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Short note

Parasite biodiversity of *Leporinus piau* Fowler, 1941 (Characiformes, Anostomidae) in a lentic ecosystem from the Salgado River basin, Caatinga Domain, Brazil

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ABSTRACT. *Leporinus piau* is a freshwater fish belonging to the family Anostomidae, popularly known as "*piau*" in Brazil. This species has wide distribution in Brazilian northeast basins and presents an economic and sporting fishing importance. The present study aims to inventory the parasitofauna of *L. piau* of a freshwater ecosystem of Caatinga domain (Brazil). A total of 598 parasite specimens were recovered from nine parasitized hosts, belonging to four taxonomic groups: one Myxozoa (*Henneguya* sp.); four Monogenea (Dactylogyridae gen. sp., *Jainus* sp., *Urocleidoides* sp. 1 and *Urocleidoides* sp. 2); one Nematoda – *Procamallanus* (*Spirocamallanus*) *inopinatus* and two Copepoda (*Ergasilus* sp. and *Gamispatulus schizodontis*). Previous studies reported five parasitic associations in *L. piau*: two nematodes – *P.* (*S.*) *inopinatus* and *Procamallanus* (*Spirocamallanus*) *saofrancicencis*, and three crustaceans (*Argulus* sp., *Brasergasilus* sp. and *Ergasilus* sp.). For the first time, this study records myxozoan and monogeneans parasitizing the host *L. piau*. The present study stands out the importance of the knowledge of the parasite biodiversity of freshwater fish in neotropics, reporting new occurrences and parasitic association for ichthyofauna of the Caatinga domain.

Keywords: biodiversity, freshwater fish, Myxozoa, Monogenea, Nematoda, Copepoda

Introduction

In South America, Brazil is known for the extensive network of hydrographic basins [1] and consequently the greatest diversity of freshwater fish [2,3]. This diversity is a consequence of extensive and varied hydrographic systems with considerable ichthyofaunistic differentiation between them [4]. The Northeast region of Brazil has from small to large dams with socioeconomic development purposes [5].

The Neotropical region has the richest and most diverse freshwater fish fauna in the world, with around 8,000 species [6–8]. In Brazil, more than 2,500 species of fish occur in its aquatic ecosystems [9], this diversity is also highlighted by high levels of endemism in several ecosystems. Unfortunately, these areas have demonstrated knowledge gaps about this diversity, causing concerns regarding the conservation status of such species [10].

Leporinus Agassiz, 1829 is the richest genus in number of species in the family Anostomidae, possessing approximately 90 valid species [11], reaching its greatest diversity in the Amazon, Orinoco and Guianas rivers, where there are records of more than 60 valid species described [12]. The species *Leporinus piau* Fowler, 1941, popularly known as "*piau*" in Brazil, is a medium-sized, high-bodied fish with three horizontally elongated spots on the sides and lateral bands with spots erased across its body [13]. This fish species has an omnivorous feeding habit with high plasticity [14], consuming a wide variety of available resources and abundant in the environment [15,16].

Among vertebrates, fish have long lived in close association with various groups of invertebrates, and therefore, they have the largest amount and variety of parasites than any other vertebrates [17]. In any fish species, one or more parasites species can be found, and almost all site of infection or

infestation [18]. Ichthyoparasitology is a science that studies parasitism in fish, such as: host-parasite interaction, parasite biogeographic, taxonomy, systematics, and their economic impact in aquaculture [18,19]. In last decades, it still represents a growing scientific area mainly due to the increase in fish farming [17,20]. In this context, the present study aimed to inventory the parasitic fauna of *L. piau* of a freshwater ecosystem of Caatinga domain (Brazil).

Materials and Methods

The present study was carried out at the Cumbe weir, in the municipality of Barro, southeastern of Ceará state (Brazil) (7°11'14"S; 38°47'06"W) (Fig. 1) [21]. A total of 11 specimens of *L. piau* were collected using fishing rod from February 2019 to August 2021, with a standard length ranging from 10.3 to 19.07 cm. The fish were stored individually in plastic bags to avoid cross-contamination and frozen afterward. Each host was measured in terms of standard length (Ls, to the nearest 0.1 mm) and weight (to the nearest 0.1 g).

The fish collection was authorized under a Permanent License for the Collection of Zoological Material (SISBIO #61328-1). All animal procedures were performed in full compliance with the Ethics Committee for Animal Experimentation (CEUA/ protocols #00165/2018.1) of the Universidade Regional do Cariri (URCA), Ceará state (Brazil). Taxonomic identification of the host followed Britski et al. [13]. The parasitological procedures and host necropsy process followed methodology proposed by Eiras et al. [22]. The parasite identification followed Thatcher [17], Moravec [23] and Cohen et al. [24]. The ecological descriptors (prevalence, mean intensity and mean abundance) of each parasite component community were performed according to Bush et al. [25].

Results and Discussion

Among of the analyzed fish, 81.8% (n=9) were parasitized by at least one species. Eight parasite taxa were found, totaling 598 specimens, and belong to the following taxonomic groups: Myxozoa (*Henneguya* sp.), Monogenea (Dactylogyridae gen. sp., *Jainus* sp., *Urocleidoides* sp. 1 and *Urocleidoides* sp. 2), Nematoda (*Procamallanus* (*Spirocamallanus*) *inopinatus* Travassos, Artigas and Pereira, 1929) and Copepoda (*Ergasilus* sp. and *Gamispatulus schizodontis* Thatcher and Boeger, 1984) (Tab. 1).

Table 1. Parasite community of *Leporinus piau* Fowler, 1941 collected in the Cumbe weir, municipality of Barro, Ceará state (Brazil).

Parasites	TA	MA	MI	P (%)	NI	SI
Myxozoa						
Henneguya sp.	17	1.56	4.25	36.36	4	Gills
Monogenea						
Dactylogyridae gen. sp.	7	0.63	2.33	27.27	3	Gills
Jainus sp.	33	3	6.6	45.45	5	Gills
Urocleidoides sp. 1	9	0.81	1.8	45.45	5	Gills
Urocleidoides sp. 2	39	3.54	6.5	54.54	6	Gills
Nematoda						
Procamallanus (*S.*) *inopinatus*	5	0.45	1.67	27.27	3	Stomach
Copepoda						
Ergasilus sp.	6	0.54	6	9.09	1	Gills
Gamispatulus schizodontis	482	43.82	96.4	45.45	5	Nostrils

Explanations: total abundance (TA), mean abundance (MA), mean intensity (MI), prevalence (P (%)), number of infected fish, (NI), and site of infection/infestation (SI)

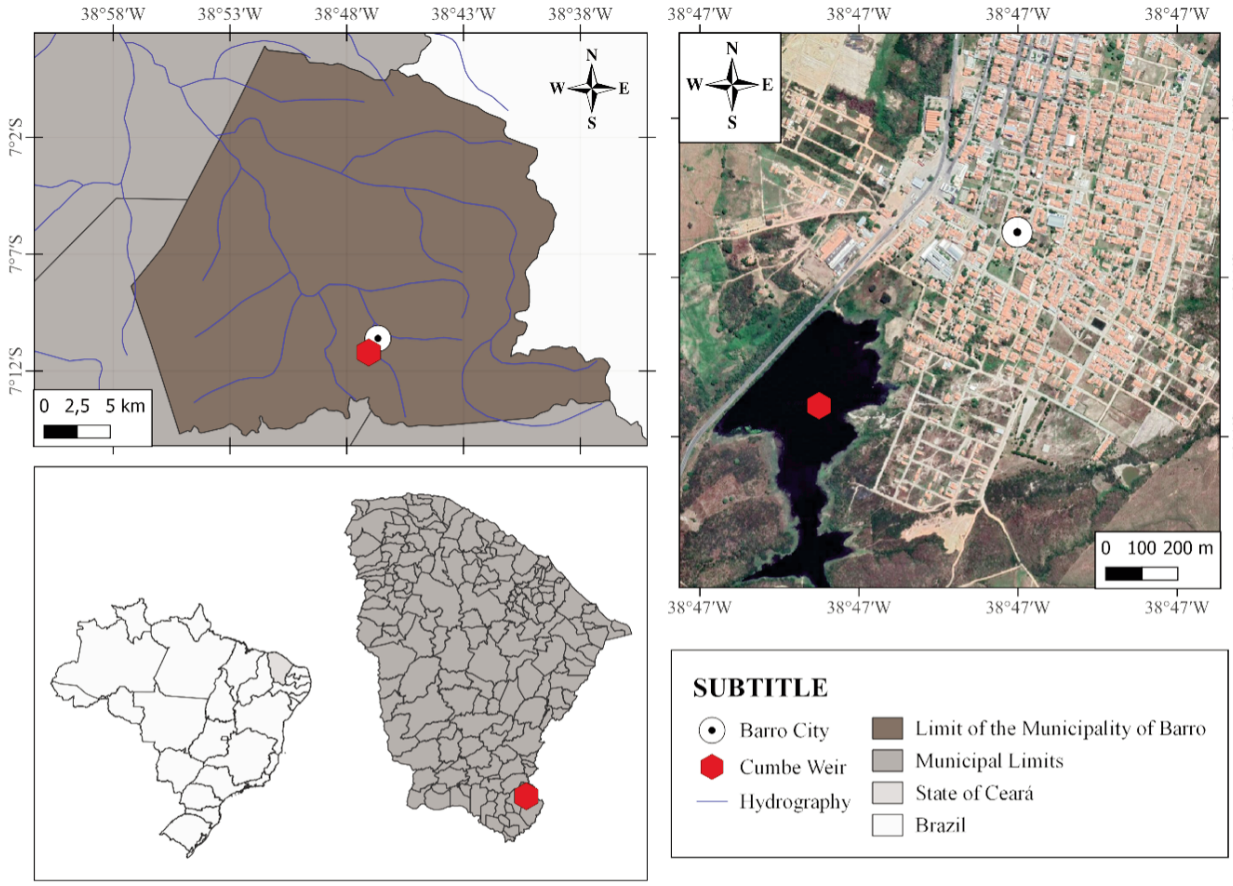

Figure 1. Sampling area in the Cumbe weir, in the municipality of Barro, southeastern of Ceará state, Brazil

To date, no myxosporid or monogenean have been recorded in *L. piau*, and this is the first record of species of these groups parasitizing this host, thus extending the geographic and host distribution of these two groups.

The genus *Henneguya* Thélohan, 1892 is one of the most frequent myxosporids found in fish, with records of approximately 43 infected host species in South America [22,26,27]. In Brazil, nine species have been described parasitizing fish of the anostomid fish: *Henneguya azevedoi* Barassa, Adriano, Cordeiro, Arana and Ceccarelli, 2012 in *Megaleporinus obtusidens* (Valenciennes, 1837) (=*Leporinus obtusidens*)) [28]; *Henneguya caudicula* Eiras, Takemoto and Pavanelli, 2008 in *Leporinus lacustris* Amaral Campos, 1945 [29]; *Henneguya friderici* Casal, Matos and Azevedo, 2003 in *Leporinus friderici* (Bloch, 1794) [30–32]; *Henneguya leporini* Nemeczek, 1926 in *Hypomasticus mormyrops* (Steindachner, 1875) (=*Leporinus mormyrops*)) [33]; *Henneguya leporinicola* Martins, Souza, Moraes and Moraes, 1999 in *Megaleporinus macrocephalus* (Garavello and Britski, 1988) (=*Leporinus macrocephalus*)) [34,35]; *Henneguya piaractus* Martins and Souza, 1997 in *M. macrocephalus* [19]; *Henneguya schizodon* Eiras, Malta, Varela and Pavanelli, 2004 in *Schizodon fasciatus* Spix and Agassiz, 1829 [36]; *Henneguya travassosi* Guimarães and Bergamin, 1933 in *Hypomasticus copelandii* (Steindachner, 1875) (= *Leporinus copelandii*)) [19] and *Henneguya visibilis* Moreira, Adriano, Silva, Ceccarelli and Maia, 2014 in *M. obtusidens* [37]. Specimens of *Henneguya* sp. have also been recorded in *L. friderici*, *M. obtusidens* and *Schizodon borellii* (Boulenger, 1900) [19].

The richness of monogeneans per host species is very variable, with hosts recorded as having more than 30 species of monogeneans, while others have records of only a single species [38]. In the present study, the group of monogeneans had the largest number of species, with the species *Urocleidoides* sp. 2 having the highest prevalence, occurring in 6 hosts.

The genus *Urocleidoides* Mizelle and Price, 1964 is commonly found in Brazilian freshwater fish [39]. Nine species of *Urocleidoides* have been described parasitizing fish of the anostomid fish:

Urocleidoides digitabulum Zago, Yamada, Yamada, Franceschini, Bongiovani and Silva, 2020 in *L. friderici* (Bloch, 1794), *Leporinus octofasciatus* Steindachner, 1915 and *Megaleporinus elongatus* (Valenciennes, 1850) (=*Leporinus elongatus*) [40]; *Urocleidoides eremitus* Kritsky, Thatcher and Boeger, 1986 in *M. macrocephalus* [41–43]; *Urocleidoides falxus* Zago, Yamada, Yamada, Franceschini, Bongiovani and Silva, 2020 in *M. elongatus* [40]; *Urocleidoides jariensis* Oliveira, Santos-Neto, Tavares-Dias and Domingues, 2020 in *S. fasciatus* [44]; *Urocleidoides paradoxus* Kritsky, Thatcher and Boeger, 1986 in *L. friderici*, *L. lacustris*, *M. elongatus*, *M. macrocephalus*, *M. obtusidens*, *Rhytiodus microlepis* Kner, 1858 and *S. fasciatus* [31,39,41,42–48]; *Urocleidoides ramentacuminatus* Oliveira, Santos-Neto, Tavares-Dias and Domingues, 2020 in *Laemolyta proxima* Garman, 1890 and *S. fasciatus* [44]; *Urocleidoides sapucaiensis* Zago, Yamada, Yamada, Franceschini, Bongiovani and Silva, 2020 in *M. elongatus*; *Urocleidoides sinus* Zago, Yamada, Yamada, Franceschini, Bongiovani and Silva, 2020 in *Leporinus striatus* Kner, 1858, *Schizodon intermedius* Garavello and Britski and *Schizodon nasutus* Kner, 1858, and *Urocleidoides solarivaginatus* Zago, Yamada, Yamada, Franceschini, Bongiovani and Silva, 2020 in *L. friderici*, *L. octofasciatus* and *L. striatus* [40]. Besides there are records of *Urocleidoides* sp. in *L. friderici*, *L. lacustris*, *M. elongatus*, *M. obtusidens* and *S. borellii* [31,48,45,46,49].

The monogeneans of the genus *Jainus* Mizelle, Kritzky and Crane, 1968 are commonly found in fish of the order Characiformes [19]. In Brazil, two species of *Jainus* have been described parasitizing fish of the anostomid fish: *Jainus leporini* Abdallah, Azevedo and Luque, 2012 in *H. copelandii*, *L. friderici*, and *M. macrocephalus* [41–43,50] and *Jainus piava* Karling, Bellay, Takemoto and Pavanelli, 2011 in *L. friderici*, *M. obtusidens* and *S. borellii* [48,49,51]. Besides there are records of *Jainus* sp. in *Leporellus vittatus* (Valenciennes, 1850), *L. friderici*, *L. lacustris*, *M. elongatus*, *M. obtusidens* and *S. borellii* [31,45,46,49].

Leporinus piau has few studies on its parasitic fauna, with only five species of parasites described: two species of nematoda – *P.*(*S.*) *inopinatus* and *Procamallanus* (*Spirocamallanus*) *saofrancicencis* (Moreira, Oliveira and Costa, 1964) and three species of crustaceans (*Argulus* sp., *Brasergasilus* sp. and *Ergasilus* sp.) [52,53].

Nematodes of the genus *Procamallanus* Baylis, 1923 have been recorded in several freshwater fish species [52,54]. Its main characteristic is the presence of a very peculiar mouth capsule, with orange or brown coloring, with a smooth internal surface or with spiral thickening [23]. It is considered of the subgenus *Spirocamallanus* Moravec and Thatcher, 1997 when the specimen shows spiral thickening on its mouth capsule [19,23].

Procamallanus (*S.*) *inopinatus* is usually found parasitizing the intestine of fish, but it has also been recorded in the stomach and pyloric caecum. This nematode has been recorded in fish of several orders in South America [23,52,55,56]. This parasite has been recorded parasitizing 16 species of the anostomid: *H. copelandii*, *L. vittatus*, *Leporinus fasciatus* (Bloch, 1794), *L. friderici*, *L. lacustris*, *L. octofasciatus*, *L. piau*, *Leporinus reinhardti* (Lütken, 1875), *L. striatus*, *Leporinus taeniatus* (Lütken, 1875), *M. elongatus*, *M. macrocephalus*, *M. obtusidens*, *S. borelli*, *Schizodon knerii* (Steindachner, 1875) and *S. nasutus* [31,41–46,52,57–59]. In the present study, *P.* (*S.*) *inopinatus* was the species that showed the lowest abundance and intensity of infection. According to Pavanelli et al. [19] fish may have a low nematodes burden, but these authors pointed out that environmental changes or inappropriate environmental conditions may promotes a high level of prevalence of these parasites.

The copepods and monogeneans have a similar life cycle, being associated with only one host during their cycle [60], however, monogeneans are usually specific to a single species or to species of the same genus [38,61]. The occurrence of parasites in the gills of fishes may be influence by the heterogeneity of site of infestation, Falkenberg et al. [62] showed that the organization in microhabitats by monogeneans and copepods may associated to the heterogeneous water flow in the gills and size of the arches. Probably, in the present study, the differences in the monogeneans and copepods abundance are related to these abiotic factors. Dogiel [63] postulated that for copepod infestation to occur it is only necessary that they are present in the environment and approach the host.

Ergasilus Nordmann, 1832 is the most representative genus within the family Ergasilidae, containing approximately two-thirds of the species [62–64]. One of the most important characteristics for the identification of ergasilids is that their

antennae have three segments with a strong claw at the distal extremity [65]. In Brazil, four species of *Ergasilus* have been described parasitizing anostomid fish: *Ergasilus bryconis* Thatcher, 1981 in *L. lacustris*, *M. elongatus* and *M. obtusidens* [45,46]; *Ergasilus leporinidis* Thatcher, 1981 in *L. fasciatus* and *R. microlepis* [47,66]; *Ergasilus triangularis* Malta, 1996 in *Laemolyta taeniata* (Kner, 1858) and *L. taeniatus* [52,67]; *Ergasilus turucuyus* in *Leporinus affinis* Günther, 1864 [68]. Besides there are records of *Ergasilus* sp. in *L. friderici*, *L. piau*, *L. reinhardti*, *M. elongatus* and *M. macrocephalus* [43,52].

In the present study, *G. schizodontis* was reported for the first time in *L. piau*. Its main characteristic is the presence of a retrostylet with a spatulate medial process, besides presenting bluish spots on the body [17]. In Brazil, it is recorded parasitizing seven anostomid species (*L. friderici*, *L. lacustris*, *M. elongatus*, *M. obtusidens*, *S. borellii*, *S. fasciatus* and *S. intermedius*) [19,31,45,46,60,69].

This work demonstrates the existence of a great diversity of parasites not yet recorded in the literature for the host species and locality studied. There is the possibility of potentially new *taxa* being described, which may add to and enrich the knowledge about fish parasite biodiversity in the northeast region of Brazil.

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