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Original papers

# Parasites community of *Astronotus crassipinnis* (Cichlidae), a fish from the Brazilian Amazon

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**ABSTRACT.** We provide the first study on the diversity and community of parasites in *Astronotus crassipinnis* from the lower Amazon River, in Brazil. Of 35 hosts examined, 100% were infected with one or more species of parasites, such as *Gussevia asota*, *Gussevia astronoti*, *Gussevia rogersi*, *Posthodiplostomum* sp., *Contracaecum* sp., *Gorytocephalus* sp. and *Dolops longicauda*. *Gussevia asota, G. astronoti* and *G. rogersi* were dominant, and, in total, 9788 parasites were collected. The richness of parasite species (4.9±0.7), Brillouin diversity (0.46±0.28) and evenness (0.29±0.17) were low. Parasites had aggregated dispersion, parasitism did not affect the host condition factor, and host size did not influence abundance, species richness and parasite diversity. The parasitic fauna was characterized by the presence of few species of parasites with high prevalence and low abundance, specifically the endoparasites, besides dominance of ectoparasites. The presence of endoparasites indicates that the diet of *A. crassipinnis* consists mostly of mollusks and microcrustaceans. This fish species is an intermediate host for *Posthodiplostomum* sp., *Contracaecum* sp. and *Gorytocephalus* sp., parasites found in larval stage. Finally, the behavior and availability of infective stages, which are intermediate hosts for endoparasites, were factors structuring the communities of endoparasites.

**Key words**: *Astronotus crassipinnis*, Cichlidae, aggregation, parasites, Amazon

## Introduction

The family Cichlidae represents one of the most species-rich and widespread families of fish distributed across the Americas, Africa, and Asia. Many species are important ornamental fish and are among the most important sources of protein in many parts of the world. Thus, the parasites studies of cichlid species are of great relevance to global and local aquaculture and fisheries economy, sustainable development, and biodiversity conservation [1]. Moreover, most of them are of interest because of their richness of specialist parasites [2–4], as well as by its endemic nature and geographic distribution.

The genus *Astronotus* Swainson, 1839 (Cichlidae) has only two valid species: *Astronotus crassipinnis* Heckel, 1840 (Oscar) and *Astronotus ocellatus* Agassiz in Spix and Agassiz, 1831 (Oscar). Both species of cichlids are distributed in the Amazon River basin, Madre de Dios River drainage in Peru, Paraná River and Paraguay drainage basins [5–7]. Phylogeographic studies indicate that these species of *Astronotus* have sedentary and territorial habits with low dispersal potential; therefore, are likely to be influenced by climatic and geomorphological events [6].

*Astronotus crassipinnis*, object of the current study, is a benthopelagic fish commonly found in shaded lentic areas of calm and clear waters, where they can find shelter under submerged branches. In nature, this fish has the ability to ambush and capture prey, which are mainly small fish and crustaceans, besides feed on aquatic insects, seeds and fruits [7,8]. The reproduction of this occurs at the beginning of the Amazonian flooding, and

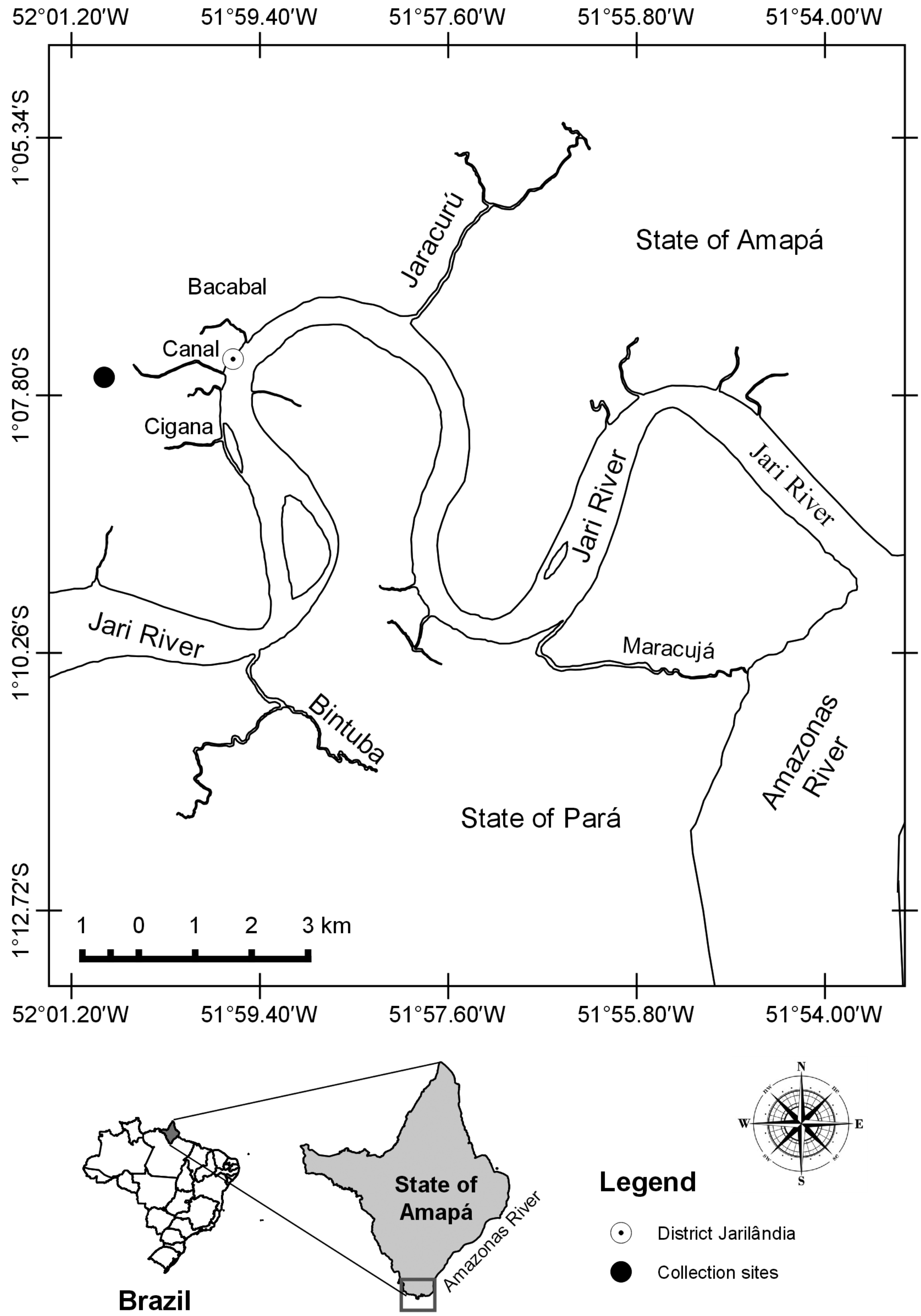


Fig. 1. Collection site of *A. crassipinnis* in the Brazilian Amazon

females have sexual maturity with 13 cm length, when the couples form nests and cares for the offspring [8]. However, *Astronotus crassipinnis* has been not focus of studies on parasite diversity and community of quantitative form.

Wild fish populations generally can harbor a wide range of ecto- and/or endoparasite species [2,4,9–11], which can have serious consequences ecological, as well as in growth, reproduction and welfare of fish [4,9,11]. Therefore, in wild fish population, the study and

Table 1. Parasites in *Astronotus crassipinnis* from the Brazilian Amazon

| Species of parasites | P (%) | MI | MA ± SD | Range | TNP | SI |
|---|---|---|---|---|---|---|
| *Gussevia asota* Kritsky, Thatcher & Boeger, 1989<br>*Gussevia astronotus* Kritsky, Thatcher & Boeger, 1989<br>*Gussevia rogersi* Kritsky, Thatcher & Boeger, 1989 | 97.1 | 213.8 | 207.7 ± 139.0 | 32-522 | 7268 | Gills |
| *Posthodiplostomum* sp. (metacercariae) | 85.7 | 69.8 | 59.8 ± 107.6 | 1-458 | 2094 | Gills |
| *Posthodiplostomum* sp. (metacercariae) | 14.3 | 6.6 | 0.9 ± 3.1 | 1-13 | 33 | Intestine |
| *Posthodiplostomum* sp. (metacercariae) | 2.9 | 20.0 | 0.6 ± 3.4 | 1-20 | 20 | Mesentery |
| *Posthodiplostomum* sp. (metacercariae) | 5.7 | 48.0 | 2.7 ± 11.5 | 1-58 | 96 | Stomach |
| *Contracaecum* sp. (larvae) | 22.9 | 2.9 | 0.7 ± 1.5 | 1-6 | 23 | Intestine |
| *Contracaecum* sp. (larvae) | 5.7 | 2.5 | 0.1 ± 0.7 | 1-4 | 5 | Stomach |
| *Contracaecum* sp. (larvae) | 2.9 | 1.0 | 0.03 ± 0.2 | 0-1 | 1 | Liver |
| *Contracaecum* sp. (larvae) | 91.4 | 1.9 | 10.2 ± 16.3 | 1-76 | 70 | Mesentery |
| *Gorytocephalus* sp. (larvae) | 11.4 | 1.0 | 0.03 ± 0.3 | 0-1 | 4 | Intestine |
| *Gorytocephalus* sp. (larvae) | 2.9 | 48.0 | 2.7 ± 0.2 | 0-1 | 1 | Mesentery |
| *Dolops longicauda* Heller, 1857 | 5.7 | 0.1 | 0.09 ± 0.4 | 1-2 | 3 | Gills |

P: prevalence; MI: mean intensity; MA: mean abundance; TNP: total number of parasites; SI: site of infection

understanding of the community structure of parasites can provide support for the use of this knowledge in fish farming. Parasites play a key role in natural ecosystems, mainly considering that their life cycles involve different hosts, either vertebrates or invertebrates. There currently exists a consensus that parasite species represent a large fraction of the Earth's total biodiversity. Thus, studies of fish parasites are of great relevance to understand their key roles in ecosystems, by regulating the abundance or density of host populations, stabilizing food webs and structuring host communities [2,11,12], but the parasitic diversity for many fish species remains to be investigated. To the best of our knowledge, only two studies examined the parasites of *A. crassipinnis*, reporting the occurrence of the monogeneans *Gussevia asota Gussevia astronoti*, *Gussevia rogersi* and *Gussevia* sp. [13,14], but without describing the parasitic infection levels. Thus, the goal of this study was to investigate the diversity and structure of the parasites community in *A. crassipinnis* from the Jari River, a tributary from the lower Amazon River, northern Brazil.

## Materials and Methods

**Study area and fish collection.** From October to November 2014, 35 specimens of *A. crassipinnis* were collected in the Jari River (Fig. 1), near to the community of Jarilândia, municipality of Laranjal of Jari, in the state of Amapá (northern Brazil). Fish were collected with gill nets of different meshes, for parasitological analysis.

The Jari River, an important tributary from the Amazon River system, in the eastern Amazon (Brazil), runs through some municipalities in the states of Pará and Amapá. It rises out in the Tumucumaque Mountains Park, in the border between Suriname and Brazil, flowing into the south of the state of Amapá. From its mouth, this basin is strongly influenced by daily tides of the Amazon River and it has clear waters downstream and black waters upstream, according to the concentration of suspended matter [15]. This river is responsible for forming large floodplain areas. In the rainy season, waters spread over the floodplain, creating favorable conditions that lead most fish to reproduce earlier in the season. This is the main season for feeding, growth and accumulation of energy reserves used to support the reduced food supply during the dry season. In the basin, regional vegetation consists of plants characteristic of floodplain forests and periodically flooded herbaceous fields, composed mainly of various macrophyte species.

**Parasite collection and analysis procedures.** Gills, nostrils, opercula and mouth cavity of the fish were examined to ascertain whether any protozoan and metazoan parasites were present. The gastrointestinal tract was removed and examined to collect endoparasites. Previously, methodological techniques were used to collect, fix, preserve, count and stain the parasites for identification [16]. To analyze the parasites, the ecological terms used were those recommended by Bush et al. [17].

The following descriptors for the parasite community

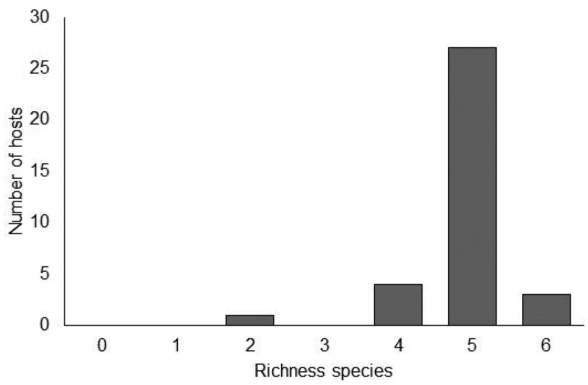


Fig. 2. Frequency distribution of *Astronotus crassipinnis* according to the species richness of parasites host from the Brazilian Amazon

were calculated: species richness, Brillouin diversity index (*HB*), evenness (*E*) in association with the diversity index, Berger-Parker dominance index (*d*) and dominance frequency (percentage of infracommunities in which a parasite species is numerically dominant) [18,11], using the Diversity software (Pisces Conservation Ltd., UK). The variance-to-mean ratio (ID), and the index of discrepancy of Poulin (D) were calculated using the Quantitative Parasitology 3.0 software to detect the distribution pattern of parasite infracommunities [19] for species with prevalence >10%. The ID significance for each infracommunity was tested using the *d*-statistics [20]. Principal component analysis (PCA) was carried using the Past-Paleontological Statistics software, version 3.0.

Body weight (Wt) and total length (Lt) were used to calculate the relative condition factor (Kn) of hosts [11], which was compared to the standard value (Kn = 1.00) using the *t*-test. The Spearman correlation coefficient (*rs*) was used to determine possible correlations between parasite abundance and the length, weight, Kn, parasite species richness and Brillouin index of the hosts [21].

## Results

In this study, all examined fish (100%) were parasitized by one or more species, and 9788 parasites were collected. Fish were infected with *G. asota*, *G. astronotus*, *G. rogersi*, *Posthodiplostomum* sp., *Contracaecum* sp., *Gorytocephalus* sp. and *Dolops longicauda* (Table 1), but *G. asota*, *G. astronotus* and *G. rogersi* (97.1%) were the dominant parasites, while *Gorytocephalus* sp. and *Dolops longicauda* were the least prevalent parasites. These parasites had an aggregated dispersion (Table 2).

The mean species richness varied between 2 and 6 parasites per host, diversity of Brillouin, from 0.07 to 1.01, evenness, from 0.04 to 0.63 and Berger-Parker dominance, from 0.45 to 0.99 (Table 3). The length of the hosts did not show correlation (*rs* = -0.159, p = 0.361) with the Brillouin diversity index, but showed a weak negative correlation (*rs* = -0.335, p = 0.049) with parasite species richness. There was a predominance of hosts infected with five species of parasites (Fig. 2).

Principal component analysis (PCA) based on the hosts' body and diversity parameters showed that the weight, length, Brillouin diversity index, evenness, species richness of parasites and Berger-Parker dominance were not correlated with *A. crassipinnis* (Fig. 3).

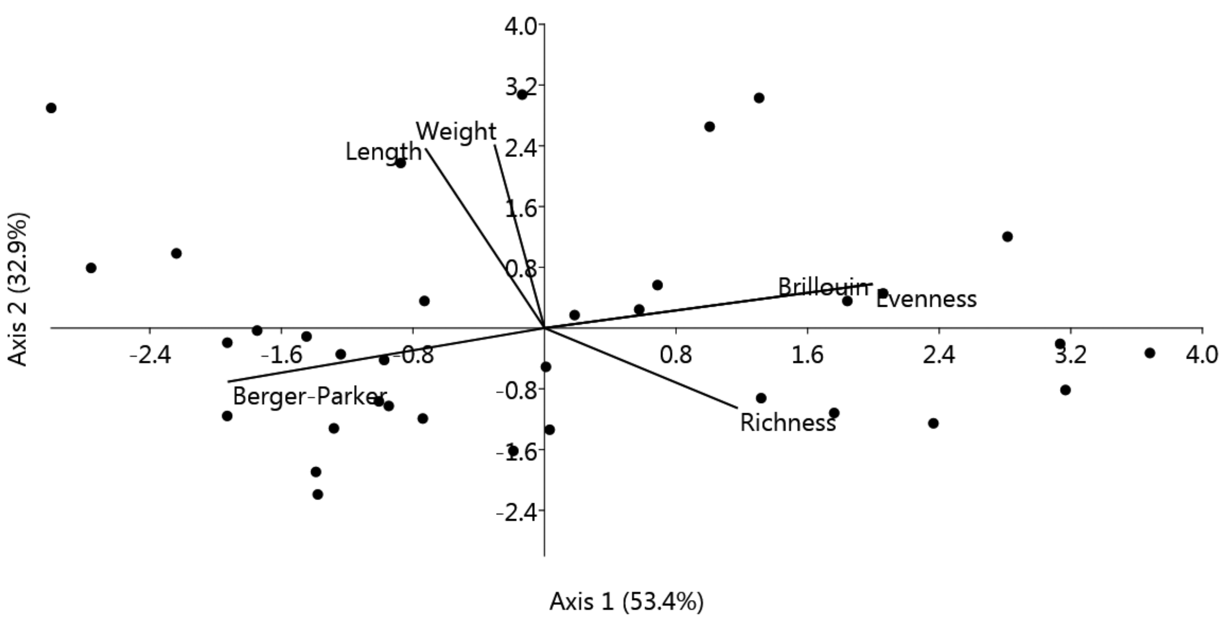


Fig. 3. Scatterplot plot of scores of principal component analysis (PCA) on factors influencing the parasite communities of *Astronotus crassipinnis* from the Brazilian Amazon. Richness: species richness.

Table 2. Dispersion index (DI), *d*-statistic and discrepancy index (D) and frequency of dominance (FD) for the parasite infracommunities in *Astronotus crassipinnis* from the Brazilian Amazon

| Parasites | DI | *d* | D | FD (%) |
|---|---|---|---|---|
| *Gussevia* spp. | 2.595 | 5.10 | 0.332 | 0.73 |
| *Posthodiplostomum* sp. | 2.484 | 4.81 | 0.867 | 0.21 |
| *Contracaecum* sp. | 3.560 | 7.32 | 0.415 | 0.03 |
| *Gorytocephalus* sp. | 2.580 | 5.06 | 0.874 | 0.0004 |

The Kn (1.00 ± 0.01) of hosts was not different (t = 0.008, p = 0.994) from the standard Kn (Kn = 1.00). The abundance of monogeneans *G. asota, G. astronotus* and *G. rogersi* had no correlation with the length (*rs* = 0.084, p = 0.633) and weight (*rs* = -0.058, p = 0.739) of the hosts. The abundance of *Posthodiplostomum* sp. showed no correlation with the length (*rs* = -0.072, p = 0.680) and weight (*rs* = -0.015, p = 0.934) of the examined fish. The abundance of *Contracaecun* sp. had no correlation with the length (*rs* = 0.038, p = 0.827) and weight (*rs* = 0.059, p = 0.734), as well as the abundance of *Gorytocephalus* sp. with the length (*rs* = 0.153, p = 0.381) and weight (*rs* = 0.182, p = 0.296) of the hosts, due to little variation in hosts size examined.

Table 3. Body parameters and descriptors of diversity for the community of parasites in *Astronotus crassipinnis* from the Brazilian Amazon

| Parameters | Mean ± SD | Range |
|---|---|---|
| Body weight (g) | 303.5 ± 51.8 | 10–16 |
| Total length (cm) | 17.5 ± 1.1 | 328–435 |
| Species richness | 4.9 ± 0.7 | 2–6 |
| Brillouin (*HB*) | 0.46 ± 0.28 | 0.07–1.01 |
| Evenness (*E*) | 0.29 ± 0.17 | 0.04–0.63 |
| Berger-Parker Dominance (*d*) | 0.82 ± 0.16 | 0.45–0.99 |

## Discussion

The diversity of fish fauna that lives in the wide range of aquatic habitat across the Amazon basin, including extensive floodplain areas, streams, lakes and tributaries suffers seasonal fluctuation [4,22,23]. Thus, the seasonal fluctuation in the Amazon basin together with attributes of fish population such as sex, age, body size, behavior, and feeding habits, may affect the parasite community structure [2,4,9,11,24]. Consequently, for each host fish population from the Amazon basin, the structure and composition of the parasite community are constituted from a set of parasite species available in the environment. In *A. crassipinnis* collected only during the dry season, the parasites found have been not recorded previously for this cichlid, except for *G. asota*, *G. astronotus* and *G. rogersi*. In contrast, most of species of helminths have been reported parasitizing *A. ocellatus* in the Brazilian Amazon [24], except for the acanthocephalan species found. The parasite community of *A. crassipinnis* was composed of seven species, including three species of Monogenea, one Digenea, one Nematoda, one Acanthocephala and one Branchiura, which presented an aggregated dispersion pattern. Therefore, *A. crassipinnis* host play an important role in the ecological balance of the aquatic ecosystems, sometimes acting as a control mechanism for the size of lesser fish populations. Factors controlling parasite species composition and infection levels are often ecological, because life history and diet of the hosts are the main factors determining the number of fish parasite species

Brazilian cichlids have been studied are mostly parasitized by *Gussevia* and *Sciadicleithrum* species and infection levels are highly variable. Therefore, Dactylogyridae species are the most frequent monogeneans in these freshwater cichlids [10]. Vanhove et al. [1] reported that in cichlid species from the Americas, the mean richness of monogenoideans is 2.3 ± 1.9. Concerning to the monogeneans in *A. crassipinnis,* three species were found, *G. asota*, *G. astronotus* and *G. rogersi*, which were the dominant species of parasites. These monogenoidean species were originally described for *A. ocellatus* from the Janauacá Lake, in Amazonas state, northern Brazil [13]. These monogenoideans were also found Takemoto et al. [14]), infecting *A. crassipinnis* in the Paraná River, Brazil. In *A. crassipinnis* of this study, the prevalence of *G. asota*, *G. astronotus* and *G. rogersi* was similar to that reported for *A. ocellatus* from the eastern Amazon, Brazil [24], but the values of mean intensity and mean abundance were higher. Nevertheless, both congeneric hosts are species from different environments in the Brazilian Amazon.

Metacercariae of *Posthodiplostomum* sp. have been the digenean most registered in fish species of different families from the eastern Amazon [9,11,24,25].

*Posthodiplostomum nanum* Dubois, 1937 is the species of this genus known by infecting wild fish in Brazil [26]. Species of *Postodiplostomum* are digenean belongs to trematode species that use mainly fish-eating birds and mammals as definitive hosts [27]. We found *Posthodiplostomum* metacercariae infecting the gills, stomach and intestine of *A. crassipinnis*, with higher infection levels than for *A. ocellatus* from the Pracuúba Lake, state of Amapá, Brazil [24]. Wild *A. crassipinnis* feed on small fish, crustaceans, aquatic insects, seeds and fruit [7,8], as well as mollusks, the primary intermediate hosts of *Posthodiplostomum* species [26,27].

Different species of anisakid nematodes are widely distributed in Brazil, and are known for accidental infection in man and other aquatic animals [28]. Larvae of *Contracaecum* sp. were found in mesentery, intestine, stomach and liver of *A. crassipinnis*, and infection levels were similar to those reported for *A. ocellatus* from Pracuúba Lake [24]. In *A. crassipinnis*, infection with *Contracaecum* sp. is related to its feeding, once this host also feed on small fish and microcrustacean species [7,8], which are primary intermediate hosts of this nematode [24]. In addition, *A. crassipinnis* serves as prey for other species of larger piscivorous fish [29], thus this fish is a secondary intermediate host for *Contracaecum* sp. However, in order to increase chances of reaching a final host, many parasites with complex life cycles, including nematodes, may adapt strategies to manipulate conditions or behavior of their intermediate hosts.

In fish from South America, the fauna of acanthocephalans has been the less studied when compared with other helminth taxa, with only 83 species reported from the different countries [12]. The genus *Gorytocephalus* was established to accommodate *Gorytocephalus plecostomurum*, an acanthocephalan of Loricariidae fish from the Panama River, when these authors also included *Gorytocephalus spectabilis*, which was previously described as *Neoechinorhynchus spectabilis* in Brazilian fish [30]. In *A. crassipinnis*, larvae of *Gorytocephalus* sp., probably *G. spectabilis*, occurred at low infection levels when compared to *Mesonauta acora*, *Aequidens tetramerus* and *Satanoperca jurupari*, cichlid species from the Igarapé Fortaleza basin in the Brazilian Amazon [25].

In *A. crassipinnis*, the infection with *D. longicauda* was low, and similar to that reported for *Chaetobranchopsis orbicularis* and *A. tetramerus* from the eastern Amazon, Brazil [25]. This argulid species is the most frequent in fish of the eastern Amazon, northern Brazil [31], and has a low parasitic abundance. However, this is the first report of *D. longicauda* for *A. crassipinnis*.

Parasitic infections may cause losses in fishery production through direct fish mortality, reduction in growth, fecundity and stamina, increasing thus the fish predation [9,11]. Such factors may therefore influence the physiology, growth and body condition of fish [32] due to reduced ingestion of food. Nevertheless, in *A. crassipinnis*, the relative condition factor of the hosts was not affected by the presence of ecto- and endoparasites, indicated by the similar body condition of infected and non-infected fish, because both groups has consumed a similar amount of food. In addition, parasite abundance, species richness and diversity index were not influenced by the body size of the hosts, because of the small range of weight and length of the hosts examined.

In summary, this first on the parasites diversity and community study for *A. crassipinnis* shown that the parasite community was dominated by ectoparasites and characterized by low richness of species, low Brillouin diversity and low evenness. This host fish plays an important role in the life cycle of nematodes, digeneans and acanthocephalans, the parasitic taxa that presented low infection levels and predominance of the larval stage, favored by the mode of life of this fish, a host occupying an intermediate position in the trophic chain. Finally, body size do not explained the variance on parasites abundance and species richness.

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