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Parasitic fauna of *Prochilodus nigricans* (Prochilodontidae) from Brazilian Amazon floodplain lakes

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ABSTRACT

The *Prochilodus nigricans* is an important fish species for fisheries and aquaculture in the Amazon. Despite its importance, little is known about its parasitic fauna. Thus, the purpose of this study was to investigate the metazoan parasites that occur in *P. nigricans* collected of western Amazon floodplain lakes (Brazil). Thirty-Seven *P. nigricans* were examined, being identified: *Tereancistrum curimba, Tereancistrum toksonum* and *Apenduculata discoidea* (Monogenoidea), *Neochinorhynchus curemai* (Acanthocephala), *Amplexibranchius bryconis, Brasergasilus* sp.1, *Brasergasilus* sp.2, *Ergasilus urupaensis, Miracetyma* sp., *Rhinergasilus piranhus* (Copepoda), *Argulus chicomendesi* and *A. multicolor* (Branchiura). Standard length of *P. nigricans* was not correlated with the abundance of parasites. All parasites species presented aggregated distribution pattern with low degree of aggregation. The parasites species recorded except *E. urupaensis* are cited for the first time for *P. nigricans*.

Keywords: correlation; distribution pattern; metazoan parasites; parasitic index.

Fauna parasitária de *Prochilodus nigricans* (Prochilodontidae) de lagos de várzea da Amazônia brasileira

RESUMO

O *Prochilodus nigricans* é uma espécie importante para a pesca e aquicultura na Amazônia. Apesar de sua importância, pouco se conhece sobre sua fauna parasitária. Assim, o objetivo deste trabalho foi identificar os metazoários parasitas que ocorrem em *P. nigricans* coletados em lagos de várzea da Amazônia ocidental (Brasil). Trinta e sete *P. nigricans* foram examinados, sendo identificados *Tereancistrum curimba, Tereancistrum toksonum* e *Apenduculata discoidea* (Monogenoidea), *Neochinorhynchus curemai* (Acanthocephala), *Amplexibranchius bryconis, Brasergasilus* sp.1, *Brasergasilus* sp.2, *Ergasilus urupaensis, Miracetyma* sp., *Rhinergasilus piranhus* (Copepoda), *Argulus chicomendesi* e *A. multicolor* (Branchiura). O comprimento padrão de *P. nigricans* não teve correlação com a abundância parasitária. Todas as espécies parasitas apresentaram padrão de distribuição agregada com baixo nível de agregação. As espécies identificadas exceto *E. urupaensis* são citadas pela primeira vez para *P. nigricans*.

Palavras-chave: correlação, padrão de distribuição, índices parasitários, metazoários, parasitas.

Introduction

Prochilodus nigricans Spix & Agassiz, 1829 popularly known as curimata, is a detritivorous species which feeds on periphytic algae, microorganisms and decomposing organic matter (SANTOS et al., 2006). Is a migratory fish that can reach up to 45 cm in length, and 1,2 kg in weight (CASTRO; VARI, 2004; GIARRIZZO et al., 2015; SOARES et al., 2008). It can be found in several Amazonian landscapes biotypes, such as "várzea" (floodplain inundated by white water rivers) and "igapó" (floodplain inundated by black water rivers) forests, streams and rapids (LOPERA-BARRETO et al., 2008). *Prochilodus nigricans* has a high economic importance, being exploited in intensive and extensive aquaculture in the Brazilian Amazon (GONÇALVES; BATISTA, 2008). However, despite of importance of *P. nigricans*, little is known about its parasitic fauna.

For *P. nigricans*, only four parasite species are cited: the branchiuran *Dolops bidentata* Bouvier, 1899 (MALTA, 1982), the copepod *E. urupaensis* Malta, 1993 (MALTA, 1993) the monogenoidean *Rhinonastes pseudocapsaloideum* Kritsky, Thatcher & Boeger, 1988, and the trematode *Lecithobotrioides elongates* Thatcher, 1999 (MATHEWS et al., 2013). Thus, the aim of this study was to investigate the metazoan parasites that occur in *P. nigricans* from Brazilian Amazon floodplain lakes, including its parasitic index, the influence of the host's length on the abundance of parasite species, and its distribution pattern.

Materials and Methods

Between March and December 2013, 37 *P. nigricans* were captured in five floodplain lakes of the Solimões River: Lake Baixio (03°17'27, 2"S/ 60°04'29,6"W) in the township of Iranduba, Lake Preto (03°21'17, 1"S/ 60°37'28,6"W) in Manacapurú; Lake Ananá (03°53'54,8"S/ 61°40'18,4"W) in Anori; Lake Araçá (S03°45' 04,3" S/ 62°21' 25,9" W) in Codajás and Lake Maracá (03°50'32,8"S/ 62°34'32,4"W) in Coari and one lake of the Purus River: São Tomé (03°49' 39,0"S/ 61°25' 24,6" W). The lakes are fairly elliptical with "white water" coloration; their margins are dominated by aquatic plants. They present a maximum depth around 8.5 m in the full and minimum of 0.8 m in the dry season.

Fish were caught using 100 mm between adjacent nodes-meshed, 20 m long x 2 m high gillnets. For parasitological analysis, the fishes were quickly immersed in a 75 mg clove oil·L−1 and euthanized (CONCEA, 2013). Posteriorly, fishes were measured and weighed. After the necropsy, gills and nasal fossae were removed and preserved in formalin 5% and the digestive tract preserved in ethanol 70% for posterior analyses at the laboratory of Fish Parasitology (LPP) in the National Institute of Amazonian Research (INPA).

At the laboratory, the Monogenoidea species found were identified, preparing permanent slides. For the observation of sclerotized structures, monogenoideans were mounted unstained in Hoyer's medium and Gomori's trichrome was used to visualize internal structures. Whole mount preparations were made by means of the phenol balsam method according to THATCHER (2006). Copepods were identified by using permanent slides. The specimens were stained in 70% ethanol with small amounts of eosin and orange-G, dehydrated in pure phenol, cleared in methyl salicylate and mounted on microscope slides in Canada balsam (THATCHER, 2006). Branchiura parasites were collected from the gills, nasal fossae and body surface of the fish, preserved in 70% ethanol and clarified in glycerin. Acantocephalan individuals were collected from the gut and preserved in AFA (alcohol – formaldehyde and acetic acid) solution. For the identification the specimens were stained with Langeron's alcoholic carmine, cleared in Eugenol and mounted in Canada balsam as permanent slides. The ecological terms in parasitology follow BUSH et al. (1997).

Voucher specimens (Monogenoidea: INPA 725, INPA 726, INPA 727; Acantocephala: INPA 022; Copepoda: INPA 2299, INPA 2300 and Branchiura: INPA 2301, INPA 2302) were deposited in the Crustacean Collection of the National Institute of Amazon Research (INPA), Manaus, AM, Brazil.

The value of importance (BUSH; HOLMES, 1986) was used to verify the importance of each species in the metazoan parasite community. Species considered core were present in more than 66.66 % of the analyzed fish; secondary = presence between 33.33 % and 66.66 %; satellites = less than 33.33 %.

The Shapiro–Wilk W statistic was used to test normality of distributions. The possible correlation between abundance of parasites and host standard length was determined using Spearman's rank correlation (*rs*).

The variance-to-mean-ratio (VMR) and the Green index (GI) were used to examine dispersion patterns of parasite infracommunities (LUDWIG; REYNOLDS 1988). Statistical tests were applied to species that had presented prevalence higher than 10% (BUSH et al., 1990).

Results

The analysis of the *P. nigricans* demonstrated that this fish species was parasitized by 1,060 specimens belonging to 12 species being 3 species of Monogenoidea 1 Acanthocephala, 6 Copepoda and 2 Branchiura (Table 1). According to the value of importance, only *Tereancistrum curimba* Lizama, Takemoto & Pavanelli, 2004 and *T. toksonum* Lizama, Takemoto & Pavanelli, 2004 were considered secondary, while the other species were considered satellites. No core species was registered.

Table 1. Parasitic index of the metazoans in *Prochilodus nigricans* collected in western Amazon floodplain lakes (Brazil). FE = number of examined fish; FP = number of parasitized fish; IM = mean intensity of infection; MA = mean abundance; SD = standard deviation. TNP: total number of parasites.

Species of parasites	Site of infection	FE	FP	P(%)	TNP (ranges)	MI ± SD	MA
Apedunculata discoidea	Gills	37	6	16.2	187 (1-144)	31.2 ± 30.2	5.0
Tereancistrum curimba	Gills	37	21	56.8	268 (1-58)	12.8 ± 14.5	7.2
Tereancistrum toksonum	Gills	37	16	43.2	426 (1-190)	26.6 ± 41.9	11.5
Neoechinorhynchus curemai	Gut	37	2	5.4	4 (2)	2.0	0.1
Amplexibranchius bryconis	Gills	37	1	2.7	1	1.0 ± 0.3	0.03
Brasergasilus sp. 1	Gills	37	9	24.3	123 (1-36)	13.7 ± 13.0	3.3
Brasergasilus sp. 2	Gills	37	1	2.7	5	5.0 ± 1.3	0.1
Ergasilus urupaensis	Gills	37	8	21.6	24 (1-13)	3.0 ± 3.4	0.6
Miracetyma sp.	Gills	37	3	8.1	4 (1-2)	1.3 ± 0.6	0.1
Rhinergasilus piranhus	Nasal fossae	37	4	10.8	15 (1-12)	3.7 ± 3.2	0.4
Argulus chicomendesi	Body surface	37	1	2.7	1	1.0 ± 0	0.03
Argulus multicolor	Gills	37	1	2.7	1	1.0 ± 0	0.03

There was a negative non-significant correlation between the abundance of monogenoidean species and the standard length of the host (rs = -0.21, p = 0.19) and a positive non-significant correlation between the abundance of copepoda species and the standard length of the host (rs = 0.16, p = 0.33).

Values of the variance-to-mean-ratio (VMR > 1) and Green's index (GI < 1) for *Apedunculata discoidea* Cugliana, Cordeiro & Luque, 2009, *T. curimba, T. toksonum, Brasergasilus* sp.1, *Ergasilus urupaensis* Malta, 1993 and *Rhinoxenus piranhus* Kritsky, Boeger & Thatcher suggested an aggregate distribution of the parasites in the host with a low degree of aggregation.

Discussion

The opportunity to colonize new host species is related to the availability of suitable hosts for a successful colonization. Only hosts phylogenetically or ecologically related to their parasites will provide them with the necessary conditions for their survival and transmission (NOBLE et al., 1961). Parasites with direct life cycle, such as ectoparasites, are frequently found in high numbers in lentic environments. This type of environment is very favorable for the transmission and proliferation of these parasites (FLORES-CRESPO; FLORES, 2003). This may explained the predominance of ectoparasites in the metazoan parasite community of *P. nigricans* registered in this study.

Apedunculata discoidea was cited by CUGLIANNA et al. (2009) parasitizing the gills of *Prochilodus lineatus* (Valenciennes, 1836) from a fish farm in Pirassununga-São Paulo, Brazil and by MONTEIRO and BRASIL-SATO (2014) collected in the gills of *Prochilodus argenteus* Agassiz, 1829 from the São Francisco River. *Tereancistrum curimba* and *T. toksonum* were first described by LIZAMA et al. (2004) in *P. lineatus* from the Paraná River, Brazil. Posteriorly they were cited in the same host by TAKEMOTO et al. (2009). In this study, *A. discoidea*, *T. curimba* e *T. toksonum* were identified parasitizing the gills of *P. nigricans*, confirming the specificity of those species for the genus *Prochilodus*.

Neoechinorhynchus curemai Noronha, 1973, was found parasitizing *Prochilodus scrofa* Steindachner, 1881 and *P. lineatus* (Valenciennes, 1836) (NORONHA, 1984; MARTINS et al., 2001; SANTOS et al., 2005; LIZAMA et al., 2005). In the present study, this parasite is cited for the first time in *P. nigricans*, expanding the number of known host for this species. Apparently, this acantocephalan is specific to *Prochilodus species.* Our results support this hypothesis.

For *Prochilodus* species, the copepods *Gamidactylus jaraquensis* Thatcher & Boeger, 1984, *Gamispatulus* sp. *Amplexibranchius* sp. and *Ergasilus* sp. were found in *P. lineatus* collected from the Upper Paraná River floodplain (LIZAMA et al., 2005) and *E. urupaensis* was found in *P. nigricans* captured in the River Urupá, Rondonia (MALTA, 1993). In the present study, all copepod species, with exception of *E. urupaensis* are cited for the first in *P. nigricans.*

Up to now, only two branchiurans are cited in *Prochilodus* species: *Dolops bidentata* Bouvier, 1899 in *P. nigricans* (MALTA, 1982) and *Dolops* sp. in *P. lineatus* (Lizama et al. 2005). In this study, two new species are cited parasitizing *P. nigricans*. Additionally, *Argulus* species are recorded for the first time in *Prochilodus.*

Host size and age have an effect on parasite communities, since larger hosts are also older and have been exposed to parasite colonization for a longer period. Moreover, as fish body size increases, the body area increases, thus permitting a larger number of parasites to infect hosts (BELL; BURT 1991). The correlation patterns between the length of fish and the abundance of parasites may be significantly positive or negative or even non-significant (SAAD-FAREES; COMBES 1992). This is due to the intensity-dependent regulation (limitation of size and resources). The length of the host, considered an expression of its age, is one of the most important factors in parasite infrapopulation variation (LIZAMA et al., 2005).

Correlations are influenced by biological (physiology and immunology) and ecological (distribution dynamics) restrictions of populations hosts. Also by stochastic events and/or biotic interactions such as competition and dependent regulation of intensity. Such restrictions avoid high intensities, abundance and parasite richness (ALVES; LUQUE 2006). In this study, non-significant correlation of parasitic abundance with standard length of the host was found.

The aggregated distribution pattern tends to increase stability in the host-parasite relationship and may increase the reproductive efficiency of some adult parasites. In this kind of distribution severe effects caused by high infection intensity may be restricted to few individuals instead of affecting the whole population (DOBSON, 1990). The aggregated distribution pattern of the parasites of *P. nigricans* is in accordance with the typical distribution pattern found in fish parasites from natural environments and can be explained by the differences between the host populations (LUQUE et al., 1996). Thus, the aggregated utilization of fragmented resources favors species coexistence (MORAND et al., 1999), in this way; many individuals of the host population are not parasitized, while few hosts shelter many parasites (LUDWIG; REYNOLDS, 1988).

The presence of core species indicates the existence of stable and balanced populations, indicating higher colonization and growth rates (BUSH; HOLMES, 1986). The presence of secondary species suggests moderate colonization rates and the establishment of their populations in unsaturated sites by the core species, interacting to occupy the same habitat (BUSH; HOLMES, 1986). Satellite species with a low rate of colonization usually settle in an infracommunity with a basic structure already determined by core and secondary species, being able to establish themselves only in small numbers or in existing random gaps (BUSH; HOLMES, 1986).

In this study, the absence of core species and the presence of some secondary and several satellite species in the gills of *P. nigricans* can be explained with the high number of species registered for this host. The absence of core species increases the availability of the colonization area, where small groups of secondary and satellite species can be established. Possibly this is a strategy used by these parasite species to cohabit in the gills of *P. nigricans*. In this way the secondary species registered in this study, are established first and later in unoccupied spaces, the satellite species are established in smaller groups.

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