

Ecological aspects of ectoparasites from the gills of *Satanoperca pappaterra* (Heckel, 1840) (Cichlidae) from the upper Paraná river floodplain, Brazil

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ABSTRACT. The gills of 34 specimens of *Satanoperca pappaterra* (Heckel, 1840) were analyzed, all of which had been collected from the upper Paraná river floodplain in Brazil, between March 2004 to June 2005. Five species of parasites were found: two digenean (metacercariae), only one monogenean, one cestode (plerocercoid) and one copepod. The monogenean *Sciadideithrum* sp. was the most abundant and prevalent, followed by the metacercariae *Ascocotyle* sp. The results did not show any significant difference in relation to host sex with regard to the prevalence and abundance of parasites between males and females. Only *Sciadideithrum* sp. presented a significant positive correlation between standard host length and the abundance and prevalence of parasitism. The metacercariae *Ascocotyle* sp. presented a significant positive relation only between standard host length and abundance. Through the results, a great abundance was observed for *Sciadideithrum* sp. and the metacercariae *Ascocotyle* sp. in connected lagoons. These differences suggest this type of environment can favor parasitism, especially in the case of monoxenic cycle ectoparasites, such as the monogenean. According to the importance value, only the *Sciadideithrum* sp. and the metacercariae *Ascocotyle* sp. were considered secondary, while the others were considered satellites. The typical pattern of overdispersion or aggregation from the parasite system was observed for *Sciadideithrum* sp., the metacercariae *Ascocotyle* sp. and the metacercariae *Diplostomum* sp.

Key words: ectoparasites, *Satanoperca pappaterra*, floodplain, Paraná river.

RESUMO. Aspectos ecológicos dos ectoparasitos branquiais de *Satanoperca pappaterra* (Heckel, 1840) (Cichlidae) da planície de inundação do alto rio Paraná, Brasil. Foram examinadas brânquias de 34 espécimes de *Satanoperca pappaterra* (Heckel, 1840), coletados na planície de inundação do Alto rio Paraná, Brasil, entre março de 2004 a junho de 2005. Foram encontradas cinco espécies de parasitos: dois digenéticos (metacercária), apenas um monogenético, um cestóide (plerocercóide) e um copepoda. O monogenético *Sciadideithrum* sp. foi a espécie mais abundante e a mais prevalente, seguida pela metacercária *Ascocotyle* sp. Em relação ao sexo do hospedeiro, os resultados não indicaram diferenças significativas com a prevalência e com a abundância entre machos e fêmeas. Somente *Sciadideithrum* sp. apresentou correlação positiva significativa entre o comprimento-padrão e a abundância e prevalência de parasitismo. A metacercária *Ascocotyle* sp. apresentou correlação positiva significativa somente entre o comprimento padrão e a abundância. Por meio dos resultados, observou-se maior abundância de *Sciadideithrum* sp. e metacercária *Ascocotyle* sp. em lagoas com conexão. Estas diferenças sugerem que este tipo de ambiente pode favorecer o parasitismo, principalmente no caso dos ectoparasitos de ciclo monoxênico como os monogenéticos. De acordo com o grau de importância, apenas *Sciadideithrum* sp. e a metacercária *Ascocotyle* sp. foram consideradas secundárias, sendo o restante todas satélites. O típico padrão de superdispersão ou agregação dos sistemas parasitários foi observado para *Sciadideithrum* sp., a metacercária *Ascocotyle* sp. e a metacercária *Diplostomum* sp.

Palavras-chave: ectoparasitos, *Satanoperca pappaterra*, planície de inundação e rio Paraná.

Introduction

Floodplains are characterized as ecosystems subjected to constant floods, which leads to adaptations in their organisms, resulting in the presence

of communities with characteristic structure and functions (Junk *et al.*, 1989). These environmental modifications can alter the population dynamics of the ichthyofauna, as well as their physiological and

biological conditions, influencing the structure and composition of the parasite fauna. The chemical and physical factors of the water, as well as the dissolved oxygen, temperature, turbulence can contribute to the emerging and increase in some parasites species (Pavanelli *et al.*, 1997).

The aim of this research was to expand the knowledge about the parasite fauna in fish from the upper Paraná river floodplain, through the abundance and diversity of the infracommunity of *Satanoperca pappaterra* ectoparasites, and analyze the possible influence of sex, standard length and host habitat in this infracommunity.

Material and methods

The specimens of *Satanoperca pappaterra* were collected every three months during the period between March 2004 to June 2005, from the upper Paraná river floodplain (22°50' - 22°70'S and 53°15' - 53°40'). After capture and identification, the fish were measured, weighed and had their sex identified. The gills were removed and fixed in 5% formalin. Later, the parasites were removed from the gills with the aid of a stereo microscope and preserved in 70% alcohol (Eiras *et al.*, 2006).

For statistical data analysis, the following statistical tests and ecological indices were used: Spearman's rank correlation coefficient (rs) to determine possible correlations between the host's standard length and abundance of each parasite species; the Pearson linear correlation (r) to determine possible correlations between the host's standard length and the prevalence of infestation of each parasite species (Zar, 1996); the Mann-Whitney U test with normal approximation "Z" to determine the influence of host sex on the abundance of infestation of each parasite species (Siegel, 1975); the log-likelihood G test, using a 2 x 2 contingency table to determine the effect of host sex on the prevalence of each parasite species (Zar, 1996); the Kruskal-Wallis test to compare the influence of three environments (River, Disconnected lagoons and Connected lagoons) on parasitism levels (Zar, 1996). The dispersion index (DI) and Green index (GI) were used to examine dispersion patterns of the parasites species. The dispersion index was tested using the statistics "d" (Ludwig and Reynolds, 1988). The importance value of Caswell (1978) and Hanski (1982) *apud* Bush and Holmes (1986) was used to verify the importance level of each species in the parasite community. The tests were taken for the

species of parasites that presented prevalence greater than 10% (Bush *et al.*, 1990). The values of the tests were considered significant when $p \leq 0.05$.

Results

From the 34 specimens of *Satanoperca pappaterra* analyzed, 24 (70.06%) were parasitized by at least one species of ectoparasite in the gills. A total of 611 parasites were collected, representing a mean intensity of 25.50 parasites per fish.

Structure of the parasite community

Only one species of monogenean *Sciadicleithrum* sp., two digenean (metacercariae) *Ascocotyle* sp. and *Diplostomum* sp., one cestode Proteocephalidea (plerocercoid) were found, one copepod and one nematode that probably were regurgitated and therefore will not be considered in the analysis. According to the importance level, only the *Sciadicleithrum* sp. and the metacercariae *Ascocotyle* sp. were considered secondary and the others were all satellites (Table 1).

Table 1. Prevalence values (P%), mean intensity (MI), mean abundance (MA), Range of variation (Range), Classification of the species (Classification) of the metazoan ectoparasite community from the gills of *Satanoperca pappaterra* captured from March 2004 to June 2005, in the upper Paraná river floodplain, Paraná, Brazil.

Parasites	P (%)	MI	MA	Range	Classification
<i>Sciadicleithrum</i> sp.	64.71	23.00	14.88	1-116	Ce
<i>Ascocotyle</i> sp. (metacercariae)	41.18	5.50	2.26	1-18	Ce
<i>Diplostomum</i> sp. (metacercariae)	16.65	3.50	0.62	1-6	Sa
Proteocephalidea (plerocercoid)	2.94	1.00	0.04	1	Sa
Copepod	2.94	4.00	0.12	1-4	Sa

The classification of the species was done according to the importance value for the community (Caswell, 1978 and Hanski, 1982 *apud* Bush and Holmes, 1986) (Central (Ce) = species presented in more than of 66.6% of the total number of fish analyzed; Secondary (Se) = present between 33.3 and 66.6% of samples; and Satellite (Sa) = lower than 33.3% of samples).

The monogenean *Sciadicleithrum* sp. was the most abundant and most prevalent, followed by the metacercariae *Ascocotyle* sp. The parasite species richness varied from 1 to 4, and 29.4% of fish were infected by one species of parasite (Figure 1).

The metazoan parasite community in the gills of *Satanoperca pappaterra* presented a typical pattern of overdispersion or aggregation of the parasite system, and the metacercariae *Ascocotyle* sp. and *Diplostomum* sp. were the species of parasites that presented the greater values of Green's index (GI). According to the dispersion index, all species were aggregated in the sample of hosts. The aggregation level was, in general, low, as shown by Green's index (Table 2).

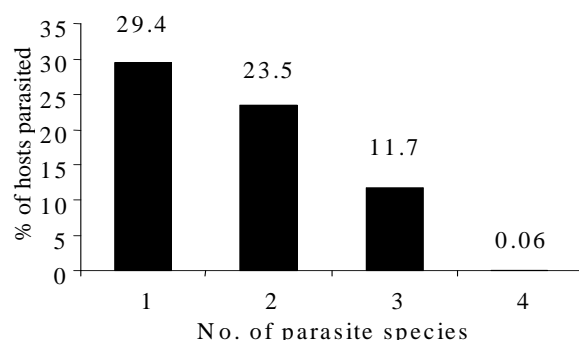


Figure 1. Richness of the metazoan ectoparasite community from the gills of *Satanoperca pappaterra* captured from March 2004 to June 2005, in the upper Paraná river floodplain, Paraná, Brazil.

Table 2. The dispersion index result (DI), the statistic "d" and the Green's index (GI) estimated for ectoparasites of *Satanoperca pappaterra* captured from March 2004 to June 2005, in the upper Paraná river floodplain, Paraná, Brazil. When $d > 1.96$ = aggregated distribution; $d < -1.96$ = uniform distribution; $d < 1.96$ = casual distribution (according to Ludwig and Reynolds, 1988).

Parasites	DI	d	GI	Distribution
<i>Sciadicleithrum</i> sp.	16.521	53.462	0.012	Aggregated
<i>Ascoctyle</i> sp. (metacercariae)	10.231	17.923	0.121	Aggregated
<i>Diplostomum</i> sp. (metacercariae)	3.730	7.628	0.136	Aggregated

Sex

From the analyzed fish specimens, 15 were female and 10 of them (66.6%) were parasitized by at least one species of parasite, presenting a mean intensity of 29.99 parasites per fish. Fourteen of the 19 analyzed males (73.68%) were parasitized by at least one species of parasite, presenting a mean intensity of 22.29 parasites per fish. According to the values obtained from the log-likelihood G test and the Mann-Whitney U test, it was verified that host sex did not influence the prevalence and intensity of parasite infestation, respectively (Table 3).

Table 3. Values from the log-likelihood G test and Mann-Whitney U test, with normal approximation "Z", between the host sex and the prevalence and abundance of parasitism, respectively, to *Satanoperca pappaterra* captured from March 2004 to June 2005, in the upper Paraná river floodplain, Paraná, Brazil (p = significance level).

Parasites	G	P	Z	P
<i>Sciadicleithrum</i> sp.	0.2597	0.6104	0.2775	0.7814
<i>Ascoctyle</i> sp. (metacercariae)	0.6873	0.4071	0.5029	0.6150
<i>Diplostomum</i> sp. (metacercariae)	1.5037	0.2201	0.9180	0.3672

Standard length

According to Pearson's coefficient correlation (r) and Spearman's rank correlation coefficients (r_s), a significant positive correlation was verified between the standard length and the abundance and prevalence only for *Sciadicleithrum* sp. (Table 4 and Figure 2) and a significant positive correlation

between the standard length and abundance for metacercariae *Ascoctyle* sp. and no significance to the prevalence (Table 4 and Figure 3). There were no correlations between the standard length of hosts and abundance and prevalence for the metacercariae *Diplostomum* sp. (Table 4 and Figure 4).

Table 4. Values of Spearman's rank correlation coefficients (r_s) and Pearson's correlation coefficients (r) to evaluate the relationship between abundance and prevalence, respectively, of the ectoparasite fauna with standard length of *Satanoperca pappaterra* captured from March 2004 to June 2005, in the upper Paraná river floodplain, Paraná, Brazil (p = significance level).

Parasites	r_s	P	r	P
<i>Sciadicleithrum</i> sp.	0.5929	0.0002*	0.9576	0.0104*
<i>Ascoctyle</i> sp. (metacercariae)	0.4059	0.0172*	0.8674	0.0567
<i>Diplostomum</i> sp. (metacercariae)	0.2635	0.1321	0.2217	0.7200

*Significant values.

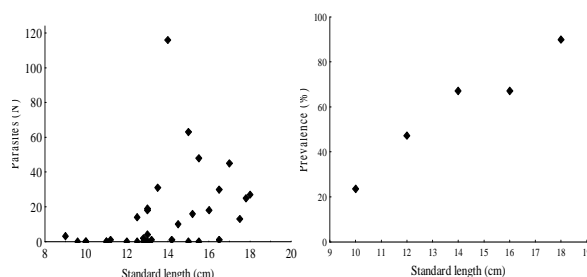


Figure 2. Correlation between the standard length and the abundance and prevalence, of the monogenean *Sciadicleithrum* sp. from the gills of *Satanoperca pappaterra* captured from March 2004 to June 2005, in the upper Paraná river floodplain, Paraná, Brazil.

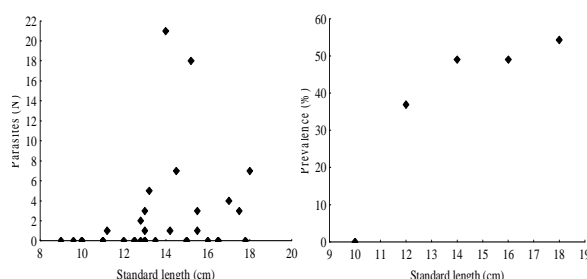


Figure 3. Correlation between the standard length and the abundance and prevalence of the metacercariae *Ascoctyle* sp. from the gills of *Satanoperca pappaterra* captured from March 2004 to June 2005, in the upper Paraná river floodplain, Paraná, Brazil.

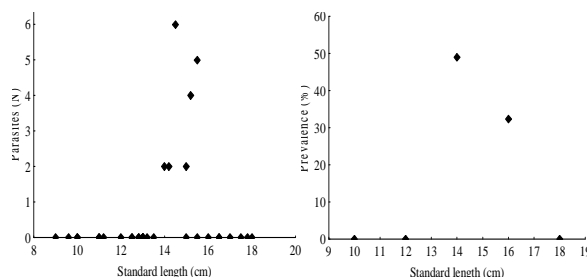


Figure 4. Correlation between the standard length and the abundance and prevalence of the metacercariae *Diplostomum* sp. from the gills of *Satanoperca pappaterra* captured from March 2004 to June 2005, in the upper Paraná river floodplain, Paraná, Brazil.

Environment

According to the Kruskal-Wallis test, *Sciadicleithrum* sp. and metacercariae *Diplostomum* sp. presented differences in the intensity of infestation in relation to the environment (Table 5), with the connected lagoons being the environment with the greatest levels of parasitism; however, disconnected lagoons did not have parasitized fish (Figure 5).

Table 5. Values of the Kruskal-Wallis test (H) to verify the influence of the environments (River, Disconnected lagoons and Connected lagoons) in the levels of parasitism in *Satanoperca pappaterra* captured from March 2004 to June 2005, in the upper Paraná river floodplain, Paraná, Brazil (p = significance level).

Parasites	H	p
<i>Sciadicleithrum</i> sp.	10.8187	0.0010*
<i>Ascocotyle</i> sp. (metacercariae)	2.4324	0.1189
<i>Diplostomum</i> sp. (metacercariae)	4.2109	0.0402*

*Significant values.

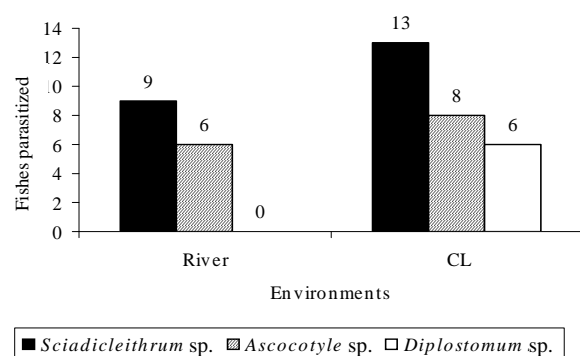


Figure 5. Levels of parasitism in *Satanoperca pappaterra* in two different environments (River, disconnected lagoons (CL) of the upper Paraná river floodplain.

Discussion

Structure of the parasite community

By the results obtained in this work, it was observed that the majority of fish were parasitized by monogenean *Sciadicleithrum* sp., which had more abundance and prevalence, followed by metacercariae *Ascocotyle* sp. The presence of secondary species (prevalence between 33.3 and 66.6%) like *Sciadicleithrum* sp. and metacercaria *Ascocotyle* sp. showed that there was no dominance of one species and absence of competition among the parasites species.

Satanoperca pappaterra is able to present a high richness of parasites because it is a fish with intermediate trophic levels and that shelters parasites in the adult stage, being also infected by several larval forms, whose definitive hosts are fish, birds and mammals.

For *Satanoperca pappaterra*, which displays a sedentary behavior and detritivore habits, the parasite larvae can be acquired by active

penetration, by the swimming of some species, through the ingestion of eggs and/or stuck larva, or by direct ingestion of some larvae forms of these metazoans.

In previous studies of the upper Paraná river floodplain, Pavanelli et al. (2004) registered the occurrence of metacercariae *Diplostomum* sp., of the monogenetic *Cleidodiscus* sp. and a nematode in the intestine of *Satanoperca pappaterra*. The nematode found in the present work was probably regurgitated during the stress caused by net capture, given that it was loose in the gills. Recently, Machado et al. (2005) carried out an ecological study of the metacercariae of *Diplostomum* (*Austrodiplostomum*) *compactum* from the eye of several species of fish, among them *Satanoperca pappaterra*. This parasite is probably the same species found in the gills of *Satanoperca pappaterra* in this present work, knowing that this parasite has the habit of migrating through the host's body until it finds the eyes.

The aggregated distribution showed by the entire population of parasites is considered typical of parasitism, as it was demonstrated in previous studies of fish parasites in the upper Paraná river floodplain with *Hoplias malabaricus* (Almeida, 1998), *Pimelodus maculatus* (Brasil-Sato and Pavanelli, 1999), *Cichla monoculus* (Machado et al., 2000), and *Hemisorubim platyrhynchos* (Guidelli et al., 2003). This kind of distribution tends to increase the stability of the parasite-host relationship, since the regulatory mechanism of the parasite population, as well as the host mortality or the reduction in the fecundity and survival of the parasite dependable of density, influenced a greater proportion of the parasite population (Dobson, 1990).

Sex

According to Esch et al. (1988), host sex can influence parasitism levels due to the behavior and physiological differences between them. However, based on the results, it was observed that the sex of *Satanoperca pappaterra* did not influence the prevalence and abundance of parasite infestation. Perhaps this is due to the similar sizes of males and females hosts; consequently the available physical space and exposure time to the parasites were equivalent.

The ecological relationships (habitat, behavior, diet) among them also proved to be similar, as with the majority of species from the cichlid family. Probably because of this kind of similar behavior between both sexes, they did not present any difference in parasitism levels.

Standard length

The standard length of fish can be related to their age (Shotter, 1976), and is one of most important factors in size variations of the parasite population (Dogiel, 1961). As the fish grows, several changes take place in its behavior and biology, which can influence the parasite fauna (Takemoto *et al.*, 1996). Factors like the quantity and type of food consumed, size of the prey, greater exposure time, the increase in the surface area of the body, and the changes in habitat according to age, can be responsible for the increment in the prevalence and abundance with the advance of the host's age (Dogiel, 1961; Pennycuik, 1971; Hanek and Fernando, 1978).

The significant positive correlation between the standard length of the hosts and the abundance and prevalence found only for *Sciadicleithrum* sp., significant positive correlation between the standard length and the abundance of the metacercariae *Ascocotyle* sp., matches with the hypothesis that the increase in the surface area of the gills and the greater time of exposure to the parasite favor greater parasitosis in larger-sized fish. This pattern is typical of ectoparasites, and can occur due to a cumulative effect (Rhode, 1993). These results also show that the host-parasite relationship is well-adjusted, given that there is no evidence of an immunological response from the host side against these two species of parasites.

Environment

Ectoparasites can be considered typical of lentic environments, because in these environments the free-swimming larvae forms can easily find their hosts. However, some species, such as *Sciadicleithrum* sp., can present adaptations to explore lotic environments. This species presents eggs with a short adhesive appendix, which is used to adhere to a substratum so that the eggs are not taken by the water current.

A significant difference was observed between the environment and the parasitism levels to *Sciadicleithrum* sp. and to metacercariae *Diplostomum* sp., with the former being found in the river and connected lagoons and the latter found only in the connected lagoons. This data matches the hypothesis that parasite intensity and prevalence can be influenced by the environment, especially in the case of the monoxenic cycle ectoparasites, such as the monogeneans, as they are in direct contact with the environment. According to what was mentioned above, the presence of adaptive structures in the eggs of *Sciadicleithrum* sp. can justify the occurrence of

these parasites in greater abundance in the lotic (river) environment as well. In the case of digenetic metacercariae, which needed more than one host to complete its cycle, this correlation would supposedly be linked to the fact that these connected lagoons have a community of macrophytes that shelter and support a greater quantity of intermediate hosts, such as mollusks.

As an overview, the disconnected lagoons of the upper Paraná river floodplain do not favor and stop the cycle from being completed, because the majority of these lagoons dries out completely during the dry season. However, these results must be carefully analyzed, especially given the sample size, because in the disconnected lagoons only two specimens of fishes were collected, which were not parasitized.

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