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Helminths of *Steindachnerina insculpta* in two distinct stretches of the Taquari River, state of São Paulo, Brazil

Helmintos de *Steindachnerina insculpta* em dois trechos distintos do rio Taquari, Estado de São Paulo, Brasil

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Abstract

The purpose of this study was to evaluate the helminth fauna of *Steindachnerina insculpta* in the Taquari River, a tributary of the Jurumirim reservoir in the state of São Paulo, and to investigate whether some helminth species may act as a bioindicator of environmental impact. The host fish sample was composed of 60 specimens, with 30 individuals sampled in a lotic stretch and 30 in a lentic stretch. The following were found: the monogeneans *Anacanthoroides mizelli, Diaphorocleidus kabatai, Urocleidoides* sp. and *Euryhaliotrema chaoi;* the digenean *Sphincterodiplostomum musculosum* and unidentified metacercariae; the nematode *Travnema travnema* and unidentified larvae; and the acanthocephalan *Gorytocephalus plecostomorum*. The total prevalence of monogeneans ($z = 3.14$; $p = 0.002$) and *A. mizelli* ($z = 3.879$; $p \leq 0.001$), as well as the mean abundance of total monogeneans ($U = 642.0$; $p \leq 0.001$) and *A. mizelli* ($U = 623.5$; $p \leq 0.001$), were higher in the lentic stretch. *Steindachnerina insculpta* and its monogeneans comprise a potential group that could be used to investigate environmental impact, as demonstrated in this study.

Keywords: Neotropical fish, teleost, parasites, bioindicator, reservoir.

Resumo

O objetivo desde estudo foi avaliar a helmintofauna de *Steindachnerina insculpta* no rio Taquari, um tributário do reservatório de Jurumirim, estado de São Paulo, e verificar se alguma espécie pode agir como bioindicadora de impacto ambiental. A amostragem de peixes foi composta de 60 espécimes, com 30 indivíduos amostrados no trecho lótico e 30 no trecho lêntico. Foram encontrados os monogenóides: *Anacanthoroides mizelli, Diaphorocleidus kabatai, Urocleidoides* sp. e *Euryhaliotrema chaoi;* o digenético *Sphincterodiplostomum musculosum* e metacercárias não identificadas, o nematoide *Travnema travnema* e larvas não identificadas; e o acantocéfalo *Gorytocephalus plecostomorum*. A prevalência total de monogenóides ($z = 3,14$; $p = 0,002$) e *A. mizelli* ($z = 3,879$; $p \leq 0,001$) e também a abundância média de monogenóides total ($U = 642,0$; $p \leq 0,001$) e *A. mizelli* ($U = 623,5$; $p \leq 0,001$) foram maiores no trecho lêntico. *Steindachnerina insculpta* e seus monogenóides compõem um grupo em potencial que pode ser usado para investigar impactos ambientais, como mostrado neste estudo.

Palavras-chave: Peixes Neotropicais, teleósteos, parasitas, bioindicador, reservatório.

Introduction

Steindachnerina insculpta, popularly known as "saguiru", belongs to the Curimatidae family and has wide geographical distribution in South America (REIS et al., 2003). It is especially abundant in the Paranapanema River and is well-adjusted to artificial reservoirs. The main characteristics of this species are: body slightly silver, terminal mouth without teeth, sedentary with external fertilization, no parental care, and iliophagous feeding habit (DUKE ENERGY, 2008; BRANDÃO et al., 2009).

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The construction of dams is one of the most damaging activities in the Parana river-basin, affecting the main course of the river (AGOSTINHO et al., 2008). Fish assemblages suffer drastically due to the impact of reservoirs, which leads to predominance of generalist fish species (FREEMAN et al., 2001), depletion of migratory species (BRITTO; CARVALHO, 2006) and transference of pathogens and parasites (GABRIELLI; ORSI, 2000). Considering the impact of reservoirs on fish abundance, the prevalence and size of fish parasite infracommunities may also be influenced (PAVANELLI; TAKEMOTO, 2000). The Taquari River is the second biggest tributary of the Jurumirim reservoir (HENRY; NOGUEIRA, 1999) and is one of the main tributaries of the Paranapanema River, which has been significantly affected by the creation of the reservoir. There is strong local interest in artisanal fishing in the Taquari River because of the great diversity and abundance of fish. To date, there is no record of parasitological studies in this river.

Fish parasites are considered to be bioindicator species since they can reflect environmental impacts through their response to habitat alterations, such as changes in physiology, chemical composition and prevalence or intensity (VIDAL-MARTÍNEZ et al., 2010). In this context, monogeneans of fish have been used to assess environmental impacts, since they have been shown to be suitable indicators (MADI; UETA, 2009). *Steindachnerina insculpta* is a host that fits the criteria proposed by Overstreet (1997) and Sures (2004) to serve as a bioindicator fish species: restricted home range, parasites needing more than one host in the life cycle, easy to sample, small size and wide geographical distribution.

Thus, the aim of this study was to assess the helminth fauna of *S. insculpta* in the Taquari River, São Paulo, and investigate whether some helminth species in the parasite community are potential bioindicator of environmental impacts.

Materials and Methods

Study area

The Jurumirim reservoir constitutes a hydric complex formed by a water body with a surface area of 449 km^2 and three main tributaries: Paranapanema, Veados and Taquari rivers. The Taquari River (Figure 1) is in confluence with the left bank of the Upper Paranapanema River, located in a tropical region in the southeastern portion of the state of São Paulo (23° 15' 11,9" S and 49° 12' 34,2 "W). The fluctuations of the water level are determined either by natural events (rainy and dry seasons) or artificial events (the reservoir operation system).

Steindachnerina insculpta specimens were sampled in two stretches: a lotic site (upper stretch) located upstream (23° 40' 2.90" S and 49° 7' 56.85" W) with riparian forest, swamps and macrophytes; and a lentic site (reservoir stretch) located at the river mouth, flooded by the Jurumirim reservoir and located approximately 10 km away from the dam (23° 17' 2.80" S and 49° 12' 6.90" W). At the lentic site, there is an absence of riparian forest and macrophytes, and the banks are occupied by pasture lands, agricultural activity, and sand extraction activities. The physicochemical characteristics of the lentic and lotic stretches are presented in Table 1.

Field and laboratory procedures

The fish were sampled in November and December 2011, using gill nets exposed for approximately 14 hours in two distinct areas: the upper stretch of the Taquari River (lotic site) and the reservoir stretch of the Taquari River (lentic site). The fish sample was composed of 60 specimens, with 30 specimens sampled in the lotic stretch, and 30 in the lentic stretch. After sampling, the fish were placed in individual plastic bags, frozen and taken to the laboratory for parasitological analyses. The standard length in centimeters (L_s) and total weight in grams (W_t) of the fish were measured using an ichthyometer and a precise scale in centigrams.

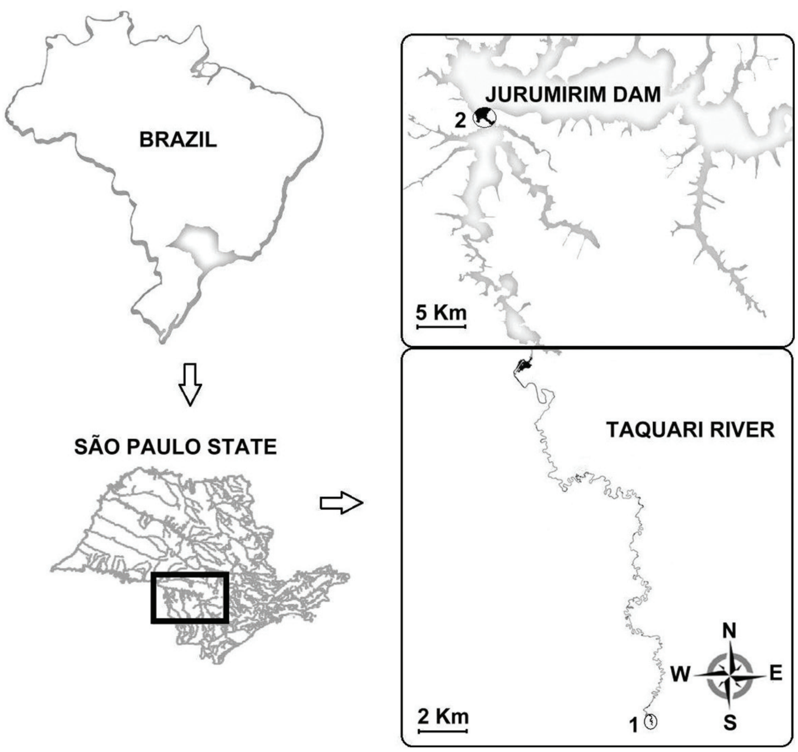

Figure 1. Map of the location of the Taquari River, a tributary of the Jurumirim Reservoir, state of São Paulo, Brazil: 1: upper stretch (lotic); 2: reservoir stretch (lentic).

Table 1. Mean values and standard deviations of the limnological parameters of the water surface for the two stretches of the Taquari River, Jurumirim reservoir, state of São Paulo, Brazil.

Variables	Stretches	
	Lotic	Lentic
Water temperature (°C)	20.5 ± 3.88	23.8 ± 3.85
pH	7.0 ± 0.48	7.1 ± 0.42
Conductivity (µS/cm)	116.8 ± 24.77	61.8 ± 7.48
DO (mg/L)	9.7 ± 33.14	8.7 ± 28.25
Water transparency (m)	0.6 ± 0.14	3.4 ± 0.67
Depth (m)	2.5 ± 0.83	61.8 ± 7.48
Width between banks (m)	10 to 20	630 to 1400

Fish voucher specimens were deposited in the Fish Biology and Genetics Laboratory, Institute of Biosciences (LBP 13313), Universidade Estadual Paulista (UNESP), municipality of Botucatu, state of São Paulo, Brazil.

Parasitological analyses

The body, fins, nasal cavity, eyes and inner face of the operculum of the fish hosts were examined to find ectoparasites. The gills were subsequently removed and washed using 53 and 75 micrometer sieves and placed in Petri dishes. The parasites were collected using a stereomicroscope. After 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 a stereomicroscope to locate endoparasites. All helminths collected were preserved in 70% alcohol. For species identification, the monogeneans were cleared with Hoyer or Grey & Wess to view the sclerotized structures; the digeneans were stained with carmine and cleared with creosote; and the nematodes were diaphanized with lactophenol (EIRAS et al., 2006).

The parasites were identified based mainly on identification keys and reference guides and were analyzed using the Qwin Lite 3.1 (Leica) computerized system for image analysis. Representatives of the helminth species were deposited in the Helminthological Collection of the Institute of Biosciences (CHIBB), UNESP, municipality of Botucatu, state of São Paulo, Brazil.

Statistical analysis

The ecological terminology, prevalence, infection/infestation mean intensity, and mean abundance followed Bush et al. (1997). The infracommunity components were classified in accordance with Bush and Holmes (1986) into core species (prevalence higher than 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 Shannon-Wiener diversity index was calculated: $H' = -\sum(pi.In\ pi)$. This was used to measure the order or disorder in a system, by attributing greater weight to rare species, and was relatively independent of sample size. In the formula, H' = species diversity; pi = proportion of species i in the community, in which pi = (ni/N); ni = individual numbers of i species and N = total number of individuals (KREBS, 1989; BEGON et al., 2007). Pielou's evenness, which is a derivate from the Shannon-Wiener index, was determined using the following formula: ($J'=H'/Log_2S$), in which J'= evenness (ranging from 0 to 1) (KREBS, 1989).

Similarity analysis on parasites communities between the stretches studied was carried out using the Jaccard coefficient, which is based on the presence or absence of the local species sampled. This index ranged from 0 (dissimilar) to 1 (similar) and was calculated from the equation ($Q = c/(a + b – c). 100$), in which Q = Jaccard similarity coefficient; c = number of species in common between a and b; a = number of species sampled in a; and b = number of species sampled in b (KREBS, 1989).

The discrepancy index (D), described by Poulin (1993), was used to evaluate the spatial distribution of parasites based on their abundance between lotic and lentic stretches. This index ranges 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 in accordance with Rózsa et al., (2000) using the Quantitative Parasitology 3.0 software.

The prevalence of parasites in the lotic and lentic stretches was compared using Z-test calculations. The mean intensity of infection/infestation and mean abundance between the two stretches were calculated using the Mann-Whitney U test. Principal component analysis (PCA) was carried out to compare parasite communities in the lotic and lentic stretches.

All values that corresponded to the variable mean were followed by their respective standard error. Statistical comparisons were made using the SigmaStat 3.1 software. The multivariate analysis was calculated using the MVSP software. The statistical significance level used was $P < 0.05$.

Results

Parasite communities

In the lotic stretch, all hosts analyzed were parasitized by at least one helminth species (total prevalence = 100%). A total of 1,527 parasites were collected, with a mean of 50.9 parasite/fish. The richness varied from 1 to 4 parasites, and the mean richness was 2.7 parasites/host. Nine helminth parasite taxa were found: the monogenean species *Anacanthoroides mizelli* (CHIBB 089L; 090L), *Diaphorocleidus kabatai* (CHIBB 091L), *Urocleidoides* sp. (CHIBB 093L; 094L) and *Euryhaliotrema chaoi* (CHIBB 092L); metacercariae of *Sphincterodiplostomum musculosum* (CHIBB 7064) and another digenean metacercaria that could not be identified; the nematode species *Travnema travnema* (CHIBB 7066) and unidentified larvae (CHIBB 7067); and the acanthocephalan *Gorytocephalus plecostomorum* (CHIBB 7065) (Table 2).

Metacercariae of *S. musculosum* and the acanthocephalan *G. plecostomorum* were classified as core species. However, only metacercariae of *S. musculosum* showed high abundance and mean intensity of infection. All the other taxa were classified as satellite species, with low rates of abundance and mean intensity of infection/infestation (Table 2).

In the lentic stretch, all hosts analyzed were parasitized by at least one helminth species (total prevalence = 100%). A total of 1,372 parasites were collected, with a mean of 45.7 parasites/fish. The richness varied from 2 to 5 parasites with a mean richness of 3.3 parasites/host. Seven helminth parasite taxa were found: the monogenean species *A. mizelli* and *D. kabatai*; metacercariae of *S. musculosum* and another digenean metacercaria that could not be identified; nematode species *T. travnema* and unidentified larvae; and the acanthocephalan *G. plecostomorum* (Table 2).

The monogenean *A. mizelli*, metacercariae of *S. musculosum* and the acanthocephalan *G. plecostomorum* were classified as core species, *T. travnema* was classified as a secondary species and the other taxa were classified as satellite species. Only the metacercariae of *S. musculosum* showed high rates of abundance and mean intensity of infection (Table 2).

Comparison between lotic and lentic stretches

The total prevalence (z = –1.297; p = 0.194), total abundance and mean intensity of infection/infestation (U = 956.0; p = 0.549) were similar between the stretches. The mean richness was greater in the lentic stretch (U = 756.0; p = 0.019), but the number of species was greater in the lotic stretch.

The prevalences of total monogenean species (z = 3.14; p = 0.002) and *A. mizelli* (z = 3.879; p ≤ 0.001) (Figure 2), as well as the mean abundance of total monogenean species (U = 642.0; p ≤ 0.001) and *A. mizelli* (U = 623.5; p ≤ 0.001), were significantly higher in the lentic stretch (Figure 3).

The Jaccard index (SJ = 8.0) showed high similarity among the parasite communities of the two stretches. However, the Shannon-Wiener index showed that the parasite communities in the lentic stretch were greater in diversity than in the lotic stretch. Pielou's evenness indexes were low for both stretches, suggesting the existence of a dominant species (Table 3). The Berger-Park index showed that in both stretches, metacercariae of *S. musculosum* were the dominant species with similar values (Table 4).

It was also observed that most of the parasite species showed aggregated distribution patterns for both stretches. Only species that occurred at high prevalence and mean abundance (metacercariae of *S. musculosum* and the acanthocephalan *G. plecostomorum*) showed a medium aggregation index (Table 5).

The multivariate analysis based on component communities of helminth parasites of *S. insculpta* led to the observation that there was relative separation between the specimens from the lotic stretch (mostly distributed in the upper squares) and lentic stretch (mostly distributed in the lower squares). In this analysis, it was observed that *A. mizelli, G. plecostomorum* and *T. travnema*

Table 2. Number of parasites (N); prevalence (P); mean intensity of infection/infestation (MII ± SE); mean abundance (MA ± SE) and infection/infestation sites (IS) of the helminth parasites of *Steindachnerina insculpta* collected in the lotic and lentic stretches of the Taquari River, Jurumirim reservoir, state of São Paulo, Brazil.

Species	Lotic				Lentic				IS
	N	P (%)	MII	MA	N	P (%)	MII	MA	
Monogeneans	19	36.7	1.7 ± 0.3 (1-5)	0.6 ± 0.2 (0-5)	116	80	4.8 ± 1.1 (1-27)	3.9 ± 0.9 (0-27)	S, G, ON
Anacanthoroides mizelli	15	26.7	1.9 ± 1.4 (1-5)	0.5 ± 1.1 (0-5)	115	80	4.8 ± 1.1 (1-27)	3.8 ± 0.9 (0-27)	S, G, ON
Diaphorocleidus kabatai	1	3.3	1	0.03 ± 0.03 (0-1)	1	3,3	1	0.03 ± 0.03 (0-1)	S, G
Urocleidoides sp.	2	6.7	1	0.07 ± 0.05 (0-1)	-	-	-	-	G
Euryhaliotrema chaoi	1	3.3	1	0.03 ± 0.03 (0-1)	-	-	-	-	G
Digeneans	1397	100	46.5 ± 10.2 (1-250)	46.5 ± 10.2 (1-250)	1097	100	36.5 ± 10.2 (2-286)	36.5 ± 10.2 (2-286)	E, S, G
Sphincterodiplostomum musculosum (metacercariae)	1394	100	46.5 ± 10.2 (1-250)	46.5 ± 10.2 (1-250)	1095	100	36.5 ± 10.2 (2-286)	36.5 ± 10.2 (2-286)	E
Unidentified metacercariae	3	6.6	1.5 ± 0.5 (1-2)	0.1 ± 0.07 (0-2)	2	6,6	1.0 ± 0 (1-2)	0.07 ± 0.07 (0-2)	S, G
Nematodes	29	40	2.4 ± 0.6 (1-8)	1 ± 0.3 (0-8)	37	47	2.6 ± 0.4 (1-5)	1.2 ± 0.3 (0-5)	I, Ca
Travnema travnema	14	24	2 ± 0.4 (1-4)	0.5 ± 0.2 (0-4)	22	34	2.2 ± 0.4 (1-4)	0.7 ± 0.2 (0-4)	I
Unidentified larvae	15	17	3 ± 1.3 (1-8)	0.5 ± 0.3 (0-8)	15	30	1.7 ± 0.2 (1-3)	0.5 ± 0.2 (0-3)	Ca
Acanthocephalans									
Gorytocephalus plecostomorum	82	80	3.4 ± 0.5 (1-10)	2.7 ± 0.5 (0-10)	122	84	4.8 ± 1.3 (1-32)	4.1 ± 1.2 (0-32)	I

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

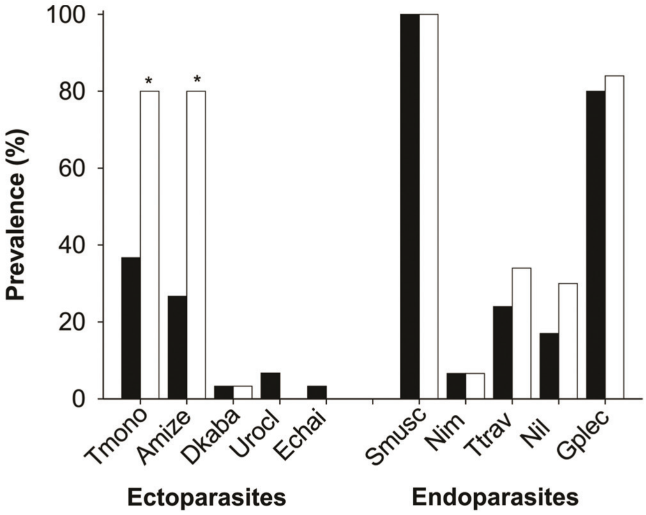

Figure 2. Prevalence of helminth parasites of *Steindachnerina insculpta* sampled in the lotic and lentic stretches of the Taquari River, Jurumirim reservoir, state of São Paulo, Brazil. Caption: Tmono – total monogeneans; Amize - *Anacanthoroides mizelli*; Dkaba - *Diaphorocleidus kabatai*; Urocl - *Urocleidoides* sp.; Echai - *Euryhaliotrema chaoi*; Smusc - *Sphincterodiplostomum musculosum* metacercariae; Nim – unidentified metacercariae; Ttrav - *Travnema travnema*; Nil – unidentified larvae; Gplec - *Gorytocephalus plecostomorum*. $^*p < 0.05$. Black bars: lotic stretch; White bars: lentic stretch.

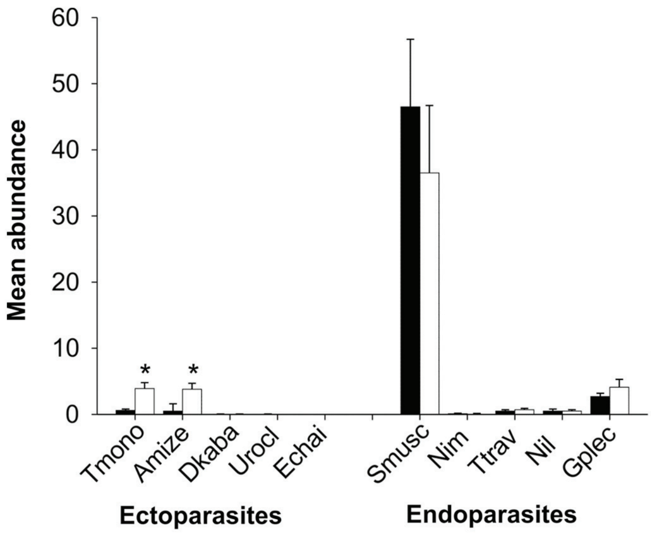

Figure 3. Mean abundance of helminth parasites of *Steindachnerina insculpta* sampled in the lotic and lentic stretches of the Taquari River, Jurumirim reservoir, state of São Paulo, Brazil. Caption: Tmono – total monogeneans; Amize - *Anacanthoroides mizelli*; Dkaba - *Diaphorocleidus kabatai*; Urocl - *Urocleidoides* sp.; Echai - *Euryhaliotrema chaoi*; Smusc - *Sphincterodiplostomum musculosum* metacercariae; Nim – unidentified metacercariae; Ttrav - *Travnema travnema*; Nil – unidentified larvae; Gplec - *Gorytocephalus plecostomorum*. $^*p < 0.05$. Black bars: lotic stretch; White bars: lentic stretch.

Table 3. Ecological indexes for the parasite communities of *Steindachnerina insculpta* sampled in the lotic and lentic stretches of the Taquari River, Jurumirim reservoir, state of São Paulo, Brazil.

Ecological indexes	Lotic	Lentic
Shannon-Wiener	0.40	0.69
Pielou's evenness	0.13	0.25

were the main species responsible for this separation, in vectorial importance order, respectively (Figure 4).

Discussion

Considering the analyses of the limnological parameters, it was possible to confirm that the lentic and lotic stretches of the Taquari River are distinct. Downstream flooding areas are more abruptly affected by impoundments and flood pulses, thus altering the natural process. Additionally, variations in the flood pulse may affect floodplains through altering the water levels that define the limits of riparian vegetation (JUNK et al., 1989).

There have been a few recent studies about the helminth parasite fauna of *S. insculpta*. Takemoto et al. (2009) found the monogenean *Urocleidoides* sp., metacercariae of *Diplostomum* sp. (Digenea: Diplostomatidae) and the nematodes *T. travnema* and *Cosmoxynema vianai* in *S. insculpta* samples from the Upper Paraná River floodplain. In a study on new host and distribution records of nematodes in the Peixe River, state of São Paulo, Abdallah et al. (2012) reported occurrences of *C. vianai, Guyanema* sp., *Ichthyouris* sp., and *T. travnema.* Finally, Zago et al. (2013) reported for the first time metacercariae of *S. musculosum* in *S. insculpta* in the Chavantes reservoir, state of São Paulo. Furthermore, Ceschini et al. (2010) studied the endoparasite fauna of the congeneric species *Steindachnerina brevipinna* sampled in the Paranapanema River, state of Paraná, Brazil, and found metacercariae of *S. musculosum* and the nematode *T. travnema*.

The helminth parasites found in *S. insculpta* are generalists and had been already reported in other freshwater fish hosts (Table 6). The monogeneans *A. mizelli*, *D. kabatai* and *E. chaoi*, and the acanthocephalan *G. plecostomorum* found in the present study are new host records for *S. insculpta*. Nevertheless, all the records found represent new geographical distribution for these parasites, given that there were no previous parasitological studies conducted in the Taquari River, São Paulo. One monogenean specimen found was identified only at genus level (*Urocleidoides*), due to difficulties in viewing the structures, and thus it was not possible to assess host-parasite interactions for it.

Metacercariae of *S. musculosum* were the dominant species in the lotic and lentic stretches, occurring in 100% of the hosts, and at high abundance. Zago et al. (2013) reported lower prevalence (96.67%) for these metacercariae than in the present study. However the mean intensity of infection (96.6 versus 41.5) and mean abundance (93.3 versus 41.5) were higher. Moreover, Zago et al. (2013) found *S. musculosum* also parasitizing the coelomic cavity. Ceschini et al. (2010) found these metacercariae in *S. brevipinna*, but they were in the ovary of the hosts, with lower prevalence

Table 4. Berger-Parker index for the helminth species of *Steindachnerina insculpta* sampled in the lotic and lentic stretches of the Taquari River, Jurumirim reservoir, state of São Paulo, Brazil.

Helminth	Lotic	Lentic
Monogeneans		
Anacanthoroides mizelli	0.010	0.084
Diaphorocleidus kabatai	0.001	0.001
Urocleidoides sp.	0.001	-
Euryhaliotrema chaoi	0.001	-
Digeneans		
Sphincterodiplostomum musculosum (Metacercariae)	0.913	0.798
Unidentified metacercariae	0.002	0.001
Nematodes		
Travnema travnema	0.009	0.016
Unidentified larvae	0.010	0.011
Acanthocephalans		
Gorytocephalus plecostomorum	0.054	0.061

Table 5. Aggregation index for the helminth species of *Steindachnerina insculpta* sampled in the lotic and lentic stretches of the Taquari River, Jurumirim reservoir, state of São Paulo, Brazil.

Species	Lotic	Lentic
Anacanthoroides mizelli	0.779	0.537
Diaphorocleidus kabatai	0.935	0.935
Urocleidoides sp.	0.903	-
Euryhaliotrema chaoi	0.779	-
Sphincterodiplostomum musculosum (Metacercariae)	0.534	0.579
Unidentified metacercariae	0.914	0.935
Travnema travnema	0.806	0.739
Unidentified larvae	0.875	0.738
Gorytocephalus plecostomorum	0.482	0.516

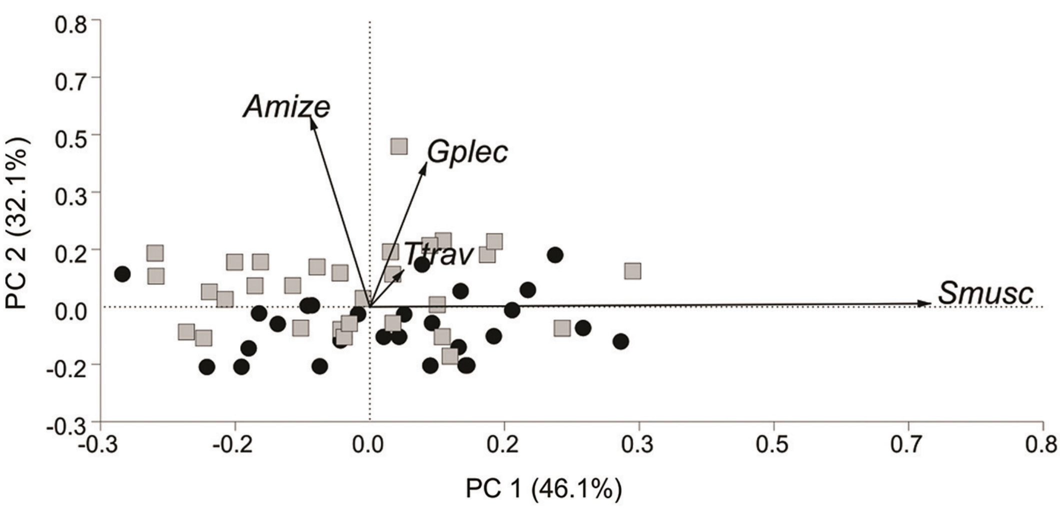

Figure 4. Scatterplot scores of the principal component analysis (PCA) on parasite communities of *Steindachnerina insculpta* in the lotic stretch (•) and lentic stretches (■) of the Taquari River, Jurumirim reservoir, state of São Paulo, Brazil. The values shown on the ordinate and abscissa axes represent the greatest quantity and variation of the data set. Vectorial scale = 0.71. Amize - *Anacanthoroides mizelli*; Gplec - *Gorytocephalus plecostomorum*; Smusc - *Sphincterodiplostomum musculosum* metacercariae; Ttrav - *Travnema travnema*.

Table 6. Helminth list of *Steindachnerina insculpta* and records in other freshwater fish hosts.

Helminth	Host	Reference
Monogeneans		
Anacanthoroides mizelli	*Prochilodus reticulatus*	Kritsky and Thatcher (1976)
Diapharocleidus kabatai	*Astyanax fasciatus*	Mendonza-Franco et al. (2009)
	Astyanax altiparanae	Almeida and Cohen (2011)
Euryhaliotrema chaoi	*Plagioscion squamosissimus*	Kritsky and Boeger (2002)
Digeneans		
Sphincterodiplostomum musculosum (metacercaria)	*Steindachnerina brevipinna*	Ceschini et al. (2010)
	Hoplias malabaricus	Takemoto et al. (2009)
	Cyphocharax gilbert	Abdallah et al. (2005)
Nematodes		
Travnema travnema	*Astyanax bimaculatus*	Abdallah et al. (2004)
	Curimata elegans	Pereira (1938)
	Cyphocarax gilberti	Luque et al. (2011)
	Pseudocurimata plumbea	Luque et al. (2011)
	Steindachnerina brevipinna	Ceschini et al. (2010)
	Cyphocharax plumbeus	Luque et al. (2011)
Acanthocephalans		
Gorytocephalus plecostomorum	*Plecostomus plecostomum*	Nickol and Thatcher (1971)

(90.47%) than in the present study, but with higher infection intensity (52.63 versus 41.5).

Thus far, metacercariae of *S. musculosum* have been found in a few fish species (CESCHINI et al., 2010; TAKEMOTO et al., 2009; ABDALLAH et al., 2005). In the present study, the Berger-Parker index showed that this digenean was the dominant species in *S. insculpta*, corroborating the findings of Zago et al. (2013) and suggesting that this fish species is highly susceptible to infections with this parasite. Moreover, this parasite species was found in the larval stage, suggesting that *S. insculpta* is in an intermediate position in the food chain and that it might be part of the diet of some piscivorous birds that are the definitive hosts of *S. musculosum* (ZAGO et al., 2013).

All the specimens of metacercariae of *S. musculosum* found in the present study were in the eyes of *S. insculpta*. A fish parasitized with approximately 40 metacercariae is likely to have cataracts or even blindness, depending on the size of the fish (EVANS et al., 1976 apud ZAGO et al., 2013). Thus, high infection rates by these metacercariae in the eyes reinforce this information, since the fish are weakened and become easy prey for the definitive host, thereby allowing this parasite to finish its life cycle (ABDALLAH et al., 2005; ZAGO et al., 2013).

Anacanthoroides mizelli and *G. plecostomorum* were also found at high prevalence, but low abundance (2.15 and 3.4, respectively). There is only one record of *A. mizelli* in freshwater fish, which was in *Prochilodus reticulatus* (KRITSKY; BOEGER, 2002), whose biology is similar to *S. insculpta,* since they are both iliophagous species (DUKE ENERGY, 2008). For *G. plecostomorum,* there is also only one record in fresh water fish, which was *Plecostomus plecostomus* (NICKOL; THATCHER, 1971). This fish is demersal (DUKE ENERGY, 2008) feeding on the substrate, like iliophagous species. Therefore, as shown in the present study, there is the possibility that *P. reticulatus, P. plecostomus* and *S. insculpta* may acquire the same parasite, since they might be ingesting the same intermediate hosts that dwell in the substrate, and also share the same habitat.

Vidal-Martínez et al. (2010) affirmed that bioindicators are species that reflect environmental impacts. In a review of parasites (helminths, crustaceans and protozoans) as potential indicators, these authors compiled pertinent data from 1997 to 2008 and grouped some environmental impact variables with parasites that showed significant interaction. These analyses demonstrated, through field and laboratory observations, that these interactions between parasites and eutrophication, pulp-mill effluents, crude oil, PCBs (polychlorinated biphenyls), pesticides or heavy metals can be positive, negative or null.

Monogeneans are fish ectoparasites with a direct life cycle that are found on the skin, in the nasal operculum and on the gills of the hosts (THATCHER, 2006). Thus, these parasites are in direct contact with the environment (NACHEV, 2010) and are very sensitive to any change in water parameters (BAYOUMY et al., 2008). Therefore, studies on monogeneans as biomarkers have been conducted by taking different approaches: Siddall et al. (1997) assessed the effects of exposure to relatively high concentrations of effluents from a pulp and paper mill on the prevalence, abundance and distribution of *Dactylogyrus* spp. on the gills of *Rutilus rutilus* that was sampled in Saravesi Lake, Finland. They found a significant discrepancy between ectoparasite levels and effluent concentration. Vital (2008) compared the parasitism indexes of the host *Pygocentrus nattereri* sampled in different phases of the hydrological cycle of Piranha Lake, Amazonas, Brazil, and pointed out that there was a significant difference in intensity of Dactylogyridae between the rainy and dry seasons. Bayoumy et al. (2008) studied monogeneans of some fish in the Gulf of Suez, Red Sea, as bioindicators for heavy metals, and found highly significant positive relationships between water temperature and prevalence of monogeneans, as well as between metal concentrations and prevalence. Madi and Ueta (2009) analyzed the role of monogeneans belonging to the Ancyrocephalinae family parasitizing *Geophagus brasiliensis*, as environmental bioindicators in reservoirs with distinct trophic characteristics in the state of São Paulo, Brazil (Juqueri reservoir – eutrophic; Jaguari reservoir – oligomesotrophic), and showed that variations in the prevalence and intensity of infection of these parasites were associated with variations in the amount of suspended material in the water of each reservoir.

It was observed in the present study that the prevalence and mean abundance of total monogeneans and *A. mizelli* were significantly greater in the lentic stretch. This significant difference corroborates previous studies that reported the use of monogeneans as indicators of environmental impact (SIDDALL et al., 1997; VITAL, 2008; BAYOUMY et al., 2008; MADI; UETA, 2009). Furthermore, this study evaluated the use of these parasites as environmental indicators for the effect of an impoundment (Jurumirim dam) on parasite communities, an approach that has not previously been reported in the literature.

Monogeneans are more easily found in lentic environments, since it is less difficult for their free-swimming larvae to reach the hosts (DOGEL, 1961). Therefore, this greater number of monogeneans may be due to the decreased water flow in the lentic environment, which enables more exchange of parasites among the hosts.

Steindachnerina insculpta is a fish species with iliophagous feeding habit that is important for food chain maintenance (REIS et al., 2003). Nevertheless, high monogenean infestations on the gills may threaten the breathing capacity of the fish, leading to death. Thus, a reduction in the number of these fish specimens may bring about impacts for other fish species that feed on *S. insculpta*, thus corroborating affirmations about the impacts of impoundments upon fish assemblages and parasite fauna (GABRIELLI; ORSI, 2000; AGOSTINHO et al., 2007).

This study contributes particularly towards initial characterization of the helminth fauna of *S. insculpta* in the Taquari River, in which nine taxa were found, thereby widening the knowledge of the geographical distribution of these parasites. Moreover, this study reports new records for *S. inscultpa* as a host for the monogeneans *A. mizelli, D. kabatai* and *E. chaoi*, and the acanthocephalan *G. plecostomorum.* Furthermore, this study indicates that the total monogenean and *A. mizelli* parasitism of *S. insculpta* could be used as potential bioindicators, due to their greater prevalence and abundance in the lentic gradient.

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