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ECOLOGICAL ASPECTS OF THE PARASITES IN *Cichlasoma bimaculatum* (CICHLIDAE), ORNAMENTAL FISH FROM THE BRAZILIAN AMAZON

Aspectos ecológicos de los parásitos en *Cichlasoma bimaculatum* (Cichlidae), pez ornamental de la Amazonia brasileña

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ABSTRACT

This study investigated the parasitic fauna of *Cichlasoma bimaculatum* of a tributary from the Amazon River system, northern Brazil. The prevalence of infection was 94.6 % and, in total, 428 267 parasites, such as *Ichthyophthirius multifiliis*, *Piscinoodinium pillulare* (Protozoa), *Gussevia arilla* (Monogenoidea), *Posthodiplostomum* sp. (Digenea) and *Procamallanus* (*Spirocamallanus*) *inopinatus* (Nematoda) were collected. However, the dominance was mainly of *I. multifiliis*, while *P.* (*S.*) *inopinatus* was the parasite species with the lower levels of prevalence and abundance of infection. These parasite species showed an aggregated dispersion pattern. The parasitic fauna was characterized by the presence of few species of parasites with high prevalence and abundance, specifically ectoparasites, and a low number of endoparasites. The observed pattern is explained by the mode of life of the host and it is suggested that *C. bimaculatum* occupies a low trophic level at the food web.

Keywords: aggregation, endoparasites, freshwater fish, infection.

RESUMEN

Este estudio investigó la fauna parasitaria de *Cichlasoma bimaculatum* (Cichlidae) en un afluente del sistema del Río Amazonas, en el norte de Brasil. La prevalencia parasitaria fue del 94,6 % y en total, 428267 parásitos fueron colectados, entre estos *Ichthyophthirius multifiliis*, *Piscinoodinium pillulare* (Protozoa), *Gussevia arilla* (Monogenoidea), *Posthodiplostomum* sp. (Digena) y *Procamallanus* (*Spirocamallanus*) *nopinatus* (Nematoda). Aunque el predominio fue de *I. multifiliis*, el nematodo *P.* (*S.*) *inopinatus* fue la especie menos frecuente y abundante. Estas especies de parásitos mostraron un patrón de dispersión agregada. La fauna parasitaria se caracterizó por la presencia de algunas pocas especies de parásitos con mayor prevalencia y abundancia de ectoparásitos y una baja presencia de endoparásitos. Se discute que lo anterior puede deberse al modo de vida del hospedero y sugieren que *C. bimaculatum* ocupa un bajo nivel en la cadena trófica.

Palabras claves: agregación, endoparásitos, infección, peces de agua dulce.

INTRODUCTION

Cichlasoma bimaculatum Linnaeus, 1758 is a cichlid species of the subfamily Cichlinae known as black acara, which is distributed in South America – in the Orinoco River basin, in the Caroni River in Venezuela; the species is also found in the Guianas, in the Essequibo River to the Sinnamary River and in the Amazon River basin (Kullander, 2003; Ottoni, 2011; Froese and Pauly, 2016). This cichlid species has been introduced in North America and Europe as an ornamental fish (Cole and Stacey, 1984). This benthopelagic and omnivorous fish that occurs in canals and floodplains tolerates low oxygen levels in the environment and it usually feeds on crustaceans, seeds, algae and insects (Nomura and Barbosa, 1980; Gurgel *et al*., 1994; Froese and Pauly, 2016). Males and females start the reproduction when they reach 7 to 9 cm, and with 11 cm are ready to spawn, depending on the region, as well as on environmental factors. However, in the Amazon, the spawning of this fish occurs in the beginning of the rainy season and their maximum length is 35 cm. The best body conditions of the fish occur in the period preceding its reproduction (Gurgel *et al*., 1994; Froese and Pauly, 2016). This fish species is not listed as "Least Concern" by IUCN.

In wild fish populations, the study and understanding of the community structure of parasites can provide support for the use of this knowledge in fish farming. However, studies addressing ecological aspects of the parasites community from *C. bimaculatum* are scarce. Travassos (1940) recorded *Prosthenhystera obesa* (Digenea) in this cichlid species in Brazil. *Gussevia alii*, *Gussevia dobosi* and *Gussevia cichlasomatis* (Monogenoidea) were described in the gills of this host from the Nariva and Talparo River, in Trinidad and Tobago (Molnar *et al*., 1974; Kritsky *et al*., 1986). *Eustrongylides ignotus* (Nematoda) was reported for this fish introduced in Florida, USA (Coyner *et al*., 2002). Kohn *et al.* (2004) found non-identified Cestoda species in *C. bimaculatum* introduced in Pentecoste, in the state of Ceará (Brazil).

Parasites are important components of most ecosystems, occurring in virtually all fish of different trophic levels, which serve as hosts for one or more parasite species. Parasites have been recognized by playing an important role in the structure of the fish communities (Moreira *et al*., 2005; Violante-González and Aguirre-Macedo, 2007; Poulin and Leung, 2008; Takemoto *et al*., 2009; Lagrue *et al*., 2011; Tavares-Dias *et al*., 2014; Alcântara and Tavares-Dias, 2015), because they may alter host physiology, and behavior and survival of the fish host (Takemoto *et al*., 2009; Lagrue *et al*., 2011). However, factors controlling parasite species composition and infection levels are often ecological, because life history and diet of the hosts are the main factors determining the number of parasite species and parasitism in fish (Moreira *et al*., 2005; Violante-González and Aguirre-Macedo, 2007; Poulin and Leung, 2008; Moreira *et al*., 2009; Tavares-Dias *et al*., 2014; Alcântara and Tavares-Dias, 2015). Thus, this paper investigated the diversity and component community of parasites in *C. bimaculatum* from eastern Amazon, northern Brazil.

MATERIALS AND METHODS

Fish and locality of collection

From June to August 2013, 37 specimens of *C. bimaculatum* (13.8 ± 1.7 cm and 61.9 ± 16.6 g) were collected in the Igarapé Fortaleza basin (00°00'56.3"S-051°05'27.1"W), for parasitological analysis. All fish were collected with nets of different mesh size (10-40 mm) according to the authorization from the ICMBio (# 23276-1). In this study the principles of the Brazilian College of Animal Experiments (Cobea) were adopted, and authorization from Ethics Committee in the Use of Animal of the Embrapa Amapá (# 004–CEUA/CPAFAP) and ICMBio (# 23276-1) was carried out.

The Igarapé Fortaleza basin is an important tributary of the Amazonas river system in the State of Amapá, eastern Amazon region (Brazil), and it is located at the estuarine coastal sector, is characterized for having a river system with extensive floodplains, constituting physical systems with a clogged river, which is drained by freshwater and connected to a main water course, influenced by high rainfalls and tides from the Amazonas River. This tributary eutrophized by urbanization is widely used for refuge and food by many fish species (Gama and Halboth, 2004; Tavares-Dias *et al*., 2014), including some cichlid species.

Collection procedures and analyses of parasites

All fish were weighed (g) and measured for total length (cm), and then necropsied for parasitological analysis. The mouth, opercula, gills and gastrointestinal tract were examined to collect the parasites (protozoans and metazoans). Gills were removed and analyzed with the aid of a microscope. To quantify metazoan parasites, each viscera was dissected separately and washed in sodium chloride solution and examined under the stereomicroscope. Previously described techniques were used to collect, count, fix, preserve, and stain the parasites for identification (Boeger and Viana, 2006; Eiras *et al*., 2006).

To analyze the parasites, the ecological terms used were those recommended by Rohde *et al*. (1995) and Bush *et al.* (1997). The index of dispersion (ID), and the index of discrepancy of Poulin (D) were calculated using the Quantitative Parasitology 3.0 software to detect the distribution pattern of parasite infracommunity (Rózsa *et al*., 2000) for species with prevalence > 10 %. The ID significance for each infracommunity was tested using the *d*-statistics (Ludwig and Reynolds, 1988).

Fish data on weight (g) and total length (cm) were used to calculate the relative condition factor (Kn) of hosts, which was compared to a standard value (Kn = 1.00) using t-test. Body weight (g) and total length (cm) were used to calculate the relative condition factor (Kn) of fish using the length-weight relationship ($W = aL^b$) after logarithmic transformation of length and weight and subsequent adjustment of two straight lines, obtaining $\ln y = \ln A + B\ln x$ (Le-Cren, 1951). The Spearman correlation coefficient (*rs*) was used to determine possible correlations of parasites abundance with the body length and weight (Zar, 2010).

RESULTS

Of 37 necropsied fish, 94.6 % were parasitized by one or more species, and 428,267 parasites were collected. Five species of parasites were found, being 2 Protozoa, 1 Monogenoidea, 1 Digenea and 1 Nematoda. However, there was a predominance of *I. multifiliis* (Table 1). The parasites had an aggregate dispersion pattern (Table 2). There was a predominance of hosts infected by three parasites species (Fig. 1).

Table 1. Parasites in *Cichlasoma bimaculatum* (N=37) from the Brazilian Amazon. P: Prevalence, MI: Mean intensity, AM: Mean abundance, TNP: Total number of parasites, SI: Site of infection.

Species of parasites	P (%)	MI	MA ± SD	NTP	SI
Ichthyophthirius multifiliis Fouquet, 1866	78.4	14,719.1	11,536.6 ± 26,395.0	426,853	Gills
Piscinoodinium pillulare Schäperclaus, 1954, Lom, 1981	5.4	24.0	1.3 ± 5.8	48	Gills
Gussevia arilla Kritsky, Thatcher & Boeger, 1986	45.9	11.1	5.1 ± 7.8	188	Gills
Posthodiplostomum Dubois, 1936 (metacercariae)	56.8	35.3	20.1 ± 89.5	742	Gills
Posthodiplostomum Dubois, 1936 (metacercariae)	29.7	39.3	11.7 ± 28.1	432	Intestine
Procamallanus (*Spirocamallanus*) *inopinatus* Travassos, Artigas & Pereira, 1928	5.4	2.0	0.1 ± 0.5	4	Intestine

Table 2. Index of dispersion (ID), *d*-statistic and discrepancy index (D) for the parasites infracommunities of *Cichlasoma bimaculatum* (N=37) from the Brazilian Amazon. FD: Frequency of dominance

Parasites	ID	*d*	D	FD (%)
Ichthyophthirius multifiliis	3.69	3.10	0.50	0.9967
Gussevia arilla	3.16	2.23	0.63	0.0004
Posthodiplostomum sp. (gills)	3.27	2.41	0.60	0.0017
Posthodiplostomum sp. (intestine)	3.59	2.94	0.79	0.0010

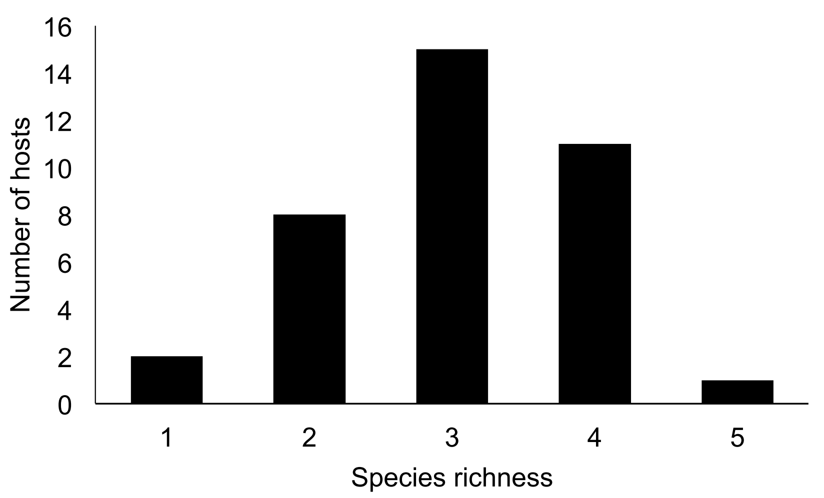

Figure 1. Species richness of parasites in *Cichlasoma bimaculatum* from the Brazilian Amazon.

There was no correlation between parasite abundance and weight, length or Kn of the hosts (Table 3). The equation of weight (W)-length (Lt) relationship for this host was Wt= $0.273Lt^{2.0559}$, r^2 = 0.80), with negative allometric, indicating greater increase in body weight than in size. The Kn (0.999 ± 0.03) of hosts was not different (t = -0.013, p = 0.99) from the pattern Kn (Kn= 1.000), indicating good body conditions.

DISCUSSION

The parasitic fauna of *C. bimaculatum* consisted of *I. multifiliis*, *P. pillulare*, *G. arilla*, the metacercariae of *Posthodiplostomum* sp. and *P. (S.) inopinatus*, parasites with aggregate dispersion and a predominance of the ectoparasites. Such parasite species have been also reported in other fish species from the eastern Amazon region (Tavares-Dias *et al*., 2014; Alcântara and Tavares-Dias, 2015). *Ichthyophthirius multifiliis* dominated the identified parasite fauna in *C. bimaculatum,* and *P. (S.) inopinatus* was the least abundant parasite. This pattern is similar to that reported for freshwater fish parasite communities in eastern Amazon (Tavares-Dias *et al*., 2014; Alcântara and Tavares-Dias, 2015). In *C. bimaculatum*, the species richness varied from one to four parasites per host. In contrast, high species richness of parasites has been recorded in the cichlid *Aequidens tetramerus* Heckel, 1840 (Tavares-Dias *et al*., 2014) and erythrinids *Hoplerythrinus unitaeniatus* Spix and Agassiz, 1829 and *Hoplias malabaricus* Bloch, 1794 (Alcântara and Tavares-Dias, 2015), hosts from the same region of this study. The species richness of parasite depends on many factors, such as the parasite and its life cycle, host and its feeding habits, reproductive stage, trophic category and the physical factors of water body where the fish inhabit. It also depends on the presence of intermediate hosts in the environment (Moreira *et al*., 2005; Violante-González and Aguirre-Macedo, 2007; Poulin and Leung, 2008; Takemoto *et al*., 2009; Lagrue *et al*., 2011; Alcântara and Tavares-Dias, 2015).

Low infection levels exhibited by *P. pillulare* and the high infection levels by *I. multifiliis* in *C. bimaculatum* were influenced by the characteristics of the local environment and by the sedentary behavior of this host, which generally lives close to aquatic vegetation, the site of its capture in this study. Therefore, we can infer that the aquatic vegetation plays an important role in structuring aquatic communities, probably by providing refuge to this fish and, at the same time, increasing the possibilities to acquire parasitic infections. Moreover, these protozoans are known to proliferate in eutrophic environments like those of this study (Tavares-Dias *et al*., 2014; Alcântara and Tavares-Dias, 2015).

Monogenoideans are common ectoparasites of fish parasite communities in freshwater habitats. Several monogenoidean species are host-specific (e.g. cichlids), while other species are generalists and thus can infect several hosts from different families (Boeger and Viana, 2006; Takemoto *et al*., 2009; Braga *et al*., 2014; Mendlová and Šimková, 2014). This host specificity has been attributed to various factors including phylogenetic, physiological and ecological aspects (Braga *et al*., 2014; Mendlová and Šimková, 2014). *Gussevia arilla* is a dactylogyrid described for first time in *Cichla ocellaris*, a cichlid from the Rio Negro basin, in central Amazon, Brazil (Kritsky *et al*., 1986), and later in *Cichla kelberi* Kullander & Ferreira, 2006 from the Paraná River basin (Takemoto *et al*., 2009), and now it was found infecting about 46.0 % of the specimens of *C. bimaculatum* with a low parasitic abundance. Therefore, these data indicate that this monogenoidean species has a wide geographic distribution. Monogenoideans are ectoparasites more frequent in lentic environments, since it is easier for the free-swimming larval stages to find the hosts (Boeger and Viana, 2006; Takemoto *et al*., 2009). In this study, *C. bimaculatum* were collected in floodplain areas, a lentic environment that favored the proliferation of *G. arilla*.

The presence of *Posthodiplostomum* sp. *metacercariae* and of *P. (S.) inopinatus* in *C. bimaculatum*, an omnivorous fish that feeds on crustaceans, insects, seeds, algae, insects (Nomura and Barbosa, 1980; Froese and Pauly, 2016) and mollusks, suggest that this cichlid acts as an intermediate host of these helminths. In addition, the presence of *Posthodiplostomum* sp. *metacercariae* in intestine indicate that is possible that *C. bimaculatum* feed also on other smaller fish, although this is not part of the diet of this fish. The metacercarial stage of the digenean *Posthodiplostomum* sp. may be found in various freshwater fish around the world. The life cycle of *Posthodiplostomum* species involves two intermediate

Table 3. Spearman correlation coefficient (*rs*) of the abundance of parasites with the total length, body weight and Kn of *Cichlasoma bimaculatum* from the Brazilian Amazon.

Body parameters	Length		Weight		Kn	
Parasite species	rs	p	rs	p	rs	p
Ichthyophthirius multifiliis	0.24	0.17	0.11	0.53	-0.26	0.12
Gussevia arilla	0.15	0.36	0.06	0.72	-0.14	0.39
Posthodiplostomum sp.	-0.16	0.33	-0.09	0.609	0.32	0.18

hosts, a fish and a snail species, and then a definitive host, a piscivorous bird (Ritossa *et al*., 2013). The nematodes *P. (S.) inopinatus* have chironomid species as intermediate hosts (Moreira *et al*., 2009). The presence and abundance of these helminth species depend on various abiotic factors (e.g. seasonality, temperature, pH and oxygen.) and biotic factors (e.g. ecology, host size and age.), which are related to hosts and parasites (Moreira *et al*., 2009; Ritossa *et al*., 2013).

Host fish size is related positively or negatively with its age, and may influence the parasite population size, as the host's parasitic population can increase with its size and age (Poulin and Leung, 2008). However, parasite population size can also be influenced by other factors, such as the fish exposition period to parasites, the increase of its surface area with the growth of hosts, the environment changes, life mode of hosts, and type of ingested food by host (Moreira *et al*., 2005; Poulin and Leung, 2008; Takemoto *et al*., 2009; Tavares-Dias *et al*., 2014). The lack of correlation between the parasite abundance with total length and weight of *C. bimaculatum*, suggests that during fish development there is no parasite cumulative effect, in contrast to other studies (Poulin and Leung, 2008; Tavares-Dias *et al*., 2014). This lack of correlation may be due to fact that the parasites can have a short life cycle, and, thus, are constantly infected and eliminated by the hosts. Consequently, as the host life cycle is longer than the life period of parasites (Moreira *et al*., 2005; Takemoto *et al*., 2009), we observed that the fish growth does not influence the abundance of parasites.

CONCLUSIONS

The component community of parasites in *C. bimaculatum* was poor in species and highly numerically dominated by ectoparasites. This omnivorous host occupies an initial position in the food web and is consumed by other piscivorous fish and birds. The parasitism did not influence the condition factor of hosts; therefore, it can be inferred that the parasites found are not causing damages to these fish. This study represents the first eco-epidemiological record for *C. bimaculatum*.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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