Natural Resources, 2017, 8, 268-277
http://www.scirp.org/journal/nr
ISSN Online: 2158-7086
ISSN Print: 2158-706X

Metazoan Parasites of *Geophagus proximus*, a Cichlidae Fish from the Eastern Amazon (Brazil)

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How to cite this paper: Oliveira, M.S.B., Corrêa, L.L., de Araújo Castro, L., Brito, L.S. and Tavares-Dias, M. (2017) Metazoan Parasites of *Geophagus proximus*, a Cichlidae Fish from the Eastern Amazon (Brazil). *Natural Resources*, **8**, 268-277.
https://doi.org/10.4236/nr.2017.83015

Received: February 26, 2017
Accepted: March 28, 2017
Published: March 31, 2017

Abstract

The present study investigated the fauna of metazoan parasites of a *Geophagus proximus* population from the lower Tapajós River, in the state of Pará, northern Brazil. A total of 137 monogeneans were collected from the gills of *G. proximus*, including *Sciadicleithrum kritskyi*, *Sciadicleithrum paranaensis* and *Sciadicleithrum geophagi*, while 119 *Raphidascaris* (*Sprentascaris*) *lanfrediae* nematodes and 28 metacercariaes of digenea undetermined were collected from the intestine. Hosts harboring four species of parasites were predominant. The parasites had an aggregated dispersion pattern. The present study represents the first record of *S. geophagi* parasitizing *G. proximus*, increasing the geographic distribution of these parasite species to the Tapajós River basin.

Keywords

Helminths, Parasites, Freshwater Fish, Tapajós River

1. Introduction

The Cichlidae Bonaparte, 1840 family comprises the greatest wealth of fish species, with 202 genera and around 1762 species [1]. Cichlids are freshwater fish, but some species can tolerate variations in salinity and may invade brackish water [1]. The family is widely geographically distributed and contains species with different life habits, with the majority of neotropical species presenting extragenital sexual dimorphism, wide variations in size and shape, diversified coloration and great potential for use in aquariums [1].

Among cichlid species, *Geophagus proximus* Castelnau, 1855 is endemic to South America, and is distributed in the Ucayali River in Peru and the Solimões-Amazon River, Tocantins River and the Trombetas River in Brazil [2]. This benthopelagic fish inhabits riverbanks and lakes, feeding on small fruits, seeds, algae, crustaceans, insect larvae and mollusks [3] [4]. Its sexual maturation occurs when it reaches approximately 12 cm in length, and it exhibits split spawning and the habits of incubating the eggs in the mouth and caring for its offspring after hatching [3].

Despite the wide geographical distribution of *G. proximus* and its importance for fishing, there are few studies on its parasitic fauna. [5] described the occurrence of *Argulus chicomendesi* Malta and Varella, 2000, *Ergasilus turucuyus* Malta and Varella, 1996, and *Excorallana berbicensis* Boone, 1919 in *G. proximus* from the Araguari River, in state of Amapá, Brazil. However, most studies with *G. proximus* have been carried out in regions where the fish does not occur naturally. For *G. proximus* from the Paraná River basin, in the state of Paraná (Brazil), Proteocephalidea, *Austrodiplostomum compactum* Lutz, 1928, *Clinostomum heluans* Braun, 1899, *Clinostomum* Leidy, 1856, *Raphidascaris* (*Sprentascaris*) *hypostomi* Petter and Cassone, 1984, *Raphidascaris* Railliet and Henry, 1915 and *Contracaecum* Railliet and Henry, 1912 [6] have been registered. For this host from the Ilha Solteira Reservoir, on the Dourados River, in state of São Paulo (Brazil), [7] described *Sciadicleithrum kritskyi* Bellay, Takemoto, Yamada and Pavanelli, 2009 and *Sciadicleithrum paranaensis* Bellay, Takemoto, Yamada and Pavanelli, 2009. *Austrodiplostomum compactum* was also reported in *G. proximus* from the Nova Avanhandava Reservoir, on the Tietê River, also in the state of São Paulo, Brazil [8].

Knowledge of parasitic infracommunities and their relationships with host fish is of great importance, as parasites play a key role in ecosystems, regulating the abundance and density of natural populations, therefore stabilizing food chains and host community structure [5] [9] [10] [11]. The present study therefore aimed to investigate the parasitic fauna of metazoans from *G. proximus* from Lake Juá in the Tapajós River basin, in the state of Pará, Brazil.

2. Materials and Methods

In September 2015, 23 specimens of *G. proximus* were collected in the Juá Lake located on the lower Tapajós River (2˚26'05.8"S 54˚46'26.9"W), in the municipality of Santarém, state of Pará, in the eastern Amazon region of Brazil (**Figure 1**). Gill nets were used to capture the fish (20 and 30 mm of mesh). All the fish were then transported alive to Multiple Production Laboratory for Aquatic Organisms (LAMPOA) of the West Pará Federal University (UFOPA), for parasitological analysis. The identification of *G. proximus* was through the morphological characteristics [12]. The study was carried out in accordance with the principles adopted by the Brazilian College of Animal Experimentation (COBEA). All the fish were collected pursuant to a collection authorization granted by IBAMA/ICMBio-N˚ 46202-2/2015.

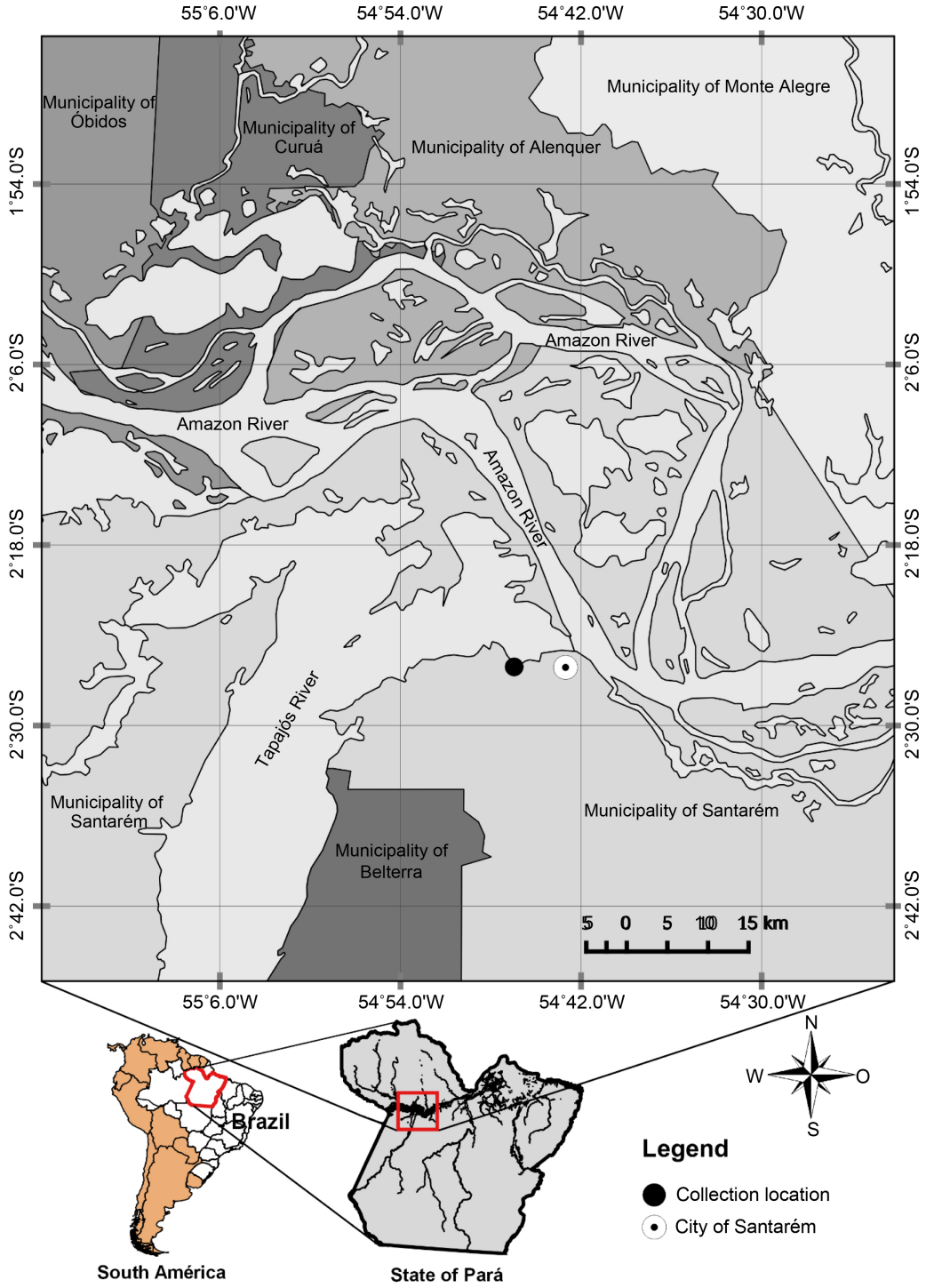

Figure 1. Collection sites of *Geophagus proximus* in the lower Tapajós River, state of Pará, in Eastern Amazon (Brazil).

After collection, each fish was euthanized by the spinal cord transection method, and the standard length (cm) and total weight (g) were measured. Then the mouth, gills, operculum and fins of each fish were examined to verify the presence of ectoparasites, and the viscera and gastrointestinal tract were analyzed for the presence of endoparasites. The collection, fixation and preparation

of the parasites for identification followed the recommendations of [13]. The identification of the parasites was in accordance with [6] and [14], following the morphological characteristics.

The ecological terms used (prevalence, mean intensity, mean abundance) were those recommended by [15] and dominance frequency was evaluated in accordance with [16]. The degree of dispersion of each parasitic infra-community with prevalence >10% was evaluated using the Green index, as shown by the equation:

$$GI = \frac{\left(\frac{s^2}{\overline{x}}\right) - 1}{n-1} = \frac{IC}{n-1}$$

where: GI = Green's index, s^2 = variance, $\overline{x}$ = mean number of individuals, n = total number of individuals.

The dispersion index was tested using the d-statistic test, where $d > 1.96$ = aggregate distribution; $d < -1.96$ = uniform distribution; $-1.96 < d < 1.96$ = random distribution [17].

3. Results

A total of 23 specimens of *G. proximus* measuring $\overline{x}$ = 11.4 cm ± 1.5 cm and $\overline{x}$ = 21.0 g ± 8.5 g were analyzed, of which 95.7% were parasitized by one or more metazoan species, with the dominance of monogenoidean species. The species of parasites found were *Sciadicleithrum kritskyi* Bellay, Takemoto, Yamada and Pavanelli 2009; *Sciadicleithrum paranaensis* Bellay, Takemoto, Yamda and Pavanelli 2009; *Sciadicleithrum geophagi* Kritsky, Thatcher and Boeger, 1989 (Dactylogyridae); *Raphidascaris* (*Sprentascaris*) *lanfrediae* Melo, Santos, Giese, Santos and Santos 2011 (Raphidascarididae) and Digenea gen. sp. metacercariae (Trematoda) (**Table 1**).

The species richness of the parasites varied from 0 to 5, although hosts infected by four species predominated (**Figure 2**). The parasites had an aggregated distribution pattern (**Table 2**).

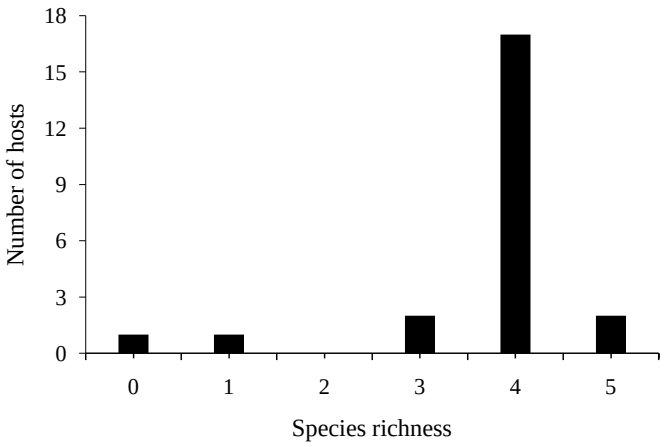

Figure 2. Species richness of metazoan parasites of *Geophagus proximus* from the lower Tapajós River, state of Pará, in Eastern Amazon (Brazil).

Table 1. Metazoan parasites of *Geophagus proximus* from the lower Tapajós River, state of Pará, in Eastern Amazon (Brazil). P: Prevalence, MI: Mean intensity, MA: Mean abundance, TNP: Total number of parasites, IS: Infection sites, FD: Frequency of dominance.

Parasite species	P (%)	MI	MA	TNP	FD (%)	IS
Monogenea						
Sciadicleithrum kritskyi						
Sciadicleithrum paranaensis	91.3	73.9 ± 6.7	6.0	137	0.482	Gills
Sciadicleithrum geophagi						
Nematoda						
Raphidascaris (*Sprentascaris*) *lanfrediae* (larvae)	73.9	7.0 ± 4.6	5.2	119	0.419	Intestine
Trematoda						
Digenea gen. sp. (metacercariae)	21.7	5.6 ± 3.1	1.2	28	0.099	Intestine

Table 2. Dispersion index (D), *d*-statistical test, Green index (G) for the infracommunities of metazoan parasites of *Geophagus proximus* from the lower Tapajós River, state of Pará, Eastern Amazon (Brazil).

Parasites	D	*d*	G
Monogenea	7.97	12.17	0.32
Raphidascaris (*Sprentascaris*) *lanfrediae*	4.21	7.05	0.15
Digenea gen. sp.	8.51	12.79	0.34

4. Discussion

Different fish species are important hosts for the biological cycle of a variety of endoparasites, due to their behavior and feeding habits, which are important factors in the composition of their endoparasite fauna [9] [10] [18]. In the present study of *G. proximus*, while a total of five species of parasites were found, of which three were monogenoidea, one was nematoda and one was digenea, ectoparasites predominated. The species richness of parasites in *G. proximus* was similar to that of the same host from the Paraná River basin, in state of Paraná, Brazil [7]. On the other hand, it was less rich than that of *Geophagus brasiliensis* Quoy and Gaimard, 1824 from the Guandu River, in state of Rio de Janeiro, which presented fauna composed of 14 species of parasites [18], none of which occurred in the present study. Such differences are expected for congeneric species and those from different environments.

Aggregate distribution is a common pattern in freshwater fish parasites [19] and has been observed in other species of freshwater fish in Brazil [10] [18] [20] [21] [22]. This pattern of parasitic distribution may be influenced by the width of the ecological niche, environmental heterogeneity, and immunological and behavioral differences between individual hosts [2] [10] [22] [23] [24] as well as indicating little competition between parasites of the same species, which are allowed to occur in great abundance in the same host and at the same infection site.

Monogeneans *S. kritskyi*, *S. paranaensis* and *S. geophagi* predominated in the *G. proximus* of the present study, indicating a greater contact with the infecting forms (oncomiracidium) of these monoxide parasites, which explained this predominance. In contrast, there was a low richness of endoparasite larvae such as *R.* (*S.*) *lanfrediae* and non-identified digenea, indicating that the diet of *G. proximus* diversified little in the environment studied, and was limited to a few items such as crustaceans and mollusks. In contrast, a greater richness of endoparasites was identified in *G. proximus* from the Paraná River, with the dominance of *A. compactum* [7]. For *G. brasiliensis* from the Guandu River, the dominance of *Posthodiplostomum macrocotyle* Dubois, 1937 [9] and *Posthodiplostomum* sp. [25] have been described.

Monogeneans *S. kritskyi* and *S. paranaensis* were originally described from *G. proximus* from the Paraná River basin, Brazil [6], where *G. proximus* was introduced. As such, we can assume that these parasites were transferred together with this host to this region of Brazil. According to [26] parasites transferred to regions where they do not occur naturally may specialize and parasitize other species of fish, competing with the natural parasites of this region. So far, however, there is no record of *S. kritskyi* or *S. paranaensis* parasitizing other species of fish. On the other hand, *S. geophagi*, originally described from the gills of *Geophagus surinamensis* Bloch, 1791 from the Negro River, in the state of Amazonas, Brazil [27], was first recorded here in *G. proximus*, and Lake Juá, in the Tapajós River basin in the state of Pará, is a new locality for this parasite. *Sciadicleithrum geophagi* has also been reported infecting other cichlids in the state of Amapá, such as *Chaetobranchopsis orbicularis* Steindachner, 1875 [11] and *Geophagus camopiensis* Pellegrin, 1903 [18].

Larvae of *R.* (*S.*) *lanfrediae* were found in the intestine of *G. proximus* with high prevalence, but low intensity and average abundance values. However, these levels of parasitism were higher than those recorded from *Satanoperca jurupari* Heckel, 1840 from the Guamá River. In general, *Raphidascaris* spp. uses Chironomidae species as primary intermediate hosts and small fish as intermediate hosts, reaching the adult stage in predatory fish [28]. Therefore, the fact that *G. proximus* is a small cichlid favors its predation. *Raphidascaris* (*S.*) *lanfrediae* is a nematode that has also been reported parasitizing *Geophagus argyrosticus* Kullander, 1991 and *G. proximus* from the Araguari River, in state of Amapá, and the Xingu River, in state of Pará [29], as well as *S. jurupari* from the River Guamá [14]. However, species of *Raphidascaris* have been reported parasitizing fish from the Loricaridae [30] [31], Pimelodidae [31] and Serrasalmidae [32] [33] families. This study extends the distribution of *R.* (*S.*) *lanfrediae* to the Juá Lake, in the western part of the state of Pará, Brazil.

Digenea are widely geographically distributed, and in South America are known 662 species infecting diverse fish species [34], as they parasite different species of vertebrates, especially fish and piscivorous birds. The life cycle of these endohelminths usually includes three hosts: mollusks, fish and piscivorous birds [35] [36]. Digenean metacercariae occurred in the intestine of *G. proximus* with

low levels of infection, indicating that this host feeds on small mollusks in the studied environment. Depending on the region of Brazil, *G. proximus* has been infected by *A. compactum* [6] [8] and *C. heluans* [6]. However, the species of digenea in *G. proximus* from the Amazon are unknown.

5. Conclusion

In conclusion, the parasite community in *G. proximus* was composed by ecto- and endoparasites, with low species richness and moderate infection levels. *Geophagus proximus* is an intermediate host for digeneans and *R.* (*S.*) *lanfrediae*. Finally, more studies with parasites of natural populations of *G. proximus* from different localities of Brazil are suggested, to better understand the parasitic ecology of these host fish.

Acknowledgements

The authors would like to thank the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (the Coordination for the Improvement of Higher Education Personnel) (Capes) for the Master's grant awarded to M. S. B. Oliveira, and to the Conselho Nacional de Desenvolvimento Científico (National Council for Scientific Development) (CNPq) for the productivity scholarship awarded to M. Tavares-Dias.

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