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Inventory

Ichthyofauna of sandy beaches along the Acre river, Brazil

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Abstract: Despite increasing efforts in recent years to catalog the fish diversity of Amazonian rivers, many regions are still under-sampled, and sandy beach environments are particularly poorly understood. The present study focused on a 300 km stretch of the Acre river, in the southwestern Amazon basin, where we sampled 30 sandy beaches separated by a mean interval of 10 km. We collected 15,329 fish representing 80 species, 26 families, and nine orders. The Characiformes were the most abundant order, providing 88.24% of the individuals collected, followed by the Siluriformes, with 10.03%, while the Siluriformes had the highest species richness, with 37 species (45.0%), followed by the Characiformes, with 30 (37.5%). The most abundant species were the characiforms *Knodus orteguasae* and *Creagruto barrigai*. Reliable data on a region's biota is fundamental for the evaluation of patterns of biodiversity, and the occurrence and management of threatened species. As fish are directly affected by pollutants and the degradation of aquatic environments, further research in areas that are still poorly sampled will be essential for the elaboration of effective conservation strategies.
Keywords: *Amazon; Characiformes; Neotropical Region; Sampling Gaps; Siluriformes; Species Diversity.*

Ictiofauna de praias arenosas ao longo do rio Acre, Brasil

Resumo: Apesar dos crescentes esforços para catalogar a diversidade de peixes nos rios amazônicos, muitas regiões ainda estão sub-amostradas e os ambientes de praias arenosas são particularmente pouco compreendidos. Este estudo foi realizado ao longo de um trecho de 300 km do Rio Acre, no sudoeste da bacia amazônica, onde foram amostradas 30 praias, separadas por uma distância média de 10 km. Foram coletados 15.329 peixes, representados em 80 espécies, 26 famílias e nove ordens. Characiformes foi a ordem mais abundante, representando 88,24% dos indivíduos coletados, seguidos pelos Siluriformes, com 10,03%, enquanto os Siluriformes apresentaram a maior riqueza, com 37 espécies (45,0%), seguidas pelos Characiformes, com 30 espécies (37,5%). As espécies mais abundantes foram os characiformes *Knodus orteguasae* e *Creagruto barrigai*. Dados confiáveis sobre a biota de uma região são fundamentais para a avaliação dos padrões de biodiversidade e conhecimento sobre a ocorrência e manejo de espécies ameaçadas. Como os peixes são diretamente afetados por poluentes e pela degradação dos ambientes aquáticos, mais pesquisas em áreas que ainda são pouco amostradas serão essenciais para a elaboração de estratégias eficazes de conservação.
Palavras-chave: *Amazônia; Characiformes; Diversidade de espécies; Lacunas de amostragem; Região Neotropical; Siluriformes.*

Introduction

The hydrographic network of the Neotropical region supports the world's most diverse freshwater fish fauna, with approximately 5,160 species (Reis et al. 2016, Jézéquel et al. 2020). This diversity is likely still underestimated, and recent predictions have pointed to a final total of between 8000 and 9000 species (Albert & Reis 2011, Reis et al. 2016). The basin of the Neotropical Amazon river is the world's largest and most diverse freshwater system, with a total area of approximately 7 million km^2, representing 20% of all the freshwater discharged into the oceans (Callède et al. 2010). Up to now, 2406 fish species have been recorded in the Amazon basin, including approximately 1402 endemic forms, distributed in 514 genera, 56 families, and 18 taxonomic orders (Dagosta & de Pinna 2019, Jézéquel et al. 2020). This fauna is distributed throughout an ample diversity of aquatic systems, including major rivers, lakes, streams, floating vegetation, and beaches (Beltrão et al. 2019, Oberdorff et al. 2019). Beaches are key environments for the maintenance of regional fish diversity, in particular due to their provision of shelter for many species (Olds et al. 2018).

Fluvial beaches are areas formed mainly by deposits of sand and clay carried by rivers, primarily during the flood period, and are present on approximately half of the area of river margin in the Amazon basin. The fish fauna found in these environments is very diverse (Goulding 1997, Lowe-McConnell 1999, Py-Daniel et al. 2007, Duarte et al. 2010), composed mainly of small species with diverse feeding habits and reproductive strategies. This enormous diversity of species is linked to several evolutionary factors, including the formation of the drainage basins, hydrological dynamics, environmental heterogeneity, and flood and reflux pulses (Val 2019).

A number of studies have recorded greater fish species richness in beach environments on rivers of the Amazon basin, in comparison with other aquatic systems, such as lakes, streams, and floating vegetation (Py-Daniel et al. 2007). In an early ichthyological survey of the Negro river, Lowe-McConnell (1989) recorded 488 species, of which 248 were found in beach environments, 184 in flooded forests, and 56 under floating aquatic macrophytes. On the Madeira river, Py-Daniel et al. (2007) compiled a list of 247 species, with 119 in beach environments, 32 in the main channel, 44 under floating macrophytes, and 52 in streams. The high diversity of fish recorded in beach environments may be related to the nutrient dynamics and availability of habitats in these environments, which have a direct influence on energy flow and favor species richness (Lowe-McConnell 1999, Roach & Winemiller 2015). On the lower Purus river, in the westernmost Amazon basin, Duarte et al. (2010) studied the ichthyofauna of beach environments, while Py-Daniel & Deus (2003) surveyed the local ichthyofauna and commented on local fisheries. Silva et al. (2010) studied the structure and dynamics of the fish communities of streams in the flood zone, while Morales et al. (2019) surveyed the ichthyofauna of the floodplain lakes of the Piagaçu-Purus Sustainable Development Reserve, also on the Purus river.

The Acre river is a medium-sized watercourse, by the standards of the Amazon basin, running 1190 km from its source, in Peru, to its confluence with the Purus river in the Brazilian state of Amazonas, first passing through Bolivia and then the state of Acre, Brazil. Ichthyological research in Acre has included studies on the Juruá river (Silvano et al. 2001) and the middle Purus (Dos Anjos et al. 2008), as well as studies of the streams (Claro-García et al. 2013, Corrêa et al. 2018, Virgilio et al. 2018, 2019) and lakes (da Silva et al. 2013) of the Acre basin. Other specific studies on the Acre river have included the evaluation of the conservation status of the river's fish in Bolivia (Añez et al. 2010) and the analysis of the population growth patterns of some fish species that inhabit beach environments in the Brazilian stretch.

Although the number of studies in the region has increased over time, considerable sampling gaps persist, and beach environments are particularly under-sampled. Data on the diversity, ecology, and distribution of fishes are essential for the development of effective conservation strategies for both threatened species and areas that have been affected by anthropogenic impacts (Closs et al. 2016). To help revert this scenario, the present study provides a comprehensive checklist of the ichthyofauna of sandy beaches along the Acre river. We also used the data to obtain an estimate of the of fish species richness of these beach environments.

Material and methods

1. *Study area*

The present study focused on an area between the municipalities of Brasiléia (11°1'1.56" S, 68°44'38.51" W) and Rio Branco (10°9'21.84" S, 67°49'4.86" W), in the state of Acre, Brazil. A total of 30 beaches were sampled over a 300 km stretch of the Acre river, with a mean interval of 10 km between each pair of sites (Figure 1). The majority of the Acre basin (27,263 Km2) is located within the Brazilian state of Acre, prior to flowing into the Purus river in the neighboring state of Amazonas, Brazil. The principal tributary of the Acre river is the Riozinho do Rola, while other important affluent include the Xapuri, Antimary, and Andirá rivers.

2. *Ichthyofauna sampling*

Two samplings were performed between August and September 2017, at the end of the region's dry season. At each site, we used a trawl net, 9 m long and 2 m in height, with a 5 mm mesh. We collected fish both during the day (between 6h and 10h) and at night (between 18h and 21h), with three parallel trawls being conducted during each session, in order to guarantee an adequate sample of the local fish assembly. Even so, some species were only acquired from third parties or by other collection techniques, i.e., by line fishing. These techniques were used selectively within the area of the beach, targeting either the deepest water or other environments that could not be trawled. Similarly, specimens donated by third parties were only included in the sample when they were known to have been collected within the area of the beach.

The morphometric measurements were taken on the left side of the body, using a digital caliper with an accuracy of 1 mm. The specimens were anesthetized in aqueous lidocaine solution, fixed in 10% formalin, and packed in plastic bags. The species were identified at the Ichthyology and Aquatic Ecology Laboratory of the Universidade Federal do Acre (UFAC), based on taxonomic keys and works (e.g., Albert et al. 2012, Queiroz et al. 2013, Brito et al. 2018) and, when necessary, specialists were consulted. The taxonomic nomenclature followed Fricke et al. (2020). After identification, the fish were transferred to 70% alcohol and some specimens were deposited at the UFAC fish collection in Rio Branco. The specimens were collected under permanent collection license no. 11185, emitted by the Brazilian Biodiversity Authorization and Information System (SISBio).

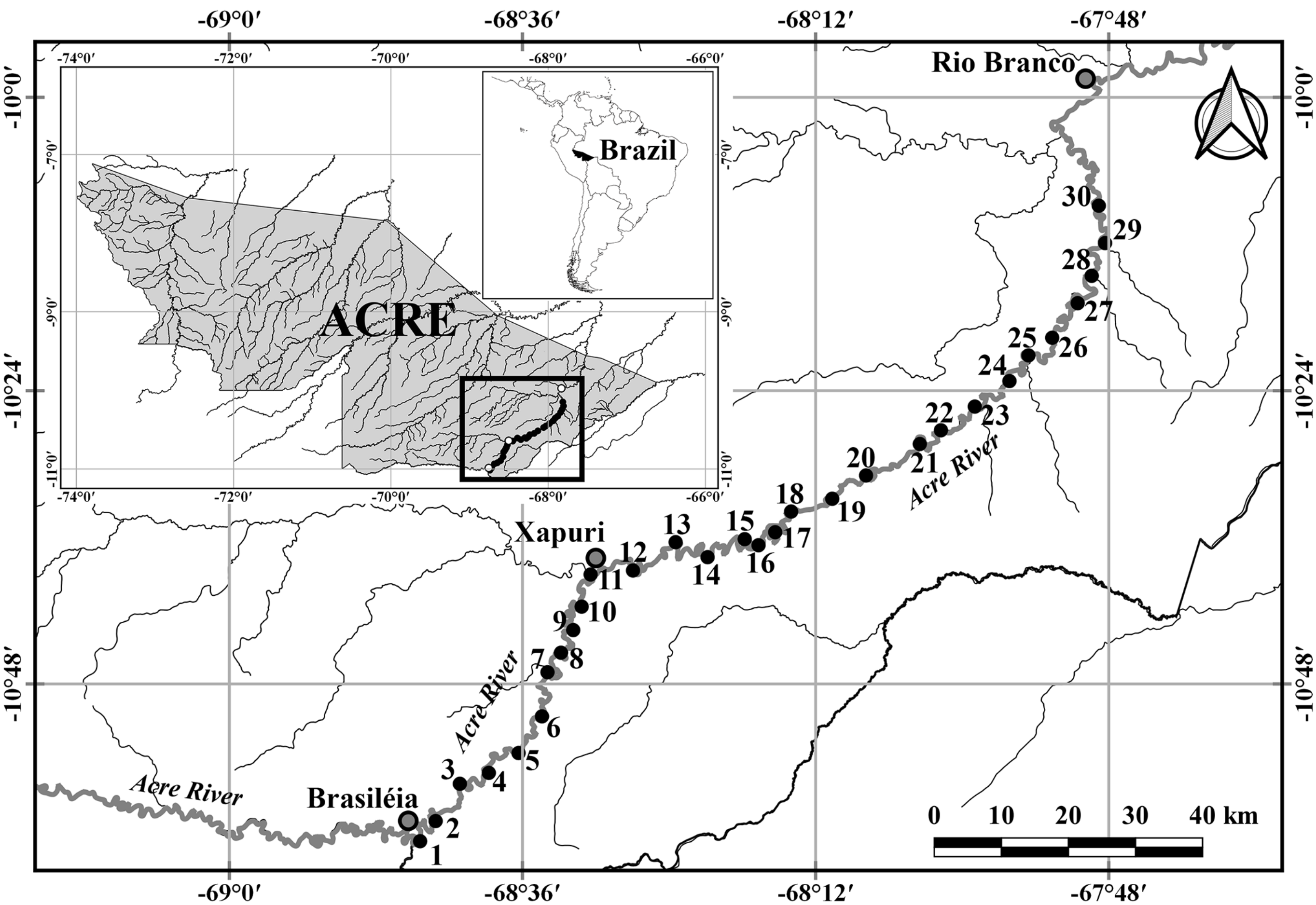

Figure 1. Beaches sampled along a 300 km stretch of the Acre river, between the municipalities of Brasiléia and Rio Branco in the state of Acre, Brazil.

3. Statistical analysis

The exploratory analyzes of the data considered all the species recorded during the study period. To estimate species richness, however, only the species caught in the trawls were included, given that this collection method was standardized at all sampling sites. Species richness was estimated using a sampled-based accumulation curve, with 999 permutations of the abundance matrix, with the rows corresponding to the sites and the columns to the species. We used the Jackknife 1 estimator to obtain the expected richness. This analysis was run in EstimateS® (Colwell & Elsensohn 2014).

Results

We collected a total of 15,329 individuals representing 80 species, 26 families, and nine orders (Table 1). The order Siluriformes had the highest species richness (37 species), followed by the Characiformes (30 species), and Gymnotiformes (4 species). The Characiformes was the most abundant order (88.58% of the individuals collected), followed by the Siluriformes (10.03%), and the Perciformes (1.08%) (Figure 2A).

The families with the highest species richness and abundance were the Characidae (14 species and 12,931 individuals), followed by the Loricariidae (12 species and 950 individuals), and the Pimelodidae, with 10 species and 364 individuals (Figure 2B). The most abundant species were *Knodus orteguasae* (Fowler, 1943), with 76.25% of the individuals, followed by *Aphanotorulus unicolor* (Steindachner, 1908), with 4.68%, *Creagrutus barrigai* Vari & Harold, 2001 (4.59%), *Engraulisoma taeniatum* Castro, 1981 (2.35%), and *Clupeacharax anchoveoides* Pearson, 1924, with 2.13% of the individuals (Figure 2C). The other 75 species represented 10% of the total, and 30 were considered rare, being represented by only a single individual. The beach with the most diverse fish fauna was S08 (25 species), followed by S21 (22 species), and S18 and S24, each with 20 species. The sites with the greatest abundance of fish were S19 (1391 individuals), S27 (1151), S11 (1079), and S18, with 1,069 individuals being collected (Figure 3). We obtained 60 fish species in the trawls and 20 by alternative methods (third parties).

The observed species richness (60 species) represented 77.92% of the richness estimated by Jackknife 1 (77±5 species). The accumulation curve presented a tendency to stabilize, but did not reach an asymptote, indicating that even more species would be recorded with increasing sampling effort (Figure 4). The fish species recorded in the present study are shown in Figures 5–9.

Discussion

The fish species richness recorded in the present study, in the sandy beach habitats of the Acre river is greater than that found in other aquatic environments within the same basin, such as lakes (53 species; da Silva et al. 2013) and streams (34 species; Ramalho et al. 2014), although

Table 1. Fish species recorded in sandy beach environments of the Acre river in the present study, indicating the capture period (CP; D = day; N = night; D/N = day and night), the mean total length (TL) of the specimens collected, the abundance (AB) of individuals, and the catalog numbers (CN) of the voucher specimens deposited in the UFAC fish collection in Rio Branco, Brazil. Species with no data on the capture period were donated by third parties. *Species classified as Critically Endangered in the Brazilian Red Book of Endangered Fauna. The orders and families are classified according to Fricke et al. (2020).

TAXA	SP	TL (mm)	AB	CN
MYLIOBATIFORMES				
Potamotrygonidae				
Paratrygon aiereba (Müller & Henle, 1841)*	–	445±55.1	3	MUFAC–IC1146
Potamotrygon cf. *orbignyi*	–	679.5±85.56	2	MUFAC–IC1147
CLUPEIFORMES				
Pristigasteridae				
Pellona castelnaeana (Valenciennes,1847)	–	–	–	MUFAC–IC1220
CHARACIFORMES				
Crenuchidae				
Characidium cf. *steindachneri*	D	43.6±3.6	17	MUFAC–IC1177
Curimatidae				
Psectrogaster amazonica Eigenmann & Eigenmann, 1889	–	128±10.9	9	MUFAC–IC1166
Psectrogaster rutiloides (Kner, 1858)	N	131	1	MUFAC–IC1167
Steindachnerina guentheri (Eigenmann & Eigenmann, 1889)	D	90±6.6	4	MUFAC–IC1168
Steindachnerina leucisca (Günther, 1868)	N	140	1	MUFAC–IC1169
Steindachnerina pupula Vari, 1991	D/N	101.4±17.3	41	MUFAC–IC1170
Prochilodontidae				
Prochilodus nigricans Spix & Agassiz, 1829	N	211	1	MUFAC–IC1176
Anostomidae				
Abramites hypselonotus (Günther, 1868)	D	178±123	2	MUFAC–IC1148
Serrasalmidae				
Serrasalmus maculatus Kner, 1858	–	138	1	MUFAC–IC1171
Mylossoma duriventre (Cuvier, 1818)	–	159	1	MUFAC–IC1172
Cynodontidae				
Rhaphiodon vulpinus Spix & Agassiz, 1829	–	282	1	MUFAC–IC1173
Gasteropelecidae				
Thoracocharax stellatus (Kner, 1858)	D/N	53.8±8.6	195	MUFAC–IC1175
Characidae				
Aphyocharax pusillus (Günther, 1868)	D/N	56.42±2.13	8	MUFAC–IC1149
Astyanax abramis (Jenyns, 1842)	D	75	1	MUFAC–IC1150
Astyanax bimaculatus (Linnaeus, 1758)	D/N	134.5±42.8	6	MUFAC–IC1151
Creagrutus barrigai Vari & Harold, 2001	D/N	31.3±7.4	703	MUFAC–IC1153
Ctenobrycon spilurus (Valenciennes, 1850)	D/N	61.8±8.3	8	MUFAC–IC1154
Galeocharax gulo (Cope, 1870)	D/N	73.8±39.4	28	MUFAC–IC1156
Knodus orteguasae (Fowler, 1943)	D/N	32±10.9	11690	MUFAC–IC1157
Leptagoniates steindachneri Boulenger, 1887	D/N	58.2±5	13	MUFAC–IC1158
Moenkausia sp. “lepidura alta”	D/N	57.7±5.3	38	MUFAC–IC1159
Odontostilbe fugitiva Cope, 1870	D/N	34.5±2.7	63	MUFAC–IC1160

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Paragoniates alburnus Steindachner, 1876	D/N	58.6±7.3	17	MUFAC–IC1161
Prionobrama filigera (Cope, 1870)	D/N	49.5±9	24	MUFAC–IC1162
Protocheirodon pi (Vari, 1978)	D/N	40.3±4.9	4	MUFAC–IC1163
Tetragonopterus argenteus Cuvier, 1816	D	84.5±2.1	2	MUFAC–IC1164
Triportheidae				
Clupeacharax anchoveoides Pearson, 1924	D/N	36.3±15.5	327	MUFAC–IC1152
Engraulisoma taeniatum Castro, 1981	D/N	28.3±4.4	360	MUFAC–IC1155
Triportheus albus Cope, 1872	D/N	132.9±11.9	13	MUFAC–IC1165
Bryconidae				
Salminus sp.	D	200	1	MUFAC–IC1174
GYMNOTIFORMES				
Rhamphichthyidae				
Gymnorhamphichthys hypostomus Ellis, 1912	N	255.5±23.3	2	MUFAC–IC1212
Sternopygidae				
Eigenmannia virescens (Valenciennes, 1836)	D/N	141.9±38.7	18	MUFAC–IC1213
Apteronotidae				
Sternarchogiton nattereri (Steindachner, 1868)	N	162	1	MUFAC–IC1210
Sternarchorhynchus chaoi de Santana & Vari, 2010	D/N	210±35.4	2	MUFAC–IC1211
SILURIFORMES				
Aspredinidae				
Amaralia hypsiura (Kner, 1855)	D	75	1	MUFAC–IC1178
Micromyzon cf. *akamai*	N	18	1	MUFAC–IC1219
Trichomycteridae				
Henonemus punctatus (Boulenger, 1887)	D/N	87.4±18	23	MUFAC–IC1207
Pseudostegophilus nemurus (Günther, 1869)	D/N	99.7±29.6	24	MUFAC–IC1208
Vandellia cirrhosa Valenciennes, 1846	D/N	62±8.5	27	MUFAC–IC1209
Loricariidae				
Ancistrus sp.	D	77	1	MUFAC–IC1188
Aphanotorulus unicolor (Steindachner, 1908)	D/N	39.61±26.5	717	MUFAC–IC1189
Farlowella nattereri Steindachner, 1910	D	95±5.7	3	MUFAC–IC1191
Hypostomus cf. *pyrineusi*	D	122±42.4	2	MUFAC–IC1192
Lamontichthys filamentosus (La Monte, 1935)	D	300.5±45.9	2	MUFAC–IC1193
Limatulichthys griseus (Eigenmann, 1909)	D/N	207.5±15.4	6	MUFAC–IC1194
***Loricaria* sp.**	–	233.9±154.2	11	MUFAC–IC1195
Panaqolus purusiensis (La Monte, 1935)	–	124	1	MUFAC–IC1196
Peckoltia brevis (La Monte, 1935)	–	111.7	1	MUFAC–IC1197
Rhadinoloricaria bahuaja (Chang & Castro, 1999)	D/N	103.9±107.7	202	MUFAC–IC1190
Spatuloricaria cf. *puganensis*	–	361	1	MUFAC–IC1198
Sturisoma lyra (Regan, 1904)	D	284	1	MUFAC–IC1199
Heptapteridae				
Imparfinis guttatus (Pearson, 1924)	D	95	1	MUFAC–IC1186
Pimelodella howesi Fowler, 1940	D/N	79.6±29.2	131	MUFAC–IC1187

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Doradidae				
Leptodoras acipenserinus (Günther, 1868)	–	260	1	MUFAC–IC1183
Nemadoras sp.	–	150	1	MUFAC–IC1184
Oxydoras niger (Valenciennes, 1821)	–	625	1	MUFAC–IC1185
Pterodoras granulosus (Valenciennes, 1821)	–	–	–	MUFAC–IC1225
Auchenipteridae				
Auchenipterus nuchalis (Spix & Agassiz, 1829)	N	185	1	MUFAC–IC1179
Centromochlus heckelii (De Filippi, 1853)	N	101.7±24.5	7	MUFAC–IC1180
Centromochlus perugiae Steindachner, 1882	N	28.3±3.5	3	MUFAC–IC1181
Tympanopleura piperata Eigenmann, 1912	N	103	1	MUFAC–IC1182
Pimelodidae				
Calophysus macropterus (Lichtenstein, 1819)	–	–	–	MUFAC–IC1221
Cheirocerus eques Eigenmann, 1917	D/N	78.8±56.1	144	MUFAC–IC1200
Exallodontus aguanai Lundberg, Mago-Leccia & Nass, 1991	–	–	–	MUFAC–IC1222
Leiarius marmoratus (Gill, 1870)	–	–	–	MUFAC–IC1223
Megalonema amaxanthum Lundberg & Dahdul, 2008	D/N	55±35.4	204	MUFAC–IC1201
Megalonema platycephalum Eigenmann, 1912	D/N	81.6±59.8	5	MUFAC–IC1202
Pimelodus blochii Valenciennes, 1840	N	209	1	MUFAC–IC1203
Pimelodus cf. *maculatus*	N	148.5±36.9	5	MUFAC–IC1204
Platysilurus mucosus (Vaillant, 1880)	–	148	1	MUFAC–IC1205
Sorubim lima (Bloch & Schneider, 1801)	N	290	1	MUFAC–IC1206
PLEURONECTIFORMES				
Achiridae				
Apionichthys finis (Eigenmann, 1912)	D/N	86.5±2.1	2	MUFAC–IC1215
CICHLIFORMES				
Cichlidae				
Bujurquina syspilus (Cope, 1872)	D	30.5±13.7	4	MUFAC–IC1217
Crenicichla sp. "Juvenil"	D/N	28±4.5	6	MUFAC–IC1218
BELONIFORMES				
Belonidae				
Pseudotylosurus angusticeps (Günther, 1866)	D/N	148.2±19.8	5	MUFAC–IC1214
PERCIFORMES				
Sciaenidae				
Pachypops pigmaeus Casatti, 2002	D/N	36.3±16.9	165	MUFAC–IC1216
Plagioscion squamosissimus (Heckel,1840)	–	–	–	MUFAC–IC1224

Claro-García et al. (2013) recorded 94 species in the streams of the Acre basin. However, this species richness was lower than that found at many other sites in the western Amazon basin, including the Purus river, with 112 species being recorded in beach environments (Stewart et al. 2002, Duarte et al. 2010) and 86 species in streams (dos Anjos et al. 2008), 248 species in beach environments of the Negro river (Goulding 1997), 119 species at beaches of the Madeira river (Py-Daniel et al. 2007) and 90 species on the upper Juruá river (Silvano et al. 2001). The relatively low species richness recorded in the present study may be at least partially accounted for by the relatively short period of the study and the use of only one collection method, which is selective of species of reduced swimming capacity (small characids). The use of several alternative collection methods can be essential to guarantee a representative sample of local fish diversity, through the capture of species with distinct swimming capacities found in different environments (Stewart et al. 2002, Duarte et al. 2010). Similarly, a greater sampling effort over a longer period of time may have provided a more reliable sample of local fish diversity, as indicated by the specimens obtained from third parties, which added 20 species to the inventory, almost half the number obtained by trawling. It is important to consider that the variation in

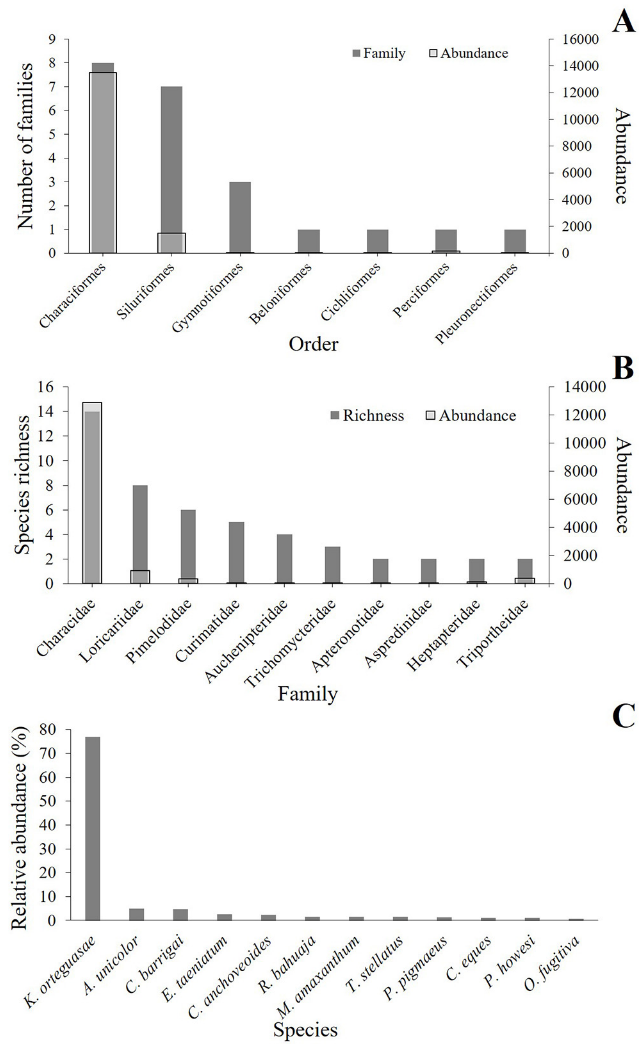

Figure 2. A) The number of families and the abundance of the principal fish orders collected from sandy beaches on the Acre river in the state of Acre, Brazil. B) Species richness and abundance of the different fish families collected from the study area. C) Abundance of the predominant fish species collected from the sandy beaches of the study area.

richness between studies may be due to differences in collection effort and sampling time.

We recorded a predominance of characiform and siluriform species, which is typical of the Neotropical freshwater ichthyofauna (Lowe-McConnell 1999, Reis et al. 2016, Dagosta & de Pinna 2019). As observed in previous studies, the beaches surveyed in the present study were dominated by small characids (Ibarra & Stewart 1989, Jepsen 1997), which reflects their ability to obtain oxygen in the upper layers of the water column, their high trophic plasticity (Abelha et al. 2001), and their ample distribution in the Neotropical region (Jungfer et al. 2013). The considerable abundance of characids, in particular *K. orteguasae* and *C. barrigai*, may be related to their generalist habitat use and high trophic plasticity (Lowe-McConnell 1999, Albert & Reis 2011, Carvalho et al. 2016, Torgler 2016). Trophic plasticity is linked to environmental structure (Abelha 2001), which affects the availability of food, and obliges the species to adapt to different environments, being reflected in the ample feeding spectrum of most teleosts.

Despite a tendency for the stabilization of the species accumulation curve, the regional species pool did not appear to have been sampled as a whole, although the secondary data (specimens donated by third parties) did complement the inventory. Even so, we believe that the true number of species that occur in the beach habitats of the Acre river may be even greater than that recorded here, which reinforces the need for further studies using alternative sampling methods to cover poorly-sampled environments, such as the deepest areas of the river, as well as targeting larger species. The morphology of the fish specimens not identified to the specific level in the present study was incompatible with that of their known congeners, which indicates that these specimens may represent undescribed species. In the past few years, an increasing number of new fish species have been described from all areas of the Amazon basin, and all estimates indicate that many species are yet to be described (Reis et al. 2016, Dagosta & de Pinna 2019, Jézéquel et al. 2020). Even so, the morphological divergences observed in the present study may not necessarily represent new taxa, given that many species are very amply distributed in the Amazon basin, raising the possibility of morphological variation among different populations (Petrolli & Benine 2015; Mateussi et al. 2018).

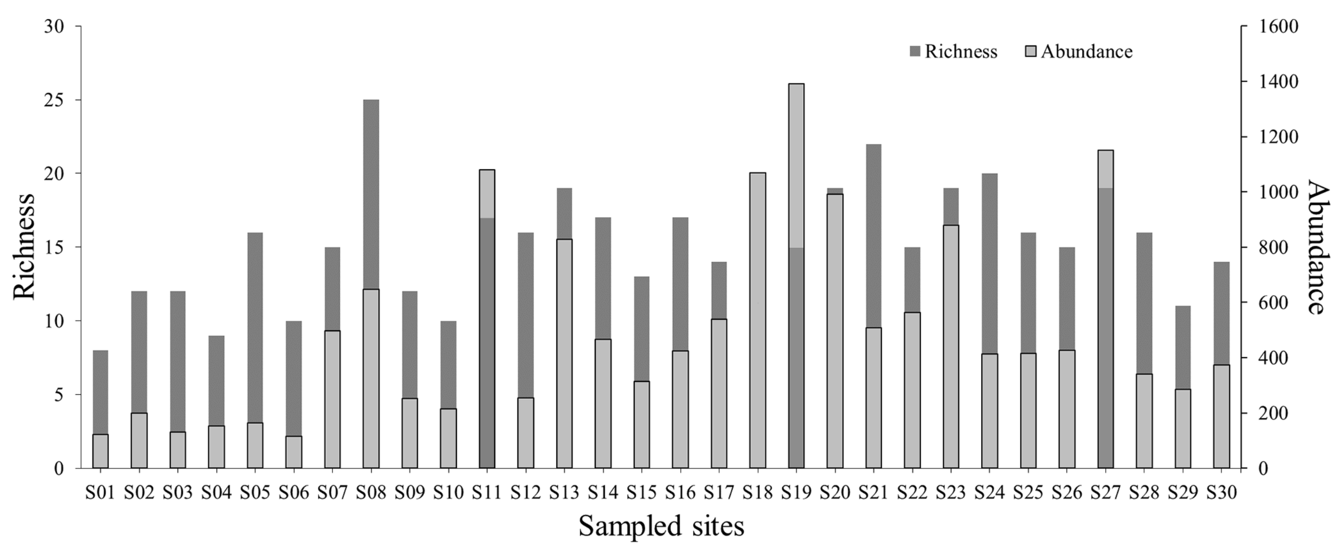

Figure 3. Fish species richness and abundance at the beaches along a 300 km stretch of the Acre river in the state of Acre, Brazil.

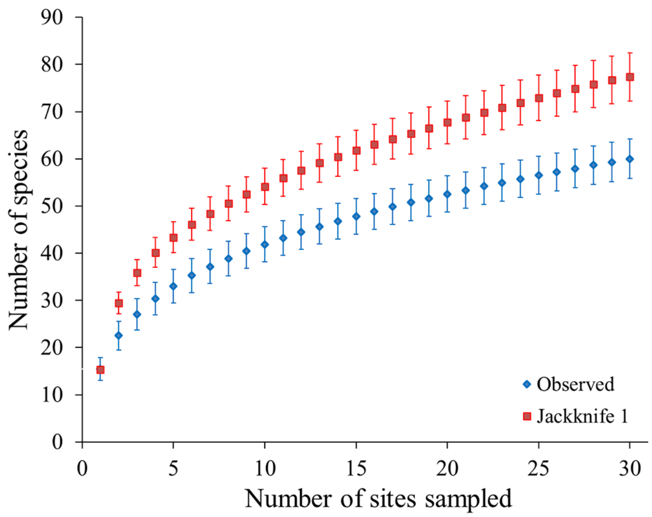

Figure 4. Species accumulation curve of the fish collected from sandy beaches of the Acre river, state of Acre Brazil. The bars represent the confidence interval.

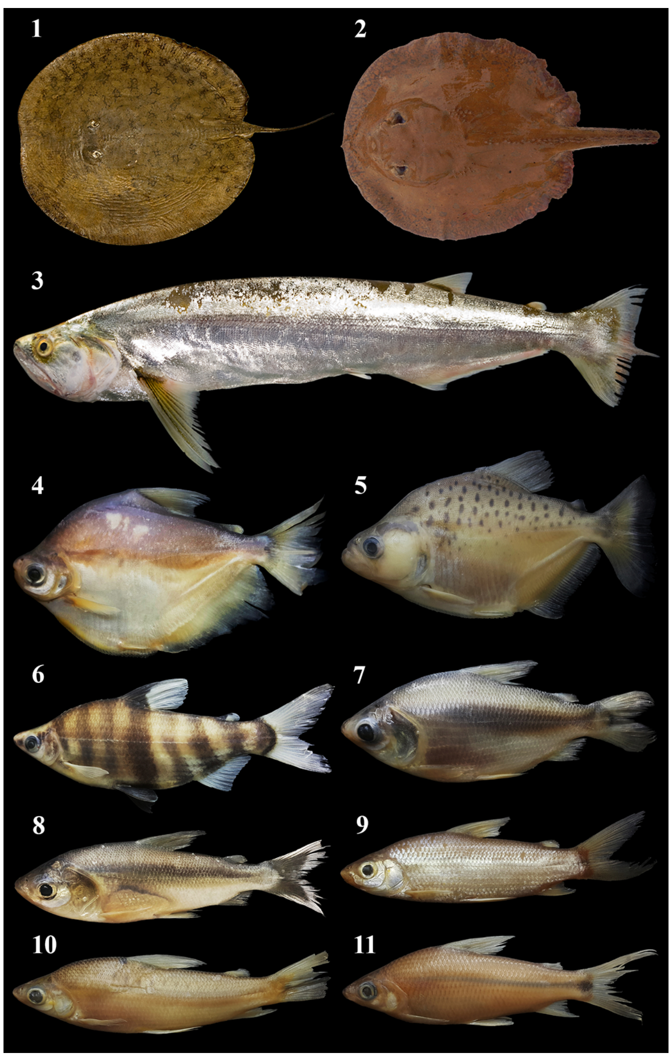

Figure 5. Fish species collected from sandy beaches of the Acre river, Acre, Brazil. **1)** *Paratrygon aiereba*; **2)** *Potamotrygon cf. orbignyi;* **3)** *Rhaphiodon vulpinus*; **4)** *Mylossoma duriventre*; **5)** *Serrasalmus maculatus*; **6)** *Abramites hypselonotus*; **7)** *Psectrogaster amazonica*; **8)** *Psectrogaster rutiloides*; **9)** *Steindachnerina guentheri*; **10)** *Steindachnerina leucisca*; **11)** *Steindachnerina pupula.*

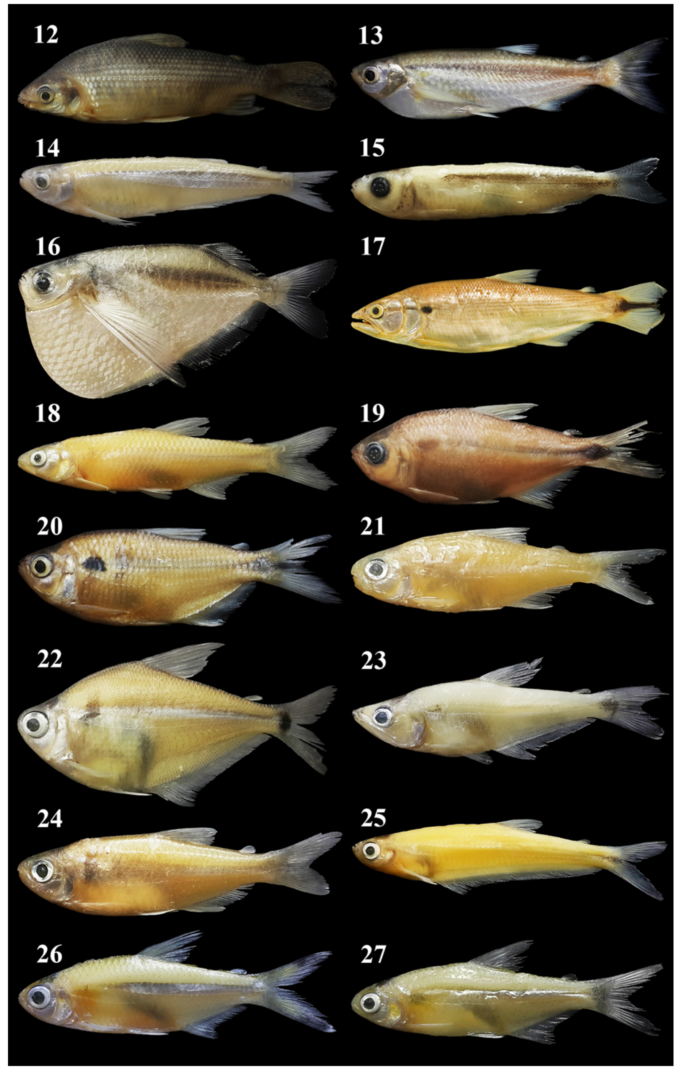

Figure 6. Fish species collected on the beaches of Acre river, Acre, Brazil. **12)** *Prochilodus nigricans*; **13)** *Triportheus albus*; **14)** *Clupeacharax anchoveoides*; **15)** *Engraulisoma taeniatum*; **16)** *Thoracocharax stellatus*; **17)** *Salminus sp.*; **18)** *Aphyocharax pusillus*; **19)** *Astyanax abramis*; **20)** *Astyanax bimaculatus*; **21)** *Creagrutus barrigai*; **22)** *Ctenobrycon spilurus*; **23)** *Galeocharax gulo*; **24)** *Knodus orteguasae*; **25)** *Leptagoniates steindachneri*; **26)** *Moenkausia* sp. "lepidura alta"; **27)** *Odontostilbe fugitive.*

Surveys on the biodiversity of the western Amazon region have enormous potential, not only for the expansion of our knowledge of species distributions, but also the discovery of new species (Corrêa et al. 2018, Silva et al. 2019). In the present study, we collected a specimen of *Micromyzon akamai* Friel & Lundberg, 1996, which is a small fish that buries itself in the substrate to avoid predators (Friel & Lundberg 1996) and is thus collected only very rarely (Ohara & Zuano 2013). This is the first record of *M. akamai* from the state of Acre, and the nearest recorded locality is the main channel of the Madeira river, more than 400 km to the east (Ohara & Zuano 2013). We also recorded *Paratrygon aiereba* (Müller & Henle, 1841), a freshwater stingray not previously known to occur in the Acre basin, with the nearest known localities being on the upper Purus river, approximately 250 km to the northeast (Albert et al. 2012), the Juruá river around 400 km from the Acre river (Silvano et al. 2001), and the Madeira river, approximately 900 km away (Queiroz et al. 2013).

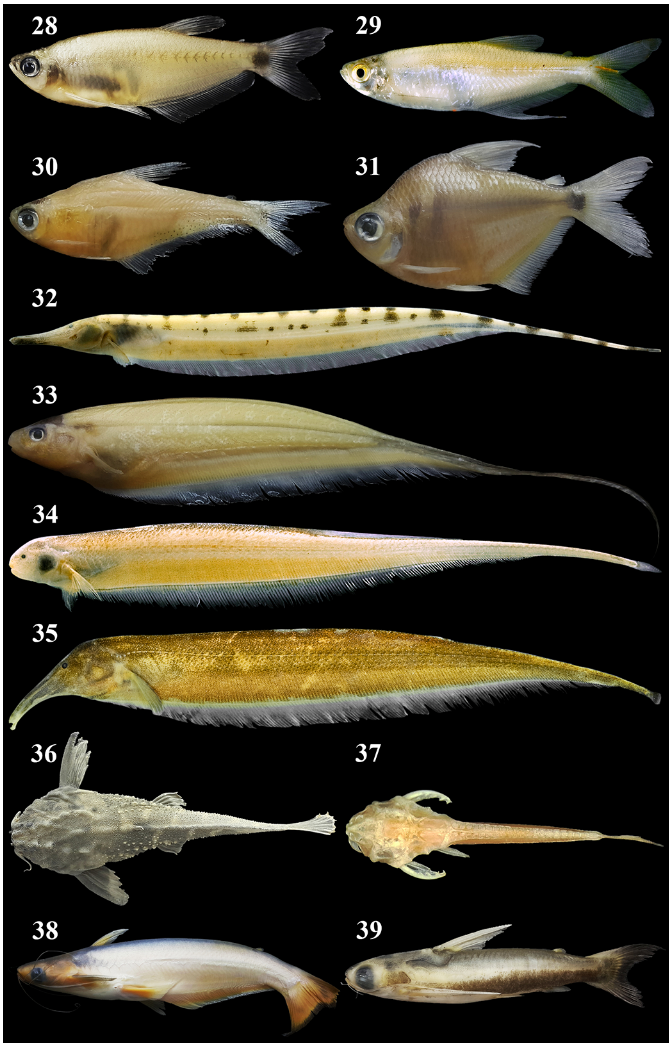

Figure 7. Fish species collected on the beaches of Acre river, Acre, Brazil. **28)** *Paragoniates alburnos*; **29)** *Prionobrama filigera*; **30)** *Protocheirodon pi*; **31)** *Tetragonopterus argenteus*; **32)** *Gymnorhamphichthys hypostomus*; **33)** *Eigenmannia virescens*; **34)** *Sternarchogiton nattereri*; **35)** *Sternarchorhynchus chaoi*; **36)** *Amaralia hypsiura*; **37)** *Micromyzon* cf. *akamai*; **38)** *Auchenipterus nuchalis*; **39)** *Centromochlus heckelii*.

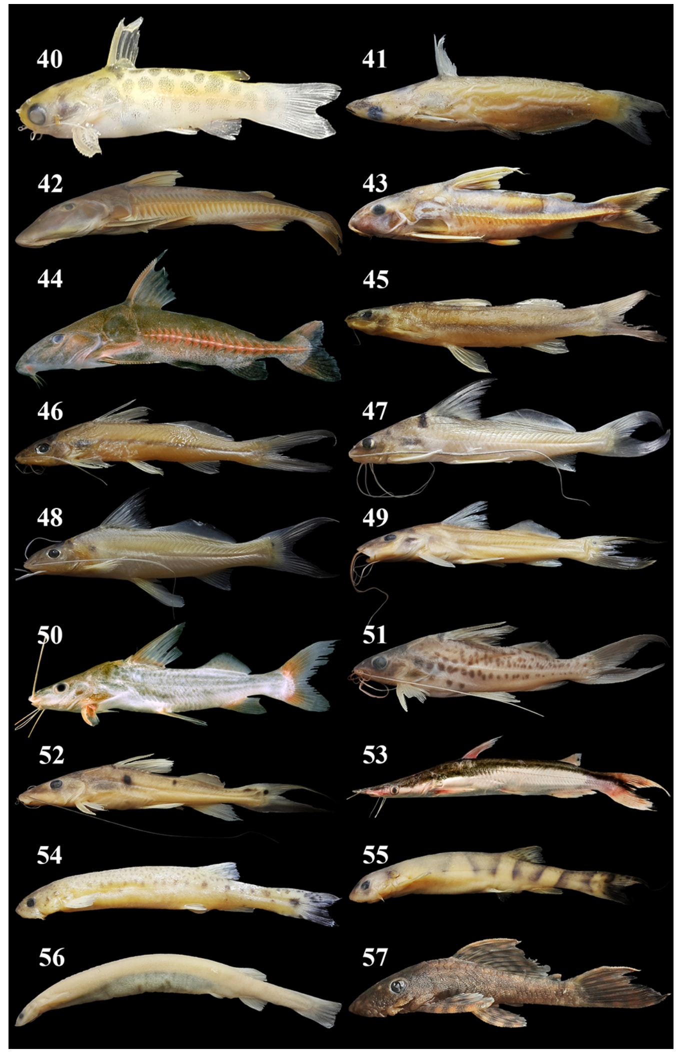

Figure 8. Fish species collected on the beaches of Acre river, Acre, Brazil. **40)** *Centromochlus perugiae*; **41)** *Tympanopleura piperata*; **42)** *Leptodoras acipenserinus*; **43)** *Nemadoras* sp.; **44)** *Oxydoras niger;* **45)** *Imparfinis guttatus*; **46)** *Pimelodella howesi*; **47)** *Cheirocerus eques;* **48)** *Megalonema amaxanthum*; **49)** *Megalonema platycephalum*; **50)** *Pimelodus blochii*; **51)** *Pimelodus* cf. *maculatus*; **52)** *Platysilurus mucosus*; **53)** *Sorubim lima*; **54)** *Henonemus punctatus*; **55)** *Pseudostegophilus nemurus*; **56)** *Vandellia cirrhosa*; **57)** *Ancistrus* sp.

Paratrygon aiereba is currently classified as Critically Threatened in the Red Book of Endangered Brazilian Fauna, and as Data Deficient by the IUCN (Araújo et al. 2018). One of the principal threats to *P. aiereba* is from ornamental fisheries, and while its capture is illegal in Brazil, Colombia and Peru are known to export this species for the ornamental fish trade (Araújo et al. 2018). Demographic studies of *P. aiereba* have shown that its population is declining rapidly and may decrease more than 80% in the near future (Araújo et al. 2018). In addition, Frederico et al. (2012) found genetic variation among populations that may be evidence of a species complex (Carvalho et al. 2003, Rosa et al. 2010). Given this, further research and local conservation initiatives are urgently needed for this species.

Studies of Amazonian fish have found a greater species diversity in beach habitats than in other aquatic systems, such as lakes, streams, and floating vegetation (Goulding 1997, Py-Daniel et al. 2007). This is due to the physical and structural characteristics of beach environments, such as their slower currents, transparency, and depth, which result in an abundance of both small species and the juveniles of larger species. These fish use the shallow waters of the beach habitat to shelter from predators, such as large catfish, as well as to forage (Lowe-McConnell 1999, Duarte et al. 2010, Olds et al. 2018). Given this, increasing the amount of data available on the fish diversity of sandy beaches will be essential not only for future studies of general biodiversity patterns, but also for the development of effective conservation strategies.

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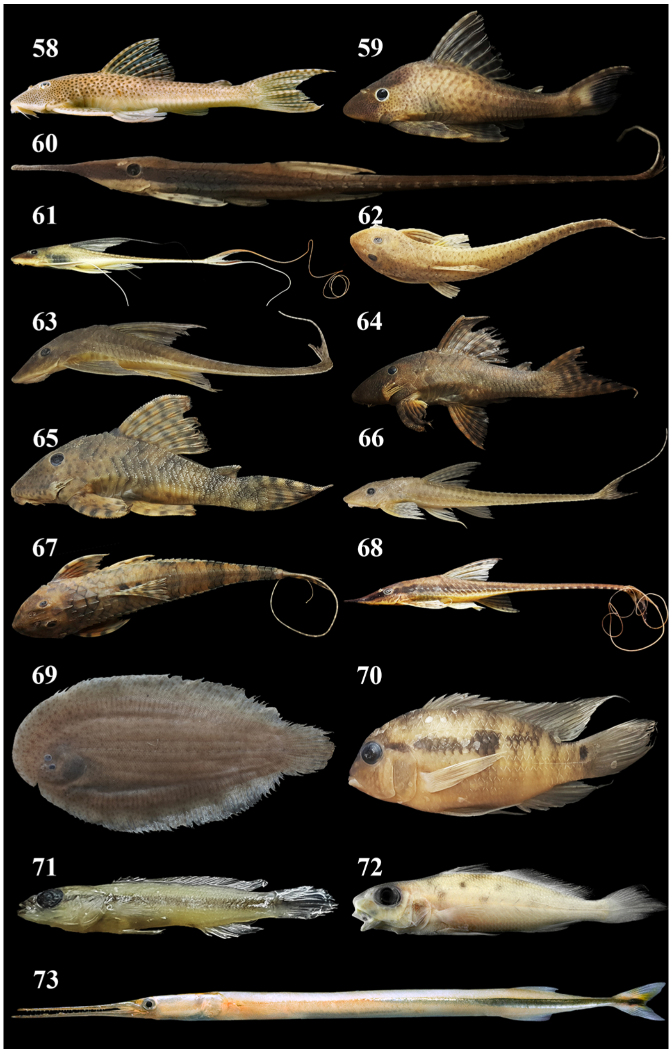

Figure 9. Fish species collected on the beaches of Acre river, Acre, Brazil. **58)** *Aphanotorulus unicolor*; **59)** *Hypostomus* cf. *pyrineusi*; **60)** *Farlowella nattereri*; **61)** *Lamontichthys filamentosus*; **62)** *Limatulichthys griseus*; **63)** *Loricaria* sp.; **64)** *Panaqolus purusiensis*; **65)** *Peckoltia brevis*; **66)** *Rhadinoloricaria bahuaja*; **67)** *Spatuloricaria* cf. *puganensis*; **68)** *Sturisoma lyra*; **69)** *Apionichthys finis*; **70)** *Bujurquina* cf. *syspilus*; **71)** *Crenicichla* sp. "Juvenil"; **72)** *Pachypops pigmaeus*; **73)** *Pseudotylosurus angusticeps.*

Author Contributions

Ronaldo Souza da Silva: Conducted the fieldwork, Identified the specimens in the laboratory, Performed the data analysis and interpreted the results.

Fabiano Corrêa: Ran the data analysis and interpreted the results.

Lucas Pires de Oliveira: Identified the specimens in the laboratory.

Vinicius Guerra: Performed the data analysis and interpreted the results.

Bruno Stefany Barros: Identified the specimens in the laboratory.

Lisandro Juno Soares Vieira: Performed the data analysis and interpreted the results.

Conflicts of interest

The authors declare no competing interests.

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