Ecology of endoparasites of the fluvial stingray *Potamotrygon falkneri* (Chondrichthyes: Potamotrygonidae) from the upper Paraná River floodplain, Brazil

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Abstract

The present study investigated the ecological relationships between endoparasites and the host *Potamotrygon falkneri* from the upper Paraná River by using as indicators the host's relative condition factor (Kn), sex and hepatosomatic relation (HSR). Forty-seven specimens of *P. falkneri* were analyzed between March 2005 and September 2006. Statistical analysis showed that the Kn was positively correlated with the abundance of *Acanthobothrium regoi* and *Rhinebothrium paratrygoni*; only the abundance of *A. regoi* was positively correlated to the HSR, whereas *R. paratrygoni* did not present correlation and there was no influence of the host's sex on the abundance and prevalence of parasites. This is the first study concerning the ecology of parasites of potamotrygonids.

Keywords: potamotrygonids, parasites, relative condition factor, hepatosomatic relation, Paraná.

Ecologia de endoparasitos da raia fluvial *Potamotrygon falkneri* (Chondrichthyes: Potamotrygonidae) da planície de inundação do alto rio Paraná, Brasil

Resumo

O presente estudo investigou as relações ecológicas entre os endoparasitos e os hospedeiros *Potamotrygon falkneri* do alto rio Paraná, utilizando como indicadores o fator de condição relativo (Kn), sexo e relação hepatossomática (HSR) dos hospedeiros. Entre março de 2005 e setembro de 2006, 47 espécimes de *P. falkneri* foram analisados. As análises mostraram que o Kn estava positivamente correlacionado com a abundância de *Acanthobothrium regoi* e *Rhinebothrium paratrygoni*; apenas a abundância de *A. regoi* estava correlacionada positivamente com a HSR, enquanto *R. paratrygoni* não apresentou correlação e não houve influência do sexo do hospedeiro na abundância e prevalência dos parasitos. Este é o primeiro estudo sobre ecologia de parasitos de potamotrigonídeos.

Palavras-chave: potamotrigonídeos, parasitos, fator de condição relativo, relação hepatossomática, Paraná.

1. Introduction

Potamotrygon falkneri Castex (Potamotrygonidae) is a fluvial stingray found in the Paraná-Paraguay basin, from the Cuiabá River to La Plata River (Carvalho et al., 2003). Despite of some studies on the systematic (Rego, 1979; Marques and Brooks, 2003) and phylogeny (Brooks, 1992) of endoparasites of potamotrygonids, little is known about this host-parasite association. The application of indicators that use organs as the liver and the relative condition factor of fishes regarding the levels of parasitism are important tools for understanding the ecological relationship between parasites and hosts (Lizama et al., 2006). Thus, the present study had the objective to analyze *P. falkneri* and its endoparasites from the upper Paraná River floodplain, using the sex, the relative condition factor and the hepatosomatic relation of the hosts.

2. Materials and Methods

Forty-seven specimens of *P. falkneri* were analyzed, captured between March 2005 and September 2006 in the upper Paraná River floodplain, near the City of Porto Rico, Paraná and Mato Grosso do Sul States (22° 43' S and 53° 10' W) (Figure 1).

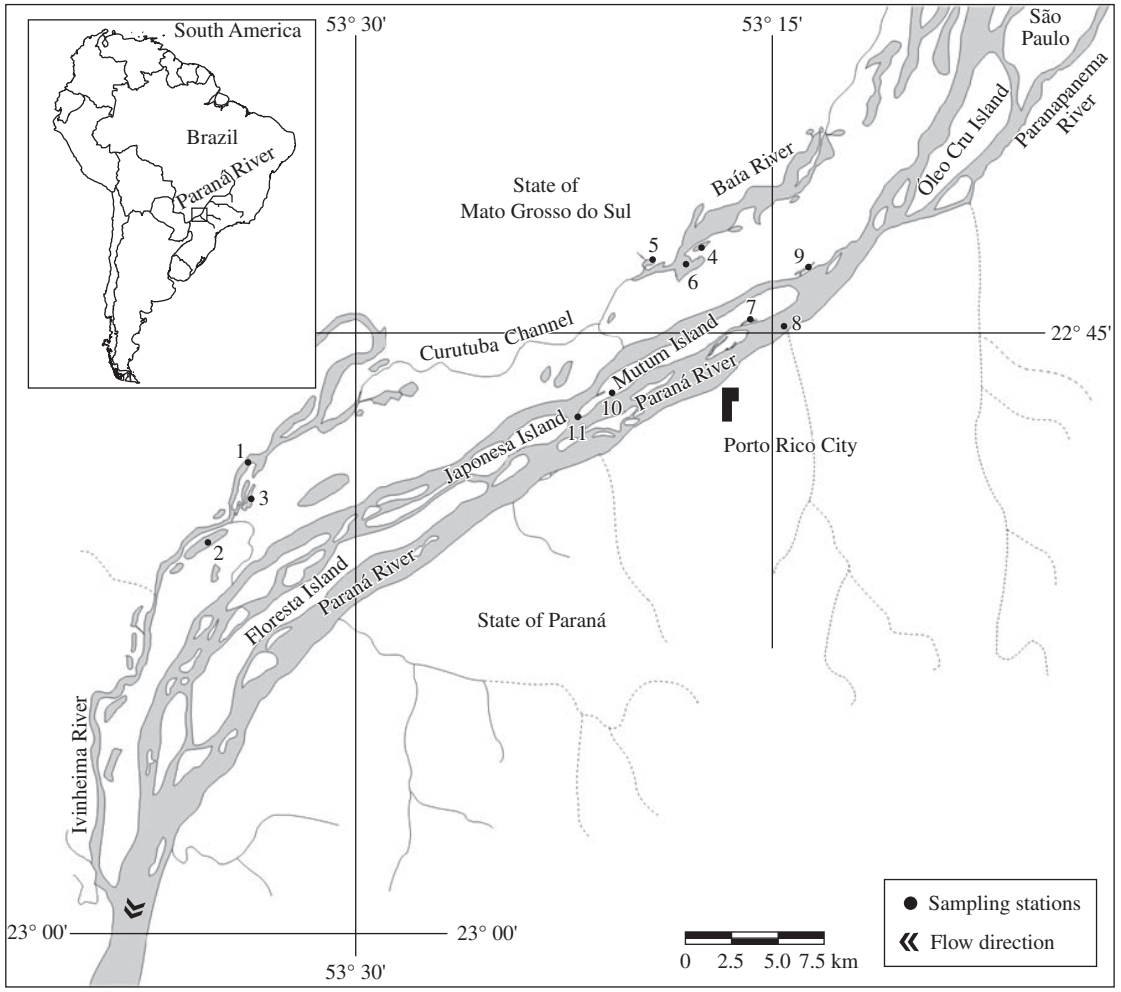

Figure 1. Upper Paraná River floodplain. Sampling stations: 1 - Ivinhema River; 2 - Ventura Lagoon; 3 - Patos Lagoon; 4 - Fechada Lagoon; 5 - Guaraná Lagoon; 6 - Baía River; 7 - Pau Véio backwater; 8 - Paraná River; 9 - Garças Lagoon; 10 - Osmar Lagoon; and 11 - Mutum Island.

Total length, disk length, total weight, liver weight and sex of the captured fish were recorded. Sampling, fixation, conservation and preparation of the endoparasites followed the methodology of Eiras et al. (2006).

Diversity was calculated by the Brillouin index (HB). To verify the existence of dominant taxa in the infracommunities, the index of dominance of Simpson was calculated. The dispersion patterns of the parasite species were determined by the index of dispersion (ID) and tested by the statistic *d*. The Green index (GI) was used for measuring the aggregation level of the species. The values of importance of the taxa in the infracommunities of endoparasites were determined according to the value of importance of Caswell (1978) and Hanski (1982), cited by Bush and Holmes (1986).

The influence of the sex of the hosts on the abundance and prevalence of each species of parasite was determined by the Mann-Whitney *U* test and by statistic *G* ("log-likelihood"), respectively. The relative condition factor (Kn) was calculated, considering the coefficient between the observed weight and the weight theoretically expected for a given length (Le Cren, 1951). The hepatosomatic relation (HSR%) was calculated by the expression: liver weight (g)/body weight (g) x 100. For each species of parasite, the Spearman rank correlation "rs" was calculated between abundance and Kn and abundance and HSR. The tests adopted level of significance of $p \leq 0.05$ and were applied only to the species that presented prevalence higher than 10%. The ecological terminology was based on Rózsa et al. (2000).

3. Results

Twenty-two out of 47 specimens of *P. falkneri* presented at least one species of endoparasite (46.8%). In total, 175 specimens of parasites were collected from the

intestinal tract of the fish and the group that presented the greatest number of species was Cestoda; *Rhinebothrium paratrygoni* Rego and Dias presented the highest prevalence and mean abundance (Table 1).

In March 2005, the only fish examined was not parasitized. In April 2005, of 13 specimens of *P. falkneri* collected, four were parasitized by *Rhinebothrium paratrygoni* (30.8%). In June 2005, eight out of 13 analyzed fish were parasitized (61.5%) by the following species: *Genarchella* sp. (15.4%), *Tylodelphis* sp. (metacercariae) (7.7%), *Acanthobothrium regoi* Brooks, Mayes and Thorson (15.4%), *R. paratrygoni* (53.8%), *Paroncomegas araya* (Woodland) (15.4%), Cestoda (larva) (7.7%), *Brevimulticaecum* sp. (larvae) (7.7%), *Cucullanus* (*Cucullanus*) sp. (7.7%), *Echinocephalus* sp. (7.7%), *Spinitectus* sp. (7.7%) and *Quadrigyrus machadoi* Fabio (15.4%). In September 2005, the only examined fish was parasitized by *Genarchella* sp., *P. araya* and *R. paratrygoni*. In December 2005, four analyzed fish were not parasitized, as well as two fish analyzed in March 2006. In May 2006, four out of nine fish were parasitized (44.4%) by *A. regoi* (22.2%) and *R. paratrygoni* (33.3%). In June 2006, the only analyzed specimen was parasitized by *A. regoi*, *P. araya, Potamotrygonocestus travassosi* Rego, *R. paratrygoni* and *Clinostomum complanatum* (Rudolphi) (metacercaria). In September 2006, one of three analyzed fish was parasitized (33.3%) by *A. regoi* and *R. paratrygoni* (Figure 2).

The species richness of the infracommunities varied from one to five, being constituted by only one species of parasite in the majority of the hosts (Figure 3). The community of endoparasites presented mean diversity of HB = 0.32 ± 0.35, with the majority of the hosts under 0.5. The parasites that presented prevalence higher than 10%, *A. regoi* and *R. paratrygoni*, presented aggregated distribution (ID = 12.71; *d* = 24.67; GI = 0.38 and ID = 13.25; *d* = 25.38; GI = 0.14, respectively). No species of parasite was considered central. *R. paratrygoni* was considered secondary and all the other species were considered satellites. There was not dominance in the proportion of parasitized fish regarding the species of parasites (C = 0.22).

The total length of the fish varied between 39.00 and 89.80 cm (55.80 ± 13.80). Total weight varied from 375.00 to 7300.00 g (1771.90 ± 1534.60). Kn varied between 0.72 and 1.44 (1.01 ± 0.19) and the HSR from 0.99 to 6.67 (3.23 ± 1.33). The Kn was positively correlated to the abundance of *A. regoi* (rs = 0.29; p = 0.04) and *R. paratrygoni* (rs = 0.29; p = 0.04). Only the abundance of *A. regoi* was positively correlated to the HSR of the hosts (rs = 0.34; p = 0.04), while *R. paratrygoni* did not present correlation (rs = 0.15; p > 0.05).

Twenty-five hosts were females and 22 were males. Significant influences of the host sex on the abundance and prevalence of *A. regoi* (Z = 0.08;

Table 1. Parasite taxa, infection sites and parasitism indexes in 47 specimens of *Potamotrygon falkneri* collected in the upper Paraná River floodplain between March 2005 and September 2006. PF = parasitized fish; P = prevalence; MI = mean intensity ± SD; MOI = mode of intensity; MA = mean abundance ± SD.

Parasite taxa	Infection sites	Parasitism indexes				
		PF	P (%)	MI	MOI	MA
Digenea						
Clinostomum complanatum (Rudolphi, 1819) (metacercaria)	Spiral valvae	1	2.13	1	1	0.02
Tylodelphis sp. (metacercariae)	Spiral valvae	1	2.13	8	8	0.17
Genarchella sp.	Stomach	2	4.25	1	1	0.04
Cestoda						
Acanthobothrium regoi Brooks, Mayes and Thorson, 1981	Spiral valvae	6	12.76	5.83 ± 6.88	1	0.74 ± 3.00
Paroncomegas araya (Woodland, 1934)	Spiral valvae	3	6.38	3 ± 2.00	1;3;5	0.19 ± 1.04
Potamotrygonocestus travassosi Rego, 1979	Spiral valvae	1	2.13	4	4	0.58
Rhinebothrium paratrygoni Rego and Dias, 1976	Spiral valvae	17	36.17	5 ± 7.29	1	2 ± 4.98
Nematoda						
Brevimulticaecum sp. (larvae)	Stomach (external wall)	1	2.13	16	16	0.34
Cucullanus (*Cucullanus*) sp.	Spiral valvae	1	2.13	3	3	0.06
Echinocephalus sp.	Spiral valvae	2	2.13	1	1	0.02
Spinitectus sp.	Spiral valvae	1	2.13	3	3	0.06
Acanthocephala						
Quadrigyrus machadoi Fabio, 1983	Spiral valvae	3	6.38	2 ± 1	1;2;3	0.13 ± 0.54

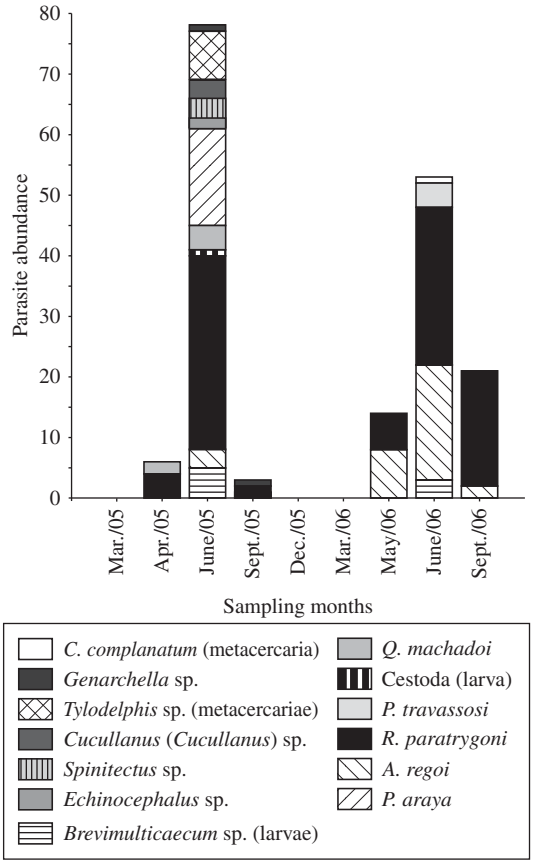

Figure 2. Abundance of parasites of *Potamotrygon falkneri* in different months in the upper Paraná River floodplain, between March 2005 and September 2006.

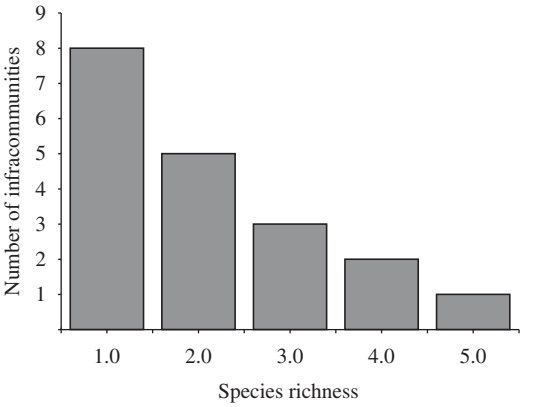

Figure 3. Species richness of parasites in the infracommunities of *Potamotrygon falkneri* collected in the upper Paraná River floodplain, between March 2005 and September 2006.

$p > 0.05$ and $G = 0.09$; $p > 0.05$) and *R. paratrygoni* ($Z = 0.11$; $p > 0.05$ and $G = 0.09$; $p > 0.05$) were not observed. However, *P. araya, P. travassosi*, Cestoda (larva), *Q. machadoi, Brevimulticaecum* sp. (larvae), *Echinocephalus* sp., *Spinitectus* sp., *Cucullanus* sp., *Tylodelphis* sp. (metacercariae), *Genarchella* sp. and *Clinostomum complanatum* (metacercaria) occurred only in females.

4. Discussion

Considering all species of parasites, approximately half of the analyzed fish were parasitized (46.8%). Only one metacercaria of *Clinostomum complanatum* was found in a single host. It is possible to consider that the host *Potamotrygon falkneri* acted as an accidental host for this metacercaria, since its prevalence was very low and it is an abundant species in the study region (Pavanelli et al., 2004). The same can be considered for *Tylodelphis* sp., *Brevimulticaecum* sp., *Cucullanus* (*Cucullanus*) sp. and *Spinitectus* sp., that were found in only one host, but with higher intensity.

The most prevalent species were *Acanthobothrium regoi* (12.76%) and *Rhinebothrium paratrygoni* (36.17%), cestodes that are not very specific, but parasitize only potamotrygonids (Brooks and Amato, 1992; Lacerda et al., 2008). Unfortunately, the majority of the studies with parasites of fluvial stingrays do not present information about parasitism levels, but we can say that the prevalence of *Acanthobothrium regoi* in *P. falkneri* in the present study is low when compared to other species of *Acanthobothrium* and other species of hosts, being closer to the values found in Argentina (Ivanov, 2005). Those values indicate that the genus is better represented (in relation to infected hosts) in the populations of marine stingrays. In fact, these parasites are more adapted to the marine environment, since they probably occupied the freshwater environment with the ancestor of the potamotrygonids, during Plioceno (three to five millions years ago) (Brooks, 1992).

Although the number of hosts did not permit a seasonal analyses, a higher number of parasites was observed in May 2005 and May and June 2006. The annual cycles and reproductive periods of fish parasites are frequently related to the hydrologic variation of the habitat of the host, as well as to the fluctuations in the abundance of plankton and bentic organisms (Ginetsinskaya, 1970) and fish that feed on them. Analysing the annual variation of the hydrologic level (monthly mean) of the region, Souza Filho et al. (2004) emphasized a decrease in May and June, being the lowest level recorded in August. According to Machado et al. (1994), intermediate hosts present a tendency to aggregate in the low water period, when the activity of feeding of the fish is more intense. In addition, Lonardoni et al. (2007) analysed the feeding habits of *Potamotrygon falkneri* in the upper Paraná River floodplain, where they consumed predominantly molluscs in the period of flood and mainly fishes in the dry period. Thus, the high values of prevalence of cestodes observed in June 2005 and May and June 2006 can be explained by the low hydrologic level and consequent increase of the aggregation of intermediate hosts (fish) and of the feeding activity of the stingrays. These re-

sults contrast with Machado et al. (1994) for the hosts *Pseudoplatystoma corruscans* and *Schizodon borelli*, where the highest occurrence of three species of proteocephalideans occurred in the period of high water in the same studied region. The increase of the aggregation of intermediate hosts and of the feeding activity when the climate is dry can also explain the highest species richness recorded in June 2005 and 2006.

According to Poulin (1998), one of the factors that can increase the aggregation of parasites is the reproduction inside the host. When the parasites do not present monoxenic reproduction, the aggregation can be explained by the heterogeneity in the exposition of the individuals to the parasites and in the susceptibility of the individuals to the infections. Considering that the cestodes are not capable of reproducing directly inside the host, the aggregated distribution of *A. regoi* and *R. paratrygoni* in the analyzed individuals of *P. falkneri* suggests that the population of hosts occupies a great variety of environments in the studied region. Besides, the hosts should also exhibit different levels of tolerance to the infection by parasites, due to genetic or environmental factors (food, stress).

Caswell (1978), cited by Bush and Holmes (1986), proposed the idea that a community is formed by a nucleus of dominant species in equilibrium, enclosured by species interacting against this equilibrium. Hanski (1982), cited by Bush and Holmes (1986), then, elaborated the concept of central species (few frequent and numerous species) and satellites (many species limited in number and low frequency). According to Bush and Holmes (1986), only the central species (in equilibrium) present foreseeable patterns, while satellite species behave in an unstable way. As expected, the majority of the species of parasites were considered satellites. However, the absence of species considered central indicates the absence of this equilibrium proposed by Caswell (1978), cited by Bush and Holmes (1986) and consequently the unpredictability of patterns in the infracommunities of parasites of *P. falkneri* in the studied region. The absence of dominance between the species of parasites was also confirmed by the index of dominance of Simpson, a result that according to Poulin (1998) suggests low, or the absence of, competition inside the infracommunities.

Considering that the parasites are harmful to their hosts, a negative correlation is expected between abundance and Kn. However, in the present study, positive correlation occurred. Studies about the condition factor (K) of parasitized fish show that the parasitism can be related to low values of K or Kn (Tavares-Dias et al., 2000) or increase with the host's condition factor (Lizama et al., 2006), as well as the absence of correlation (Ranzani-Paiva et al., 2005). The positive correlations between the relative condition factor of *P. falkneri* and the abundances of *A. regoi* and *R. paratrygoni* indicate that the number of parasite specimens increases along with the condition factor of the fish. As these parasites are transmitted by the feeding activity, these results can be explained by a cumulative process, where stingrays that are in better physical conditions fed on a great quantity of potential intermediate hosts (fish), being more susceptible to infections (Luque et al., 1996).

The present study did not find significant differences between the host's sex regarding parasitism, as mentioned by other authors studying teleosts (Machado et al., 1994). Other authors found differences in the abundance of parasites between males and females, some finding males more parasitized (Takemoto and Pavanelli, 2000), others finding females more parasitized (Lizama et al., 2005).

The composition of the parasite fauna is a product of interactions of biotic and abiotic factors of the environment (Dogiel, 1970). Still according to the same author, the parasite fauna is affected more seriously by the physiological characteristics of the hosts, food being the most important factor. Lonardoni et al. (2007) pointed to molluscs, crustaceans, small fish and aquatic insects as part of the diet of *P. falkneri* in the upper Paraná River basin, not differing males from females. Despite the absence of significant differences between males and females in the present study, some species of parasites were recorded only in females. The difference between males and females regarding the species of parasites found can be an indicator of feeding and/or behavioural differences between the sexes, or still a result of the cumulative process previously mentioned, since females of *P. falkneri* exhibit bigger measures than males (Silva, 2006).

According to Aime and Pappas (1983) the effects of parasitism can be observed in organs with which the cestodes do not have contact; fibrosis was observed in the intrahepatic ducts and also lesions on the liver surface of vertebrate hosts.

In teleosts, parasitism can be related with the reduction of the hepatosomatic relation (Kurovskaya and Osadchaya, 1993), to hepatomegaly (Tierney et al., 1996) or do not present liver alterations (Lizama et al., 2006). According to Griffith et al. (1973), correlation exists between the hepatosomatic index and the health of the potamotrygonids; fish with low indexes present very low values of glucose, total carbohydrates, cholesterol, urea and proteins. Thus, the present study indicates that the parasitism by *A. regoi* can be related to damage to the host's health. *R. paratrygoni* did not present correlation with the hepatosomatic index of the hosts. According to Aime and Pappas (1983), many authors affirm that adult cestodes have little or no harmful effect on the host. That can be due to the long evolutive relation between hosts and parasites and/or to the compensatory effects of alternative physiological mechanisms that can occur in parasitized animals.

Considering that *A. regoi* presented positive correlation with the condition factor and with the HSR of the hosts, doubts arise about which is the best indicator of the real condition of the fish. Future studies are necessary for the determination of the most efficient indicator

for the evaluation of the damage caused by the relationship parasite-host in potamotrygonids.

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