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HOST-PARASITE RELATIONSHIPS OF MONOGENEANS IN GILLS OF *ASTYANAX ALTIPARANAE* AND *RHAMDIA QUELEN* OF THE SÃO FRANCISCO VERDADEIRO RIVER, BRAZIL

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Summary:

This study investigates the ecology of monogenean gill parasites of *Astyanax altiparanae* Garutti & Britski, 2000 and *Rhamdia quelen* (Quoy & Gaimard, 1824) in a stretch of the São Francisco Verdadeiro River, Paraná, Brazil. Statistical and ecological indices were used to examine observed levels of parasitism in relation to host and environmental characteristics. *A. altiparanae* and *R. quelen* had infestation intensities of 2.8 and 23.1 parasites per fish, respectively. The only significant environmental influence was observed at the upstream station for *R. quelen*. For both host species, parasitized and non-parasitized individuals presented similar weight-length relationships. Parasitized individuals had dispersed K_n values indicating abnormal conditions. The low levels of parasitism observed in this study suggest that the environment is relatively undisturbed. Additional studies should compare these two species and their respective parasites following completion of the hydroelectric headquarters planned for construction in this stretch of the São Francisco Verdadeiro River.

KEY WORDS : monogeneans, poisson, condition factor, weight-length relationship, prevalence, river impoundment.

Résumé : RELATIONS HOTE-PARASITE DE MONOGÈNES PARASITES DES BRANCHIES D'*ASTYANAX ALTIPARANAE* ET DE *RHAMDIA QUELEN* DU FLEUVE SÃO FRANCISCO VERDADEIRO AU BRÉSIL

*Cette étude s'intéresse à l'écologie des monogènes parasites des branchies d'*Astyanax altiparanae *Garutti & Britski, 2000 et de* Rhamdia quelen *(Quoy & Gaimard, 1824) dans une partie du fleuve São Francisco Verdadeiro, Paraná, au Brésil. Des indices statistiques et écologiques ont été utilisés pour mesurer les taux de parasitisme observés chez l'hôte en fonction de son environnement.* A. altiparanae *et* R. quelen *avaient des taux d'infestation de 2.8 et 23.1 parasites par poisson, respectivement. La seule influence environnementale notable sur ce taux a été observée pour* R. quelen *dans la partie haute du cours d'eau. Pour les deux espèces hôte, les individus parasités et non-parasités présentaient des rapports poids/longueur semblables. Les faibles taux de parasitisme observés dans cette étude suggèrent que l'environnement est relativement peu perturbé. Des études supplémentaires devront comparer ces deux espèces et leurs parasitismes respectifs après l'achèvement des travaux de contruction de barrages hydroélectriques prévus sur ce fleuve.*

MOTS CLÉS : *monogène, poisson, facteur de condition relative, rapport poids/longueur, prévalence, barrage fluvial.*

Parasitic fauna of fishes respond strongly to alterations in the physical and chemical characteristics of the aquatic environment and modifications in the physiological and biological conditions of hosts (Dogiel, 1961). River impoundment changes the aquatic environment from lotic to lentic, promoting a considerable increase in water residence time. This transformation is the principal force responsible for modification of limnological characteristics in the body of the reservoir as well as upstream (Lansac-Tôha *et al.*, 1999). River impoundment also provokes alterations in fish species composition and abundance, favoring species adapted to lentic conditions (Tundisi *et al.*, 1999). River impoundment may therefore affect fish parasite communities both directly and indirectly.

This study addresses host-parasite relationships of monogenean gill parasites in *Astyanax altiparanae* Garutti & Britski, 2000 and *Rhamdia quelen* (Quoy & Gaimard, 1824) of the São Francisco Verdadeiro River, Brazil, prior to construction of the PCH São Francisco Dam. Specifically, we examine relationships between prevalence and infestation intensity and sampling location, sex, body size and relative condition for both host species. Ecological studies of fish parasites offer important information not only regarding their hosts, but also of the aquatic environment in general through patterns of parasite species occurrences, and the prevalence and intensity of parasitism. The results presented here therefore provide an important baseline for comparative studies following dam closure, which may provide insight into community level impacts of hydrological modification.

MATERIALS AND METHODS

STUDY AREA AND FISH COLLECTION

The Paraná River is the second longest river in South America, and is the principal river of the Prata basin (Agostinho & Júlio Jr, 1999). The São

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Francisco Verdadeiro River is a tributary of the upper Paraná River that drains into Itaipu Reservoir (Fig. 1). A small hydroelectric dam (PCH São Francisco) is planned for construction along the São Francisco Verdadeiro River between the municipal districts of Toledo (right margin) and Ouro Verde do Oeste (left margin), Paraná State (24º 44' S-53º 54' W), prompting the present study. Field collections were made in the São Francisco Verdadeiro River at four sampling locations: a) downstream of the location designated for construction of the dam, between the localities of Cerro da Lola and Ouro Verde do Oeste; b) in the locality of the future dam; c) in the locality of the future reservoir; and d) upstream of the future reservoir (Fig. 1). Bi-monthly samplings were made between August 2002 and June 2003 (total of six samplings).

Fishes were collected using gill-nets, baited lines, and by seining. Weight, standard length (SL), sex and stage of maturation were determined for all individuals (Vazzoler, 1981).

Monogenean sampling and processing

The techniques used for sampling and processing of the ectoparasites follow Eiras *et al.* (2000). Monogenean identification was based on Yamaguti (1963), Kritsky *et al.* (1986, 1995, 1996 and 1997), Suriano (1986) and Thatcher (1991).

Data Analyses

Student's test was used to determine if male host standard length was similar to that of females. Effect of host sex on infestation intensity of each parasite species was examined using Mann-Whitney's test. We used the Log-Likelihood's test (G) to determine the effect of host sex on the prevalence of infestation of each parasite species. Spearman's correlation coefficient and the correlation coefficient (r) were used to examine relationships between host standard length and intensity and prevalence of infestation for each monogenean species. The Kruskal-Wallis test was used to test for differences in intensity and prevalence of infestation among sampling locations. Following a significant main effect, Dunn's post-hoc analysis was used to test pairwise comparisons. The aforementioned analyses were applied only for parasite species with prevalence greater than 10 %, and results were considered significant at $p < 0.05$.

Length-weight relationships of parasitized and non-parasitized hosts were compared using ANCOVA for both species. Body condition of parasitized and non-parasitized hosts was compared within species using the relative condition factor K_n (Le Cren, 1951), and differences in mean K_n values were tested using Mann-Whitney's test. Variations in observed and expected

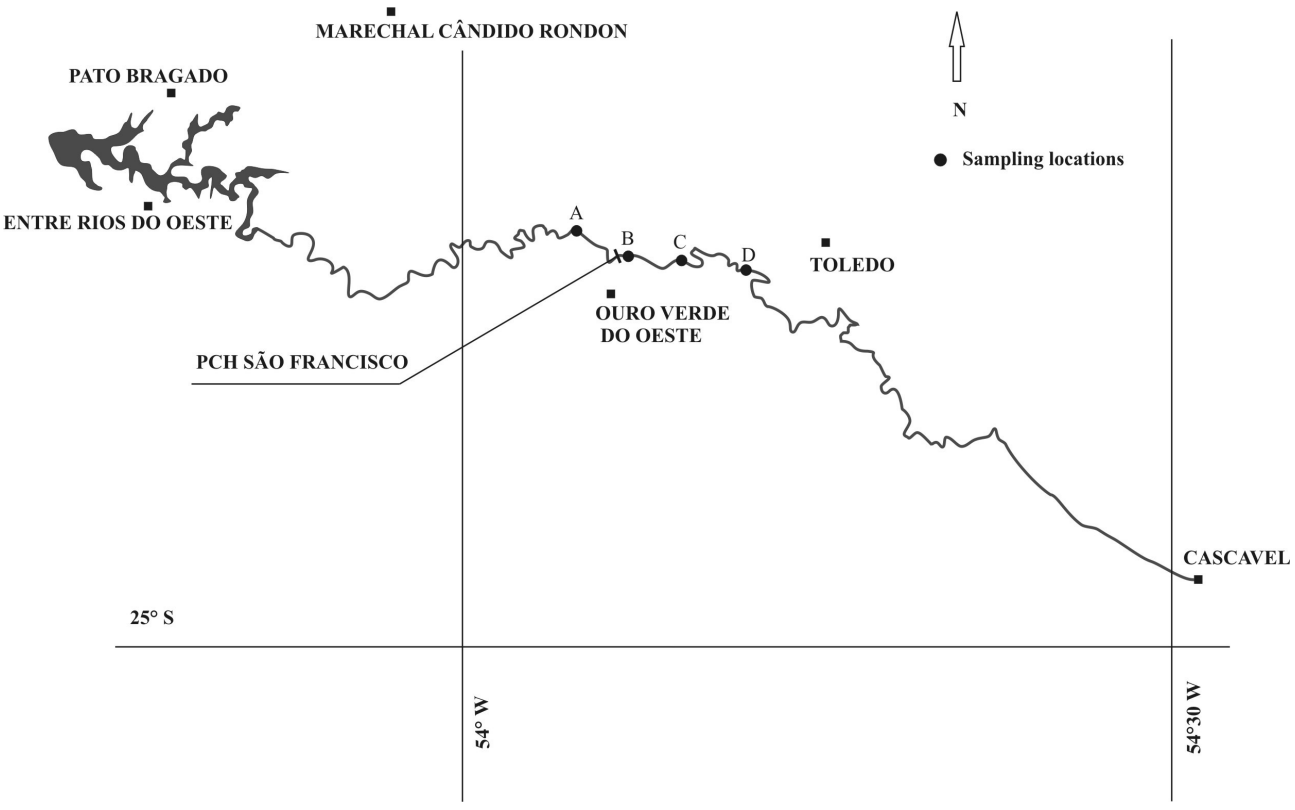

Fig. 1. – Map of the São Francisco Verdadeiro River with study locations: A) downstream of the planned dam, B) location of the planned dam, C) location of the planned reservoir, and D) upstream of the planned reservoir.

condition values may be due to environmental conditions such as limited food resources or parasitism.

RESULTS

Of the 76 specimens of *Astyanax altiparanae* analyzed, 15 were parasitized by monogeneans of the family Dactylogyridae (*Amphithecium* sp. and *Notozothecium* sp.). A total of 42 parasites were collected, representing a mean infestation intensity of 2.80 parasites per fish. *Notozothecium* sp. presented higher mean intensity and prevalence than *Amphithecium* sp. (Table I). 48 specimens of *Rhamdia quelen* were analyzed, of which 20 were parasitized by monogeneans. Two monogenean species were recorded: *Urocleidoides mastigatus* (Suriano, 1986) and *Scleroductus* sp. of the families Dactylogyridae and Gyrodactylidea respectively. A total of 462 parasites were collected, representing a mean intensity of infestation of 23.1 parasites per fish, with *U. mastigatus* presenting greater mean intensity and prevalence (Table I).

INFLUENCE OF HOST SEX AND STANDARD LENGTH ON PREVALENCE AND INTENSITY OF PARASITISM

Of the 76 specimens of *A. altiparanae* analyzed, 38 were female, 35 were male and three were of undetermined sex. Seven of the 38 females were parasitized by at least one species of monogenean, representing a mean intensity of infestation of 3.85. Of the 35 males, seven were parasitized, with a mean intensity of 2.0. Prevalence of *Amphithecium* sp. and *Notozothecium* sp. was higher in males than females (Table I). For *R. quelen*, 48 specimens were analyzed, of which 19 were female and 24 were male (five undetermined). Ten females were parasitized, presenting a mean intensity of infestation of 36.4. For males, nine were parasitized, presenting a mean intensity of infestation of 9.88. Mean intensity and prevalence were higher for *U. mastigatus* in females than males (Table I). Prevalence and mean infestation intensity values for males and females were not significantly different (all comparisons, $p > 0.05$).

Standard length of *A. altiparanae* examined varied from 5.2 to 13.1 cm. *Rhamdia quelen* were larger, from 11.3 to 36.0 cm SL. Prevalence and intensity of infestation by monogeneans was not significantly correlated with length for either species.

INFLUENCE OF SAMPLING LOCATION ON PREVALENCE AND INTENSITY OF PARASITISM

The highest mean intensity of parasitism for *A. altiparanae* was at the location of the future reservoir, followed by the locations upstream, downstream and at the site of the future dam (Table II). For *R. quelen*, the highest mean intensity of parasitism was observed at

							Female		Male	
Species	**MI**	**P (%)**	**G**	**P-value**	**Z**	**P-value**	**MI**	**P (%)**	**MI**	**P (%)**
Astyanax altiparanae	2.80	19.74	–	–	–	–	3.85	18.42	2.00	20.00
Amphithecium sp.	1.16	7.89	–	–	0.0176	0.986	1.33	7.89	1.00	8.57
Notozothecium sp.	2.12	10.52	1.4712	0.225	0.6200	0.530	1.33	5.26	2.20	14.28
Rhamdia quelen	23.10	41.67	–	–	–	–	36.40	52.63	9.88	37.50
Scleroductus sp.	1.00	8.33	0.5700	0.450	0.3791	0.705	1.00	15.78	1.00	4.16
Urocleidoides mastigatus	27.50	33.33	0.3486	0.555	0.7214	0.471	43.37	42.10	12.00	29.16

Table I. – Mean intensity (MI) and prevalence (P) of infestation, Log-likelihood (G) and Mann-Whitney (Z) test statistics and significance level of monogenean parasites in *Astyanax altiparanae* and *Rhamdia quelen*, and MI and P for male and female hosts separately.

Species	**H**	**P-value**	**Location**	**Fishes examined**	**Fishes parasitized**	**MI**	**P (%)**
Astyanax altiparanae			*Astyanax altiparanae*				
Amphithecium sp.	0.6133	0.893	Downstream	9	2	2.00	22.22
Notozothecium sp.	1.1450	0.766	Dam	19	3	1.00	15.78
			Reservoir	10	1	4.00	10.00
			Upstream	38	9	3.55	23.68
Rhamdia quelen			*Rhamdia quelen*				
Scleroductus sp.	3.7660	0.288	Downstream	5	3	4.00	60.00
Urocleidoides mastigatus	8.3580	0.039	Dam	10	4	69.75	40.00
			Reservoir	7	5	12.00	71.42
			Upstream	26	8	13.87	30.76

Table II. – Kruskal-Wallis (H) test comparing parasitism levels for each parasite species among sampling locations, and mean intensity (MI) and prevalence (P) of infestation in *Astyanax altiparanae* and *Rhamdia quelen* at each sampling location.

the location of the future dam, followed by the locations upstream, at the site of the future reservoir and downstream (Table II). *Urocleidoides mastigatus* was found to be significantly more abundant in *R. quelen* collected at the upstream station than the other sampling stations (Table II). No other significant difference was observed for monogenean species abundances among sampling locations.

Length-weight relationships and relative condition (K_n) of parasitized and non-parasitized hosts

The observed length-weight relationship for *R. quelen* ($y = 0.0223x^{2.931}$) was slightly negative allometric (*i.e.* $b < 3$), whereas the relationship for *A. altiparanae* ($y = 0.0165x^{3.301}$) was positive allometric (*i.e.* $b > 3.0$). Parasitized and non-parasitized individuals presented similar length-weight relationships in both species (*R. quelen* – non-parasitized: $y = 0.0209x^{2.947}$, $R^2 = 0.93$; parasitized: $y = 0.0253x^{2.896}$, $R^2 = 0.94$; *A. altiparanae* – non-parasitized: $y = 0.0161x^{3.309}$, $R^2 = 0.96$; parasitized: $y = 0.0168x^{3.310}$, $R^2 = 0.97$). ANCOVA interaction terms were significant ($p < 0.05$) for both species, so y-intercepts could not be tested. However, inspection of the relationships graphically showed that they were almost identical (*i.e.* the significant interaction term was due to complete overlap in both cases).

Mean relative condition (K_n) values were not significantly different between parasitized and non-parasitized hosts for either species ($p > 0.05$). Non-parasitized and parasitized individuals of *A. altiparanae* had similar K_n distributions (non-parasitized: mean = 1.01, SD = 0.13; parasitized: mean = 1.04, SD = 0.12). Non-parasitized individuals of *R. quelen* presented values approximating $K_n = 1$ (mean = 1.01, SD = 0.17), whereas parasitized individuals presented a higher mean and greater variation (mean = 1.30, SD = 0.87).

DISCUSSION

Mean infestation intensities observed for *Astyanax altiparanae* and *Rhamdia quelen* were 2.8 and 23.1 respectively. This among host species difference may be attributable to physical and ecological characteristics of the hosts. Larger individuals, in this case *R. quelen*, may accumulate larger infrapopulations due to greater age or by feeding higher in the food web (Zelmer & Arai, 1998; Bell & Burt, 1991). Of interest here are general trends across host species, such as the potential influences of host sex and body size on infrapopulations and the relationship between infrapopulation size and host condition. Therefore, we compare trends observed for each host species, and not values among host species.

Due to behavioral and physiologic differences, host sex can potentially influence levels of parasitism (Esch *et al.*, 1988). Susceptibility to parasites is greater for some species of fish during the reproductive period, as in the case of *Cichla monoculus* (Machado *et al.*, 2000). In this study, significant differences were not observed between males and females for either host species although males had lower levels of parasitism in general. In contrast with *Cichla* species (Jepsen *et al.*, 1999), tambiú *A. altiparanae* and jundiá *R. quelen* do not have marked reproductive behaviors such as parental care of young, and both sexes are of similar size (Nakatani *et al.*, 2001). Another fish species common in South American rivers, the cachara *Pseudoplatystoma fasciatum*, was also found to lack differences in infestation intensities of monogenean gill parasites between sexes (Siqueira *et al.*, 2002).

In addition to host sex, ontogenetic alterations in behavior, physiology and ecology can influence the parasitic fauna of fishes (Takemoto *et al.*, 1996). Fish standard length is a correlate of age (Shotter, 1976), and is one of the most important factors influencing parasite population sizes (Dogiel, 1961). According to Zelmer & Arai (1998), increases in parasite infrapopulation sizes are expected to increase with host age (and host length) as a result of simple accumulation. This scenario requires parasites with direct life-cycles or which use intermediate hosts whose consumption is not limited to one phase of host development.

In the present study, correlations between host standard length and intensity of parasitism and prevalence were not observed for either host species. The observed lack of correlation between host length and parasitism levels may be due to physiological properties of larger individuals. For example, if the physiologic properties of host tissue can not supply the demands of parasitism, growth and development may be limited (Olsen, 1974). Additionally, larger fish may have lower levels of intensity and prevalence due to immunological responses of the hosts (Adams, 1985; Luque & Olive, 1993).

Monogeneans are more common in lentic environments because lentic conditions facilitate the transmission of parasites of direct life cycle by allowing larvae to encounter hosts with ease (Pavanelli *et al.*, 1997). In this study, collections were made in lotic environments, however largest mean intensities were observed for *R. quelen* at the Upstream station where water velocity is relatively lower. The higher mean intensities of parasitism registered in the Upstream station may also be attributed to municipal effluents entering the river in this stretch. Pollution may alter environmental characteristics and physiologic conditions of hosts, thereby facilitating infestation.

The condition factor is a quantitative indicator of fish well-being, reflecting recent physiological conditions

(Le Cren, 1951). Parasitized individuals of both host species presented dispersed K_n values indicating abnormal conditions provoked by parasitism. Effects of parasitism on host condition may translate to reduce reproductive output, as fishes in low condition typically produce relatively fewer or smaller young than fishes in normal or high condition (Vazzoler, 1996; Machado *et al*., 2005).

The study of host-parasite relationships in natural environments can be instructive in comparison with studies of fish pathologies in confined or modified environments, in which the likelihood of infestations may be higher. This study provides an important baseline for comparative studies of host-parasite relationships of *A. altiparanae* and *R. quelen* in the São Francisco Verdadeiro River following construction of the hydroelectric dam. Because ecological characteristics of fish parasites reflect the aquatic environment in general and not only their hosts, comparative studies following dam construction may provide insight into environment and community level impacts of hydrological modification.

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