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 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, “Colecção 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 Parnaíba 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 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 of Parnaíba 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; Britski et al. 1988; Ploeg 1991; Ferreira et al. 1998; Reis et al. 2003; Staack 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).

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, Crenicichla 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

**Table 1.** Geographical coordinates from the collecting sites in the mouth of Parnaíba River basin.

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

**Figure 1.** Map of the study area showing the collecting sites in lower Parnaíba River basin, Piauí State Brazil, Ilha Grande.
Table 2. List of species collected from down Parnaíba River basin, Piauí State, Brazil.

<table>
<thead>
<tr>
<th>TAXON</th>
<th>SITE 1</th>
<th>SITE 6</th>
<th>SITE 7</th>
<th>SITE 8</th>
<th>SITE 9</th>
<th>SITE 10</th>
<th>SITE 11</th>
<th>SITE 12</th>
<th>FREQUENCY OF CAPTURE</th>
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<td>Anchoviela lepidentostole (Fowler, 1911)</td>
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<td>Astyanax aff. bimaculatus</td>
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<tr>
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<td>Serrapinnus heterodon (Eigenmann, 1915)</td>
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<td>Serrapinnus piaba (Lütken, 1875)</td>
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<td>144</td>
<td>31</td>
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<tr>
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<td>Cichlasoma orientale Kullander, 1983</td>
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<td>30</td>
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<td>Geophagus paraibae Staeck &amp; Schindler, 2006</td>
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<td>Ophiacion punctatissimus Meek &amp; Hildebrand, 1925</td>
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<td>Mugil sp.</td>
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<td>Sphoeroides testudineus (Linnaeus, 1758)</td>
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</table>
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, Psollogramus 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, Hoplerythrinus 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.
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, Spherooides 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 .............. *Spherooides 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 ........................................ 3

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 branched arch with a flesh
lobule, stripes in longitudinal position along with
caudal fin rays
...... Geophagus (1 species), Geophagus pardalbae (Figure 3B)
7b First branched arch without lobule, stripes in
transversal position along with caudal fin rays or no
stripes
.................... Oreochromis niloticus (Figure 3C)
8a Parallel stripes in transversal position on caudal fin
.................... Cichlididae .... 8
8b No stripes on caudal fin .................................. 9
9a Serrated posterior margin of preopercular bone, dark
lateral band along the body
............. Crenicichla (1 species), Crenicichla menezesi
(Figure 3A)
9b Non Serrated posterior margin of preopercular bone,
stain median dark side
.................. Cichlasoma (1 species), Cichlasoma 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 melanipterus (Figure 3F)
12b Non protractile mouth, two prominent spines on the
anal fin, five spines on dorsal fin
.................. Oligopix 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 ...... Achovilla lepidostomostole (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. Dentercy
with canine teeth ..... Hoplias malabaricus (Figure 2K)
17b Dorsal portion of opercular bone with black spot.
Maxillary bone and dentercy without canine teeth
............. Hopleitherium untiareniatis (Figure 2L)
18a Gibbosity in predorsal area. Outer mammiliform
teeth in premaxillary bone
.................. Roeboides sasimai (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 procurent
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 macrosp (Figure 2B)
23b No mouth folds in the roof of the oral cavity, black
spot in the middle dorsal fin rays
..................... Steindacherinera notonota (Figure 2C)

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