Ecology of the parasitic endohelminth community of *Piaractus mesopotamicus* (Holmberg, 1887) (Characiformes) from Aquidauana and Miranda Rivers, Pantanal, state of Mato Grosso do Sul, Brazil

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Abstract

In this study the structure and diversity of the endohelminth community, as well as its interactions with 73 specimens of *Piaractus mesopotamicus* are described. The fish were caught in Aquidauana and Miranda rivers, both located in the Pantantal region, in the state of Mato Grosso do Sul. A total of 608,788 specimens of helminthes were found, representing five species: *Dadaytrema oxycephala*, *Chabaudinema americanum*, *Spectatus spectatus*, *Rondonia rondoni* and *Echinorhynchus jucundum*. *D. oxycephala* was more prevalent (91.78%) followed by *R. rondoni* (73.97%). Simpson's index indicated dominance in the endohelminth infracommunities (C = 0.396) and *D. oxycephala* was considered central species. A total of 54 hosts had between 2 and 3 species of helminthes. The pairs of the species *R. rondoni/D. oxycephala* and *S. spectatus/D. oxycephala* showed significant positive correlation between abundances. There was a significant positive correlation between total length and abundance of *S. spectatus* (rs = –0.2467 and p = 0.0353). Abundance of *R. rondoni* between the periods of 1/2003 and 2/2003 (p = 0.0356) and 1/2003 and 4/2004 (p = 0.0009) was significantly different. There was significant prevalence of *E. jucundum* in the female hosts.

Keywords: ecology, fish, helminth, Pantanal, *Piaractus mesopotamicus*.

Ecologia da comunidade parasitária endo-helmíntica de *Piaractus mesopotamicus* (Characiformes) no rio Aquidauana, Pantanal, Mato Grosso do Sul, Brasil

Resumo

Neste trabalho, foram descritas a estrutura e a diversidade da comunidade endo-helmíntica de 73 exemplares de *Piaractus mesopotamicus* e suas interações com os hospedeiros, capturados nos rios Aquidauana e Miranda, MS. Foram encontrados 608.788 espécimes de helmintos, representados por cinco espécies: *Dadaytrema oxycephala*, *Chabaudinema americanum*, *Spectatus spectatus*, *Rondonia rondoni* e *Echinorhynchus jucundum*. O digenético *D. oxycephala* foi a espécie mais prevalente, com 91,78%, seguido do nematoda *R. rondoni* com 73,97%. O índice de Simpson indicou dominância entre as infracomunidades de endo-helmintos (C = 0,396), sendo *D. oxycephala* a espécie dominante. Dos hospedeiros amostrados, 54 continham entre duas e três espécies de endo-helmintos. Os pares *R. rondoni/D. oxycephala* e *S. spectatus/D. oxycephala* apresentaram correlações positivas significativas entre as abundâncias. Correlação positiva significativa foi observada entre comprimento total e abundância parasitária para *S. spectatus* (rs = – 0,2467 e p = 0,0353). A abundância de *R. rondoni* foi diferente estatisticamente entre o período 1/2003 e 2/2003 (p = 0,0356) e o período 1/2003 e 4/2004 (p = 0,0009). A prevalência de *E. jucundum* foi maior significativamente nas fêmeas.

Palavras-chave: ecologia, helmintos, Pantanal, peixe, *Piaractus mesopotamicus*.

1. Introduction

The Pantanal region consists of 140,000 km^2 of flooding plains located in the basin of the Paraguai River and it is one of the biggest flooding areas in the world. The basin of the Paraguai River receives water of smaller sub-basins such as the one of the Miranda river and, its affluent, the Aquidauana River (EMBRAPA, 1991). The ecological factor that determines the standards and processes in the Pantanal is the flooding cycle (Junk and Silva, 1999; Oliveira and Calheiros, 2000), which follows an annual mono-modal cycle, whose amplitude varies between two and five metres and lasts from three to six months.

Ecological aspects of the parasites found in freshwater teleosts are often studied in Brazil, but mainly in the fish from the rivers located in the flooding area in the Paraná River. Machado et al. (1994; 1996), Takemoto and Pavanelli (2000), Guidelli et al. (2003), Lizama et al. (2005) are some of the authors that have researched the structure of the parasite community in several different fish species from the Upper Paraná River floodplain.

Studies of the parasites found in the fish from Pantanal rivers were conducted by Santos et al. (2003), Adriano et al. (2002; 2005) who reported data on parasite prevalence, intensity and abundance.

This study deals with the ecological aspects of the endohelminth parasites found in pacu captured in rivers. Pacu is one species of great interest for human consumption, sports and professional fishing and for fish farming as well. Knowledge of the host population dynamics, identification of the parasite species, helminths life cycle and pathogens are vital to adopt prophylactic measures in rearing systems.

This work describes the structure and diversity of the endohelminth community and its interactions with *Piaractus mesopotamicus* (Holmberg, 1887), captured in both Aquidauana and Miranda rivers, MS.

2. Material and Methods

Seventy-three specimes of *Piaractus mesopotamicus* were captured during 2003 and 2004, monthly, in the Miranda and Aquidauana rivers, Pantanal region, MS. Fish captures were undertaken using net with mesh sizes six to 17 cm between opposite knots. Fish were killed by cerebral commotion and the standard length (cm) and total weight (g) of each fish were registered. After that, necropsy was done to determine sex and to separate the intestines for macroscopic and microscopic analysis in order to collect the parasites.

The collected helminthes were processed according to Eiras et al. (2000) and identified following the classifications of Travassos et al. (1928), Yamaguti (1961), Anderson et al. (1974), Thatcher (1991), Moravec et al. (1992), Khalil et al. (1994) and Vicente and Pinto (1999).

Since the majority of the intestines collected presented a great amount of *Rondonia rondoni*, this parasite was therefore quantified by an estimative method (Campos et al., 2007). Data relative to abundance, parasite prevalence and richness of species, were used to describe the structure of the infra-communities, according to Bush et al. (1997). The Importance Value based on prevalence was used to verify the importance of each species of the endohelminth community (Bush and Holmes, 1996). Species whose prevalence was higher than 66.66% were considered as central; between 33.33 and 66.66%, secondary; and less than 33.33%, satellite. The Simpson Dominance Index (C) was calculated to indicate dominance among parasite species, dominance being accepted when $C \geq 0.25$ (Stone and Pence, 1978). The Q-square test was used to determine interspecific associations between pairs of species found in the same host. The Spearman rank correlation coefficient (rs) was used to verify if parasite abundance and condition factor were correlated with host standard length; to establish the correlation between abundance of parasite species for each pair; and to correlate parasite abundance with temperature and rainfall (Zar, 1996). Pearson's linear correlation (r) was used to determine the correlation between host standard length and parasite prevalence, whose values were previously arc sin $\sqrt{X}$ transformed (Zar, 1996). Length was distributed according to six classes, at 10 cm intervals. The G log-likelihood test (using the contingence table 2 x 2) was used to determine host sex effect on the prevalence and parasite prevalence to both environments. The Mann-Whitney's (U) test was used to determine host sex effect on the abundance of each species (Zar, 1996). Abundance of each species was compared among periods and years using the Kruskal-Wallis (H) test, in which period 1 of year 1 corresponded to the period between April and September 2003; period 2 of year 1, between October 2003 and March 2004; period 1 of year 2, between April and September 2004; and finally, period 2 of year 2, between October and December 2004. The analysis included only endohelminth species whose prevalence was higher than 10% (Bush et al., 1990). The statistical significance level adopted was $p \leq 0.05$. The water quality data such as temperature, transparency, dissolved oxygen, conductivity and pH were collected at three different sampling points within a 20 km range, in order to obtain mean data. The data were collected in the morning and afternoon, to represent a 24-hour cycle. Rainfall data were supplied by the meteorological station in Aquidauana.

3. Results

From the 73 *Piaractus mesopotamicus* analyzed, 25 were females, 43 males and 5 undetermined. Total weight and standard length varied between 665 g and 4,970 g (SD = 627.78 g) and, 30 and 60 cm (SD = 4.24 cm), respectively. A total of 608,788 helminth parasites, representing 5 species, were found in the intestines of *Piaractus mesopotamicus*.

The species found were as follows: *Dadaytrema oxycephala* (Digenea), *Rondonia rondoni*, *Spectatus*

spectatus, *Chabaudinema americanum* (Nematoda) and *Echinorhynchus jucundum* (Acantocephala). *Chabaudinema americanum* prevalence was inferior to 10% and therefore was not taken into account in the statistical analysis.

Fifty seven and 16 pacu individuals were captured respectively in the Aquidauana and Miranda Rivers. As seen in Table 1, parasite prevalence between the two environments was not significantly different, which allowed the data to be treated as a whole, without distinction.

The species *D. oxycephala* was prevalent with 91.78%, followed by the nematode *R. rondoni* with 73.97%. The latter presented also the highest mean abundance and intensity (Table 2). According to importance value, *D. oxycephala* and *R. rondoni* were considered to be central species, while *S. spectatus* and *E. jucundum* were secondary and satellite species, respectively. Simpson's index indicated dominance among the infra-communities of endohelminths (C = 0.396) where *D. oxycephala* was the dominant species.

From the sampled individuals, 97.26% presented at least one species of endohelminth parasite. Four was the largest number of helminth species found in one single host. From the sampled hosts, 54 presented between 2 and 3 endohelminth species.

From the possible associations, 5 were positive and, from these, with the exception of the pair *R. rondoni/E. jucundum*, all others were significant associations. The two pairs *R. rondoni/D. oxycephala* and *S. spectatus/D. oxycephala* presented significant positive correlation for abundance too (Table 3).

The correlation between water temperature and rainfall with parasite abundance was not significant (Table 4). The same held true for total length and parasite prevalence (Table 5). There was, however, significant positive correlation between standard length and parasite abundance for the species *S. spectatus* as observed in Table 5.

The abundance of *R. rondoni* differed significantly for the period 1/2003 and 2/2003 (p = 0.0356), as well as period 1/2003 and 4/2004 (p = 0.0009), according to results given by the Kruskal-Wallis test (Table 6).

Sex was not a factor in parasite abundance. However, *E. jucundum* species was significant prevalent in female pacu (Table 7).

Table 1. Log-likelihood G test to evaluate the differences between parasite prevalence in 57 and 16 *Piaractus mesopotamicus* individuals captured in Aquidauana and Miranda rivers, State of Mato Grosso do Sul, during 2003 and 2004.

Parasites	G	p
Dadaytrema oxycephala	0.1117	0.7382
Spectatus spectatus	0.0064	0.9364
Rondonia rondoni	0.5935	0.4411

Significant value $p \leq 0.05$.

Table 2. Developmental stage, mean intensity and abundance, prevalence and importance of endohelminth in 73 *Piaractus mesopotamicus* individuals captured in Aquidauana and Miranda rivers, State of Mato Grosso do Sul, during 2003 and 2004.

Parasite species	DS	IF	NP	MI	MA	AA	P (%)	I
Digenea								
Dadaytrema oxycephala	L e A	67	15.096	225.3	206.8	0-1.454	91.78%	Ce
Nematoda								
Rondonia rondoni	L e A	54	591.932	10,032.7	8,108.6	0-68.441	73.97%	Ce
Spectatus spectatus	A	29	1.666	57.45	22.82	0-364	39.72%	Se
Acantocephala								
Echinorhynchus jucundum	A	8	42	5.25	0.57	0-16	10.95%	Sa

DS – developmental stage (L – larvae; A – adult); IF – number of infected fish; NP – number of parasites; MI – mean intensity of parasite; MA – mean abundance of parasites; AA – amplitude of abundance variation; P (%) – prevalence; I – species importance based on prevalence (P > 60% = central (Ce); P < 33% = satellite (Sa); P between 33% and 66% = secondary (Se)).

Table 3. Spearman rank correlation coefficient (rs) and X^2 values to evaluate for each pair, respectively, abundance correlation and association of endohelminth species in 73 *Piaractus mesopotamicus* individuals, captured in Aquidauana and Miranda, state of Mato Grosso do Sul, during 2003 and 2004.

			X^2	
Parasite species	**(1)**	**(2)**	**(3)**	**(4)**
Rondonia rondoni (1)	——	(+) 0.038	(+) 1.018	(–) 0.210
Spectatus spectatus (2)	(–) 0.0283	——	(+) 0.592	(+) 0.061
Dadaytrema oxycephala (3)	0.2768*	0.2585*	——	(+) 0.046
Echinorhynchus jucundum (4)	0.086	0.1790	0.0649	——

rs

*Significant values for X^2 and rs, > 3.84 and ≤ 0.05, respectively.

Table 4. Spearman rank correlation coefficient (rs) for water temperature and rainfall, as well as parasite abundance in *Piaractus mesopotamicus* captured in Aquidauana river, in 2004.

	Abundance and temperature		Abundance and rainfall	
	rs	p	rs	p
Dadaytrema oxycephala	–0.1541	0.2801	–0.0148	0.9298
Spectatus spectatus	–0.1036	0.4693	0.1459	0.3819
Rondonia rondoni	0.1638	0.2507	–0.0025	0.9880
Echinorhynchus jucundum	0.1589	0.2654	0.2764	0.0929

Table 5. Pearson's linear correlation (r) and Spearman rank correlation coefficient (rs) to evaluate, respectively, the relationship between total length and parasite prevalence and abundance in 73 *Piaractus mesopotamicus* individuals, captured in Aquidauana and Miranda rivers, state of Mato Grosso do Sul, during 2003 and 2004.

Parasites	r	p	rs	p
Dadaytrema oxycephala	0.7164	0.1091	–0.0703	0.5547
Spectatus spectatus	0.6755	0.1408	0.2467	0.0353*
Rondonia rondoni	0.2507	0.6318	–0.1584	0.1808
Echinorhynchus jucundum	–0.6970	0.1237	–0.0929	0.4343

*Significant values for $p \leq 0.05$.

Table 6. Kruskal-Wallis test results (H) comparing parasite abundance of each species found in 73 *Piaractus mesopotamicus* individuals captured in Aquidauana and Miranda Rivers, state of Mato Grosso do Sul, during the periods (1 and 2) and years (2003 and 2004).

	Rondonia rondoni	***Spectatus spectatus***	***Dadaytrema oxycephala***	***Echinorhynchus jucundum***
H	11.1461	4.3298	7.4234	1.1274
p	0.0110*	0.2280	0.0596	0.7705

*Significant values.

Table 7. Mann-Whitney (U) and G Log-likelihood test results to evaluate the relationship between sex and parasite abundance and prevalence of 73 *Piaractus mesopotamicus* individuals captured in Aquidauana and Miranda rivers, state of Mato Grosso do Sul.

Parasites	Z(U)	p	G	p
Dadaytrema oxycephala	1.2845	0.1990	0.2236	0.3436
Spectatus spectatus	0.7440	0.4569	0.5530	0.4571
Rondonia rondoni	1.8018	0.0716	0.8970	0.3436
Echinorhynchus jucundum	0.9707	0.3317	3.8859	0.0487*

*Significant values $p \leq 0.05$.

4. Discussion

Feeding habits of the host is one of the most influential factors determining the parasite fauna composition, since many of the animals that play the part of intermediate host to the parasites are also found in the diet of the final host (Dogiel, 1970). The parasite fauna that prevailed in the intestines of *P. mesopotamicus*, an omnivorous species, was digenean helminth. These parasites need at least one intermediate host, generally, a mollusk. Since the helminth fauna in fish is acquired by ingesting intermediate hosts, which are part of the diet, the helminth distribution is attributed to qualitative and/or quantitative changes in the diet. These changes occur with age, sex, host behaviour and according to environmental factors, such as season of the year or habitat.

Higher abundance and mean intensity for *R. rondoni* was observed. During their life cycle, nematodes live generally in two intermediate hosts, a microcrustacean copepod and a vertebrate. The highest mean abundance and intensity for *R. rondoni* may be explained by the endogenous multiplication of this parasite. According to Travassos et al. (1928) the host may ingest larva or even adult expelled in the feces, due to the large amount of parasites found in the intestine, making up 50% of the feces. Costa (1962) confirmed the breaking of the pregnant female body, thus freeing the larvae to the exterior.

Prevalence data of *R. rondoni* observed in this study are close to the data reported by Parra et al. (1997), who found 71% prevalence of this parasite in farmed *P. mesopotamicus*.

In this study, *R. rondoni* practically obstructed the light in the intestine of the hosts, a fact that has already been reported by Rego and Vicente (1988) for the same host collected in the Paraguai and Miranda rivers.

Dias et al. (2004), while studying *Pterodoras granulosus* from Paraná, PR and Ivinhema, MS rivers, also a Siluriformes species reported a mean intensity for *R. rondoni* of 13,168.82. Such high value coupled with a good condition factor suggests adjusted parasitism. In the present work, apparently *R. rondoni* was not causing damage to the hosts, taking into account the condition factor. According to Thatcher (1991) *R. rondoni* is not responsible for tissue changes in the hosts.

In spite of omnivorous feeding habits, this host presents trend towards herbivorous, thus justifying the absence of cestodas in the intestine.

D. oxycephala and *R. rondoni* were considered central species with importance values based on prevalence and confirmed by the Simpson's index. According to Takemoto and Pavanelli (2000) the dominance of certain species or groups of parasites is common, and there are many mechanisms that interfere with dominance. Holmes (1990) reported that a certain species of parasite may constitute a hostile environment to other species or compete for certain nutrients, thus prevailing in the local of infection.

The positive associations between pairs of species may indicate the utilization of the same intermediate hosts; in principle, however this was not occur in this study. The positive associations between the pairs *R. rondoni/D. oxycephala* and *S. spectatus/D. oxycephala* indicate that species may coexist in the same host without competition, probably because they do not occupy the same local along the intestine. According to Holmes (1990), the occupation of niches inside the intestines may be influenced by the competition among species and utilization of nutrients by the parasites. Shotter (1973) also cites factors such as seasonal changes and age of the fish.

Esch et al. (1990) states that several factors may interfere with the structure of the parasite community, such as the age and length of the host, changes in the diet or in the volume of food ingested, changes ontogenetic in the imuno-competence and probability of contact with intermediate hosts. Correlations between host length and parasite load may give an idea of the parasite community during the host life cycle.

In this study, a significant positive correlation between standard length and parasite abundance was observed only for the species *S. spectatus*, thus suggesting that larger fish may ingest a larger quantity of food. Takemoto and Pavanelli (1994, 2000) and Machado et al. (1994) studying *Pseudoplatystoma corruscans* and *Paulicea luetkeni* reported increasing parasitism with increasing length and age of the hosts.

No significant correlations were observed between standard length and parasite prevalence, which indicates that there was no change in the host feeding habits during the studied periods. Host total length varied between 30 and 60 cm, thus showing the presence of juvenile and adult fish.

Abundance of *R. rondoni* was significantly different between the periods 1/2003 and 2/2003; and 1/2003 and 4/2004. The period 1/2003 displayed higher values, probably due to higher rainfall. Rivers located in flooding plains are extremely seasonal during flooding season. In this period, it is common to find aloctone feeding items, brought on by the water that overflows the riverbeds, thus increasing the food spectrum of the fish (Resende et al., 1996).

The prevalence of *E. jucundum* was dependent on the sex of the host, with the female hosts being more infected by this parasite. Considering the smaller number of females compared to males, among the sampled hosts, maybe a behavioural or physiological difference between male and female can explain the higher prevalence of this acantocephala in the females, since the same difference of parasitism levels was not observed for other helminthes.

At least 5 species of helminth were found to parasite *P. mesopotamicus* from the Aquidauana and Miranda rivers. *D. oxycephala* (Digenea) and *R. rondoni* (Nematode) were the most prevalent and classified as central species, with the latter presenting higher mean abundance and intensity values.

Significant positive associations were observed in four parasite pairs. Sex affected parasite abundance of *E. jucundum*.

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