Research Note

Rev. Bras. Parasitol. Vet., Jaboticabal, v. 22, n. 4, p. 611-615, out.-dez. 2013
ISSN 0103-846X (impresso) / ISSN 1984-2961 (eletrônico)

Community ecology of metazoan parasites of the sairú *Cyphocharax nagelii* from the Peixe River

Ecologia da comunidade de metazoários parasitos do sairú *Cyphocharax nagelii* do Rio do Peixe

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Received April 24, 2013
Accepted October 11, 2013

Abstract

A total of 57 sairus (*Cyphocharax nagelii*) from the Peixe River, state of São Paulo, southeastern Brazil, were examined between April 2011 and February 2012. Eleven species of metazoan parasites were collected and identified: *Palombitrema triangulum, Curvianchoratus hexacleidus, Curvianchoratus singularis, Sphincterodiplostomum musculosum, Contracaecum* sp., *Cacatuocotyle paranaensis, Cosmoxynemoides aguirrei, Amplexibranchius bryconis, Brasergasilus* sp., *Ergasilus* sp. and *Clinostomum* sp. The monogenean *P. triangulum* was the most prevalent species (61.40%) with the highest mean intensity (4.88). The monogeneans *C. hexacleidus* and *C. singularis*, the digenean *S. musculosum* and the nematode *Contracaecum* sp. also showed high prevalence. Only *S. musculosum* presented significant correlation between the total body weight of the host and its abundance. The parasitic infracommunities had a mean Brillouin diversity (*HB*) of 1.165 ± 0.987 and the maximum diversity was 1.671. The sex and length of the hosts did not influence the abundance of any parasite species. The community of metazoans in *C. nagelii* from the Peixe River was characterized by high richness and low uniformity.

Keywords: Fish, Curimatidae, parasites, Peixe River, Brazil.

Resumo

Cinquenta e sete "sairú" (*Cyphocharax nagelii*) foram examinados entre abril de 2011 e fevereiro de 2012, provenientes do Rio do Peixe, Estado de São Paulo, Sudeste do Brasil. Onze espécies de metazoários parasitos foram coletadas e identificadas: *Palombitrema triangulum, Curvianchoratus hexacleidus, Curvianchoratus singularis, Sphincterodiplostomum musculosum, Contracaecum* sp., *Cacatuocotyle paranaensis, Cosmoxynemoides aguirrei, Amplexibranchius bryconis, Brasergasilus* sp., *Ergasilus* sp., *Clinostomum* sp. O monogenético *P. triangulum* foi o parasito mais prevalente (61,40%) e com a maior intensidade média (4,88). Os monogenéticos *C. hexacleidus* e *C. singularis*, o digenético *S. musculosum* e o nematóide *Contracaecum* sp. também apresentaram alta prevalência. Apenas *S. musculosum* apresentou correlação significativa entre o peso total do corpo do hospedeiro e sua abundância. As infracomunidades parasitárias tiveram uma diversidade média de Brillouin (*HB*) =1,165±0,987 e a diversidade máxima foi de 1,671. O sexo e comprimento dos hospedeiros não influenciaram a abundância parasitária. A comunidade de metazoários de *C. nagelii* no Rio do Peixe foi caracterizada pela alta riqueza e baixa uniformidade.

Palavras-chaves: Peixe, Curimatidae, parasitos, Rio do Peixe, Brasil.

Cyphocharax nagelii (Steindachner, 1881), known locally as the *sairú*, is a Curimatidae with geographical distribution restricted to South America, and is found especially in the upper Paraná River basin. The species is involved in large seasonal migration from the Mogi Guaçu River, an upper Paraná River tributary. Young fish aged up to 50 days were reported as being zooplanktivorous, and the larger ones as detritivorous. This species reaches maturity at around the length of 8.9 centimeters for both sexes, and can reach a maximum length of 16.3 cm (VARI, 1992).

The Peixe River begins in the municipality of Torre de Pedra, state of São Paulo, in the basaltic cuesta of the Botucatu Environmental Preservation Area and it is a drainage basin comprising 584 km^2 that runs from north to south (CARAMASCHI, 1986). According to Caramaschi (1986), the physiographic and landscape characteristics vary: some areas present primary vegetation on the

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mountainside of the cuesta and some stretches present gallery forests among pastures and small-scale farming. There are several ecosystems next to dams that interface with the main river. Besides the gallery forest stretches, there are many marginal lagoons that present mosaics of aquatic macrophytes that are connected to the river under natural and anthropic hydrological regimes (controlled by the Barra Bonita hydroelectric power plant). In addition, over a large extent of its surroundings, there are human settlements of increasing size (recreational farms and ranches for both sport and artisanal fishing), intensive agricultural activities (especially sugar cane) and cattle-raising activities (NOVAES, 2008). There are many species of fish in this river, including the species *Cyphocharax nagelii* (Steindachner, 1881).

Few studies have been conducted on *Cyphocharax nagelii* metazoan parasites in Brazil, but this same host is called *Curimata nagelii* and *Pseudocurimata plumbea* in other parasitological papers. Among these records, it is important to highlight the following: Abdallah et al. (2012), Kohn et al. (2011) and Pavanelli et al. (2000) for nematodes; Kohn and Fernandes (1987) and Kohn et al. (2011) for digeneans; Pavanelli et al. (2000) for crustaceans; and Martins and Onaka (2006) for the myxozoan species *Henneguya garavelli* and *Myxobolus peculiaris* in the Peixe River.

The present paper had the aim of presenting a qualitative and quantitative analysis on the structure of the *Cyphocharax nagelii* parasite community of the Peixe River, because of the strategic importance of this river for the region. Moreover, good knowledge of parasite diversity is crucial for environmental management and conservation.

Fifty-seven specimens of *C. nagelii* were collected from the Peixe River (22° 49' 53.1" S and 48° 06' 38" W) in the municipality of Anhembi, state of São Paulo, Brazil. The fish were collected between April 2011 and February 2012. Immediately after being caught, the specimens were killed by transection of the spinal cord. The mean total length of the female specimens was 12.9 ± 3.1 (8.9-15.3) cm and the mean weight was 64.2 ± 10.4 (17.9-103) g. The mean total length of the male specimens was 14.1 ± 2.4 (9.4-17.8) cm and the mean weight was 67.3 ± 13.6 (19.6-108) g. Parasite prevalence, intensity and abundance were calculated as prescribed by Bush et al. (1997). Parasites were classified according to their prevalence in the core species (prevalence higher than 66.66%), secondary species (prevalence from 33.33 to 66.66%) and satellite species (prevalence lower than 33.33%) to verify the importance value of each species in the helminth parasite community (BUSH; HOLMES, 1986). The variance of the mean ratio of parasite abundance (dispersion index) was used to determine spatial distribution patterns and was tested by means of the *d* statistical index (LUDWIG; REYNOLDS, 1988). The frequency dominance and relative dominance (number of specimens of one species/total number of specimens of all species in the infracommunity) of each parasite species were calculated in accordance with Rohde et al. (1995). Spearman's rank correlation coefficient (*rs*) was calculated to determine possible correlations between the host's total body length and the abundance of parasites, and between the host's total weight and the abundance of parasites (ZAR, 1999). The analysis only included parasite species with prevalence greater than 10% (BUSH et al., 1990). The following community descriptors were calculated at the infracommunity level: Brillouin's diversity index (log 10 based), Pielou's evenness index, Margalef's richness index and the Berger-Parker dominance index. The statistical significance level was established as $p < 0.05$. The ecological terminology followed Bush et al. (1997). Voucher specimens of the helminths were deposited in the Helminthological Collection of the Institute of Biosciences, Botucatu (CHIBB), in the state of São Paulo, Brazil.

Component community. Eleven metazoan parasite species were collected (Table 1). Most of the parasite species collected were monogenetic (62.26%), followed by nematodes (20.59%), digenetic (13.56%) and crustaceans (3.56%). *Palombitrema triangulum* was

Table 1. Prevalence, mean abundance, mean intensity and infection site of the metazoan parasites of *Cyphocharax nagelii* (Steindachner, 1881) in the Peixe River, state of São Paulo, Brazil.

Parasites	Prevalence (%)	Mean abundance	Mean intensity	Infection/infestation site	Species importance[a]
Crustacea					
Amplexibranchius bryconis	14.03	0.33	2.37	Gills and body surface	Sa
Ergasilus sp.	1.75	0.03	2	Gills	Sa
Brasergasilus sp.	1.75	0.01	1	Gills	Sa
Digenea					
Sphincterodiplostomum musculosum	42.1	1.43	3.41	Eyes	Se
Clinostomum sp.	1.75	0.01	1	Eyes	Sa
Nematoda					
Cosmoxynemoides aguirrei	15.78	0.59	3.77	Intestine	Sa
Contracaecum sp.	36.84	1.61	4.38	Intestine and stomach	Se
Monogenea					
Cacatuocotyle paranaensis	21.05	1.05	5	Nostril	Sa
Curvianchoratus hexacleidus	42.1	0.82	1.95	Body surface	Se
Curvianchoratus singularis	54.38	1.8	3.21	Body surface	Se
Palombitrema triangulum	61.4	3	4.88	Body surface	Se

[a]Species importance based on prevalence: Se, secondary species (prevalence from 33.33 to 66.66%); Sa, satellite species (prevalence lower than 33.33%).

the predominant species, with 171 specimens collected (27.95% of the total parasites), presenting the highest value for dominance frequency (Table 2). The parasites presented the typical aggregated distribution pattern (Table 3). The species *Sphincterodiplostomum musculosum* presented a significant correlation between host body total weight and parasite abundance (*rs* = –0.28, P = 0.03), while the other species did not present any significant correlation.

The effect of the sex and length of the hosts and the abundance of the parasites did not present any significant difference. *Sphincterodiplostomum musculosum*, *Contracaecum* sp., *Curvianchoratus hexacleidus*, *Curvianchoratus singularis* and *Palombitrema triangulum* were the secondary species and the remaining ones were considered to be satellite species (Table 1).

Infracommunities. Fifty out of the 57 specimens of *C. nagelii* examined were parasitized by at least one metazoan species. A total of 612 parasite specimens were collected with a mean of 10.74 parasites per fish. Seven hosts (12.28%) were not parasitized by any metazoan parasite species; ten (17.54%) were parasitized by one species, eight (14.04%) were parasitized by two species, eight (14.04%) were parasitized by three species, ten (17.54%) were parasitized by four species, eight (14.04%) were parasitized by five species, five (8.77%) were parasitized by six species and one (1.75%) was parasitized by seven species. The effect of the sex and length of the hosts and parasite abundance did not present statistically significant results. The mean parasite richness index was d = 2.402 and the Pielou uniformity mean index was J = 0.463. The parasite infracommunities presented mean diversity of *HB* = 1.165 ± 0.987 and maximum diversity of 1.671. No significant correlation was detected between the diversity of parasite species and the sex, total length and weight of the hosts. The Berger-Parker dominance index presented a mean of 0.51 ± 0.30.

The results from this study indicate that the metazoan community of *C. nagelii* has high diversity due to high species richness, despite the great variability in species abundance. According to Bush et al. (1997), diversity is the concept that describes the composition of a community regarding the number of species and some factor that measures the relative equality of the distribution of each species. There is no environment where all of the species are equally common. Some are very abundant, others are moderately common, and most are rare. Biodiversity can be split in two components: species richness and uniformity (equitability). In these, species richness is the number of species in a sample and uniformity describes the variability in the abundance of species. A community is considered rather uniform when all the species contain approximately the same number of individuals, whereas a wide disparity in the relative abundance of species results in low uniformity (MAGURRAN, 1988). Pielou (1977) commented that communities with high richness of species, high uniformity or both are generally considered to be more diverse.

The host length, which is considered to be an expression of its age, is one of the most important factors in the variation in the size of the parasite infracommunities. Age causes several changes to fish biology, especially in relation to trophic levels, which are directly reflected in the parasite fauna, particularly for parasites acquired through food chain, as mentioned by Dogiel et al. (1961). In the present study, the length did not have any positive correlation with any species, and this may have been due to the small amplitude of the host length since all of the specimens studied were adults and there was no change in the fish feeding. Although the sex of the host has an essential role in the host-parasite relationship, it had no influence on the *C. nagelii* parasitism rate in the present study. This may suggest that the ecological relationships (habitat, behavior and diet) between male and female hosts are similar.

The pathogenic significance of digenetic parasites in fish is much more pronounced in infections caused by metacercariae than in those caused by adults, because the metacercariae can be encysted in any tissue or organ except cartilages or bones, thereby weakening the host (THATCHER, 1991; EIRAS, 1994; PAVANELLI et al., 1998). In the present study, *S. musculosum* metacercariae were found in the eyes of *C. nagelii*.

Ramadan (2012) comments that the *Diplostomum spathaceum* metacercariae in the fish eye leads to severe ocular lesion and results in host mortalities in commercial fish farming. In their study, typical pathological signs of a metacercarial occurrence in the fish eye were included exophthalmia, local hemorrhage and lens cataract. Cloudy eyes were an indication of cataract in fish eyes caused by heavy infestation of metacercariae.

Gil de Pertierra and Ostrowski de Núñez (1990, 1995) observed that the parasite life cycle is directly related to the host life cycle, which is related to the characteristics of the external environment in which it lives. The metacercariae found parasitizing the eyes of the fish reinforces these observations, because in that place, the parasite can harm their hosts, thus making them weaker and easier preys. Consequently, the parasite is able to complete its cycle faster. In this study, host weight presented a significant negative correlation

Table 2. Frequency of dominance and mean relative dominance of the metazoan parasites of *Cyphocharax nagelii* (Steindachner, 1881) in the Peixe River, state of São Paulo, Brazil.

Parasites	Dominance frequency	Mean relative dominance
Amplexibranchius bryconis	5.26	0.03 ± 0.003
Sphincterodiplostomum musculosum	17.54	0.133 ± 0.0036
Cosmoxynemoides aguirrei	0	0.055 ± 0.0033
Contracaecum sp.	15.78	0.150 ± 0.0073
Cacatuocotyle paranaensis	5.26	0.098 ± 0.0047
Curvianchoratus hexacleidus	7.01	0.076 ± 0.0019
Curvianchoratus singularis	1.75	0.168 ± 0.0037
Palombitrema triangulum	29.82	0.279 ± 0.0064

Table 3. Dispersion index (DI) and statistical test (*d*) values of the metazoan parasites of *Cyphocharax nagelii* (Steindachner, 1881) in the Peixe River, state of São Paulo, Brazil.

Parasites	DI	d
Amplexibranchius bryconis	5.87	15.07
Sphincterodiplostomum musculosum	3.52	9.32
Cosmoxynemoides aguirrei	6.88	17.22
Contracaecum sp.	12.51	26.9
Cacatuocotyle paranaensis	8.02	19.44
Curvianchoratus hexacleidus	1.65	3.06
Curvianchoratus singularis	2.87	7.39
Palombitrema triangulum	5.09	13.34

with the abundance of *S. musculosum* and the low-weight hosts presented a greater abundance of *S. musculosum*. This can occur due to host feeding difficulty, which is impaired by metacercariae in its eyes, hampering their vision. The metacercariae found may indicate that *C. nagelii* is at an intermediate position in the food chain, since *S. musculosum* is found in the adult stage in birds.

The monogeneans *C. singularis* and *P. triangulum* showed the highest prevalence in this study, while *P. triangulum* showed the highest dominance frequency and relative dominance. This may have occurred because the hosts were collected from a lentic environment (still water). In general, ectoparasites can be found more easily in lentic environments because that is where free-swimming larvae find their host more easily (DOGIEL et al., 1961).

In the present study, all of the parasites presented an aggregated distribution pattern, which is characteristic of parasite systems. The main cause of such distribution in host populations relates to environmental stochastic factors. Among these factors are the environmental changes to physical parameters in time and space, especially differences in host susceptibility to infection, which can occur due to immunological and behavioral differences, as well as genetic factors (ZUBEN, 1997). Parasite population aggregation in a small host population increases the relationship stability, due to regulatory mechanisms such as host mortality, which depends on the parasite density and the decrease in survival and fecundity of parasites caused by intraspecific competition between parasites or immunological reactions of hosts (DOBSON, 1990). According to Zuben (1997), the aggregated distribution pattern works such that it increases the regulation that depends on the density and abundance of hosts and parasites, besides decreasing the interspecific competition level between parasites.

In *C. nagelii* from the Itaipu hydroelectric power station (KOHN et al., 2011) and from the Peixe River (ABDALLAH et al., 2012), *Cosmoxynemoides* sp. and *Contracaecum* sp. (ABDALLAH et al., 2012) were recorded. Except for these two species, the other parasites reported in the present study were recorded for the first time in *C. nagelii.*

In conclusion, this study has expanded the geographical distribution and recorded new hosts and infection/infestation sites for some parasite species, thereby increasing the scientific knowledge of biodiversity in a river of great importance for the region.

Acknowledgements

The authors would like to thank Elisa Pinto de Oliveira for editing the English version. Sponsorships: FAPESP (2010/06564-5, 2011/22292-8 e 2011/10055-1).

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