São Paulo, Trad. de Edgar Siissekind de Mendonça.

ALMEIDA, V.L.L., RESENDE, E.K. & VAZZOLER, A.E. 1997. Feeding patterns in five predatory fishes of the hight Paraná River flooddplain (PR Brazil). Ecol. Freshw. Fish 6(3): 123-133.

ATTAYDE, J.L., OKUN, N., BRASIL, J., MENEZES, R., & MESQUITA, P. 2007. Impactos da introdução da tilápia do Nilo, *Oreochromis niloticus*, sobre a estrutura trófica dos ecossistemas aquáticos do bioma caatinga. Oecologia Brasiliensia. 11(3): 450-461.

BARBOSA, J.E.L., MEDEIROS, E.S.F., BRASIL, J., CORDEIRO, R.S., CRISPIM, M.C.B. & SILVA, G.H.G.S. 2012. Aquatic systems in semi-arid Brazil: limnology and management. Acta Limnol. Bras. 24(1): 103-118.

BENNEMANN, S.T. & SHIBATTA, O.A. 2002. Dinâmica de uma assembleia de peixes do rio Tibagi. A bacia do rio Tibagi. In (M.E. Medri, E, Bianchini, O.A. Shibatta & J. A. Pimenta eds). Londrina, M. E. Medri, p.433-442.

BRASIL. 2014. Lista Nacional Oficial de Espécies da Fauna Ameaçada de Extinção - Portaria N° 443, de 17 de dezembro de 2014. Ministério do Meio Ambiente. Diário Oficial da União, Brasília, Seção 1(245): 121-130.

BRITISKI, H.A. 1972. Peixes de água doce do Estado de São Paulo. In Poluição e Piscicultura. Comissão Interestadual da Bacia Paraná-Uruguai. Faculdade de Saúde Pública da USP, São Paulo, p.79-108.

BRITSKI, H.A., SATO, Y. & ROSA, A.B.S. 1984. Manual de identificação de peixes da região de Três Marias: com chave de identificação para os peixes da bacia do São Francisco. Brasília, Câmara dos Deputados, Codevasf, Divisão de Piscicultura e Pesca.

BUCKUP, P.A., MENEZES, N.A. & GHAZZI, M.S. 2007. Catálogo das espécies de peixes de água doce do Brasil. Museu Nacional, Rio de Janeiro.

CÂMARA, J.J.C., RODRIGUES A.M., CAMPOS, E.C., SANTOS, R.A. & MANDELLI J. 1991. Pesca seletiva do tambiú, *Astyanax bimaculatus* (Linnaeus, 1758) (Characiformes, Characidade), com a utilização de redes de emalhar, na represa de Ibitinga, rio Tietê, Estado de São Paulo, Brasil. Boletim do Instituto de Pesca. 18: 51-60.

CASTRO, R.M.C., & VARI R.P. 2004. Detritivores of the South American Fish Family Prochilodontidae (Teleostei: Ostariophysi: Characiformes): a phylogenetic and revisionary study. Smithsonian Contributions and Studies Series, p.622- 189.

DRENNER, R.W., SMITH, J.D. & THRELKELD, S.T. 1996. Lake trophic state and the limnological effects of omnivorous fish. Hydrobiologia. 319(3): 213-223.

ESCHMEYER, W.N., FRICKE, R. & VAN DER LAAN, R. (eds). 2017. Catalog of fishes: genera, species, references. http:// research.calacademy.org/research/ichthyology/catalog/fishcatmain.asp (the last access in 06/02/2017).

FONTANA, C.S., BENCKE, G.A. & REIS, R.E. 2003. Livro vermelho da fauna ameaçada de extinção no Rio Grande do Sul. Edipucrs, Porto Alegre.

FONTENELE, O. & PEIXOTO, J.T. 1978. Análise dos resultados de introdução da pescada do Piauí, *Plagioscion squamosissimus* (Heckel,1840), nos açudes do Nordeste. Boletim Técnico DNOCS. 36(1):85-112.

FOWLER, H.W. 1941. A collection of freshwater fishes obtained in eastern Brazil by Dr. Rodolpho von Ihering. Proceedings of the Academy of Natural Sciences of Philadelphia. 93: 123–199.

GOLDSTEIN, R.J. 1973. Cichlids of the world. T.F.H. Publ. Inc. New Jersey.

GURGEL, J.J.S. & FERNANDO, C.H. 1994. Fisheries in semi-arid Northeast Brazil with special reference on the role of tilapias. International Review of Hydrobiology. 79(1): 77-94.

GURGEL-LOURENÇO, R.C., SOUSA, W.A., SÁNCHEZ-BOTERO, J.I. & GARCEZ, D.S. 2013. Ichthyofauna of two reservoirs in the middle Acaraú River basin, Ceará, Northeastern Brazil. Check List. 9(6): 1391–1395.

GURGEL-LOURENÇO, R.C., RODRIGUES-FILHO, C.A.S., ANGELINI, R., GARCEZ, D.S. & SÁNCHEZ-BOTERO, I.J. 2015. On the relation amongst limnological factors and fish abundance in reservoirs at semiarid region. Acta Limnol. Bras. 27(1): 24-38.

HUBBS, C.L. & LAGLER K.F. 2006. Fishes of the Great Lakes region. University of Michigan Press.

INSA. http://www.insa.gov.br/ (the last access in 04/12/2015).

KULLANDER, S.O. 1983. A revision of the South American cichlid genus *Cichlasoma* (Teleostei: Cichlidae). Swedish Museum of Natural History, Sweden.

KULLANDER, S.O. 2003. Family Cichlidae. In Check list of the freshwater fishes of South and Central America (R.E. Reis, S.O. Kullander & C.J. Ferraris Jr.). Edipucrs, Porto Alegre, p.605-654.

LANGEANI, F., CASTRO, R.M.C., OYAKAWA, O.T., SHIBATTA, O.A., PAVANELLI, C.S. & CASATTI, L. 2007. Diversidade da ictiofauna do Alto rio Paraná: composição atual e perspectivas futuras. Biota Neotrop. 7(3): 181-197.

LANGEANI, F., BUCKUP, P.A., MALABARBA, L.R., PY-DANIEL, L.H.R., LUCENA, C.A.S., ROSA, R.S., ZUANON, J.A.S., LUCENA, Z.M.S., DE BRITTO, M.R., OYAKAWA, O.T. & GOMES-FILHO, G. 2009. Peixes de Água Doce. In Estado da arte e perspectivas para a zoologia no Brasil (R.M. Rocha, & W.A.P. Boeger, orgs.). Ed. UFPR, Curitiba, p.211-230.

LOWE-MCCONNELL, R.L. 1975. Fish communities in tropical freshwaters. Longman London.

LOWE-MCCONNELL, R.H. 1987. Ecological studies in tropical fish communities, Cambridge University Press.

MALABARBA, L.R. & REIS, R.E. 1987. Manual de técnicas para a preparação de coleções zoológicas. Sociedade Brasileira de Zoologia, Campinas. 36: 1-14.

MALTCHIK, L. 1996. Nossos rios temporários, desconhecidos, mas essenciais. Ciências Hoje. 21(122): 64-65.

MALTCHIK, L. 1999. Ecologia de Rios Intermitentes Tropicais. In Perspectivas da Limnologia no Brasil (M.L.M. Pompêo, ed.). Gráfica e Editora União. São Luís.

MARINHO, R.S.A., TORELLI, J.E.R.S., SILVA, A.S. & RIBEIRO, L.L. 2006. Biodiversidade de peixes do semi-árido paraibano. Revista de Biologia e Ciências da Terra. (1): 112-121.

MONTENEGRO, A. K. A., TORELLI, J. E. R., CRISPIM, M. C., HERNÁNDEZ, M. I. M. & MEDEIROS, A.M.A. 2012. Ichthyofauna diversity of Taperoá II reservoir, semi-arid region of Paraíba, Brazil. Braz. J. Biol. 72(1): 113-120.

MEDEIROS, E.S. & MALTCHIK, L. 2001. Fish assemblage stability in an intermittently flowing stream from the Brazilian semiarid region. Austral Ecology. 26(2): 156–164

MEDEIROS, P.H.A., GÜNTNER, A., FRANCKE, T., MAMEDE, G.L. & ARAÚJO, J.C. 2010. Modelling spatio-temporal patterns of sediment yield and connectivity in a semi-arid catchment with the WASA-SED model. Hydrol. Sci. J. 55(4): 636-648.

NELSON, J.S. 2006. Fishes of the World. 4. ed. New Jersey: John Wiley & Sons.

NOVAES, J.L.C., MOREIRA, S.I.L., FREIRE, C.E.C., SOUSA, M.M.O. & COSTA, R.S. 2013. Fish assemblage in a semi-arid Neotropical reservoir: composition, structure and patterns of diversity and abundance. Braz. J. Biol. 74(2): 290-301.

PAIVA, M.P. 1978. A ictiofauna das Grandes Represas Brasileiras. Revista DAE. 38(116): 49-57.

PAIVA, R.E.C., LIMA, S.M.Q., RAMOS, T.P.A. & MENDES, L. 2014. Fish fauna of Pratagi River coastal microbasin, extreme north Atlantic Forest, Rio Grande do Norte State, northeastern Brazil. Check List. 10(5): 968-975.

PARAÍBA, SECRETARIA DE PLANEJAMENTO. 2007. Avaliação da infraestrutura hídrica e do suporte para o sistema de gerenciamento de recursos hídricos do Estado da Paraíba. João Pessoa, SEPLAN.

PAVANELLI, C.S. 2006. New species of *Apareiodon* (Teleostei: Characiformes: Parodontidae) from the Rio Piquiri, upper Rio Paraná basin, Brazil. Copeia. (2006)1: 89-95.

PEIXOTO, J.T. 1982. Alimento de tucunaré, *Cichla ocellaris* Bloch & Scheneider, 1801 no açude Lima Campos, Icó, Ceará, (Actinopterygii, Cichlidae). Colet. de Trab. Técn. DNOCS, Fortaleza, 2: 159-172.

PITTOCK, J., MENG, J. & CHAPAGAIN, A.K. 2009. Interbasin water transfers and water scarcity in a changing world -a solution or a pipedream? A discussion paper in a burning issue, 2nd, WWF Germany, Frankfurt.

RAMOS, R.T.C., RAMOS, T.P.A., ROSA, R.S., BELTRÃO, G.B.M. & GROTH, F. 2005. Diversidade de Peixes (Ictiofauna) da bacia do rio Curimataú, Paraíba. In Análise das variações da biodiversidade do bioma caatinga: suporte das estratégias regionais de conservação (F.S. Araujo, M.J.N. Rodal & M.R.V. Barbosa, eds.). Ministério do Meio Ambiente, Brasília, p. 291-318.

RAMOS, T.P.A. 2012. Ictiofauna de Água Doce da Bacia do Rio Parnaíba. Unpublished Ph.D. Universidade Federal da Paraíba, João Pessoa.

RAMOS, T.P.A. RAMOS, R.T.C. & RAMOS, S.A.Q.A. 2014. Ichthyofauna of the Parnaíba River Basin, Northeastern Brazil. Biota Neotrop. 14(3): 1-6. http://dx.doi.org/10.1590/S1676-06020140039.

REIS, R.E., ALBERT, J.S., DARIO, F. DI., MINCARONE, M.M., PETRY, P. & ROCHA, L.A. 2016. Fish biodiversity and conservation in South America. J. Fish Biol. 89(1): 12-47. doi:10.1111/jfb.13016.

REIS, R.E., KULLANDER, S.O. & FERRARIS JR, C.J. 2003. Check list of the freshwater fishes of South and Central America. Edipucrs, Porto Alegre.

REBOUÇAS, A.C., BRAGA, B.B., TUNDISI, J.G. 2006. Águas Doces no Brasil. 3° ed. São Paulo: Escrituras.

RESENDE, E.K., PEREIRA, R.A.C., ALMEIDA, V.L.L. & SILVA, A.G. 1996. Alimentação de peixes carnívoros da planície inundável do rio Miranda, Pantanal, Mato Grosso do Sul, Brasil. Embrapa Pantanal.

ROSA, R.S., MENEZES, N.A., BRITSKI, H.A., COSTA, W.J.E. & GROTH F. 2003. Diversidade, padrões de distribuição e conservação dos peixes da caatinga. In Ecologia e Conservação da Caatinga (I.R. Leal, M. Tabarelli & J.M.C. Silva eds.). Editora Universitária da Universidade Federal de Pernambuco, Recife, p.135–180.

ROSA, R.S. & MENEZES, N.A. 1996. Relação preliminar das espécies de peixes (Pisces: Elasmobranchii e Actinopterygii) ameaçadas no Brasil. Revista Brasileira de Zoologia 13 (3): 647-667.

SÁNCHEZ-BOTERO, I.J., REIS, V.C., CHAVES, F.D.N. & GARCEZ, D. 2013. Fish assemblage of the Santo Anastácio reservoir (Ceará state, Brazil). Bol. Inst. Pesca. 40(1): 1–15.

SATO, Y. & GODINHO, H. P. 1999. Peixes da Bacia do rio São Francisco. In Estudos ecológicos de comunidades de peixes tropicais (R.H. Lowe-Mcconnell ed.). Edusp, São Paulo, p.401-416.

SEMARH - Secretaria Extraordinária do Meio Ambiente, dos Recursos Hídricos. 2006. Plano Estadual de Recursos Hídricos da Paraíba-PERH-PB. João Pessoa, Resumo Executivo e Atlas.

SILVA, M.J., COSTA, B.G., RAMOS, T.P.A., AURICCHIO, P. & LIMA, S.M.Q. 2015. Ichthyofauna of the Gurgeia River, Parnaíba River basin, northeastern Brazil. Check List. 11(5): 1765.

SILVA, M.J., RAMOS, T.P.A., DINIZ, V.D., RAMOS, R.T.C. & MEDEIROS, E.S. F. 2014. Ichthyofauna of Seridó/Borborema: a semi-arid region of Brazil. Biota Neotrop. 14(3): 1-6. (the last access in 17/02/2016).

SILVA, M.A.V. 1987. Atlas climatológico do Estado da Paraíba. Universidade Federal da Paraíba, Núcleo de Meteorologia Aplicada, Paraíba.

SILVA-FILHO, E.G., SANTANA, F.M.S. & SEVERI, W. 2011. Ictiofauna do reservatório de Duas Unas, bacia do rio Jaboatão, Pernambuco: resultados preliminares da composição e estrutura da assembleia. Revista Brasileira de Ciências Agrárias. 6(2):351-361.

STARLING, F., LAZZARO, X., CAVALCANTI, C. & MOREIRA, R. 2002. Contribution of omnivorous tilapia to eutrophication of a shallow tropical reservoir: evidence from a fish kill. Freshwater Biol. 47(12): 2443-2452.

VARI, R.P. 1989. Systematics of the Neotropical Characiform genus *Psectrogaster* Eigenmann and Eigenmann (Pisces, Characiformes). Smithsonian Instituion Press. 481: 1-41.

ZILLER, S.R. & ZALBA, S. 2007. Propostas de ação para prevenção e controle de espécies exóticas invasoras. Nature and Conservation. 5(2):8-15.

Received: 07/02/2017
Revised: 17/07/2017
Accepted: 18/07/2017
Published online: 14/08/2017