Helminth fauna of *Astyanax fasciatus* Cuvier, 1819, in two distinct sites of the Taquari River, São Paulo State, Brazil

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Abstract

This study assessed the helminth fauna of *Astyanax fasciatus* in two distinct sites of the Taquari River, São Paulo State, with 30 individuals sampled in a lotic site and 30 in a lentic site, recording the monogeneans: *Cacatuocotyle paranaensis, Characithecium costaricensis, Diaphorocleidus kabatai, Jainus* sp., *Notozothecium* sp. and *Gyrodactylus* sp., the digenean *Antorchis lintoni* and no-identified metacercariae; the nematode *Procamallanus (Spirocamallanus) inopinatus* and no-identified larvae. The mean abundances of total monogeneans (U = 1053; p = 0.042) and *C. costaricensis* (U = 1107; p = 0.005) were higher in the lotic site. This difference may be due to the higher density of the host population in the lotic site, and the water transparence in lentic environments that prevents *A. fasciatus* to form shoals, precluding the exchange of parasites with direct cycle within a host population. This study is the first report of the helminth fauna of *A. fasciatus* in the Taquari River, with ten *taxa* recorded, and reports *A. fasciatus* as a new host for *Notozothecium* sp. and *C. paranaensis*.

Keywords: Neotropical fish, *Astyanax fasciatus*, parasites, Reservoir.

Fauna de helmintos de *Astyanax fasciatus* Cuvier, 1819, em dois locais distintos do rio Taquari, estado de São Paulo, Brasil

Resumo

Este estudo avaliou a helmintofauna de *Astyanax fasciatus* em dois trechos distintos no rio Taquari, São Paulo, com 30 indivíduos coletados no trecho lótico e 30 no trecho lêntico, registrando os monogenóides: *Cacatuocotyle paranaensis, Characithecium costaricensis, Diaphorocleidus kabatai, Jainus* sp., *Notozothecium* sp. e *Gyrodactylus* sp., o digenético *Antorchis lintoni* e metacercárias não identificadas, o nematoide *Procamallanus (Spirocamallanus) inopinatus* e larvas não identificadas. A abundância média de monogenóides total (U = 1053; p = 0,042) e *C. costaricensis* (U = 1107; p = 0,005) foi maior no trecho lótico. Esta diferença pode ser devido à densidade mais alta da população de hospedeiros no trecho lótico e à transparência da água em trechos lênticos que previne a formação de cardumes de *A. fasciatus* e a troca de parasitas com ciclo direto dentro da população de hospedeiros. Este estudo é o primeiro registro da helmintofauna de *A. fasciatus* no rio Taquari, com dez *taxa* encontrados, e registra *A. fasciatus* como novo hospedeiro para os monogenóides *Notozothecium* sp. e *C. paranaensis*.

Palavras-chaves: peixes Neotropicais; *Astyanax fasciatus*; parasitas; reservatório.

1. Introduction

The genus *Astyanax* Baird & Girrard, 1854, include fishes known as "lambaris" or "piabas", and is one of the most rich and complex genus in terms of species within the family Characidae, occurring from the South of the United States to Argentina (Oyakawa, 2006). *Astyanax* spp. are relatively small (10 to 12 cm when adults), live in shoals, are restricted to freshwater, show morning habits, and good sights (Orsi, 2001). They are commercially appreciated, used for recreational fishing, and are potentially useful for pisciculture (Andrade et al., 1985). They dwell the benthopelagic area of rivers, show annual and long reproductive period, partial spawning, and are also used as ornamental fish due to their colorful traits (Orsi, 2001).

Astyanax fasciatus is popularly known as "lambari do rabo vermelho", found along Upper Paraná River basin, and there is a higher frequency of capture of this fish in tributaries; the species shows light silver body color, red fins, cuspidate teeth, short reproductive dislocation, external fertilization, no parental care, and omnivorous feeding habit (Duke Energy, 2008). The helminth fauna of *A. fasciatus* has been studied for a long time, and the literature shows records of ten different species of monogeneans, 11 digeneans, and 13 nematodes (Table 1).

Several studies have been assessing fish parasite communities as indicators of environmental quality. Vidal-Martínez et al. (2010) summarized most of these studies from 1997 to 2008, and evaluated the changes in parasites communities related to eutrophication, pulp-mill effluents,

Table 1. List of helminth parasites species recorded in *Astyanax fasciatus*.

Helminth species	Reference
Monogenea	
Gyrodactylidae	
Gyrodactylus neotropicalis Kritsky and Fritts, 1970	Kritsky and Fritts, 1970
Anacanthocotyle anacanthocotyle Kritsky and Fritts, 1970	Kritsky and Fritts, 1970
Dactylogyridae	
Characithecium costaricenses Price and Bussing, 1967	Mendoza-Franco et al., 2009
Diaphorocleidus kabatai Molnar, Hanek, and Fernando, 1974	Mendoza-Franco et al., 2009
Jainus hexops Kritsky and Leiby, 1972	Kritsky and Leiby, 1972
Palombitrema heteroancistrium Price and Bussing, 1968	Suriano, 1997
Urocleidoides astyanacis Gioia, Cordeiro, and Artigas, 1988	Gioia et al., 1988
Urocleidoides costaricensis Price and Bussing, 1967	Kritsky and Leiby, 1972
Urocleidoides heteroancistrium Price and Bussing, 1968	Kritsky and Leiby, 1972
Urocleidoides strombicirrus Price and Bussing, 1967	Price and Bussing, 1968
Digenea	
Antorchis lintoni Travassos, Artigas, and Pereira, 1928	Travassos et al., 1928
Auriculostoma astyanace Scholz, Aguirre-Macedo, and Choudhury, 2004	Scholz et al., 2004
Chalcinotrema ruedasueltensis Thatcher, 1978	Kohn et al., 1999
Dadaytremoides grandistomis Thatcher, 1979	Thatcher, 1979
Genarchella parva Travassos, Artigas, and Pereira, 1928	Kohn et al., 1990
Halipegus sp. Looss, 1899	Kohn and Fernandes, 1987
Halipegus tropicus Manter, 1936	Kloss, 1966
Prosorhynchus costai Travassos, Artigas and Pereira, 1928	Travassos et al., 1928
Prosthenhystera obesa Diesing, 1850	Eiras et al., 2010
Pseudoprosthenhystera microtesticulata Kloss, 1966	Kloss, 1966
Saccocoelioides octavus Szidat, 1970	Szidat, 1970
Nematoda	
Capillaria sp. Zeder, 1800	Luque et al., 2011
Capillaria sentinosa Travassos, 1927	Travassos et al., 1928
Capillostrongyloides sentinosa Travassos, 1927	Travassos, 1927
Contracaecum sp. Larva Tipo 1 Moravec, Kohn, and Fernandes, 1993	Eiras et al., 2010
Contracaecum sp. Larva Tipo 2 Moravec, Kohn, and Fernandes, 1993	Eiras et al., 2010
Contracaecum sp. larva Railliet and Henry, 1912	Eiras et al., 2010
Procamallanus (Spirocamallanus) hilarii Vaz and Pereira, 1934	Eiras et al., 2010
Procamallanus (Spirocamallanus) iheringi Travassos, Artigas, and Pereira, 1928	Luque et al., 2011
Procamallanus (Spirocamallanus) inopinatus Travassos, Artigas, and Pereira, 1928	Pinto and Noronha, 1976
Procamallanus (Spirocamallanus) neocaballeroi Caballero-Deloya, 1977	Moravec and Vargas-Vázquez, 1996
Procamallanus (Spirocamallanus) saofrancicensis Moreira, Oliveira and Costa, 1994	Luque et al., 2011
Rhabdochona acuminata Molin, 1860	Eiras et al., 2010
Rhabdochona fasciata Kloss, 1966	Kloss, 1966

crude oil, PCBs (Polychlorinated Biphenyls), pesticides, and heavy-metals. However, there has not been any study in the literature comparing fish parasites communities in sites with distinct characteristics in a large reservoir.

The construction of hydroelectric power-plants, resulting in artificial reservoirs, is one of the most destructive activities in the Paraná river-basin, influencing the main river courses (Agostinho et al., 2008). The reservoirs have impacts on the fish assemblages, such as predominance of generalist species (Freeman et al., 2001), depletion of specialists and migratory species (Britto and Carvalho, 2006), and transference of pathogens and parasites (Gabrielli and Orsi, 2000). Since these impoundments affect the composition and abundance of fish assemblages, the prevalence and size of fish parasites infra-communities may also be affected (Pavanelli and Takemoto, 2000).

The Taquari River is the second biggest tributary formed by Jurumirim dam (Henry and Nogueira, 1999) and is one of the main tributaries of the Paranapanema River that suffers the impacts of the reservoir. There is a strong local interest in artisanal fishing in the Taquari River, due to the great diversity and abundance of fish. To date, there is no record of parasitological studies in this river. Thus, this study aimed to assess the helminth fauna of *A. fasciatus* in the Taquari River, São Paulo, and to compare for the first time the helminth communities of this host from different habitat types: lentic and lotic sites.

2. Material and Methods

2.1. Study area

Jurumirim dam is a hydric complex formed by a reservoir with 449 km^2 of surface and three main tributaries: Paranapanema, Veados and Taquari rivers. Taquari River is in confluence with the left bank of the Upper Paranapanema River, located in the Southeast of São Paulo State (23°15’11.9”S; 49°12’34.2”W). The fluctuations of the water level are determined either by natural (rainy and dry seasons) or artificial events like the reservoir operation system (Luciano and Henry, 1998).

Astyanax fasciatus specimens were sampled in two sites: a lotic site located upstream in the main channel of the river (23°40’2.90”S; 49°7’56.85”W) with wide riparian forest, swamps and macrophytes; and a lentic site located in the river mouth, flooded by Jurumirim dam located approximately 10 km away from the impoundment (23°17’2.80”S; 49°12’6.90”W), with absence of riparian forest and macrophytes, banks occupied by pasture and agriculture, and sand extraction.

2.2. Field and laboratory procedures

The fish were sampled in November and December of 2011, using gill nets exposed by approximately 14 hours. The sample was composed of 60 fish: 30 specimens sampled in the lotic site and 30 in the lentic site, all specimens analyzed were adults. After sampling, the fish were individualized in plastic bags, frozen and taken to the laboratory to perform parasitological analyses. The standard length in centimeters (L_s) and total weight in grams (W_t) of the specimens were measured.

Fish voucher specimens were deposited at the Museu de Zoologia da Universidade Estadual de Londrina (MZUEL 5669), Londrina, Paraná State, Brazil.

2.3. Parasitological analyses

The body, fins, nasal cavity, and the inner face of the operculum of the fish hosts were examined to find helminth ectoparasites. The gills were removed and washed using 53 and 75 micrometer sieves, placed in Petri plate and examined to find helminth parasites. Following the external analyses, a longitudinal incision in the ventral surface was made and all inner organs were removed and separated. The visceral cavity and all organs were examined using stereomicroscope to find helminth endoparasites. All collected helminthes were preserved in alcohol 70%. For species identification, the monogeneans were cleared with Hoyer or Grey & Wess to visualize the sclerotized structures, the digeneans were stained with carmine and cleared with creosote, and the nematodes were diaphonized with lactophenol (Eiras et al., 2006).

The parasites were identified based mainly on identification keys and reference guides and analyzed using the computerized system for image analysis Qwin Lite 3.1 (Leica). Representatives of the helminth species were deposited in the Coleção Helmintológica do Instituto de Biociências (CHIBB), UNESP, municipality of Botucatu, São Paulo State, Brazil.

2.4. Statistical analysis

The ecological terminology, prevalence, infection/infestation mean intensity, and mean abundance were determined following Bush et al. (1997). The parasites were classified according to Bush and Holmes (1986) into core species (prevalence higher that 66.6%), secondary species (prevalence between 33.3% and 66.6%) and satellite species (prevalence less than 33%).

To determine the ecological attributes of infracommunities the following diversity indexes were calculated: Shannon-Winner: $H' = -\sum(pi.\ln pi)$, used to measure the order or disorder in a system, attributing greater weight to rare species and relatively independent of sample size, in which: H’ = species diversity; pi = proportion of species i in the community, and pi = (ni/N): ni = individuals number of i species and N = total number of individuals (Krebs, 1989; Begon et al., 2007); and the Berger-Parker index (d = Nmax/N) was used to measure the dominance of the species, in which Nmax = number of individuals of each abundance species, N = total number of individuals of all species (Krebs, 1989). The Shannon-Winner index was calculated and compared using the statistical program Past – Paleontological Statistics version 3.0 ($P < 0.05$).

Similarity analysis of parasite communities between the sites studied was carried out using Jaccard Coefficient that is based on the presence and absence of local species sampled, this index varies from 0 (dissimilar) to 1 (similar) and is calculated by the equation ($Q = c / (a + b – c). 100$), in which Q = Jaccard similarity coefficient; c = number of common species between a and b; a = number of species sampled in a; b = number of species sampled in b (Krebs, 1989).

The index of discrepancy (D), described by Poulin (1993), was used to evaluate spatial distribution of parasites based on their abundance between lotic and lentic sites. This index varies from 0 to 1, and can be interpreted as: D = 0, all hosts harboring the same number of parasites; D = 1, all parasites found in a single host. This analysis was calculated according to Rózsa et al. (2000) using the software Quantitative Parasitology 3.0.

The comparison among prevalence of parasites in the lotic and lentic sites was calculated with Z-test. The infection/infestation mean intensity and mean abundance between the two sites were calculated with Mann-Whitney U test. The statistical comparisons were made using the software SigmaStat 3.1. The statistical significance level adopted was $P < 0.05$. A principal component analysis (PCA) was carried out to compare parasites communities in the lotic and lentic sites and this multivariate analysis was calculated with the software MVSP.

3. Results

3.1. Parasites communities

A richness of ten helminth *taxa* was found in the *A. fasciatus* samples analyzed in this study. For the lotic site, 93.3% of the hosts analyzed were parasitized by at least one helminth species (overall prevalence = 93.3%). A total of 169 parasites were found, with six helminth parasite *taxa*, and a mean of 5.64 parasite/fish. The richness varied from 1 to 4 parasites and the mean richness was 2.3 parasites/fish (Table 2).

For the lentic site, 90% of the hosts analyzed were parasitized by at least one helminth species (overall prevalence = 90%). A total of 169 parasites were found, with eight helminth parasite *taxa*, and a mean of 5.4 parasites/fish. The richness varied from 1 to 5 parasites and the mean richness was 2.3 parasites/fish (Table 2).

The monogeneans *C. costaricensis* and *D. kabatai* were the species with higher prevalence in the lotic and lentic sites, considered core species. Nematode larvae were secondary species and the other *taxa* were satellite species.

3.2. Comparison between lotic and lentic sites

The mean abundance of total monogeneans (U = 1053; p = 0.042) and *C. costaricensis* (U = 1107; p = 0.005) were greater in the lotic site (see Figure 1). The mean richness was similar between both sites, however the richness was greater in the lentic stretch. The overall prevalence (z = -0.00467; p = 0.996) and the total numbers of helminth found (U = 991; p = 0,264) were similar between lotic and lentic sites.

The Jaccard index (SJ = 0.7) demonstrated similarity between the parasite communities of both sites. The Shannon-Wiener index (Lotic = 1.15; Lentic = 1.55; p < 0.001) demonstrated that in the lentic site the helminth communities show a diversity greater than in the lotic site. The Berger-Parker index demonstrated that *D. kabatai* was the dominant species in both sites. However *C. costaricensis* and nematode larvae demonstrated dominance indexes similar to *D. kabatai* in the lotic and lentic sites, respectively (Table 3). Most of the parasites species found in both sites showed aggregated distribution pattern. Only the species *C. paranaensis, D. kabatai* and no-identified nematode larvae showed median aggregation index (Table 3).

The multivariate analysis based on the component community of the helminth parasites of *A. fasciatus* allowed observing that there is not separation among the host specimens from lotic and lentic sites. *Antorchis lintoni,* nematode larvae, *D. kabatai* and *C. costaricensis* showed more importance in the analysis (see Figure 2).

4. Discussion

Most of the parasites found in this study corroborate previous records, however, there has not been any record of *Notozothecium* sp. and *C. paranaensis* in this host species, thus this study is the first record of these monogeneans in *A. fasciatus*. All the records represent a new geographic distribution for these parasites, since to date parasitological studies have not been conducted in the Taquari River, São Paulo State.

Berger-Parker index demonstrated that *D. kabatai* was the dominant species in both sites and *C. costaricensis* showed dominance index similar to *D. kabatai*. These monogeneans were first described parasitizing the gills of *Astyanax* spp. (Mendoza-Franco et al., 2009), and there is only one report of *D. kabatai* parasitizing *A. altiparanae* Garutti and Britsky, 2000 (Almeida and Cohen, 2011). Thus, this study corroborates the literature and strongly suggests the specificity of these monogeneans with the genus *Astyanax*.

Paraguassu and Luque (2007) studied the helminth fauna of *A. fasciatus* and observed a predominance of endoparasites, with the nematode *Rhabdochona acuminata* Molin, 1860, as the main component. However, they did not record monogeneans and digeneans. Kloss (1966) analyzed the occurrence of helminth parasites in simpatric species of *Astyanax*, including *A. fasciatus*, and found species of adult digeneans and nematodes. Moreover, species of *Procamallanus (Procamallanus)* Baylis, 1923 have often been recorded in *Astyanax* spp. (Table 1). Therefore, this study does not correlate with previous reports, since monogeneans were the dominant *taxa* showing the highest prevalence, infection intensity and abundance. Nonetheless, the records of the digenean *A. antorchis* and the nematode *P. (Spirocamallanus) inopinatus* in this study corroborate Travassos et al. (1928) and Pinto and Noronha (1976) respectively.

Dogiel (1961) states that monogenean are more frequently found in lentic environments, since it is easier for the free-swimming larval stages find the hosts, which does not correlate with this study, considering that a greater abundance of monogeneans was found in the lotic site.

Table 2. Number of parasites (N); prevalence (P); infection/infestation mean intensity (IMI±SE); mean abundance (AM±SE), catalogue number (CHIBB number), and infection/infestation sites (IS) of the helminth parasites of *Astyanax fasciatus* collected in the lotic and lentic stretches of Taquari River, Jurumirim reservoir, São Paulo State, Brazil.

Species	Lotic					Lentic					IS
	N	P (%)	IMI	AM	CHIBB number	N	P (%)	IMI	AM	CHIBB number	
Monogenea	132	83.3	5.3 ± 0.7 (1-16)	4.4 ± 0.7 (0-16)		89	66.7	4.5 ± 1.0 (1-20)	3.0 ± 0.8 (0-20)		S, G, NO
Dactylogyridae											
Cacatuocotyle paranaensis Boeger, Domingues and Kritsky, 1997	-	-	-	-		3	10	1	0.1 ± 0.05 (0-1)	099L	S
Characithecium costaricensis Price and Bussing, 1967	58	83.3	2.3 ± 0.3 (1-7)	1.9 ± 0.3 (0-7)	095L	27	66.7	1.3 ± 0.3 (1-7)	0.9 ± 0.2 (0-7)		S, G, NO
Diaphorocleidus kabatai Molnar, Hanek and Fernando, 1974	72	83.3	2.9 ± 0.4 (1-9)	2.4 ± 0.4 (0-9)	096L	55	66.7	2.7 ± 0.7 (1-13)	1.8 ± 0.5 (0-13)		S, G, NO
Jainus sp. Mizelle, Kritsky and Crane, 1968	1	3.3	1	0.03 ± 0.03 (0-1)	097L	2	6.7	1	0.06 ± 0.04 (0-1)		NO, S
Notozothecium sp. Boeger and Kritsky, 1988	-		-	-		2	6.7	1	0.06 ± 0.04 (0-1)	103L	S
Gyrodactylidae											
Gyrodactylus sp. Nordmann, 1832	1	3.3	1	0.03 ± 0.03 (0-1)	098L	-	-	-	-		S
Digenea											
Antorchis lintoni Travassos, Artigas, and Pereira, 1928	-	-	-	-		30	3.3	30	1.0 ± 1.0 (0-30)	7069	I
No identified metacercaria	-	-	-	-		2	6.7	1	0.06 ± 0.04 (0-1)		S
Nematoda											
Procamallanus (Spirocamallanus) inopinatus Travassos, Artigas and Pereira, 1928	1	3.3	1	0.03 ± 0.03 (0-1)	7479	-	-	-	-		
No identified larva	36	54	2.2 ± 0.4 (1-7)	1.2 ± 0.3 (0-7)	7068	48	64	2.5 ± 0.3 (1-7)	1.6 ± 0.3 (0-7)	7070	Ca

S – skin; G – gills; NO – nasal operculum; E – eyes; Ca – cavity; I – intestine.

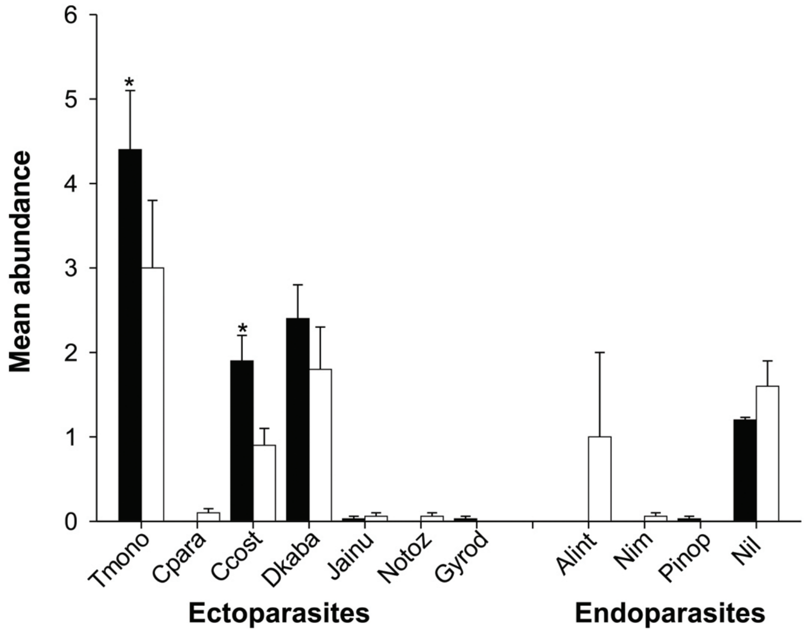

Figure 1. Mean abundance of helminths parasites of *Astyanax fasciatus* sampled in the lotic and lentic stretches of the Taquari River, Jurumirim reservoir, São Paulo State, Brazil. Caption: tMono – total monogenean; Cpara - *Characithecium costaricensis*; Dkaba - *Diaphorocleidus kabatai*; Jainu – *Jainus* sp.; Notoz - *Notozothecium* sp.; Girod - *Gyrodactylus* sp.; Alint – *Antorchis lintoni*; Nim – no identified metacercariae; Pinop - *Procamallanus (Spirocamallanus) inopinatus*; Nil – no identified larvae. *p<0.05. Black bars: lotic stretch; White bars: lentic stretch.

Table 3. Berger-Parker and Aggregation indexes for the helminth species of *Astyanax fasciatus* sampled in the lotic and lentic stretches of Taquari River, Jurumirim reservoir, São Paulo State, Brazil.

	Berger-Parker index		Aggregation index	
Helminth	**Lotic**	**Lentic**	**Lotic**	**Lentic**
Monogenea				
Cacatuocotyle paranensis	-	0.018	0.469	0.646
Characithecium costaricensis	0.343	0.16	-	0.871
Diapharocleidus kabatai	0.426	0.325	0.462	0.607
Jainus sp.	0.006	0.012	0.935	0.903
Notozothecium sp.	-	0.012	-	0.935
Gyrodactylus sp.	0.006	-	0.935	-
Digenea				
Antorchis lintoni		0.178	-	0.935
No identified metacercaria	-	0.012	-	0.935
Nematoda				
Procamallanus (Spirocamallanus) inopinatus	0.006	-	0.935	-
No identified larva	0.213	0.284	0.645	0.542

However, it must be considered that it is expected more chances of transmission of parasites with direct cycles in denser populations, due to the proximity of the individuals, as observed in farmed fishes (Franceschini et al., 2013) or in natural populations (Takemoto et al., 2005). The fish used in this study were sampled together with a fish ecology project that carried out eight sampling efforts in 2011 and 2012, and a greater amount of *A. fasciatus* was sampled in the lotic site during these two years (lotic n = 206; lentic n = 36), suggesting that *A. fasciatus* population is denser in the lotic site.

Takemoto et al. (2005) studied the population density of different host species as the major determinant of endoparasite richness in floodplain fishes of the Upper Paraná River, Brazil. The authors elucidate that host species occurring at higher population density should harbor more species of parasites, and their result was a positive relationship between hosts density and parasites

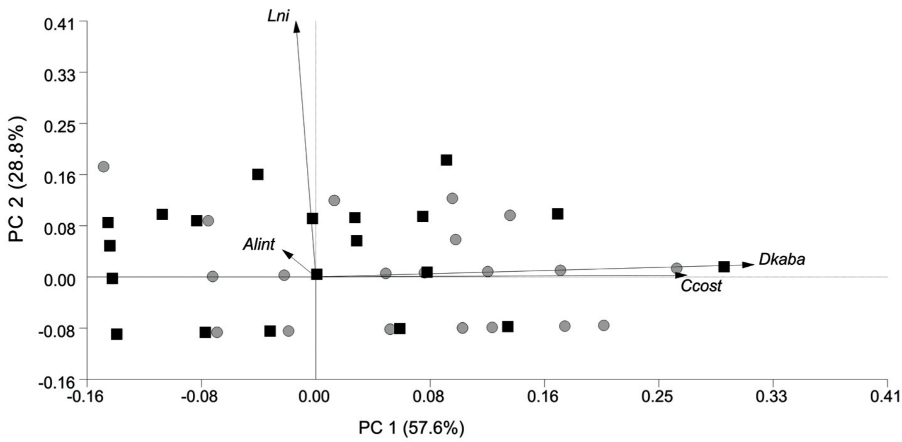

Figure 2. *Scatterplot* scores of the principal component analysis (PCA) of parasites communities of *Astyanax fasciatus* in the lotic stretch (○) and lentic stretches (■) of the Taquari River, Jurumirim reservoir, São Paulo State, Brazil. The values showed in the ordinate and abscissa axes represent the greatest quantity and variation of the data set. Vectorial scale = 0.41. Alint – *Antorchis lintoni*; Nil – no identified larvae; Dkab - *Diaphorocleidus kabatai*; Ccost - *Characithecium costaricensis*.

richness, a pattern in agreement with the epidemiological theory (Roberts et al., 2002), which predicts that the larger or denser the populations are, the more parasites populations they will support. Hence, the authors suggest that host density may develop the function of maintaining parasite species richness. Therefore, the greater abundance of the monogenean *C. costaricensis* in the lotic site might be associated with the greater amount of individuals in the population.

Additionally, it was observed that *Astyanax* spp. populations form schools and seek shelter in sites with abundance of macrophytes and organic matter in shoals close to the banks (Orsi et al., 2004). In these areas the effects of the water flow are attenuated (Champion and Tanner, 2000; Franklin et al. 2008), thus the currents might not be influencing the abundance of parasites in this host. The water transparence in lentic environments also prevents the populations of *A. fasciatus* of forming schools, which would make these fish more exposed to predators (Orsi et al., 2004; Tondato et al., 2010). Thus, the transmission of parasites with direct cycles from host to host would be hindered in lentic sites.

This study contributes with the first characterization of the helminthfauna of *A. fasciatus* in the Taquari River, with ten different *taxa* recorded, broadening the knowledge of geographic distribution for these parasites, and also reports *A. fasciatus* as a new host record for the monogenean *Notozothecium* sp. and *C. paranaensis*. Moreover, the greater abundance of *C. costaricensis* in the lotic site may be due to the higher density of the host population, and also due to the water transparence in lentic environments that prevents *A. fasciatus* to form shoals, precluding the exchange of parasites with direct cycle within a host population.

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