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# Ichthyofauna of coastal lakes and the Igaraçu River in Ilha Grande, Delta do Parnaíba, Parnaíba, Piauí State, northeastern Brazil

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**Abstract:** This study aims to provide a list of fish species from the Igaraçu River and some lakes of the lower Parnaíba River, Delta do Parnaíba, northeastern state of Piauí, Brazil. Eleven collecting points were sampled in a coastal area, in a wind farm, during the dry season in November 2011. A total of 1,023 individuals of 24 species, 13 families and 6 orders were collected. The most representative families in number of species were Characidae, Cichlidae and Curimatidae, respectively. *Astyanax* aff. *bimaculatus*, *Serrapinnus piaba* and *Psellogrammus kennedyi* presented the greatest abundance and distribution among the sampling points. *Oreochromis niloticus* was the only alien species captured. No fishes were captured in five sampling sites. Voucher material is deposited in a new zoological collection, "Coleção Zoológica do Delta do Parnaíba".

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## Introduction

The Parnaíba River basin covers an extent of about 1,700 km of the Caatinga biome, belonging to the Parnaiba freshwater ecoregion, *sensu* Abell *et al.* (2008), located in the mid northern Brazil. Its mouth belongs to the Environmental Protection Area Delta do Parnaíba, an important conservation area which extends to northern states of Maranhão and Ceará. It was created under Decree/96 on 28 August 28 1996. The Delta do Parnaíba is composed of many islands, mangroves, temporary lakes, rivers and sand dunes, and also possesses a coastal plain and an estuary, which fluctuates seasonally. Such hydrological variability throughout the year causes changes in food and movement of the fish that inhabit the lower parts of the Parnaíba River and its adjoining areas (Lima 2012). From a scientific perspective, the Delta do Parnaíba is poorly known.

The knowledge about the number of fish species occurring in the Parnaíba River was based on literature compilation, which included original descriptions, check lists and catalogues of Brazilian fish species until recently (Eigenmann 1910; Fowler 1954; Reis *et al.* 2003; Rosa *et al* 2003; Buckup *et al.* 2007; Costa *et al*. 2010). This information source enabled Albert *et al.* (2011) to characterize the fish fauna o Parnaiba River as potentially diverse with an estimative of about 95 species. Ramos *et al* (2014) recorded 146 freshwater fish species for the basin. The literature on the ichthyofauna of the lower Parnaíba River basin is scarce and deals about identification of commercial fishes (Melo 2012; Nóbrega *et al.* 2010). Additionally, there is little information about fishes which inhabit the lakes near marine environments.

This study provides the first list of fish species from lakes of the northern Piauí, collected in the year 2011 inside and near to a wind power station in the town of Parnaíba, which is very close to the Igaraçu River and the Atlantic Ocean. A dichotomous identification key is also provided.

## Material and Methods

### *Study site*

The fieldwork was carried out in November 2011, during the dry season, on Igaraçu River and eleven lakes in and around the wind power station, wind complex Delta do Parnaíba (Figure 1; Table 1). The study area consists of both coastal plains and areas flooded by freshwater, with inclusion of mangroves, lagoons between dunes and "restinga" vegetation, and communities of plants that grow on Quaternary Neosols (Santos-Filho *et al* 2011). This area also suffers anthropic pressure and is already in depleted state due to plant extraction, subsistence agriculture, fishing and livestock.

### *Data collection*

The fish were captured under license #34869-1 from the Ministério do Meio Ambiente (MMA) and the Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio). The collections were made in and around a wind farm, wind complex Delta do Parnaíba, using standard ichthyological gear, including sieves, seines and throw nets. Its mesh size varied between 3 and 2 cm between the opposing knots. Two floating gillnets were deployed with 10 m long and 1.5 m depth. The mesh size varied between 3 and 16 cm between the opposing knots, with sections mounted in random order. The sampling effort was 60 min at each site, except for the locality at Igaraçu River where two gillnets blocking fish passage were kept open for 12 h. The collected

specimens were cryoanesthetized in an ice box, fixed on-site in 10% formalin solution before being transferred to a 70% ethanol solution. All specimens collected were deposited in a new collection, the Coleção Zoológica do Delta do Parnaíba (CZDP), at the Universidade Federal do Piauí, Reis Veloso Campus, Parnaíba, Piauí. Species identification was based on dichotomic keys, original descriptions, identification manuals and taxonomic reviews (Eigenmann 1915; Géry 1977; Figueiredo and Menezes 1980, 2000; Menezes and Figueiredo 1980; Britski *et al.* 1988; Kullander 1983; Vari 1989, 1991; Ploeg 1991; Ferreira *et al.* 1998; Reis *et al.* 2003; Staeck and Schindler 2006; Buckup *et al.* 2007; Lucena 2007). Species richness and frequencies of the capture of each species were represented by percentages of each species in relation to the total of individuals.

## Results

A total of 1,023 individuals, representing 24 species belonging to 13 families and six orders were collected in the lower Parnaíba River (Table 2; Figures 2 and 3). No fishes were captured or observed in four sites (sites 2, 3, 4 and 5). The highest number of species (12) was on site 1. The predominant orders were Characiformes (11 spp.) and Perciformes (8 spp.), representing 45.8% and 33.3%, respectively, of the total fish species captured. The families with higher species richness were Characidae (29.2%), followed by Cichlidae (16.3%), Curimatidae (8.3%), Erythrinidae (8.3%) and Scianidae (8.3%), respectively. The species with the greatest abundance largest number of individuals were *Serrapinnus piaba* (34.8%), *Astyanax aff. bimaculatus* (22.9%), *Serrapinus heterodon* (11,2%) and *Psellogramus kennedyi* (7.8%). The predominance of the Characiformes, mainly Characidae, is consistent with the general pattern found by other authors for the Neotropical region (Lowe-McConnell 1987; Buckup *et al.* 2007; Barros *et al.* 2011).

## Discussion

No fish was captured or observed in lakes with abundant vegetation and less than 0.8 m depth and may be related to predatory action and water quality. It has been recorded in northern Piauí State that very deep lakes expose fish to bird predation (Guzzi *et al*. 2012).

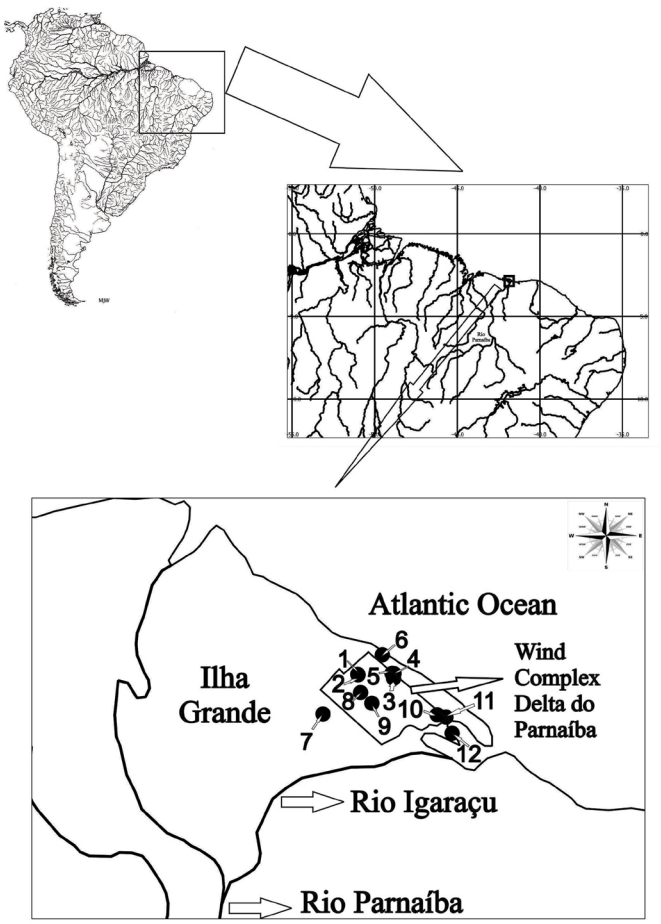


**Figure 1.** Map of the study area showing the collecting sites in lower Parnaíba River basin, Piauí State Brazil, Ilha Grande.

The species collected in the present study are equivalent to 17.4% of the species listed by Rosa *et al.* (2003) for the Maranhão-Piauí part of the northeastern ecoregions 323 and 325 of Abell *et al*. (2008) and 11.6% of species recorded in the Parnaíba River basin by Ramos *et al* (2014). Six species, *Cichlasoma orientale, Curimata macrops, Crenicihla menezesi, Geophagus parnaibae, Roeboides sazimai,* are endemic to the Brazilian Caatinga (Rosa *et al.* 2003; Lucena 2007), and *C. macrops* and *G. parnaibae* are restricted to the hydrographic region of

**Table1.** Geographical coordinates from the collecting sites in the mouth of Parnaíba River basin.

| SITE | WATER COURSE | MAXIMUM DEPTH | LATITUDE (S) | LONGITUDE (W) |
|---|---|---|---|---|
| 1 | Fresh water lake | 1.3 m | 2°49′49.62″ S | 41°44′5.55″ W |
| 2 | Fresh water lake. Body water in good conditions | 0.8 m | 2°49′50.73″ S | 41°44′5.07″ W |
| 3 | Small body water with. Beginning of eutrophication process. | 0.2 m | 2°49′57.67″ S | 41°42′53.61″ W |
| 4 | Fresh water lake. Presence of vegetation on substrate. Water body in the beginning of eutrophication process | 0.3 m | 2°49′48.07″ S | 41°42′52.75″ W |
| 5 | Fresh water body in the beginning of eutrophication process. Lake with footprints of pigs and garbage | 0.5 m | 2°49′47.74″ S | 41°42′56.66″ W |
| 6 | Fresh water body. Clear water | 1.4 m | 2°49′10.57″ S | 41°43′16.21″ W |
| 7 | Pond with clear water | 1 m | 2°51′9.19″ S | 41°45′15.43″ W |
| 8 | Pond with clear water | 1 m | 2°50′26.20″ S | 41°44′0.04″ W |
| 9 | Pond with clear water | 1.2 m | 2°50′47.63″ S | 41°43′37.41″ W |
| 10 | Pond with clear water | One m | 2°51′10.65″ S | 41°41′26.26″ W |
| 11 | Pond in the beginning of eutrophication process | 0.5 m | 2°51′15.60″ S | 41°41′8.67″O |
| 12 | Igaraçu River, with salt water great influence of tides, mangrove area | — | 2°51′47.84″ S | 41°40′56.41″ W |

Maranhão/Parnaíba rivers (Vari 1991; Rosa *et al*. 2003; Staeck and Schindler 2006; Barros *et al*. 2011). One species could only be identified to a species complex (*Astyanax* aff. *bimaculatus*). Such difficulty in identification is common among a group of species characterized by the presence of a horizontal oval black spot in the humeral region, two brown vertical bars in the humeral region, and a black spot in the caudal peduncle extended up to the extremity of the median caudal rays (Garutti and Britski 2000; Garutti and Britski 2000; Buckup 2011; Peres *et al.* 2012). Nine species, *Astyanax aff. bimaculatus*, *Hoplias malabaricus*, *Hoplerythrinus unitaeniatus*, *Pygocentrus nattereri*, *Psellogrammus kennedyi*, *Trachelyopterus galeatus*, *Serrapinnus piaba*, *S. heterodon* and *Psellogrammus kennedyi*, are considered native to the Caatinga but are known to be widespread, occurring in several South American river basins. One species, *Oreochromis niloticus*, an introduced African cichlid, was collected on sites 1, 6 and 11 and probably escaped from fish farms. Non-native species represent a serious threat to aquatic environments and native fish species in South America (Vitule 2009). The introduction of exotic species in aquatic environments can cause irreversible damage to biodiversity, because they can compete for food resources with native wildlife, spread parasites, and develop behaviors that modify the habitat in ways that are harmful to other species (Lima-Junior *et al*. 2012).

Three taxa, *Hyphessobrycon* sp., *Mugil* sp. and *Arius* sp. could not be identified to the species level due to poor taxonomic resolution. The single specimen of *Mugil* sp.

**Table 2.** List of species collected from down Parnaíba River basin, Piauí State, Brazil.

| TAXON | SITE 1 | SITE 6 | SITE 7 | SITE 8 | SITE 9 | SITE 10 | SITE 11 | SITE 12 | FREQUENCY OF CAPTURE |
|---|---|---|---|---|---|---|---|---|---|
| **CLUPEIFORMES** | | | | | | | | | |
| **Engraulidae** | | | | | | | | | |
| *Anchoviela lepidentostole* (Fowler, 1911) | | | | | | | | 5 | 0.5 % |
| **CHARACIFORMES** | | | | | | | | | |
| **Curimatidae** | | | | | | | | | |
| *Curimata macrops* Eigenmann & Eigenmann, 1889 | | | 1 | | | | | | 0.1% |
| *Steindachnerina nonota* (Miranda Ribeiro, 1937) | 11 | | | | | | | | 1.1% |
| **Characidae** | | | | | | | | | |
| *Astyanax* sp. aff. *bimaculatus* | 18 | | 7 | 54 | 83 | 1 | 1 | | 22.9% |
| *Hyphessobrycon* sp. | 70 | | | | | | | | 7.2% |
| *Psellogramus kennedyi* (Eigenmann & Kennedy, 1903) | 23 | | 20 | | 33 | 1 | 1 | | 7.8% |
| *Pygocentrus nattereri* Kner, 1858 | | | 2 | | | | | | 0.2% |
| *Roeboides sazimai* Lucena, 2007 | 2 | | | | | | | | 0,2% |
| *Serrapinnus heterodon* (Eigenmann, 1915) | | | 54 | 3 | 55 | | | | 11,2% |
| *Serrapinnus piaba* (Lütken, 1875) | 95 | | 144 | 31 | 75 | 2 | | | 34.8% |
| **Erythrinidae** | | | | | | | | | |
| *Hoplias malabaricus* (Bloch, 1794) | 1 | | | | 1 | | | | 0.2% |
| *Hoplerithynus unitaeniatus* (Spix & Agassiz, 1829) | 9 | | | | | | | | 0.9% |
| **SILURIFORMES** | | | | | | | | | |
| **Auchenipteridae** | | | | | | | | | |
| *Trachelyopterus galeatus* (Linnaeus, 1766) | 9 | | | | | | | | 0.9% |
| **Ariidae** | | | | | | | | | |
| *Arius* sp. | | | | | | | | 3 | 0.3 |
| **PERCIFORMES** | | | | | | | | | |
| **Cichlidae** | | | | | | | | | |
| *Cichlassoma orientale* Kullander, 1983 | 24 | | 8 | 30 | 5 | 7 | 1 | | 7.5% |
| *Crenicichla menezesi* Ploeg, 1991 | 9 | | | | | 1 | | | 1.0% |
| *Geophagus parnaibae* Staeck & Schindler, 2006 | | | 5 | | | | | | 0.5% |
| *Oreochromis niloticus* (Linnaeus, 1785) | 6 | 21 | | | | | 18 | | 4.5% |
| **Centropomidae** | | | | | | | | | |
| *Centropomus unidecimalis* (Bloch, 1792) | | | | | | | | 1 | 0.1% |
| **Carangidae** | | | | | | | | | |
| *Oligoplites palometa* (Cuvier, 1832) | | | | | | | | 1 | 0.1% |
| **Gerreidae** | | | | | | | | | |
| *Eucinostomus melanopterus* (Bleeker, 1863) | | | | | | | | 2 | 0.2% |
| **Scianidae** | | | | | | | | | |
| *Ophioscion punctatissimus* Meek & Hildebrand, 1925 | | | | | | | | 1 | 0.1% |
| **MUGILIFORMES** | | | | | | | | | |
| Mugilidae | | | | | | | | | |
| *Mugil* sp. | | | | | | | | 1 | 0.1% |
| **TETRAODONTIFORMES** | | | | | | | | | |
| Tetraodontidae | | | | | | | | | |
| *Sphoeroides testudineus* (Linnaeus, 1758) | | | | | | | | 1 | 0.1% |

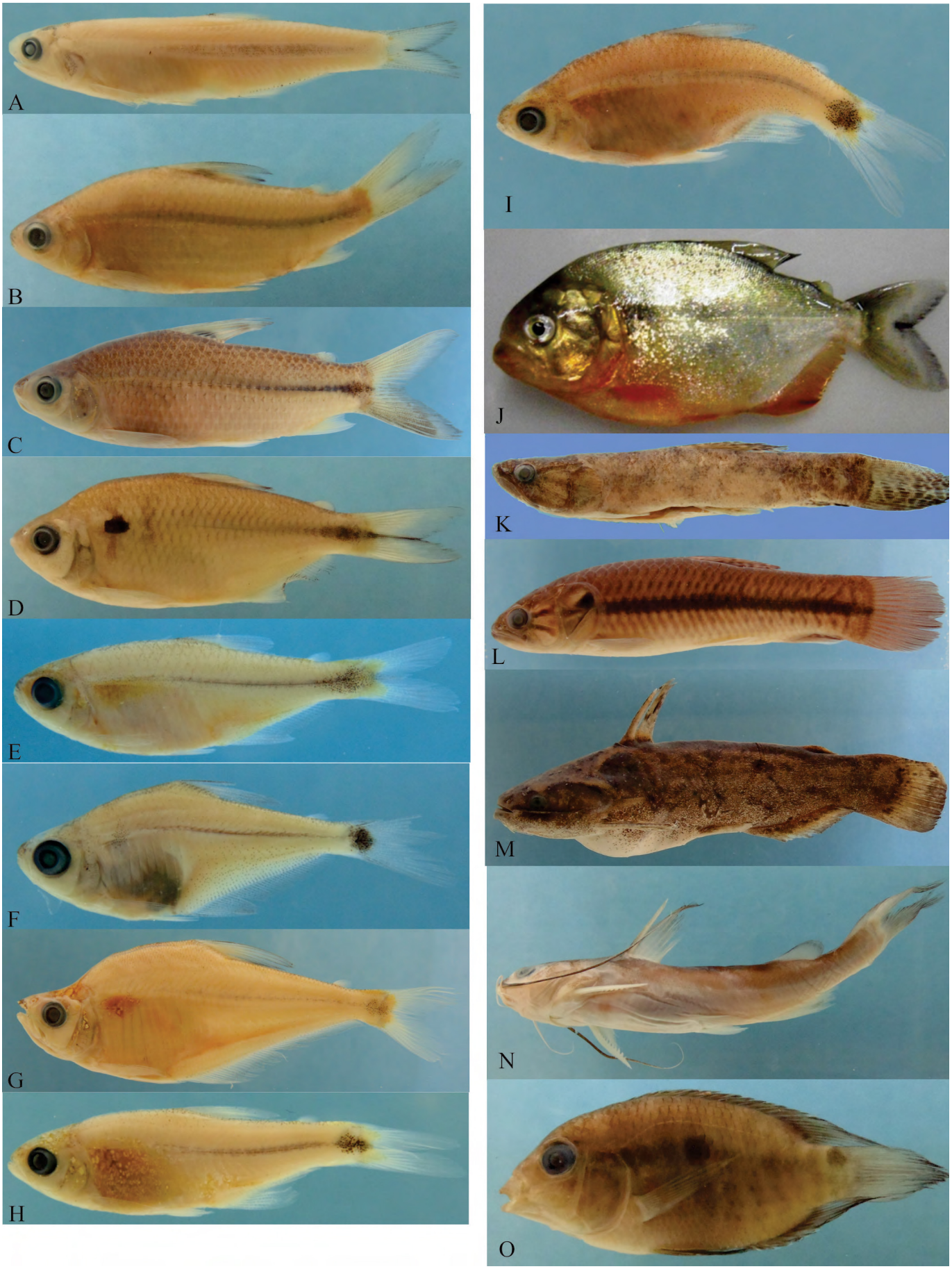


**Figure 2.** A, *Anchoviella lepidentostole* CZDP 046, 55.7 mm SL; B, *Curimata macrops* CZDP 019, 65.6 mm SL; C, *Steindachnerina notonota* CZDP 03, 68.2 mm SL; D, *Astyanax* sp. Aff. *A. bimaculatus* CZDP 04, 64.2 mm SL; E, *Hyphessobrycon* sp. CZDP 024, 24.4 mm SL; F, *Psellogramus kennedyi* CZDP 07, 29.0 mm SL; G, *Roeboides sazimai* CZDP 08, 71.0 mm SL; H, *Serrapinnus heterodon* CZDP 030, 25.6 mm SL; I, *Serrapinnus piaba* CZDP 023, 28.1 mm SL; J, *Pygocentrus nattereri* CZDP 018, 75.7 mm SL; K, *Hoplias malabaricus* CZDP 026, 113.0 mm SL; L, *Hopleritrhynus unitaeniatus* CZDP 01, 91.0 mm SL; M, *Trachelyopterus galeatus* CZDP 09, 89.1 mm SL; N, *Arius* sp. CZDP 047, 91.0 mm SL; O, *Cichlassoma orientale* CZDP 036, 55.9 mm SL.


**Figure 3.** A, *Crenicichla menezesi* CZDP 011, 91.9 mm SL; B, *Geophagus parnaibae* CZDP 021, 54.1 mm SL; C, *Oreochromis niloticus* CZDP 012, 34.4 mm SL; D, *Centropomus undecimalis* CZDP 041, 131.5 mm SL; E, *Oligoplites palometa* CZDP 044, 98.4 mm SL; F, *Eucinostomus melanopterus* CZDP 042, 95.3 mm SL; G, *Ophioscion punctatissimus* CZDP 043, 89.9 mm SL; H, *Mugil* sp. CZDP 048, 30.8 mm HL; I, *Sphoeroides testudineus* CZDP 046, 100.6 mm SL.

was found almost destroyed in the gillnet, probably preyed on by another fish.

The most abundant species in terms of total number of individuals was *Serrapinus piaba*, which is also abundant in the rio Ceará Mirim in northeast Brazil (Silvano *et al.* 2003). *Astyanax*, *Serrapinus* and *Psellogramus* showed the greatest distribution. *Serrapinnus heterodon* and *S. piaba* fall within the spatial pattern expected of cheirodontin fish, where they are very abundant inhabitant of lentic and lowland environments (Malabarba, 1998).

Seven species, *Centropomus undecimalis*, *Anchoviella lepidentostole*, *Sphoeroides testudineus*, *Eucinostomus melanopterus, Mugil* sp., *Arius* sp. *and Ophioscion punctatissimus*, were only collected in the lower Parnaíba River, in the mouth of Igaraçu River and are generally captured in shallow waters reefs, islands and especially, bays, canals, estuaries, mangroves, lagoons and coastal rivers (Lessa and Nobrega 2000). These species are also collected in artisanal fish traps, which are set up by fishermen in places with a considerable tidal height variation, off the coast of Piauí State (Mai *et al.* 2012). *Centropomus undecimalis*, *A. lepidentostole*, *E. melanopterus, O. punctatissimus* are commercial fish usually sold in the public markets of northern Piauí (Melo 2012).

Some studies have concerned the effects of wind energy facilities on bat and bird fatalities (Barclay *et al.* 2007). The effects of towers, turbines rotors and electromagnetic field on lakes and its fish fauna inside a wind far are still unknown, so monitoring is necessary to test future hypothesis of environmental impact.

*Dichotomous identification key to fishes from small lakes around mouth of the Parnaíba River*

1a Skin with spines, teeth modified in hard plates ..... ..... *Sphoeroides testudineus* (Figure 3I)
1b Skin without spines, teeth not modified in hard plates ..... 2
2a Fins with spines ..... 3
2b Fins without spines ..... 13
3a Pectoral fin in dorsal position or above middle line of the body ..... ..... Mugilidae (1 species), *Mugil* sp. (Figure 3H)
3b Pectoral fin not in dorsal position, or below middle line of the body ..... 4

4a Barbells present ..... 5
4b Barbells absent ..... 6
5a Barbell reaching dorsal fin origin. Forked caudal fin ..... Ariidae (1 species), *Arius* sp. (Figure 2N)
5b Barbell not reaching dorsal fin origin. Not forked caudal fin ..... Auchenipteridae, (1 species), *Trachelyopterus galeatus* (Figure 2M)
6a Lateral line interrupted with dorsal branch and posterior middle caudal peduncle branch ..... Cichlidae ... 7
6b Non interrupted lateral line, continuous until caudal fin; ..... Scianidae, Gerreidae, Carangidae, Centropomidae ... 10
7a Superior branch of first branchial arch with a flesh lobule, stripes in longitudinal position along with caudal fin rays ..... *Geophagus* (1 species), *G. parnaibae* (Figure 3B
7b First branchial arch without lobule, stripes in transversal position along with caudal fin rays or no stripes ..... 8
8a Parallel stripes in transversal position on caudal fin ..... *Oreochromis niloticus* (Figure 3C)
8b No stripes on caudal fin ..... 9
9a Serrated posterior margin of preopercular bone, dark lateral band along the body ..... *Crenicichla* (1 species), *Crenicihla menezesi* (Figure 3A)
9b Non Serrated posterior margin of preopercular bone, stain median dark side ..... *Cihlassoma* (1 species), *Cichlassoma orientale* (Figure 20)
10a Serrated posterior margin of preopercular bone .... Centropomidae and Scianidae ..... 11
10b Non Serrated posterior margin of preopercular bone ..... 12
11a Mouth in superior position, prognathous, forked caudal fin .... *Centropomus undecimalis* (Figure 3D)
11b Mouth in inferior position, no prognathous, caudal fin pointed..... *Ophioscion punctatissimus* (Figure 3G)
12a Protractile mouth, spines not prominent on anal fin, nine spines on dorsal fin ..... *Eucinostomus melanopterus* (Figure 3F)
12b Non protractile mouth, two prominent spines on the anal fin, five spines on dorsal fin ..... *Oligoplites palometa* (Figure 3E)
13a Adipose fin present, no large silvery lateral band, not developed gill rakers ..... Characiformes ... 14
13b Adipose fin absent, large silvery lateral band, developed gill rakers ..... *Achoviella lepidentostole* (Figure 2A)
14a Presence of maxillary teeth ..... 15.
14b Absence of maxillary teeth ..... 23.
15a Keeled abdomen, head and jaws broad and heavy, snout flat, teeth in blade shape ..... *Pygocentrus nattereri* (Figure 2J)
15b Abdomen without keel, head and jaws not broad, snout pointed, conical and canine teeth, but never in blade shape ..... 16
16a Conical or canine teeth ..... 17
16b No conical or canine teeth ..... 18
17a Dorsal portion of opercular bone without black spot. Maxillary bone with teeth on proximal portion. Dentary with canine teeth .... *Hoplias malabaricus* (Figure 2K)
17b Dorsal portion of opercular bone with black spot. Maxillary bone and dentary without canine teeth ..... *Hoplerithrynus unitaeniatus* (Figure 2L)
18a Gibbosity in predorsal area. Outer mammaliform teeth in premaxillary bone ..... *Roeboides sazimai* (Figure 2G)
18b No gibbosity in predorsal area. No outer teeth in premaxillary bone ..... 19
19a One series of teeth on premaxillary bone, presence of a triangular opening in the musculature covering the anterior part of the swim bladder in both sides of the body, pseudo tympanum, males with procurrent caudal fins developed, caudal peduncle curved ..... *Serrapinnus* ... 20
19b Two series of teeth on premaxillary bone, no pseudo tympanum ..... 21
20a Teeth with seven cusps in dentary bone, one large central cusp, remaining others smaller ..... *Serrapinnus piaba* (Figure 2I)
20b Dentary teeth with three cusps equally sized ..... *Serrapinnus heterodon* (Figure 2H)
21a More than 44 scales on lateral line ..... *Psellogrammus kennedyi* (Figure 2F)
21b Less than 41 scales on lateral line ..... 22
22a Completed lateral line, ovate humeral spot, no maxillary teeth ..... *Astyanax* aff. *bimaculatus* (Figure 2D)
22b Not completed lateral line, no humeral spot, maxillary teeth ..... *Hyphessobrycon* sp. (Figure 2E)
23a Three primary mouth folds expanded into large dangling flaps that extend distinctly ventrally from the roof of the oral cavity, no spot in caudal fin rays ..... *Curimata macrops* (Figure 2B)
23b No mouth folds in the roof of the oral cavity, black spot in the middle dorsal fin rays ..... *Steindachnerina notonota* (Figure 2C)

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**Appendix 1.** Voucher material
*Roeboides sazimai*, CZDP 08; *Steindachnerina notonota* CZDP 03; *Hyphessobrycon* sp. CZDP 05; *Astyanax* sp. CZDP 04, CZDP 014, CZDP 022, CZDP 027, CZDP 032, CZDP 037; *Hoplias malabaricus* CZDP 02, CZDP 026 ; *Hoplerithrynus unitaeniatus* CZDP 01; *Psellogrammus kennedyi* CZDP 07, CZDP 015, CZDP 028, CZDP 033,CZDP 038 ; *Cichlassoma orientale* CZDP 010, CZDP 031, CZDP 020, CZDP 025, CZDP 036, CZDP 039; *Crenicichla menezesi* CZDP 011, CZDP 035; *Oreochromis niloticus* CZDP 012, CZDP 013, CZDP 040; *Trachelyopterus galeatus* CZDP 09; *Serrapinnus piaba* CZDP 06, CZDP 017, CZDP 023, CZDP 029, CZDP 034; *Centropomus undecimalis* CZDP 041; *Eucinostomus melanopterus* CZDP 042; *Ophioscion punctatissimus* CZDP 043; *Oligoplites palometa* CZDP 044; *Anchoviela lepidentostole* CZDP 045; *Sphoeroides testudineus* CZDP 046; Ariidae CZDP 047; *Mugil* sp. CZDP 048; *Pygocentrus nattereri* CZDP 018; *Geophagus parnaibae* CZDP 021; *Curimata* sp. CZDP 019; *Serrapinnus heterodon* CZDP 016, CZDP 024, CZDP 030.