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ENDOFAUNA OF HELMINTH PARASITES OF FISH IN THE AMAZONIC BASIN

ENDOFAUNA DE HELMINTOS PARASITOS DE PEIXES DA BACIA AMAZÔNICA

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RESUMO

A biodiversidade de parasitos na Amazônia é subestimada em função da grande diversidade de peixes e elevado grau de endemismo, que favorecem a megadiversidade da fauna helmíntica na região. Assim, o presente estudo investigou a endofauna de helmintos de 13 espécies de peixes do alto Rio Juruá, estado do Acre, no sudoeste da Amazônia, Brasil. Os peixes foram capturados nos rios Juruá, Crôa, Paranã e Môa e os helmintos analisados conforme literatura especializada. Foram encontrados um total de 919 helmintos pertencentes a 25 espécies, sendo 9 espécies de Nematoda, 8 Cestoda, 6 Digenea e 2 Acanthocephalus. Entre as espécies de helmintos, *Procamallanus* (*S.*) *inopinatus* foi o mais predominante e apresentou maior intensidade de infestação e abundância. Novos relatos de peixes hospedeiros de helmintos foram verificados para *Cichla nigromaculata* parasitado por *Procamallanus (S.) inopinatus*, *Chaetobranchus favescens* hospedeiro de *Cosmoxynemoides agurei*, *Curimatella meyeri* para *Cosmoxynema vianai*, *Pseudoplatystoma fasciatum* para *Goezeella* sp., toda a endofauna de *Heros severus*, *Leporinus jamesi* para *Gibsoniela* sp., *Myloplus rubripinnis* para Digenea *Auriculostoma* sp. e *Opsodoras morei* para o Acanthocephalus *Sharpilosentis peruviensis.* Assim, o presente estudo contribuiu com informações que aumentam registro desses parasitos na Amazônia brasileira, sugerindo que essa área apresenta um grande potencial para futuros estudos.
Palavras-chaves: Peixe; Amazônia; Helmintofauna; Acre.

ABSTRACT

The Amazonian parasite biodiversity is underestimated due to the high fish diversity and a high degree of endemism, which favor the megadiversity of helminth fauna in the region. Thus, the present study investigated the helminth endofauna of 13 fish species from the upper Juruá River, state of Acre, in southwestern Amazon, Brazil. The fish were caught in the Juruá, Crôa, Paranã, and Môa rivers and the helminths were analyzed according to specialized literature. We found a total of 919 helminths distributed in 25 species, with nine species of Nematoda, eight of Cestoda, six of Digenea, and two Acanthocephalus. Among the helminth species, *Procamallanus* (*S.*) *inopinatus* was the most predominant and had the highest intensity of infestation and abundance. New records of fish hosting helminths were found for *Cichla nigromaculata* parasitized by *Procamallanus (S.) inopinatus*, *Chaetobranchus favescens* hosting *Cosmoxynemoides agurei*, *Curimatella meyeri* hosting *Cosmoxynema vianai*, *Pseudoplatystoma fasciatum* hosting *Goezeella* sp., all endofauna of *Heros severus*, *Leporinus jamesi* hosting *Gibsoniela* sp., *Myloplus rubripinnis* hosting Digenea *Auriculostoma* sp., and *Opsodoras morei* hosting Acanthocephalus *Sharpilosentis peruviensis.* Thus, the present study increased the records of these parasites in the Brazilian Amazon, suggesting that this area has high potential for future studies.
Keywords: Fish; Amazon; Helminth fauna; Acre.

1. INTRODUCTION

The diversity of parasites in fish in the Amazon is underestimated due to the highly diverse ichthyofauna and high degree of endemism, which favors the megadiversity of helminth fauna in the region [1].

The fish-parasite relationship has been the subject of many studies that have addressed the roles of interactive and non-interactive processes since parasites are attractive models to studies on the organization and structure of parasitic communities in wild fish populations [2],[3]. Parasites are considered essential and integral elements in aquatic ecosystems where they conduct fundamental ecological processes. For example, they can influence the productivity and structure of an ecosystem's food chain [4],[5]. A healthy ecosystem, i.e., functional [6] is, therefore, a system rich in parasite species [7]. Thus, knowledge regarding the diversity of fish parasites can be a useful tool for the conservation of global biodiversity [1].

However, despite the great diversity of helminth species recorded in the Amazon, knowledge about the parasite richness remains incomplete in some places. Most studies are concentrated in Central and Eastern Amazon [8],[9],[10], with few studies in southwestern Amazon. Most authors have studied the distribution, composition, and influence of the parasite-host relationship in fish from farming systems and few in natural environments [11],[12],[13]. Besides, studies in the Juruá River basin have shown only parasitic fauna in cultivation systems [14]. In other words, there is a huge gap in studies regarding the biodiversity of parasites associated with fish in natural systems in this region of southwestern Amazon.

However, fish from natural environments usually harbor several taxa of endoparasites with different strategies and life cycles [15]. It is estimated that more than 10,000 species, belonging to many phyla, parasitize fish, with constant descriptions of new species [16]. Thus, the present study assumes that these poorly studied regions may present high parasite richness, providing additional information on species distribution and occurrence.

Therefore, the present study aimed to describe the helminth fauna of 13 fish species of the Juruá River basin in the southwestern Amazon, Brazil.

2. MATERIAL AND METHODS

The study was carried out in the municipality of Cruzeiro do Sul, State of Acre, Brazil (07°37'52" S and 72°40'12" W). The fish were captured with authorization by the Brazilian Institute of Environment and Renewable Natural Resources (No. 59642-2/2019) in the Juruá, Crôa, Paranã, and Môa rivers (Fig. 1), from January to October 2019. The captured fish (Table

1) were sent to the Laboratory of Aquatic Ecology, where they were identified [17],[18] measured, and weighed. Each fish was submitted to necropsy, and the gastrointestinal tract and viscera were examined using a stereomicroscope and microscope with 40 to 100x magnification.

The collection, fixation, preservation, and preparation of the parasites for identification followed the recommendations of [19]. The parasite species were identified according to Schmidt [20], [21], [22], [23], [24], [25] . The ecological terms used were adopted from those recommended by [26].

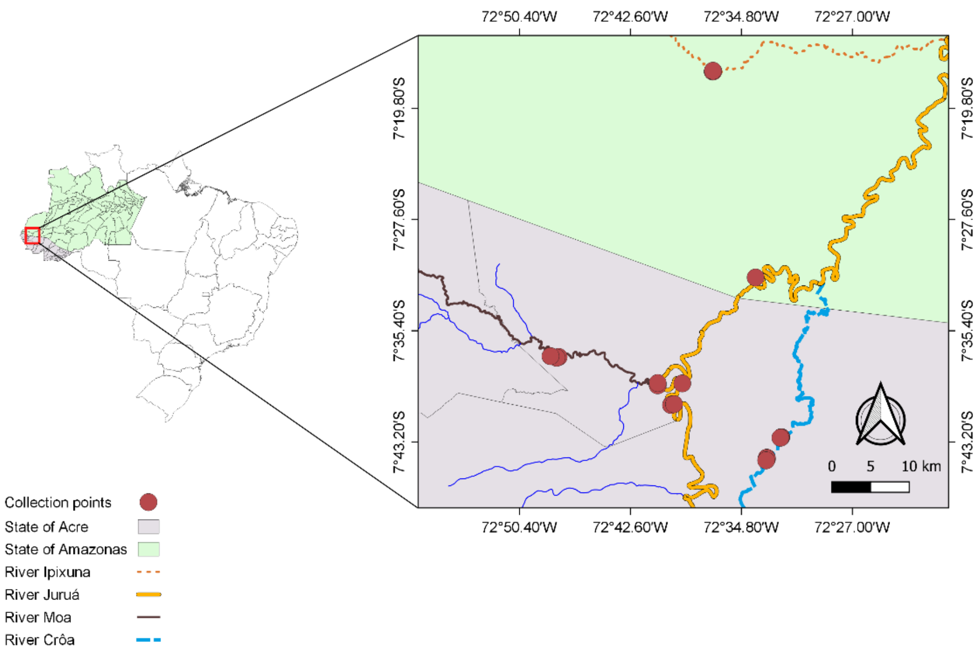

Fig. 1. Location of endoparasite collection points in southwestern Amazon, Acre, Brazil, 2019.

3. RESULTS

We collected 389 individuals of 13 fish species hosting a total of 919 helminths belonging to 25 species, with nine species of Nematoda, eight of Cestoda, six of Digenea, and two of Acanthocephala (Table 1).

Among the helminth species collected, *Procamallanus* (*Spirocamallnus*) *inopinatus* was found in the largest number of hosts, where it showed the highest intensity of infection (MI = 211.5) and mean abundance (MA = 105.8) in *Myloplus rubripinnis* (Table 1). Most hosts had adult Nematodes, and the only species in the larval stage in this group was *Contracaecum* sp. (larvae), which was found parasitizing *Pellona castelnaeana* (Table 1).

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Pseudoplatystoma fasciatum was the host with the highest number of endoparasite species (N = 7), where six helminths belonged to the Cestoda group (Tables 1 and 2).

Prochilodus nigricans, *Pseudoplatystoma fasciatum*, *Hoplias malabaricus*, and *Serrasalmus* sp. had the highest parasite prevalence (~60%), while *Heros severus* had the lowest prevalence (16.6%) of endoparasites (Table 2).

In this study, we report new host-parasite relationships, such as *Chaetobranchus flavescens* parasitized by *Cosmoxynemoides aguirrei* (Figure 2A); *Curimatella meyeri* parasitized by *Cosmoxynema vianai* (Figure 2B); *Cichla nigromaculata* parasitized by *Procamallanus (Spirocamallanus) inopinatus* (Figure 2C); *Pseudoplatystoma fasciatum* parasitized by *Goezeella* sp. (Figure 3A); all endofauna of *Heros severus* and *Leporinus jamesi* parasitized by *Gibsoniela* sp. (Figure 3B); *Opsodoras morei* parasitized by *Sharpilosentis peruviensis* (Figure 3C); *Myloplus rubripinnis* parasitized by *Auriculostoma* sp. (Fig. 3D) (Table 1).

Fig.2 Nematodes reported in new host fish from rivers of the southwestern Amazon, Acre, Brazil, 2019. A- *Cosmoxynemoides aguirrei*, male; B- *Cosmoxynema vianai*, female; C- *Procamallanus (Spirocamallanus) inopinatus*, female. 1- Anterior part; 2- Posterior part.

Fig.3 A- *Goezeella* sp.; B- *Gibsoniela* sp.; C- *Sharpilosentis peruviensis*; D- *Auriculostoma* sp. collected in fish from the upper Juruá River, a tributary of the Amazon River, northern Brazil, Acre, 2019.

Table 1. Helminth species found in 13 hosts from the upper Juruá River, a tributary of the Amazon River, Acre, northern Brazil, 2019. P: Prevalence, MI: Mean intensity of infection, MA: Mean abundance, TNP: Total number of parasites. Nem.: Nematoda, Dig.: Digenea, Cest.: Cestoda, Acant.: Acanthocephala,

Host species	Parasite species	P (%)	MI	MA	Group	TNP
Cichla nigromaculata Kullander & Ferreira, 2006	*Procamallanus (Spirocamallanus) inopinatus* Travassos, Artigas & Pereira, 1928.	54.5	4.3	2.4	Nem.	26
Chaetobranchus favescens Heckel, 1840	*Cosmoxynemoides aguirrei* Travassos, 1949	15.8	1.6	0.4	Nem.	37
Curimatella meyeri Steindachner, 1882	*Cosmoxynema vianai* Travassos, 1949	40.0	1.8	0.7	Nem.	29

	Cladorchiidae	25.0	1.8	0.3	Dig.	1
Pseudoplatystoma fasciatum Linnaeus, 1766	*Choanoscolex abscissus* Riggenbach, 1896	100.0	16.0	16.0	Cest.	48
	Nomimoscolex sudobim Woodland, 1935	66.7	2.7	4.0	Cest.	8
	Goezeella sp.	66.7	4.3	6.5	Cest.	13
	Proteocephalidae	66.7	4.0	6.0	Cest.	12
	Dichelyne moraveci Petter, 1995	66.7	2.7	4.0	Nem.	8
	Spasskyellina spinulifera Woodland, 1935	33.3	2.7	8.0	Cest.	8
	Monticellia sp.	33.3	1.7	5.0	Cest.	5
Acestrorhynchus falcatus Bloch, 1794	*Prosthenhystera obesa* Diesing, 1850	42.9	1.7	0.7	Dig.	10
	Pseudophyllidea	12.5	1.0	0.1	Cest.	1
Heros severus.	*Procamallanus (Spirocamallanus) inopinatus*	12.5	1.0	0.1	Nem.	1
	Clinostomum sp. (larvae)	25.0	2.0	0.5	Dig.	4
	Ithyoclinostomum dimorphum Diesing, 1850 (larvae)	12.5	1.0	0.1	Dig.	1
Prochilodus nigricans Agassiz, 1829	*Neoechinorhynchus curemai* Noronha, 1973	75.3	2.9	2.2	Acant.	178
Leporinus jamesi Garman, 1929	*Gibsoniela* sp.	33.3	6.0	2.0	Cest.	6
Myloplus rubripinnis Müller & Troschel, 1844	*Deltamphistoma pitingaense* Thatcher & Jégu, 1996	25.0	35.0	8.8	Dig.	35
	Procamallanus (Spirocamallanus) inopinatus	50.0	211.5	105.8	Nem.	423

	Auriculostoma sp.	100.0	1.0	0.3	Dig.	1
Opsodoras morei Steindachner, 1881	*Sharpilosentis peruviensis* Lisitsyna, Scholz & Kuchta, 2015	50.0	2.4	4.8	Acant.	19
Pellona castelnaeana Valenciennes, 1847	*Contracaecum* sp. (larvae)	41.7	4.8	2.0	Nem.	24
Hoplias malabaricus Bloch, 1794	*Paraseuratum soaresi* Fábio, 1983	66.7	1.5	1.0	Nem.	12
Serrasalmus sp.	*Raphidascaris* sp.	84.6	1.4	1.15	Nem.	15

Table 2. Host fish community of helminths from the upper Juruá River, a tributary of the Amazon River, Acre, northern Brazil, 2019.

Host species	Examined (N)	Parasitized (N)	P (%)	Total parasites
Cichla nigromaculata	11	6	54.5	26
Chaetobranchus favescens	145	23	15.86	37
Curimatella meyeri	34	13	38.2	24
Pseudoplatystoma fasciatum	3	3	100	102
Acestrorhynchus falcatus	26	7	26.9	11
Heros severus.	24	4	16.6	6
Prochilodus nigricans	81	61	75.3	178
Leporinus jamesi	3	1	33.3	6
Myloplus rubripinnis	9	4	44.4	459
Opsodoras morei	16	8	50	19
Pellona sp.	12	5	41.6	24
Hoplias malabaricus	12	8	66.6	12
Serrasalmus sp.	13	11	84.6	15

4. DISCUSSION

The helminth species of the Nematoda and Cestoda groups predominated in this study, where Nematoda occurred in a greater variety of hosts. Generally, nematodes are more prevalent in neotropical fish assemblages in different ecosystems [27],[28].

Nematodes such as *Paraseuratum* soaresi, found in *Hoplias malabaricus, Raphidascari* sp. in *Serrasalmu* sp., and *Dichelyne moraveci* in *Pseudoplatystoma fasciatum* showed a high prevalence in those host species. This fact may be associated with the carnivorous habit of those fish [29], which consume organisms that are part of the life cycle of those helminths. According to [30], the diet of fish has a strong relationship with the incidence of endoparasite species since they include intermediate, parathenic, and definitive hosts in the environment, supporting the life cycle of those nematodes.

In the present study, most fish species studied were parasitized by adult nematodes, indicating that these hosts may be occupying a final position in the food web. [22] showed that this group of helminths has indirect life cycles and that fish can act as final and intermediate hosts.

The most common Nematoda was *Procamallanus* (*S.*) *inopinatus*, with a high degree of infestation in its hosts. This helminth is very generalist, occurring in many Amazonian freshwater fish species, which probably act as post-cyclical or para-definitive hosts [22].

The only Nematoda in the larval phase (L3) observed in the present study was *Contracaecum* sp. parasitizing *Pellona castelnaeana*. Many fish species can act as intermediate and/or parathenic hosts for larvae of *Contracaecum* sp., demonstrating a lack of specificity regarding the intermediate host [22],[31]. Thus, the present study indicated yet another report of these helminth larvae hosting fish. Since *P. castelnaeana* is highly appreciated by the riverside population and it is commercialized in local markets in the Amazon region [32], we suggest careful consumption due to the presence of these larvae with zoonotic potential.

Of the eight species of Cestoda found, six were in the intestine of *P. fasciatum*. These helminth species parasitizing *Pseudoplatystoma* have been studied in recent years [33],[34],[35]. The coexistence of those species in the intestine of a single host is common. Studies (including this study) have recorded the occurrence of Cestoda such as *Choanoscolex abscissus, Spasskyelina spinulifera*, *Nomimoscolex sudobim*, and *Monticellia* sp., in a single fish [36],[37],[38]. However, no study had recorded the occurrence of *Goezeella* sp. interacting with other Cestodes in the intestine of *P. fasciatum*.

Gibsoniela sp. was reported for the first time parasitizing *Leporinus jamesi*. Helminths of this genus have hitherto been found parasitizing only species of the genus *Ageneiosus*

(Siluriformes), such as *Gibsoniela mandube* and *Gibsoniela meursaulti* [39],[40]. This predominance of Proteocefalidae species evidenced in this study can also be associated with the carnivorous and omnivorous eating habits of those fish species, considering that most intermediate hosts of Cestoda are found in the diet of those species [41],[42].

Digenea was the third group with the highest prevalence in fish species, with the first *metacercariae* of *Clinostomum* sp. and *Ithyoclinostomum dimorphum* in the intestine of *Heros severus*. *Clinostomum* sp. and *Ithyoclinostomum dimorphum*, both from the family Clinostomidae and the first being a cosmopolitan genus [43],[44], are found in the adult stage in the esophagus of birds [45],[46]. They also parasitize many species of fish and mollusks that can be considered their intermediate hosts [47],[48].

Auriculostoma sp. (Digenea) was also the first report for the host species *Myloplus rubripinnis* in the Brazilian Amazon. In Brazil, this genus of helminths was found only in the south and southwest regions [49],[50],[51]. The *Auriculostoma* species closest to the Brazilian Amazon basin have been described in snails in the Peruvian Amazon, with *Auriculostoma foliaceum* described in *Bryconops caudomaculatus* and *Auriculostoma diagonale* in *Stethaprion erythrops* [52].

Only two fish species showed infestation by *Acanthocephalus*, with *Prochilodus nigricans* being parasitized by *Neochinorhynchus curemai* and *Opsodoras morei* by *Sharpilosentis peruviensis*. Characiform fish are the most common hosts for Acanthocephalus in the neotropical region, while few species have been reported in Siluriformes [53]. *Neoechinorhynchus curemai* has been reported to infest *Prochilodus* species [54],[55] which was first described parasitizing *P. nigricans* in an Amazonian floodplain [56]. *Sharpilosentis peruviensis* (Acanthocephala) has been reported in Siluriformes from the Peruvian Amazon, being found in *Oxydoras niger* of the Doradidae family [57]. In the present study, this parasite is mentioned for the first time in Brazil, in *Opsodoras morei*, also from the Doradidae family, expanding the number of hosts and known distribution of this species.

5. CONCLUSION

The present study indicates new reports of eight fish species hosting endoparasites in new locations. Besides, it increases the records of these parasites for the Brazilian Amazon, such as *Sharpilosentis peruviensis* (Acanthocephala) and *Auriculostoma* sp. (Digenea), suggesting that this area has a high potential for future studies.

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