Are similar the parasite communities structure of *Trachelyopterus coriaceus* and *Trachelyopterus galeatus* (Siluriformes: Auchenipteridae) in the Amazon basin?

São similares a estrutura das comunidades de parasitos de *Trachelyopterus coriaceus* e *Trachelyopterus galeatus* (Siluriformes: Auchenipteridae) na bacia amazônica?

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Abstract

The aim of this study was to compare the parasite communities in two sympatric host populations, *Trachelyopterus coriaceus* and *Trachelyopterus galeatus*, which were caught in tributary of the Amazon River in Brazil. All the specimens of *T. galeatus* and *T. coriaceus* were infected by one or more parasites, such as *Ichthyophthirius multifiliis*, *Tripartiella tetramerii*, *Trichodina nobilis*, *Cosmetocleithrum striatuli*, *Contracaecum* sp., *Cystidicoloides* sp., *Dadaytremoides parauchenipteri* and *Gorytocephalus spectabilis*. Seven species were common to both host fish, and there were 1-5 parasite species per host. In both hosts, trichodinids were dominant. Aggregate dispersion of ectoparasites and endoparasites was observed, with greater aggregation among endoparasites. Only the ectoparasites species showed differences in intensity and/or abundance. However, the parasite communities of the two hosts were taxonomically similar (99%) and characterized by high prevalence and high abundance of ectoparasites, but with low diversity, prevalence and abundance of endoparasites. *Trachelyopterus galeatus*, the host with the larger body size, presented greater variation of Brillouin diversity and evenness, while *T. coriaceus* had higher Berger-Parker dominance values and total numbers of parasites. This first study on these parasites of *T. galeatus* and *T. coriaceus* showed that the life mode, size of the hosts and the availability of infective forms of the parasites were the main factors that influenced the parasite communities structure.

Keywords: Amazon, auchenipterid, diversity, infection, parasites.

Resumo

O objetivo deste estudo foi comparar as comunidades, prevalência, intensidade, abundância e interações parasito-hospedeiro em duas populações de hospedeiros simpatricos, *Trachelyopterus coriaceus* e *Trachelyopterus galeatus* de um tributário do sistema do Rio Amazonas, no Brasil. Todos os espécimes de *T. galeatus* e *T. coriaceus* estavam infectados por um ou mais parasitos, tais como *Ichthyophthirius multifiliis*, *Tripartiella tetramerii*, *Trichodina nobilis*, *Cosmetocleithrum striatuli*, *Contracaecum* sp., *Cystidicoloides* sp., *Dadaytremoides parauchenipteri* e *Gorytocephalus spectabilis*. Sete espécies de parasitos foram comuns para ambos os peixes hospedeiros e houve de 1-5 espécies de parasitos por hospedeiro. Em ambos os hospedeiros houve dominância de espécies de tricodinídeos. A dispersão dos ectoparasitos e endoparasitos foi agregada, mas a maior agregação foi de endoparasitos. Somente espécies de ectoparasitos mostraram diferenças na intensidade e/ou abundância. Entretanto, as comunidades parasitárias dos dois hospedeiros foram taxonomicamente semelhante (99%) e caracterizada por alta prevalência e abundância de ectoparasitos, mas com baixa diversidade, prevalência e abundância de endoparasitos. *Trachelyopterus galeatus*, com maior tamanho corporal, apresentou maior variação da diversidade Brillouin e uniformidade, enquanto *T. coriaceus* teve maiores valores de dominância de Berger-Parker e número total de parasitos. Este primeiro estudo sobre estes parasitos de *T. galeatus* e *T. coriaceus* mostrou que o modo de vida, tamanho dos hospedeiros e disponibilidade de formas infectantes de parasitos foram os principais fatores que influenciaram a estrutura das comunidades dos parasitos encontrados.

Palavras-chave: Amazônia, auchenipterídeo, diversidade, infecção, parasitos.

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Introduction

Aucheipteridae are Siluriformes with around 21 genera and 64 species distributed in freshwater rivers in South America, from Argentina to Panamá (BURGESS, 1989; FROESE & PAULY, 2015). Most of these species have crepuscular or nocturnal habits, swimming frenetically close to the water surface in search of insects or other food items. During the daytime, they remain hidden in crevices or holes, or under tree trunks and branches. *Trachelyopterus coriaceus* Valenciennes, 1840, and *Trachelyopterus galeatus* Linnaeus, 1766, are congeneric phylogenetically related Auchenipteridae (BIRINDELLI, 2014) of small size that reach a maximum of 22 cm, and reach sexual maturity at a length of around 11 cm. Both of these fish species are found in wet areas of floodplains, and thus, *T. galeatus* and *T. coriaceus* are adapted to these hypoxic environments. The diet of *Trachelyopterus* spp. generally consists of insects, rotifers, mollusks and crustaceans (ANDRADE-LÓPEZ & MACHADO-ALLISON, 2009; MESQUITA et al., 2011; FROESE & PAULY, 2015). These two species of *Trachelyopterus* are not listed by the IUCN as endangered. Therefore, do these two siluriforms Auchenipteridae of the Amazon basin of Brazil have similar parasite communities structure?

The Igarapé Fortaleza basin is a singular ecosystem that is located in the eastern Amazon region of northern Brazil, and is an ecosystem highly influenced by the Amazon River system. It consists of linked fluvial physical systems that provide freshwater drainage, and is influenced by the high rainfall of the Amazon region and the daily tides of the Amazon River (GAMA & HALBOTH, 2004; TAVARES-DIAS et al., 2013; BITTENCOURT et al., 2014a). The waters that periodically spread out across the floodplain are rich in nutrients, because of the rapid decomposition of grasses, animal remains and the humus layer of the forest. This leads to growth of new vegetation (Poaceae, Cyperaceae, Fabaceae, Onagraceae, Araceae, Asteraceae, Convolvulaceae and Lentibulariaceae) and invertebrate biomass (insects, zooplanktonic crustaceans and mollusks), which are used as food by fish (GAMA & HALBOTH, 2004; TAKIYAMA et al., 2012), such as by *T. galeatus* and *T. coriaceus*. This ecosystem has been strongly influenced by eutrophication due to urbanization, as observed with regard to the parasite community of *Curimata cyprinoides* Linnaeus, 1766 (TAVARES-DIAS et al., 2013). Moreover, the Igarapé Fortaleza basin suffers a strong influence of invasion from *Oreochromis niloticus*, an exotic fish in Brazil (BITTENCOURT et al., 2014a). However, studies on parasite communities of *T. galeatus* and *T. coriaceus* has been not addressed.

In populations of wild fish, ectoparasites and endoparasites of different taxonomic groups can generally be found (LUNASCHI, 1989; TAKEMOTO & LIZAMA, 2009; KOHN et al., 2011; MESQUITA et al., 2011; NEVES et al., 2013; TAVARES-DIAS et al., 2013). The possibility of obtaining numerous repeats and quantifying the entirety of the parasite population distributed in different infection sites in fish facilitates detection of patterns within population dynamics, interspecies relationships and feeding relationships. These may reveal the potential that fish could have for participating as intermediate, paratenic or definitive hosts in the ecological systems of endohelminths (TAKEMOTO & LIZAMA,

2009; MESQUITA et al., 2011; TAVARES-DIAS et al., 2013). However, the parasite community structure may be influenced by the environmental and a variety of other factors that relate mainly to the ecology and physiology of the host, seasonality, habitat quality and presence of larval stages of parasites in invertebrate transmitters (TAKEMOTO & LIZAMA, 2009; KOHN et al., 2011; NEVES et al., 2013; TAVARES-DIAS et al., 2013).

In wild populations of *T. galeatus* of the Brazil, only the following helminths such 2 species of digeneans, 3 nematodes and 1 cestode are known (PAVANELLI & SANTOS, 1990; FERNANDES & KOHN, 2001; DIAS et al., 2006; TAKEMOTO & LIZAMA, 2009; KOHN et al., 2011). In wild populations of *T. galeatus* of the Argentina, there have been reports only 2 species digeneans (LUNASCHI, 1989; LUNASCHI & SUTTON, 1995). However, the parasite communities that *T. galeatus* and *T. coriaceus* harbor are still unknown and there are also no studies on their structure. In addition, given that these congeneric hosts present similar biological and behavioral characteristics and are phylogenetically close, this may favor the presence of similar parasite communities (GONZÁLEZ & OLIVA, 2006; ALARCOS & TIMI, 2012). Thus, the present study compared the parasite communities, prevalence, intensity, abundance and parasite-host interactions of *T. galeatus* and *T. coriaceus* living in sympatry in a tributary of the Amazon River system, northern Brazil.

Materials and Methods

Fish and capture location

Between September and December 2012, 37 specimens of *T. galeatus* and 35 specimens of *T. coriaceus* were caught in the Igarapé Fortaleza basin, tributary of the Amazon River system in the municipality of Macapá (state of Amapá), in northern Brazil, for parasitological analyses. All the fish were caught using hand nets and gillnets (15 to 25 mm) and were transported alive to the Laboratory for Aquatic Organism Health at Embrapa Amapá (Macapá), for necropsy. This study was developed in accordance with the principles adopted by the Brazilian College of Animal Experimentation (Cobea).

Parasites collection and analysis procedures

The fish were weighed (g) and their lengths were measured (cm). Following this, the gills and gastrointestinal tract were examined to ascertain whether any protozoan and metazoan parasites were present. All the parasites were collected, fixed, conserved, quantified and stained for identification (EIRAS et al., 2006). The ecological terms used were those recommended by Rohde et al. (1995) and Bush et al. (1997). Voucher specimens were deposited at the Scientific and Technological Research Institute of the State of Amapá (IEPA), in the Scientific Collection Curation Office for the Fauna of Amapá (CCFA), under accession number IEPA 033-043-P.

The Brillouin diversity index (*HB*), richness of parasite species, evenness (*E*) and Berger-Parker dominance index (*d*) were calculated for each parasite infracommunity (MAGURRAN, 2004), using the

Diversity software (Pisces Conservation Ltd, UK). The dispersion index (ID) and discrepancy index (*D*) were calculated using the Quantitative Parasitology 3.0 software, in order to detect the distribution pattern of the parasite infracommunities (RÓZSA et al., 2000), for species with prevalence > 10%. The significance of the ID, for each infracommunity, was tested using the *d*-statistic (LUDWIG & REYNOLDS, 1988). Similarity in parasite communities between host populations was compared using the Jaccard index and Morisita index (LUDWIG & REYNOLDS, 1988; MAGURRAN, 2004). Both similarity indices were calculated using the Past software (Paleontological Statistics version 3.0).

Body weight (g) and total length (cm) were used to calculate the relative condition factor (Kn) of the fish using the length-weight relationship (W = aL^b) after logarithmic transformation of length and weight and subsequent adjustment of two straight lines, thus obtaining lny = lnA + Blnx (LE-CREN, 1951).

Data analyses

To compare prevalence between *T. galeatus* and *T. coriaceus*, the chi-square test (χ^2) was used, followed by the Yates correction. The intensity, abundance, species richness, diversity (*HB*), evenness (*E*) and dominance (*d*) were compared between the two hosts using the Mann-Whitney test (*U*). The Shapiro-Wilk test was used to determine whether parasite abundance data followed a normal distribution pattern. Spearman's correlation coefficient (*rs*) was used to determine possible correlations of the total length and body weight with parasites abundance, the Brillouin index (*HB*) and the richness of parasite species (ZAR, 2010).

Principal component analysis (PCA) was carried out to compare the ways in which body and diversity influenced the parasite communities of *T. galeatus* and *T. coriaceus*. This analysis was performed using the Past software (Paleontological Statistics, version 3.0).

Physical and chemical parameters of the water

The mean temperature (28.5 ± 0.25 °C), dissolved oxygen, pH (5.5 ± 0.39), electrical conductivity (0.15 ± 0.17 μ/cm), turbidity (40.9 ± 17.9 UNT) and total dissolved solids (0.02 ± 0.0 g/L) were measured using a multiparameter probe (Horiba, model U-52). The ammonia level (0.52 ± 0.41 mg/L), alkalinity (26.6 ± 5.7 mg/L) and hardness (23.3 ± 5.7 mg/L) were measured

using a kit (Alfakit®), and transparency (31.8 ± 13.5 cm) was measured using a Secchi disc.

Results

All of the 72 specimens of *T. galeatus* and *T. coriaceus* examined were parasitized by one or more species. Species of Protozoa, Monogenoidea, Digenea and Nematoda were collected from both hosts. However, the dominant species were *Tripartiella tetramerii* Martins, Marchiori, Bittencourt & Tavares-Dias, 2016 and *Trichodina nobilis* Chen, 1963 (Trichodinidae), followed by *Ichthyophthirius multifiliis* Fouquet, 1876 (Ichthyophthiriidae). *Gorytocephalus spectabilis* Machado, 1959 (Neoechinorhynchidae) was only found in the intestine of *T. coriaceus* (Table 1).

The prevalence (χ^2 = 3.657; p = 0.130) and mean abundance (*U* = 494.5; p = 0.0001) of *I. multifiliis* were similar for *T. coriaceus* and *T. galeatus*, but the mean intensity (*U* = 287.5; p = 0.0002) was greater in *T. galeatus*. The prevalence (χ^2 = 5.083; p = 0.733) of *T. tetramerii* and *T. nobilis* was similar for *T. coriaceus* and *T. galeatus*, but the mean intensity (*U* = 278.0; p = 0.0004) and mean abundance (*U* = 278.0; p = 0.0001) were greater in *T. coriaceus*. Also in *T. coriaceus*, the prevalence (χ^2 = 6.192; p = 0.039), mean intensity (*U* = 131.5; p = 0.0001) and mean abundance (*U* = 131.5; p = 0.0001) of *Cosmetocleithrum striatuli* Abdallah, Azevedo & Luque, 2012 (Dactylogyridae) were greater than in *T. galeatus*.

The prevalence (χ^2 = 3.576; p = 0.1020), mean abundance (*U* = 527.0; p = 0.175) and mean intensity (*U* = 40.0; p = 0.378) of *Dadaytremoides parauchenipteri* Lunaschi, 1989 (Cladorchiidae) were similar for *T. coriaceus* and *T. galeatus*. The prevalence (χ^2 = 0.183; p = 0.9202), mean intensity (*U* = 20.5; p = 0.943) and mean abundance (*U* = 624.0; p = 0.791) of *Contracaecum* sp. were similar for *T. coriaceus* and *T. galeatus*. The prevalence (χ^2 = 6.00; p = 0.014) and mean abundance (*U* = 443.0; p = 0.021) of *Cystidicoloides* sp. were greater in *T. galeatus* than in *T. coriaceus*, but the mean intensity (*U* = 69.5; p = 0.334) was similar for the two hosts.

The parasite species in *T. galeatus* and *T. coriaceus* presented an aggregated distribution pattern (Table 2), which is a common pattern for freshwater fish.

The richness of parasite species in *T. galeatus* and *T. coriaceus* was similar, but the Brillouin diversity index and evenness were greater for *T. galeatus*, while the Berger-Parker dominance was greater

Table 1. Parasites of two Auchenipteridae fish in a tributary in the Amazon River system (Brazil).

Host species	*Trachelyopterus galeatus* (N = 37)					*Trachelyopterus coriaceus* (N = 35)				
Parasite species	P (%)	MI	MA	FD (%)	SI	P (%)	MI	MA	FD (%)	SI
Ichthyophthirius multifiliis	83.8	958.7	803.3	0.1186	Gills	97.1	636.0	617.9	0.0423	Gills
Tripartiella tetramerii and *Trichodina nobilis*	86.5	6878.4	5948.9	0.8780	Gills	100	13894.4	13894.4	0.9512	Gills
Cosmetocleithrum striatuli	83.8	23.2	19.4	0.0029	Gills	100	93.3	93.3	0.0064	Gills
Dadaytremoides parauchenipteri	40.5	2.2	0.9	-	Intestine	20.0	3.3	0.7	-	Intestine
Contracaecum sp. (larvae)	13.5	3.6	0.5	-	Intestine	17.1	2.5	0.4	-	Intestine
Cystidicoloides sp. (larvae)	54.1	5.1	2.7	0.0004	Intestine	25.7	3.0	0.8	-	Intestine
Gorytocephalus spectabilis	0	0	0	0	-	8.6	1.3	0.1	-	Intestine

P = Prevalence; MI = Mean intensity; SD = Standard deviation; MA = Mean abundance; FD = Frequency of dominance; SI = Site of infection.

for *T. coriaceus* (Table 3). In *T. galeatus*, the Brillouin index (*HB*) did not show any correlation with length ($rs = -0.235$; $p = 0.133$) and weight ($rs = -0.225$; $p = 0.153$); nor did the parasite richness with the length ($rs = -0.154$; $p = 0.331$) and weight ($rs = -0.098$; $p = 0.535$). In *T. coriaceus*, the Brillouin index (*HB*) did not show any correlation with the hosts' ($rs = 0.094$; $p = 0.552$) and weight ($rs = 0.026$; $p = 0.869$); nor did the parasite richness with the length ($rs = -0.140$; $p = 0.375$) and weight ($rs = -0.106$; $p = 0.506$). In both *T. galeatus* and *T. coriaceus*, the predominant level of parasitism was 3-4 species per host (Figure 1).

In *T. coriaceus*, the abundance of *T. tetramerii*, *T. nobilis* and *C. striatuli* showed a negative correlation with host length. In *T. galeatus*, the abundance of *Tripartiella tetramerii* presented a positive correlation with host length and weight, while the abundance of *C. striatuli* presented a negative correlation with host length (Table 4).

Principal component analysis based on the hosts' body and diversity parameters showed that for Brillouin diversity, evenness, species richness of parasites and Berger-Parker dominance were the main factor correlated with *T. coriaceus* and *T. galeatus*.

Table 2. Index of dispersion (ID), *d*-statistic, discrepancy index (D) and frequency of dominance (FD) for the infracommunities of parasites in species of Auchenipteridae in the Amazon River system (Brazil).

Hosts	*Trachelyopterus galeatus*			*Trachelyopterus coriaceus*		
Parasites	ID	*d*	D	ID	*d*	D
Ichthyophthirius multifiliis	2.366	4.65	0.359	2.103	3.85	0.317
Tripartiella sp. and *Trichodina nobilis*	2.580	5.22	0.375	1.976	3.49	0.277
Cosmetocleithrum striatuli	2.352	4.61	0.418	2.186	4.09	0.306
Dadaytremoides parauchenipteri	1.702	2.66	0.677	2.360	4.56	0.826
Contracaecum sp.	1.833	3.08	0.875	2.392	4.65	0.856
Cystidicoloides sp.	3.461	7.38	0.659	2.638	5.29	0.810

Table 3. Mean diversity indexes and body parameters ± standard deviation and ranges (in parentheses) for the parasites community in Auchenipteridae species in the Amazon River system (Brazil). *U*: Mann-Whitney.

Parameters	*Trachelyopterus galeatus* (N = 37)	*Trachelyopterus coriaceus* (N = 35)	*U*	*p*
Body length	10.8 ± 2.0 (7.5-14.5)	9.3 ± 1.5 (6.6-13.5)	364.0	0.001
Body weight	20.1 ± 13.2 (4.0-52.0)	10.7 ± 7.1(4.0-42.0)	354.5	0.001
Brillouin (*HB*)	0.32 ± 0.16 (0-0.65)	0.26 ± 0.12 (0.03-0.56)	433.0	0.016
Species richness	3.62 ± 0.92 (1-5)	3.69 ± 0.80 (2-5)	643.5	0.964
Evenness (*E*)	0.18 ± 0.09 (0-0.38)	0.12 ± 0.06 (0.01-0.29)	460.0	0.015
Berger-Parker (d)	0.80 ± 0.06 (0.72-1.00)	0.92 ± 0.04 (0.79-1.00)	400.0	0.005
Total number of parasites	250,700	511,261	-	-
Number of ectoparasites	3	3	-	-
Number of endoparasites	3	4	-	-
Endoparasites (adult)	1	2	-	-
Endoparasites (larval)	2	2	-	-
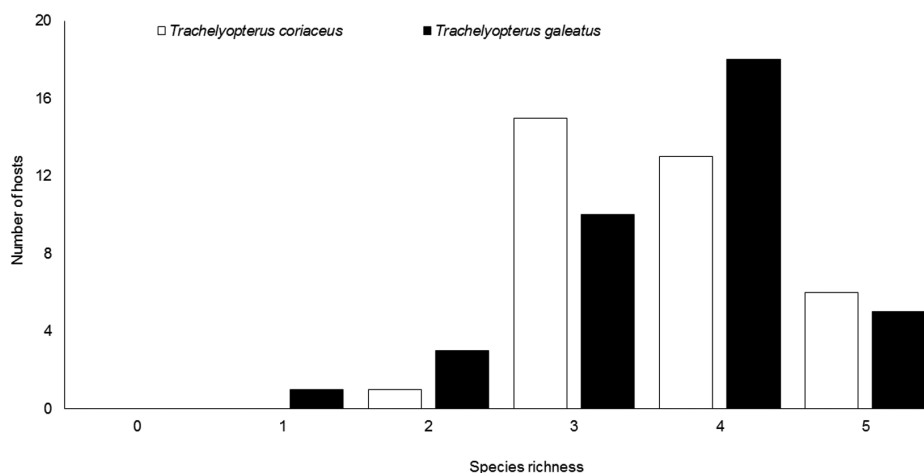
Figure 1. Species richness of parasites for species of Auchenipteridae in the Amazon River system (Brazil).

The cumulative variance explained by the variables used was 83.9% for both axes (Figure 2).

The Jaccard index (J = 0.86) and Morisita index (Cλ = 0.99) demonstrated similarity between the parasite communities of *T. coriaceus* and *T. galeatus*. The multivariate analysis based on the component community of the parasites of *T. coriaceus* and

T. galeatus allowed observing that there is no separation among these hosts and only *I. multifiliis* was the species with least importance in this analysis (Figure 3).

For *T. galeatus*, the equation for the weight-length relationship was $Wt = 0.0034Lt^{3.5798}$ ($r^2 = 0.952$); and for *T. coriaceus*, it was $Wt = 0.0091Lt^{3.1295}$ ($r^2 = 0.890$). Thus, both of these relationships

Table 4. Spearman's correlation coefficient (*rs*) for the abundance of parasites, in relation to the total length (cm) and body mass (g) for species of Auchenipteridae in the Amazon river system (Brazil).

Hosts	*Trachelyopterus galeatus* (N = 37)				*Trachelyopterus coriaceus* (N = 35)			
	Total length		Body weight		Total length		Body weight	
Parasites	*rs*	p	*rs*	p	*rs*	p	*rs*	p
Ichthyophthirius multifiliis	0.2362	0.1593	0.2245	0.1815	0.0174	0.9186	–0.0801	0.6376
Tripartiella sp. and *Trichodina nobilis*	0.3258	0.0490	0.3784	0.0209	–0.4429	0.0060	–0.3223	0.0516
Cosmetocleithrum striatuli	–0.1980	0.02401	–0.1589	0.3475	–0.3403	0.0393	–0.2375	0.1568
Dadaytremoides parauchenipteri	–0.2201	0.1905	–0.1927	0.2530	0.2718	0.1035	0.3019	0.0693
Contracaecum sp.	0.0669	0.6939	0.0534	0.7535	0.0873	0.6074	0.0367	0.8291
Cystidicoloides sp.	–0.0642	0.7058	–0.0863	0.6117	–0.0553	0.7452	–0.1357	0.4231
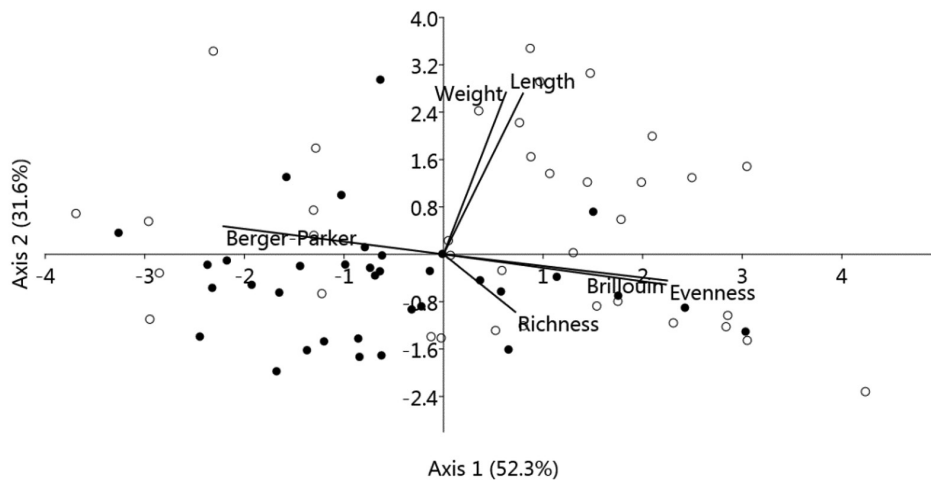
Figure 2. Scatterplot scores from the principal component analysis (PCA) on factors influencing the parasites component communities of *Trachelyopterus galeatus* (○) and *Trachelyopterus coriaceus* (●) in the Amazon River system (Brazil).
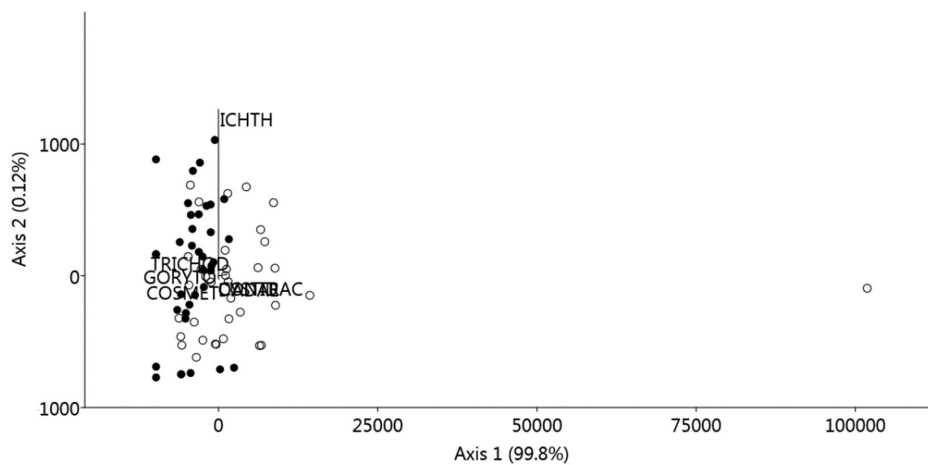
Figure 3. Scatterplot scores from the principal component analysis (PCA) of the parasites component communities of *Trachelyopterus galeatus* (○) and *Trachelyopterus coriaceus* (●) in the Amazon River system (Brazil). ICHTH: *Ichthyophthirius multifiliis*, COSMET: *Cosmetocleithrum striatuli*, TRICHOD: *Tripartiella* sp. and *Trichodina nobilis*, DADAY: *Dadaytremoides parauchenipteri*, CONTRAC: *Contracaecum* sp., CYSTID: *Cystidicoloides* sp., GORYTO: *Gorytocephalus spectabilis*.

were therefore allometrically positive, which indicates that there was greater increase in size than in body weight.

Discussion

For populations of *T. galeatus* of diverse localities in the Brazil, *Microrchis oligovitellum* Lunaschi, 1987; *Clinostomum complanatum* Rudolphi, 1814; *Cangatiella arandasi*; *Contracaecum* sp.; *Goezia* sp. and *Cucullanellus* sp. (PAVANELLI & SANTOS, 1990; FERNANDES & KOHN, 2001; DIAS et al., 2006; TAKEMOTO & LIZAMA, 2009; KOHN et al., 2011) have been recorded. For wild populations of *T. galeatus* in Argentina, only *Creptotrema creptotrema* Travassos, Artigas and Pereira, 1928 and *Dadaytremoides parauchenipteri* Lunaschi, 1989 (LUNASCHI, 1989; LUNASCHI & SUTTON, 1995) have been reported. However, among all these helminth species only *Contracaecum* larvae and *D. parauchenipteri* were also found on the hosts of this study.

This first study on the parasitic fauna of *T. coriaceus* and *T. galeatus* showed that they had similar richness of species and component community. Body size, diversity and evenness were greater for *T. galeatus*, but body size did not influence the diversity and richness of parasite species, in either of the two hosts. In these two hosts in the Amazon region, the dominant species were *T. tetramerii* and *Trichodina nobilis*, followed by *I. multifiliis*. These protozoans are typical of lentic-eutrophized environments like the hydrographic basin of this study (TAVARES-DIAS et al., 2013, 2014; BITTENCOURT et al., 2014b). In addition, in *T. coriaceus* and *T. galeatus*, the greatest richness of parasites was in species of helminths, with predominance of endoparasites of relatively high prevalence and low abundance, but only two endoparasites were found in larval stage (*Contracaecum* sp. and *Cystidicoloides* sp.). Several variables may influence the presence of endoparasites species, especially exposure to infective forms, which are directly acquired through the hosts' feeding (MOREIRA et al., 2009; TAKEMOTO & LIZAMA, 2009; MESQUITA et al., 2011; TAVARES-DIAS et al., 2013). It is well known that the diet of the fish can be deduced from trophically transmitted parasites and because most endoparasites are associated with a specific ecological niche and diet, high diversity in host parasite fauna is often a result of a diverse host diet. Hence, a diverse parasitic communities of trophically transmitted parasites may indicate that the host population consumed a diversity of prey in habitat (WILSON & HUBSCHMAN, 1985; MORAVEC, 2007; TARASCHEWSKI, 2008; MOREIRA et al., 2009; MORAVEC, 2009; NEVES et al., 2013; TAVARES-DIAS et al., 2013; BITTENCOURT et al., 2014b; TAVARES-DIAS et al., 2014).

The ectoparasites and endoparasites of *T. coriaceus* and *T. galeatus* presented aggregated dispersion, but endoparasites infections were the more aggregated. Aggregated dispersion patterns for ectoparasites and endoparasites have also been described in other freshwater hosts (MESQUITA et al., 2011; TAVARES-DIAS et al., 2014; AMARANTE et al., 2015), and these have been attributed to factors relating to the hosts, parasites and environment. These factors include formation of schools of fish, taxon in relation to sex, habitat, presence of parasite larvae, feeding habits and length of the hosts and the genetic and immune heterogeneity of

the hosts (ROHDE et al., 1995; TAVARES-DIAS et al., 2014; AMARANTE et al., 2015).

The levels of infection due to *I. multifiliis* in *T. coriaceus* and *T. galeatus* were similar. This ectoparasite ciliate, which does not have parasitic specificity, occurs more frequently in fish in farmed environments, influenced by factors related to the parasite and host, and also by the physical and chemical characteristics of the water, such as dissolved oxygen levels, pH, hardness, alkalinity and temperature (WEI et al., 2013; FORWOOD et al., 2015). However, this protozoon has wide geographic distribution and can parasitize fish on all continents. Severe infections may also cause mortality in populations of wild fish, because *I. multifiliis* has the capacity to reproduce rapidly (RAISSY et al., 2010; FORWOOD et al., 2015), when the environmental conditions are favorable. This was the first record of *I. multifiliis* for *T. coriaceus* and *T. galeatus*.

In *T. coriaceus* and *T. galeatus*, the prevalence of *T. tetramerii* and *T. nobilis* was similar for both hosts, but the intensity and abundance were higher in *T. coriaceus*. Moreover, the abundance of these trichodinids was higher in individuals of *T. galeatus* of greater size and was lower in individuals of *T. coriaceus* of greater length. In populations of wild fish, infections due to species of trichodinids are more frequent in environments that are eutrophized and have low oxygen levels (BASSON & VAN AS, 2002; TAVARES-DIAS et al., 2014), like the Igarapé Fortaleza basin. This was the first record of *T. tetramerii* and *T. nobilis* for *T. coriaceus* and *T. galeatus*.

Cosmetocleithrum striatuli, a monogenoidean originally described in *Trachelyopterus striatulus* Steindachner, 1877, in the Guandu River, Southern Brazil region (ABDALLAH et al., 2012; SILVEIRA et al., 2013), showed a higher level of infection in adults of *T. coriaceus* than in subadults of *T. galeatus*, in the present study. These differences occurred because smaller and therefore younger individuals of *T. coriaceus* were more parasitized. In *T. coriaceus*, the abundance of *C. striatuli* showed a negative correlation with host length, while in *T. galeatus* the correlation was weak. These distinct results were due to differences in the host size. Thus, since *C. striatuli* was previously only known in *T. striatulus* (COHEN et al., 2013), the present paper provides the first report of this monogenoidean for *T. galeatus* and *T. coriaceus*.

Gorytocephalus spectabilis only parasitized *T. coriaceus*, and at low infection levels, which were similar to those reported for *Aquidens tetramerus* Heckel, 1840; *Heros efasciatus* Heckel, 1840; *Chaetobranchus flavescens* Heckel, 1840; and *Satanoperca jurupari* Heckel, 1840 - all these hosts were also from the ecosystem of this study (BITTENCOURT et al., 2014b; TAVARES-DIAS et al., 2014). Although congeneric host species have similar biological and behavioral characteristics and are therefore potential hosts for parasitic fauna that is also similar, closely related species may also exhibit divergent characteristics that allow them to coexist, such as in relation to some trophic traits (GUIDELLI et al., 2009). The absence of *G. spectabilis* in *T. galeatus* in this study indicates that despite the overlapping of living, feeding and environmental habits, this host did not have any contact with the infective forms of this endohelminth through trophic means. Species of Neoechinorhynchidae in freshwater fish have life cycles involving a definitive host and an intermediate host, which may be arthropods (amphipods, ostracods, isopods or copepods). However, some

species have fish species as paratenic or definitive host, when they ingest an invertebrate that is an intermediate host or a small fish that serves as a paratenic host (WILSON & HUBSCHMAN, 1985; TARASCHEWSKI, 2008). Despite the low abundance of *G. spectabilis* in *T. coriaceus* and *T. galeatus*, these fish seem to be definitive hosts in the environment studied here. This was the first record of *G. spectabilis* for *T. coriaceus* and *T. galeatus*.

Trachelyopterus coriaceus and *T. galeatus* showed similar low levels of infection by larvae of *Contracaecum* sp. These larvae are anisakid with parasitic specificity and, during their larval stage; their primary hosts are microcrustaceans (MORAVEC, 2009; MOREIRA et al., 2009). In the adult phase, piscivorous birds are their definitive hosts and fish are paratenic hosts (MORAVEC, 2009). The levels of infection due to larvae of *Cystidicoloides* sp. were higher in *T. galeatus* than in *T. coriaceus*, thus indicating that *T. galeatus* had greater contact with the infective forms of this endohelminth. In Brazil, only *Cystidicoloides fischeri* Travassos, Artigas and Pereira, 1928, and *Cystidicoloides izecksohni* Fabio, 1982, are known to parasitize different species of fish (LUQUE et al., 2011). For Cystidicolidae, species of crustaceans are the intermediate hosts and fish are paratenic or definitive hosts during their life cycle. However, the adult forms of these parasites occur in adult piscivorous fish, which are the definitive hosts (MORAVEC, 2007). Therefore, the presence of larvae of *Cystidicoloides* sp. indicates that adults of *T. coriaceus* and subadults of *T. galeatus* are paratenic hosts for this nematode in the ecosystem of this study.

Dadaytremoides paraucheniipteri, a digenean that was originally described in *T. galeatus* from Argentina (LUNASCHI, 1989), showed similar levels of infection for *T. coriaceus* and *T. galeatus* in the present study. This species of Cladorchiidae had not previously been reported as parasitizing other species of fish in South America (KOHN et al., 2007) and therefore this was the first record of *D. paraucheniipteri* in Brazil. Moreover, this endoparasite seems to have wide geographic distribution and primary association with species of siluriform Auchenipteridae. Although the life history of *D. paraucheniipteri* is unknown, Thatcher & Jégu (1996) stated that species of Cladorchiidae have a life cycle in which cercariae are released from infected snails and, through encysting on aquatic vegetation, form metacercariae that are then consumed by host fish. Given that in the ecosystem of this study, *T. coriaceus* and *T. galeatus* live close to aquatic vegetation; this favors encounters between these hosts and metacercariae, i.e. the infective forms of *D. paraucheniipteri*. Therefore, *T. coriaceus* and *T. galeatus* are definitive hosts for this endohelminth, in the environment investigated here.

In summary, the richness of endoparasites with a complex life cycle in *T. coriaceus* and *T. galeatus* indicates that in the environment that these fish inhabit, their diet consists mainly of molluskand crustacean species. The size and behavior of these hosts, richness of parasites and availability of infective forms of intermediate hosts that make up the diet of these Siluriformes were the main factors influencing similar parasite communities. The parasite communities of these Amazonian hosts were characterized by high prevalence and high abundance of ectoparasites, but with low diversity, prevalence and abundance of endoparasites. Furthermore, the phylogenetic and taxonomic proximity of the hosts was also a strong influence on the parasite species, once the parasite communities of these two hosts were taxonomically similar (99%). Finally, the external

and internal host environment influenced the few differences in prevalence, intensity and abundance of parasites.

Acknowledgements

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