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Fish fauna of Pratagi River coastal microbasin, extreme north Atlantic Forest, Rio Grande do Norte State, northeastern Brazil

Roney Emanuel Costa de Paiva, Sergio Maia Queiroz Lima *, Telton Pedro Anselmo Ramos and Liana de Figueiredo Mendes

Universidade Federal do Rio Grande do Norte, Departamento de Botânica, Ecologia e Zoologia, Centro de Biociências, Campus Universitário Lagoa Nova, CEP 59078-900. Natal, RN, Brazil
* Corresponding author. E-mail: *smaialima@gmail.com*

Abstract: The purpose of this study was to inventory the ichthyofauna of the coastal Pratagi River basin, located on the east coast of the state, region with intense tourist activities. A total of 2,181 specimens were collected, from August 2011 to August 2013, using sieves, trawls, cast nets, traps and gillnets. Additionally, two species (*Centropomus* sp. and *Lutjanus alexandrei*) have only been recorded through underwater observations, summing 22 species and genera, 18 families and nine orders. Along the Pratagi drainage some human impacts were identified, mainly related to tourist activities, such as removal of riparian vegetation and sedimentation caused by the passage of vehicles on dunes. Species richness was lower near the most visited places and greater in the lower portion of the basin, due to the presence of estuarine and marine species. Apparently, a set of small waterfalls act as a barrier to some fish species, both upstream and downstream.

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Introduction

The knowledge about the fish diversity of the northeastern Brazil coastal basins is partial, especially from the Mid-Northeastern Caatinga freshwater ecoregion (Rosa *et al*. 2003; Abell *et al.* 2008, Albert *et al.* 2011). This region includes the coastal watersheds between the rivers São Francisco and Parnaíba, covering the Alagoas, Pernambuco, Paraíba, Rio Grande do Norte, Ceará and Piauí States (Rosa *et al*. 2003) and is considered one of the main gaps in ichthyofaunal studies in the world (Lévêque *et al.* 2008).

Although the semiarid Caatinga biome is predominant in this region, the east coastal margin of Alagoas, Pernambuco, Paraíba and Rio Grande do Norte States are characterized by the Atlantic Forest (Langeani *et al*. 2009). Despite little knowledge about fish fauna of the Atlantic Forest, this is one of the richest Neotropical biomes, and features a high variety of habitats (Abilhoa *et al*. 2011). However, the rivers of this biome are characterized by having limited extent and environmental fragility (Serra *et al*. 2005), and are threatened by urban pressure in most of its length, leaving few unchanged forest areas (Menezes *et al*. 2007; Ribeiro *et al*. 2009). According to Langeani *et al*. (2009) urgent additional inventories shall be made on stretches of rivers that drain the northeastern Atlantic Forest, mostly impacted by urban sprawl and agricultural, industrial and aquaculture activities.

Besides presenting smaller areas, microbasins can exhibit high species richness of fish due to greater environmental heterogeneity, as those of the Atlantic Forest in the southern coast of Bahia, with high levels of richness and endemism (Menezes *et al*. 2007). Moreover, the estuarine portion of these basins regions may represent areas of reproduction, protection and feeding for some marine species, including commercially important.

The east coast of Rio Grande do Norte is composed by small and medium-sized basins partially or fully inserted in the Atlantic Forest, representing the northern extreme of this biome, with only 4.1% of the native vegetation (Fundação SOS Mata Atlântica and INPE 2012), composed by small isolated fragments. Therefore, the aim of this study was to inventory the ichthyofauna of the coastal Pratagi River basin, located on the east coast of the state, region with intense tourist activities, and report the main anthropogenic impacts on the basin, to increase the knowledge and support to conservation strategies for the Atlantic Forest fish fauna.

Material and Methods

Study site

The study was conducted in Pratagi River basin, located in Ceará-Mirim Municipality, Rio Grande do Norte State. The main course of the Pratagi River has about 10 km long and is a tourist natural attraction of Rio Grande do Norte coast due to its high landscape value, with two popular sites mainly visited by tourists who make buggy rides in dune areas at the east coast, the Lavacu and Cachoeirinha Pitangui waterfall. The Pratagi River mouth is distant about 30 km from Natal, state capital city, and the main river course presents excerpts with clear waters fringed by dunes in Restinga and Atlantic Forest remnants until emptying into the Atlantic Ocean (Figure 1).

Data collection

Eleven samples were taken from five sites along Pratagi River basin, from the headwaters to the estuarine portion.

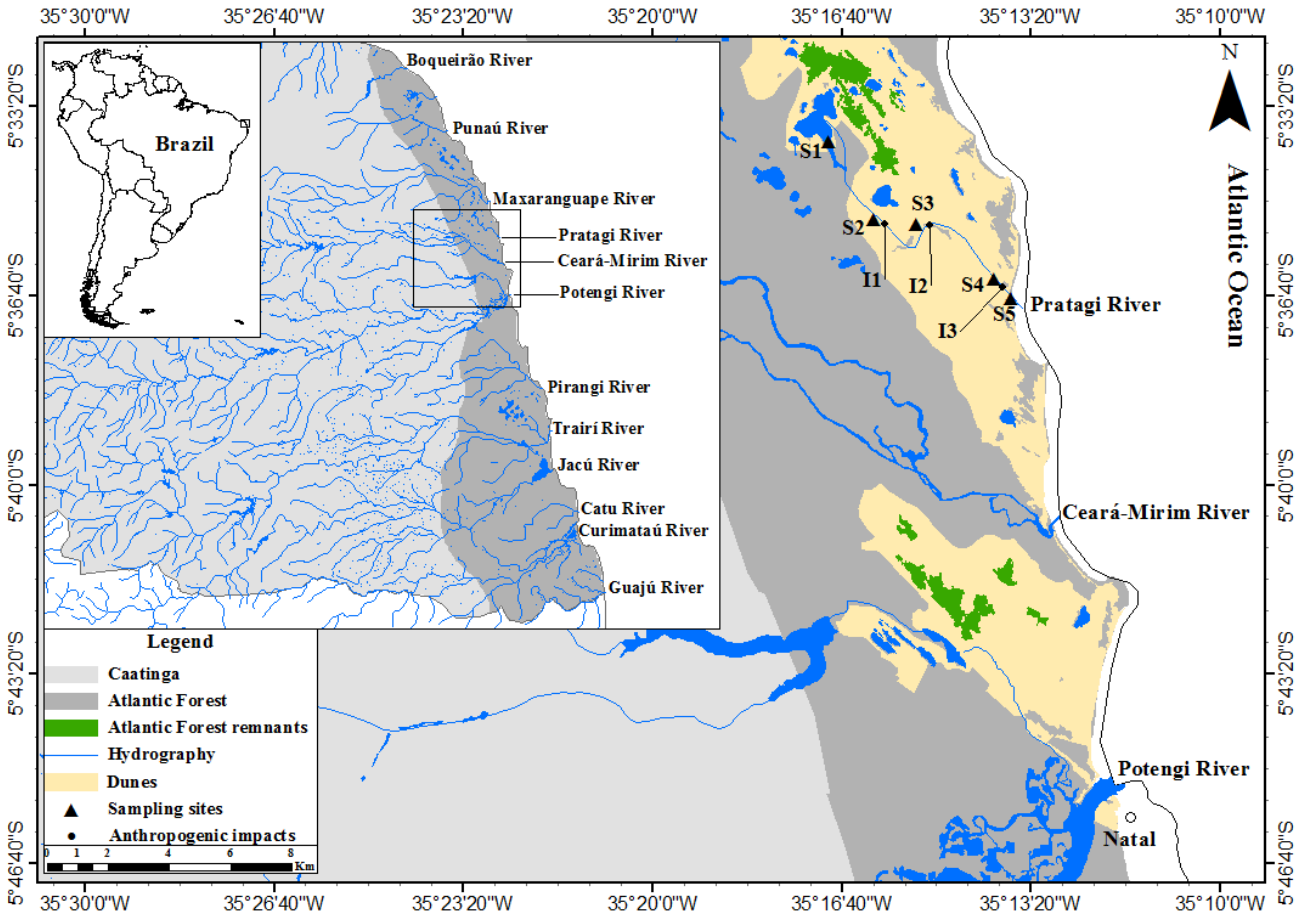

FIGURE 1. Location of Pratagi River microbasin, Rio Grande do Norte State, Brazil, showing sampling sites. Natal city indicated by open dot.

Samples were taken from August 2011 to August 2013 (Figure 1, Figure 2S1- 2S5 and Table 1). Each location was sampled traversing a stretch of about 50 m. The collections of specimens were carried out using sieves, trawls, cast nets, traps and gillnets, according to environmental and hydrological conditions of each sampling site. Besides these fishing gears, snorkeling observations were also performed. Fish collections were made under ICMBio/SISBIO (Instituto Chico Mendes de Conservação da Biodiversidade/Sistema de Autorização e Informação em Biodiversidade) permits #30532-1/2011. Collected specimens were anesthetized with eugenol (two drops per liter), fixed in 10% formalin, posteriorly preserved in 70% ethanol and deposited at Universidade Federal do Rio Grande do Norte (UFRN) fish collection (Table 2). Some specimens were photographed alive (Figure 3) to obtain registration of natural color pattern.

Species were identified to the lowest possible taxonomic level, using available specialized literature (Araújo *et al.* 2004; Britski *et al.* 1984, 2007; Figueiredo and Menezes 1978, 1980; Kullander 1988; Menezes and Figueiredo 1980, 1985; Marceniuk 2005; Menezes *et al.* 2007; Ploeg 1991). The taxonomic classification followed Eschmeyer (2013). Species were assigned to each habitat according to the classification proposed by Froese and Pauly (2013). The popular names were directly accessed through questionnaires with photos of each species to the local population and vendors, while the main anthropic impacts were identified based on direct observations and photographic records.

RESULTS

A total of 2,181 specimens belonging to 20 species and genera, 16 families and nine orders (Table 2) were collected. Besides these, two species (*Centropomus* sp. and *Lutjanus alexandrei*) have only been recorded visually through snorkeling in the stretch downstream Cachoeirinha de Pitangui waterfall (S5). Specimens of *Centropomus* sp. (10–20 cm standard length, SL) were observed in August 2012 and of *Lutjanus alexandrei* (5–30 cm SL) in July, August and October 2012. None of the species recorded in this study is rare, endangered, exotic or allochthonous.

The most significant orders were Perciformes (36%), Characiformes (22%) and Siluriformes (13%), with eight, five and three species, respectively. The Gymnotiformes, Mugiliformes, Atheriniformes, Cyprinodontiformes, Syngnathiformes, and Synbranchiformes orders were represented by a single species each (Table 2). The predominant families were Characidae (three species, 13%), followed by Eleotridae and Cichlidae, both represented by two species, corresponding to 9% of the total richness each (Table 2).

Of the 22 species recorded, 13 are freshwater, three estuarine and six marine (Figure 3, Table 2). The species *Cichlasoma orientale*, *Crenicichla menezesi*, *Hemigrammus marginatus*, *Hoplias malabaricus* and *Poecilia vivipara* were collected in all sampling sites, including the lower portion of the basin under tidal influence (approximately 0.5 km from the sea), indicating that these may have tolerance to salinity or were

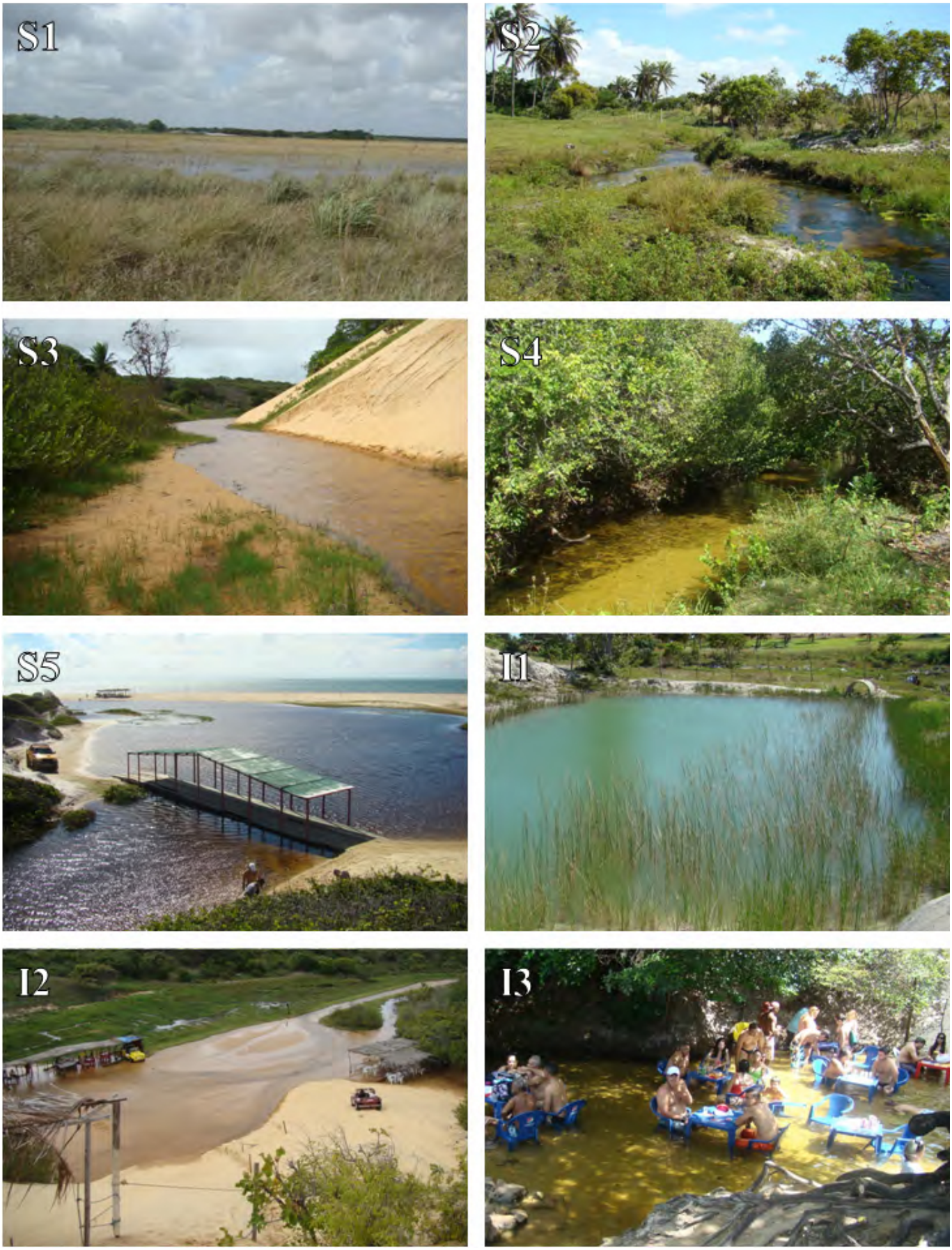

Figure 2. Sampling sites (S1–S5, see Table 1) and some anthropogenic impacts (I1-I3) in Pratagi River microbasin, Rio Grande do Norte State, Brazil. I1, carciniculture tank and removal of riparian vegetation adjacent to middle Pratagi River; I2, dune erosion and sedimentation mainly due to buggy traffic at Lavacu; and I3, uncontrolled tourism at Cachoeira de Pitangui.

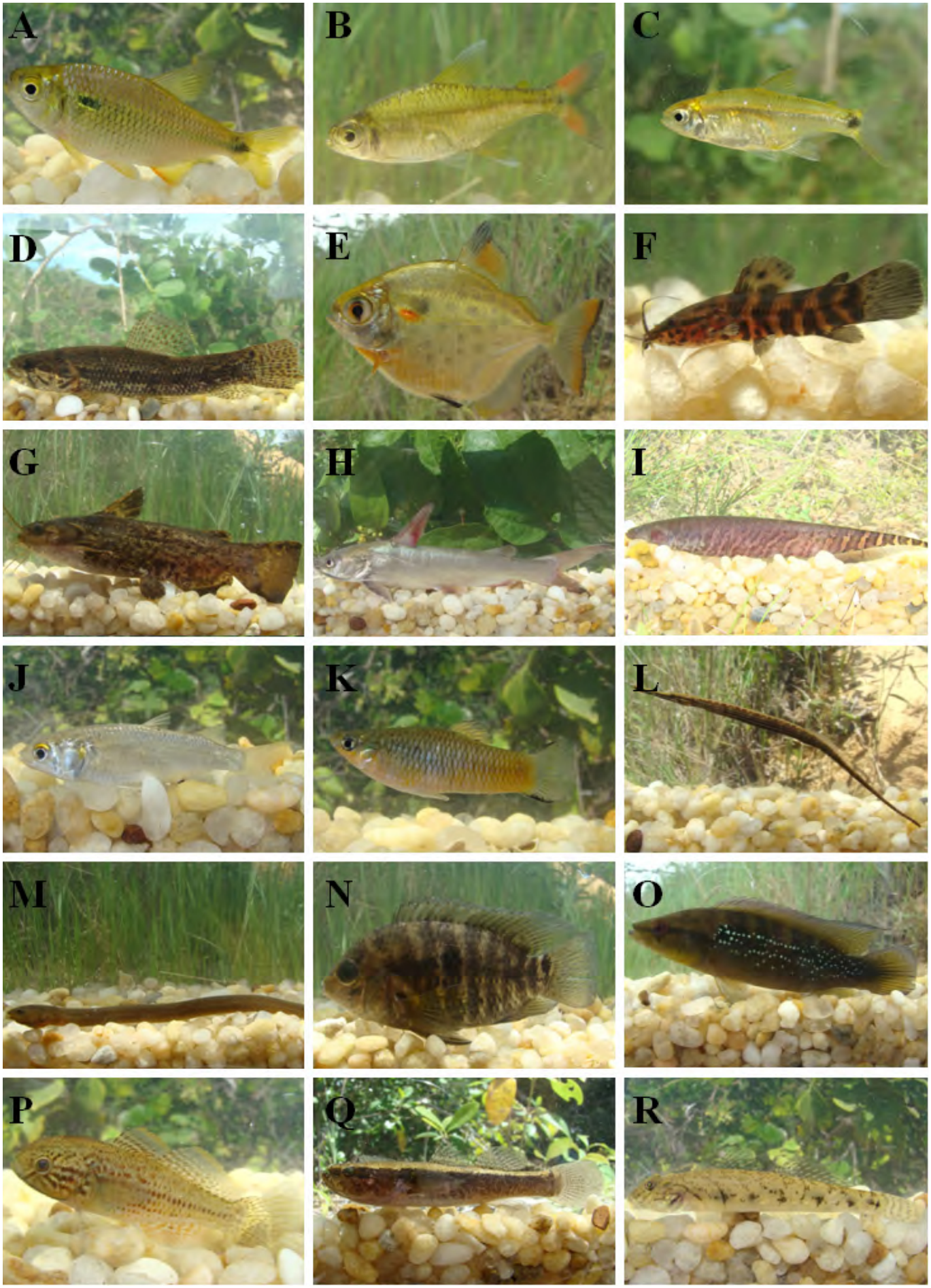

Figure 3. Some fish species of Pratagi River microbasin, Rio Grande do Norte State, Brazil. A, *Astyanax* aff. *bimaculatus*; B, *Hemigrammus marginatus*; C, *Serrapinnus piaba*; D, *Hoplias malabaricus*; E, *Metynnis* aff. *lippincottianus*; F, *Megalechis thoracata*; G, *Trachelyopterus galeatus*; H, *Genidens barbus*; I, *Gymnotus* aff. *carapo*; J, *Mugil curema*; K, *Poecilia vivipara*; L, *Microphis lineatus*; M, *Synbranchus marmoratus*; N, *Cichlasoma orientale*; O, *Crenicichla menezesi*; P, *Dormitator maculatus*; Q, *Eleotris pisonis*; R, *Awaous tajasica*.

Table 1. Geographic coordinates, elevation and locality of five sampling sites in Pratagi River microbasin, Rio Grande do Norte State, Brazil.

SAMPLING SITES	GEOGRAPHIC COORDINATES	ELEVATION	LOCALITY
S1	5°33′56.6″ S, 35°16′53.6″ W	24 m	Headwaters of Pratagi River
S2	5°35′19.2″ S, 35°16′5.3″ W	25 m	Pratagi River downstream to the bridge in RN160 road
S3	5°35′24.5″ S, 35°15′20.9″ W	25 m	Pratagi River upstream to Lavacu touristic site
S4	5°36′23.5″ S, 35°13′59.0″ W	17 m	Pratagi River upstream to Cachoeirinha de Pitangui waterfall
S5	5°36′43.3″ S, 35°13′45.1″ W	6 m	Pratagi River estuary

carried out after torrential rains. The predominance of freshwater species upstream to Cachoeirinha Pitangui and marine species downstream (Table 2) suggests that this set of small waterfalls (maximum height 1.9 m) can act as a physical barrier.

The sampling sites with lowest species richness were S3 and S4, with six and eight species, precisely the river patches that receive most tourist visitation, adjacent to the Lavacu and Cachoeirinha de Pitangui, respectively. The highest species richness was found in the lower stretch S5 with 19 species recorded, most of them estuarine or marine species, with eight of these restricted to this locality (*Genidens barbus*, *Mugil curema*, *Atherinella brasiliensis*, *Microphis lineatus*, *Centropomus* sp., *Lutjanus alexandrei*, *Eucinostomus argenteus* and *Dormitator maculatus*) (Table 2).

Three species (*Astyanax* aff. *bimaculatus*, *Gymnotus* cf. *carapo* and *Metynnis* aff. *lippincottianus*) have broad geographic distribution and confusing taxonomy confused and may represent undescribed species belonging to species complexes (Lima *et al*. 2003; Milhomem *et al.* 2008).

Among the freshwater species, five are used as sources of protein for human consumption according to the local population: *Cichlasoma orientale*, *Hoplias malabaricus*, *Trachelyopterus galeatus*, *Megalechis thoracata* and *Synbranchus marmoratus*, which are the larger freshwater species found in Pratagi River. Among the marine species, *Centropomus* sp., *Eucinostomus argenteus*, *Genidens barbus* and *Lutjanus alexandrei* are also important for subsistence feeding, but feature as small importance in local commercial fisheries.

Along the basin some human impacts were identified, primarily related to tourist activities. In many stretches occurred suppression of riparian vegetation (Figure 2 S1 and S2), with implementation of agricultural, cattle raising and carciniculture (Figure 2 I1) immediately adjacent to Pratagi River main course. During field visits, a large number of visitors was observed, mainly in Lavacu and Cachoeirinha de Pitangui (Figure 2 I2 and 2 I3). In Lavacu the intense traffic of off-road vehicles in the dunes that border the river may have intensified the erosion process (Celliers *et al*. 2004; Davenport and Davenport 2006; Thompson and Schlacher 2008) and sedimentation of the river, that could have resulted in a widest river, with laminar flow, formation of sandbanks and diversion from the main channel (Figure 2 I2), only observed in this stretch of the basin. In Cachoeirinha de Pitangui an area were opened for vehicles parking and installation of food stalls, that serve drinks and food to visitors at tables in the riverbed (Figure 2 I3), contributing to the increase of solid waste that falls in the water, and accumulates mainly in the river mouth.

Discussion

Few ichthyological surveys have been made in the coastal basins under the influence of the Atlantic Forest north of the São Francisco river, and these are practically restricted to Paraíba and Pernambuco States. Ramos *et al*. (2005) in an inventory of the fish fauna of Curimataú drainage (about 120 km extent) found 22 species from 17 genera and eleven families of freshwater fish, although this study excluded the area of the basin under marine influence. Torelli *et al*. (1997) and Gomes-Filho and Rosa (2001) conducted surveys in Gramame coastal basin (54 km long), and recorded 22 species and genera and 15 families, and 32 species of which 23 were freshwater, respectively. Rosa and Groth (2004) in studies on fish fauna of the northeastern upland forest (*brejos de altitude*) of Paraíba and Pernambuco States, which consist in wet forests remnants of Atlantic Forest in Caatinga areas at the Borborema plateau, recorded 27 species belonging to 23 genera of 12 families.

Compared to these fish surveys of largest coastal basins, the fish fauna of the Pratagi drainage present a similar species richness (22 species), however, the number of freshwater species was relatively low, with only 13 species recorded, nine of these are considered primary freshwater fishes. This species richness is relatively high considering the reduced size of the basin (about 10 km extent), and could be explained by the high diversity of habitats usually present in microbasins (Súarez 2008).

Once it is a coastal microbasin, with small extension and therefore greater marine influence, the Perciformes order showed higher species richness in Pratagi River, with presence of estuarine and marine species. In most basins of the Neotropical region, the predominant groups are Characiformes and Siluriformes (Reis *et al*. 2003; Buckup *et al*. 2007). Of the 13 freshwater species, one is peripheral (*Awaous tajasica*) and three are secondary (*Cichlasoma orientale, Crenicichla menezesi* and *Poecilia* vivipara (Albert and Reis, 2011).

One of the major differences between the freshwater fish fauna of the Pratagi River and the largest adjacent basins (*e.g.,* Ceará-Mirim and Potengi) is related to the absence of larger species (*e.g., Hypostomus pusarum* (Starks, 1913)) or species that perform small migrations (*e.g., Leporinus piau* Fowler, 1941 and *Prochilodus brevis* Steindachner, 1875). These species may not occur in this microbasin because the size and other characteristics of the basin can not meet the ecological requirements of these species, or because they may have been extirpated during marine transgressive events, above the current sea level that occurred during the late Quaternary (Suguio 1999; Bezerra *et al*. 2002), due to its low elevation (Table 1). In this case, only salt resistant species or freshwater species

TABLE 2. List of fish species of Pratagi River microbasin, Rio Grande do Norte State, Brazil, based on records by site. Abbreviations are F, Freshwater, E, Estuarine, M, Marine. * Visual records.

			SAMPLING SITES					VOUCHER
ORDER / Family / *Species*	**POPULAR NAME**	**HABITAT**	**S1**	**S2**	**S3**	**S4**	**S5**	**(UFRN)**
CHARACIFORMES								
Characidae								
Astyanax aff. *bimaculatus* (Linnaeus, 1758)	piaba-de-flor	F	x	x	x		x	154, 859, 1031, 1403
Hemigrammus marginatus Ellis, 1911	piaba-larga	F	x	x	x	x	x	819, 884, 983, 1029, 1394
Serrapinnus piaba (Lütken, 1875)	piaba	F	x	x	x		x	704, 1032, 1392, 1405
Erythrinidae								
Hoplias malabaricus (Bloch, 1794)	traíra	F	x	x	x	x	x	987, 997, 1030, 1398, 1406
Serrasalmidae								
Metynnis aff. *lippincottianus* (Cope, 1870)	tapacá	F	x	x			x	703, 1033, 1396
SILURIFORMES								
Callichthyidae								
Megalechis thoracata (Valenciennes, 1840)	cascudo	F		x				1871
Auchenipteridae								
Trachelyopterus galeatus (Linnaeus, 1766)	cangati	F		x			x	977, 1001
Ariidae								
Genidens barbus (Lacepède, 1803)	bagre	M					x	890
GYMNOTIFORMES								
Gymnotidae								
Gymnotus aff. *carapo* Linnaeus, 1758	sarapó	F	x	x				994, 1035
MUGILIFORMES								
Mugilidae								
Mugil curema Valenciennes, 1836	saúna	M					x	820
ATHERINIFORMES								
Atherinopsidae								
Atherinella brasiliensis (Quoy & Gaimard, 1825)	manjuba	M					x	816
CYPRINODONTIFORMES								
Poeciliidae								
Poecilia vivipara Bloch & Schneider, 1801	piaba-de-porco	F	x	x	x	x	x	706, 881, 984, 1034, 1395
SYNGNATHIFORMES								
Syngnathidae								
Microphis lineatus (Kaup, 1856)	agulhinha-vité	E					x	217
SYNBRANCHIFORMES								
Synbranchidae								
Synbranchus marmoratus Bloch, 1795	mussum	F	x	x		x		027, 028, 1006
PERCIFORMES								
Centropomidae								
Centropomus sp.*	camurim	M					x	
Lutjanidae								
*Lutjanus alexandrei** Moura & Lindeman 2007	caranha	M					x	
Gerreidae								
Eucinostomus argenteus Baird & Girard, 1855	carapicu	M					x	817
Cichlidae								
Cichlasoma orientale Kullander, 1983	cará	F		x	x	x	x	999, 1026, 1027, 1400
Crenicichla menezesi Ploeg, 1991	bebeu	F	x	x	x	x	x	705, 998, 1397, 1028, 1064
Eleotridae								
Dormitator maculatus (Bloch, 1792)	cundide	E					x	978
Eleotris pisonis (Gmelin, 1789)	amoré	E				x	x	982, 1401
Gobiidae								
Awaous tajasica (Lichtenstein, 1822)	chupa-areia	F				x	x	066, 1402
Total of species (*n*=22)			9	12	6	8	19	

that recently recolonized the basin would be present in Pratagi River.

Although the Pratagi River basin present relative ecological integrity, with patches of Restinga and Atlantic Forest and without introduced fish species, some human impacts were identified along the river, such as removal of riparian vegetation, carciniculture, inordinate tourism, accumulation of solid waste and sedimentation caused by the passage of vehicles on the dunes that border the river (Figure 2 I1-I3). This later is in an advanced stage and may soon jeopardize the basin downstream of Lavacu, including the regular water flow to the Cachoeirinha Pitangui. Once dunes are considered highly sensitive to direct human disturbance, including the erosion of the foredunes caused by vehicles traffic, active mitigation and conservation measures are recommended to reconcile human recreational demands with sustainable use of coastal assets (Thompson and Schlacher 2008).

Moreover, in coastal plain of the Pratagi River will be built a large real estate development, whose environmental impacts assessment study (EIA) indicates the occurrence of only six fish species in the basin (ECOPLAM 2006), which represent 27% of the species herein listed. Thus, this survey will contribute to the monitoring of environmental changes resulting from the rapid urbanization and unregulated tourism development in Pratagi microbasin, which may reduce habitat quality and biodiversity (Dudgeon *et al*. 2006).

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