

Diversity of parasites in *Curimata incompta* (Curimatidae), a host from Amazon river system in Brazil

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Abstract This paper is the first study on host-parasite relationship in wild *Curimata incompta* Vari, 1984 (Curimatidae) from Amazon river system, Northern Brazil. In 40 specimens examined from December 2012 to November 2013, 615,818 parasites were collected, such as *Ichthyophthirius multifiliis*, *Piscinoodinium pilulare*, *Urocleidoides* sp., *Posthodiplostomum* sp., *Gorytocephalus elongorchis* and *Braga patagonica*. The parasites' component community had a low Brillouin diversity (0.16 ± 0.15), a low species richness (3.1 ± 0.7), a low evenness (0.09 ± 0.09) and a high dominance of Berger–Parker (0.96 ± 0.06). *I. multifiliis* was the dominant parasite species and it showed the highest prevalence and intensity in the host population. There was an aggregate dispersion of parasites, but the low parasitism did not affect the body condition of the host. The occurrence of parasites in *C. incompta* was due to their life habits and food behavior. This study, besides expanding the geographical distribution of *G. elongorchis* in Brazil, records the first occurrence of these six parasites in *C. incompta*.

Keywords Ecology · Ectoparasites · Freshwater fish · Gills

Introduction

The Igarapé Fortaleza basin is an important tributary of the Amazonas river system in eastern Amazon region, in northern Brazil. It is in an estuarine coastal sector and is characterized by having extensive floodplains, which constitute physical systems of clogged rivers, drained by freshwater and connected to a main watercourse, influenced by high rainfalls and the tides of 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. 2013; Bittencourt et al. 2014), including *Curimata* spp. This study concerns the parasite fauna of freshwater fish, *Curimata incompta* Vari, 1984, a Curimatidae species widely distributed in South America and in the tropical region of Central America (Vari 2003; Lasso and Sánchez-Duarte 2011; Froese and Pauly 2014). Thus, this fish species is listed as “Least Concern” by IUCN.

Curimata incompta is a toothless characiform with a benthopelagic behavior and a detritivorous diet that consists mostly of algae and detritus. This fish lives in a lentic system, its spawning is total and usually occurs at the beginning of the flood season (Lasso and Sánchez-Duarte 2011; Froese and Pauly 2014). It has a relative importance in subsistence and for commercial fishery of the Amazon state. However, this fish has not been yet considered in studies on parasites' fauna, but a few studies have been performed with other *Curimata* species.

In *C. argentea* gills of from the Arouca river (Trinidad), Molnar et al. (1974) described the monogenoidean *Urocleidoides curimatae*. In *C. cyprinoides* gills from western Amazon (Brazil), ergasilids *Miracetyma etimaruya* were described (Malta 1993). Domingues and Boeger (2005) reported monogenoideans *Rhinoxenus guianensis* in nasal

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cavities of *C. cyprinoides* from Iracoubo, Degrad Forian (French Guiana). For *C. cyprinoides* from Amazon river system (Brazil), infection by *Ichthyophthirius multifiliis*, *Spiroucleus* sp., *Urocleidoides* sp., encysted metacercariae of Digenea and *Polymorphus* sp. was recorded (Tavares-Dias et al. 2013). For *C. inornata* from the Amazon river, in Pará State (Brazil), Azevedo and Matos (2009) described the *Henneguya curimata*.

Parasites can use intermediary and definite hosts through a trophic web, which allows them to infect the fish, but most parasite species shows a high specificity to their hosts. Thus, the knowledge of parasites infecting fishes is of particular interest regarding not only the host's health, but also considering the relation between parasites and host within the aquatic environment (Bullard and Overstreet 2008; Takemoto et al. 2009; Tavares-Dias et al. 2013; Bittencourt et al. 2014). Parasites may cause alterations in population dynamics and in the behavior of their hosts, as well as influence the competition capacity in the predator–prey relation. Therefore, knowledge of the parasites' fauna of wild fish constitutes a biodiversity assessment tool, allowing a greater understanding of host biology and its relation to parasites, which can be environmental indicators (Takemoto et al. 2009; Tavares-Dias et al. 2013; Shah et al. 2014). The present study investigated the host-parasite relationship in *C. incompta* from the Amazon river system (Brazil).

Materials and methods

Fish and collection area

From December 2012 to November 2013, 40 individuals of *C. incompta* (15.1 ± 1.0 cm and 48.9 ± 10.7 g) were collected in wetlands from Igarapé Fortaleza basin ($00^{\circ}00'56.3''\text{S}$ and $051^{\circ}05'27.1''\text{W}$), in a tributary river from the Amazon river system in the region of the municipality of Macapá, State of Amapá (Brazil), for parasitological analysis. All fish were collected with nets of different meshes. The pH (6.5 ± 0.2), water temperature (28.3 ± 0.3 °C) and dissolved oxygen levels (2.8 ± 0.3 mg/L) were determined using digital devices (YSI, USA) for each purpose.

Collection procedures and analysis of parasites

All fish were weighed (g) and measured for total length (cm), and then necropsied for parasitological analysis. For each individual, mouth, opercula, gills and gastrointestinal tract were examined in order to collect 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 running water. All materials retained on the 154 μm mesh were examined with

a stereomicroscope. Parasites were then fixed, preserved and stained according to Eiras et al. (2006). Voucher parasites specimens were deposited at the Scientific and Technological Research Institute of the State of Amapá (IEPA), in the Scientific Collection Curation Office for the Fauna of Amapá (CCFA), under accession number IEPA 044-048-P.

Parasitological terminology used follows that described by Bush et al. (1997). Dispersion index (DI) and discrepancy index (D) were calculated using the Quantitative Parasitology 3.0 software to detect the distribution pattern of each infracommunity parasite species (Rózsa et al. 2000), with the prevalent species being $>10\%$. The DI significance for each infracommunity was tested using the *td*-statistics (Ludwig and Reynolds 1988). The Brillouin index (*HB*), evenness (*E*), Berger–Parker dominance index (*d*) and species richness (Magurran 2004) were calculated for parasites showing more than 10 % prevalence, in order to evaluate the community of parasites using the Diversity software (Pisces Conservation Ltd., UK), as well as the frequency of dominance (percentage of infracommunities in which a parasite species was numerically dominant) (Rohde et al. 1995; Magurran 2004).

Data on weight (g) and total length (cm) were used to calculate the relative condition factor (*Kn*) of hosts (Le-Cren 1951). The Pearson coefficient (*r*) was used to determine possible correlations of parasite intensity with length, weight, *Kn*, *HB* and species richness of examined hosts (Zar 2010).

Results

Of 40 *C. incompta*, 615,818 parasites were collected: two Protozoa, one Monogenoidea, one Digenea, one Acanthocephala and one Isopoda. However, higher infection levels were caused by *I. multifiliis* and *Piscinodinium pilullare* (Table 1), both parasites with dominance (Table 2). These parasites showed an aggregate dispersion (Table 2).

Parasites community showed a low mean diversity (*HB* = 0.16 ± 0.15), a low mean species richness (3.1 ± 0.7), a low evenness (*E* = 0.09 ± 0.09) and a high Berger–Parker dominance (*d* = 0.96 ± 0.06), with predominance of individuals parasitized by two to four species (Fig. 1).

There was no correlation of length of the hosts with the richness of parasite species (*r_s* = 0.27, *p* = 0.09) and the Brillouin diversity index (*r_s* = 0.12, *p* = 0.45).

There was a weak positive correlation between the length (*r_s* = 0.34, *p* = 0.032) and the abundance of *Posthodiplostomum* sp., but no correlation with weight (*r_s* = 0.26, *p* = 0.10) was found. There was no correlation between length and the abundance of *I. multifiliis* (*r_s* = -0.57 , *p* = 0.73), *P. pilullare* (*r_s* = 0.03, *p* = 0.84) and *Urocleidoides* sp. (*r_s* = 0.14, *p* = 0.39), as well as between weight and the abundance of *I. multifiliis*

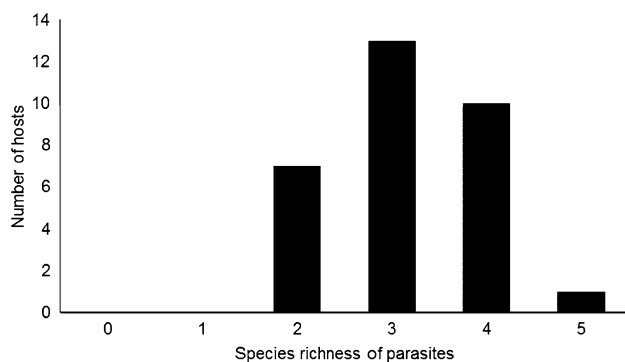
Table 1 Parasites in *Curimata incompta* (n = 40) from the Amazon river system (Brazil)

Parasites	P (%)	MI ± SD	MA ± SD	Range	TNP	SI
<i>Ichthyophthirius multifiliis</i>	97.5	15,131.8 ± 12,524.5	14,753.5 ± 12,592.3	0–53,025	590,140	Gills
<i>Piscinodinium pilulare</i>	50.0	1030.7 ± 1122.4	515.3 ± 941.4	0–3762	20,613	Gills
<i>Urocleidoides</i> sp.	100	27.2 ± 33.2	27.2 ± 33.0	0–158	1088	Gills
<i>Posthodiplostomum</i> sp. (metacercariae)	60.0	165.4 ± 504.2	99.3 ± 395.8	0–2117	3970	Gills
<i>Gorytocephalus elongorchis</i>	5.0	2.0 ± 1.4	0.1 ± 0.5	0–3	4	Intestine
<i>Braga patagonica</i>	2.5	1.0 ± 0	0.03 ± 0.2	0–1	1	Gills
<i>Braga patagonica</i>	2.5	2.0 ± 0	0.05 ± 0.3	0–2	2	Fins

P prevalence, MI mean intensity, MA mean abundance, TNP total number of parasites, SI site of infection, SD standard deviation

Table 2 Dispersion index (DI), *d*-statistic, discrepancy index (D) and frequency of dominance (FD) for main parasites of *Curimata incompta* (n = 40) from the Amazon river system (Brazil)

Parasites	DI	<i>d</i>	D	FD (%)
<i>Ichthyophthirius multifiliis</i>	2.111	4.06	0.275	0.958
<i>Piscinodinium pilulare</i>	4.264	9.46	0.623	0.033
<i>Urocleidoides</i> sp.	3.747	8.32	0.372	0.002
<i>Posthodiplostomum</i> sp.	3.498	7.75	0.600	0.006

**Fig. 1** Parasite species richness in *Curimata incompta* (n = 40) from the Amazon river system (Brazil)

($r_s = -0.15$, $p = 0.34$), *P. pilulare* ($r_s = -0.02$, $p = 0.92$) and *Urocleidoides* sp. ($r_s = -0.02$, $p = 0.89$).

For hosts, growth was a negative allometric ($b = 2.32$, $r^2 = 0.48$), and body weight was positively related to total length ($r = 0.70$, $p < 0.0001$). This negative allometric growth indicates a greater increase in body weight than in body size. The relative condition factor ($K_n = 1.00 \pm 0.04$) was not different ($t = 0.0001$, $p = 1.00$) of the $K_n = 1.00$ pattern, indicating good body conditions of the hosts.

Discussion

Curimata incompta was parasitized by *I. multifiliis*, *P. pilulare*, *Urocleidoides* sp., *Posthodiplostomum* sp., *Gorytocephalus elongorchis* and *Braga patagonica*, while *C. cyprinoides*, from the same hydrographic basin, was

parasitized by *I. multifiliis*, *Spironucleus* sp., *Urocleidoides* sp., non-identified metacercariae Digenea and *Polymorphus* sp. (Tavares-Dias et al. 2013). However, in both studies, was similar dominance of *I. multifiliis* and overdispersion of the parasite species, but the diversity and species richness of parasites was higher for *C. incompta*. Differences in species richness and diversity of parasites may also be a result of the host's individual responses to parasitism and transmission rates, among other factors (Takemoto et al. 2009; Tavares-Dias et al. 2013; Shah et al. 2014). Therefore, biotic factors such as the host immunity may have a differential effect on a fish-parasite environment system.

Cymothoids are parasites of fish, in both immature forms and adults, and they may cause damages in gill filaments, reducing the branchial surface area of the hosts (Rameshkumar and Ravichandran 2014). Only one individual of *C. incompta* had the gills and fins infested by *B. patagonica*, a cymothoid species common in fishes from the Amazon. Cymothoidae species tend to be associated with their hosts through their entire life, while species of other families are parasites only at their larval phase. As the pathogenicity of *B. patagonica* varies according to their location in the host, feeding behavior, strategy of attack and parasite size (Tavares-Dias et al. 2014). Thus, no clinical symptom was found. This is the first report for *B. patagonica* in *C. incompta*.

In *C. incompta*, the prevalence of *I. multifiliis* was similar to that reported for *C. cyprinoides*, while the intensity and abundance were higher in the hosts of this study. However, an infection by *P. pilulare* occurred only

in *C. incompta*. Therefore, these results indicate a difference in response of both hosts regarding the opportunity of infection transmission by both protozoans, opportunist and common, mostly in environments with low oxygen levels (Tavares-Dias et al. 2013; Bittencourt et al. 2014). In addition, such protozoans species are directly transmitted from fish to fish, thus the proximity among hosts might be very important for a successful transmission. This is the first report of *I. multifiliis* and *P. pilulare* for *C. incompta*.

Infection by *Urocleidoidea* sp. occurred in the gills of *C. incompta*, probably a new species of monogenoidean and similar to that reported for *C. cyprinoides*, a curimatid species also from Amazon river system. However, no *Urocleidoidea* species had been described for *Curimata* spp. in Brazil (Cohen et al. 2013). Only *U. curimatae* has been known parasitizing the gills of *C. argentea* in Trinidad (Molnar et al. 1974) and *R. guianensis* parasitizing nasal cavities of *C. cyprinoides* in French Guyana (Domingues and Boeger 2005; Cohen et al. 2013). Therefore, this is the first record of *Urocleidoidea* sp. in *C. incompta*. Infection levels of monogenoideans were higher in *C. incompta* compared to *C. cyprinoides* (Tavares-Dias et al. 2013), indicating a difference in exposition of these hosts to a same parasite species in a eutrophized environment.

In this study, metacercariae of *Posthodiplostomum* sp. were found on the gills of *C. incompta*, while for *C. cyprinoides*, the encysted metacercariae of Digenea, and were not identified. *Posthodiplostomum* sp. were reported in other wild fish species from the Amazon river system (Bittencourt et al. 2014). The genus *Posthodiplostomum* has a worldwide distribution due to its lack of host specificity, while most of the species has a restricted distribution. Thus, the metacercarial stage of this parasite can be found in various freshwater fish around the world. The life cycle of *Posthodiplostomum* species involves two intermediate hosts, a fish species and a snail species (metacercariae stage), and then a definitive host, a piscivorous bird (adult forms). Thus, the presence and abundance of this digenean depend on various abiotic (seasonality, temperature, pH, oxygen, etc.) and biotic (ecology, host size, age, etc.) factors related to these hosts and parasite (Bullard and Overstreet, 2008; Ritossa et al. 2013). Consequently, the infection levels by *Posthodiplostomum* sp. in *C. incompta* were higher than those observed for *C. cyprinoides* (Tavares-Dias et al. 2013). This was the first report of *Posthodiplostomum* sp. for *C. incompta*.

Low infection levels by acanthocephalans *G. elongorchis* were found in *C. incompta*, while low *Polymorphus* sp. infection was reported for *C. cyprinoides* (Tavares-Dias et al. 2013). As both curimatid species are detritivorous, thus such infections by acanthocephalans were accidental. This difference of infection by different acanthocephalans reflects a non-habitat overlap for both hosts from the same locality. *G.*

elongorchis is an endoparasite described parasitizing Loricariidae species, such as *Hypostomus carinatus* from Amazon river system (Thatcher 1979), *H. cochliodon*, *H. regani* and *Loricaria* sp. from Paraná river system (Lopes et al. 2011). Therefore, this is the first record of *G. elongorchis* for *C. incompta*, and suggest a wide distribution of this parasite in Brazil.

In conclusion, the parasites community in *C. incompta* composed by five taxa, it was characterized by low diversity, low species richness and low evenness, with a predominance of ectoparasite species. Because the hosts' size was not a determining factor in parasite species richness and diversity, other factors may influence this parasitic fauna, and so they should be investigated in the near future. The reduced endoparasites community in *C. incompta* was due to its lower position in the food chain, serving as an intermediate host for other piscivorous fish.

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