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ORIGINAL ARTICLE

Records of new localities and hosts for crustacean parasites in fish from the eastern Amazon in northern Brazil

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Abstract The aim of this study was to investigate parasites crustacean fauna in *Arapaima gigas*, *Cichla monoculus*, *Cichla ocellaris*, *Cichla jariina*, *Satanoperca jurupari*, *Leporinus friderici*, *Leporinus fasciatus*, *Hoplias malabaricus*, *Phractocephalus hemioliopterus*, *Serrasalmus altispinis*, *Pseudoplatystoma tigrinum* and *Potamotrygon motoro* of the State Amapá and Pará, in northern Brazil. A total of 242 parasites, including *Argulus elongatus*, *Argulus multicolor, Argulus juparanaensis*, *Argulus nattereri*, *Dolops discoidalis*, *Dolops longicauda*, *Braga patagonica*, *Braga fluviatilis*, *Livoneca guianensis* and undetermined Lernaeidae, were collected from these hosts. The *Argulus* species had the greatest richness among the community of parasitic crustaceans. There was a low abundance of parasites among the hosts, other than *D. discoidalis*, was most abundant in the integument of *A. gigas* and *P. tigrinum*. Finally, the present study reported nine new hosts for the crustacean parasite species and expanded knowledge of the occurrence of some parasite species in the Jari River basin, in eastern Amazon.

Keywords Amazon · Branchiura · Infestation · Parasites

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Introduction

Species of Crustacea Brünich, 1722 are found in a range of habitats, and require a host in at least one phase of their life cycle. Parasitic crustaceans include Branchiura Thorell, 1818; Copepoda Milne Edwards, 1940 and Isopoda Latreille, 1871. Crustacean species of these groups, most of which are ectoparasites, infect freshwater (Fryer 1968; Mamani et al. 2004; Thatcher 2006; Walker et al. 2008; Tavares-Dias et al. 2015), brackish and marine fish in various parts of world (Luque and Poulin 2007; Luque et al. 2013). Crustacean ectoparasites may attack the gills, oral cavity, nostrils and/or integument of fish populations, and can cause a range of damage to their hosts (Fryer 1968; Mamani et al. 2004; Thatcher 2006; Fontana et al. 2012; Vasconcelos and Tavares-Dias 2014; Tavares-Dias et al. 2014a), in fish aquaculture and natural environments. Some parasitic crustaceans are blood feeding, and as a result infestation, which can affect the biology and regulate abundance of wild fish populations, may lead to economic losses (Mamani et al. 2004; Tavares-Dias et al. 2014a).

In Brazil, some species of branchiurans, isopods and copepods parasites are widely geographically distributed while others are limited to the Amazon region (Tavares-Dias et al. 2015). The *Ergasilus* Nordmann, 1832 genus, for example, is frequently found in this region. Moreover, some parasitic crustaceans have specific fish species hosts, while others do not have host specificity. The genera *Argulus* Müller, 1785 and *Dolops* Audouin, 1837 are more widely distributed than others, they are present in all the hydrographic basins of Brazil, although some species of these argulids are limited to only one or two basins (Vasconcelos and Tavares-Dias 2014; Tavares-Dias et al. 2015).

In the eastern Amazon region, few parasitic crustacean species have been found with great frequency in the small

number of fish species that have been studied (Table 1). Therefore, compared to other parasites of Amazonian freshwater fish, parasitic crustaceans have been little studied. Moreover, among the wider questions relating to the distribution patterns of parasitic crustaceans among freshwater fish, geographical patterns have been little addressed (Tavares-Dias et al. 2015). Therefore, this study investigated crustacean fauna in fish species in two localities of the Jari River Basin, a tributary of the Amazon River system, and also described the reporting of these

Table 1 Ectoparasites Crustacea in teleost fish and elasmobranch species in eastern Amazon (Brazil)

Host species	Parasite species	SI	Locality	References
Acestrorhynchus falcirostris	*Ergasilus turucuyus* Malta and Varella, 1996	Gills	Araguari River (AP)	Vasconcelos and Tavares-Dias (2014)
Astronotus ocellatus	*Argulus multicolor* Stekhoven, 1937	Gills	Igarapé Fortaleza River (AP)	Bittencourt et al. (2014)
	Dolops nana Lemos de Castro, 1950	Gills	Lago Pracuúba (AP)	Neves et al. (2013)
Aequidens sp.	*Ergasilus* sp.	Gills	Igarapé Fortaleza River (AP)	Bittencourt et al. (2014)
Aequidens tetramerus	*Dolops longicauda* Heller, 1857	Gills	Igarapé Fortaleza River (AP)	Tavares-Dias et al. (2014b)
Colossoma macropomum	*Perulernaea gamitanae* Thatcher and Paredes, 1985	Nostrils	Amazon River (PA)	Fischer et al. (2003)
	Gamidactylus jaraquensis Thatcher and Boeger, 1984	Nostrils	Amazon River (PA)	Fischer et al. (2003)
	Braga patagonica Schiödte and Meinert, 1884	Integument	Macapá (AP)	Tavares-Dias et al. (2014a)
	Perulernaea gamitanae Thatcher and Paredes, 1985	Tongue, Mouth	Macapá (AP)	Tavares-Dias et al. (2011)
	Perulernaea gamitanae Thatcher and Paredes, 1985	Gills	Macapá (AP)	Dias et al. (2015)
	Perulernaea gamitanae Thatcher and Paredes, 1985	Mouth	Macapá (AP)	Dias et al. (2015)
	Braga patagonica Schiödte and Meinert, 1884	Integument	Macapá (AP)	Dias et al. (2015)
Chaetobranchopsis orbicularis	*Dolops longicauda* Heller, 1857	Gills	Igarapé Fortaleza River (AP)	Bittencourt et al. (2014)
Chaetobranchus flavescens	*Braga patagonica* Schiödte and Meinert, 1884	Gills	Igarapé Fortaleza River (AP)	Bittencourt et al. (2014)
Curimata incompta	*Braga patagonica* Schiödte and Meinert, 1884	Gills	Igarapé Fortaleza River (AP)	Neves et al. (2015)
Hemibrycon surinamensis	*Ergasilus turucuyus* Malta and Varella, 1996	Gills	Igarapé Fortaleza River (AP)	Hoshino et al. (2014)
	Argulus sp.	Gills	Igarapé Fortaleza River (AP)	Hoshino et al. (2014)
Hemiodus unimaculatus	*Ergasilus turucuyus* Malta and Varella, 1996	Gills	Araguari River(AP)	Vasconcelos e Tavares-Dias (2014)
Hoplerythrinus unitaeniatus	*Argulus pestifer* Ringuelet, 1948	Gills	Igarapé Fortaleza River (AP)	Alcântara and Tavares-Dias (2015)
Hoplias malabaricus	*Braga patagonica* Schiödte and Meinert, 1884	Gills	Igarapé Fortaleza River (AP)	Alcântara and Tavares-Dias (2015)
Metynnis lippincottianus	*Dolops longicauda* Heller, 1857	Gills	Igarapé Fortaleza River (AP)	Hoshino et al. (2014)
Potamotrygon motoro	*Argulus juparanaensis* Lemos de Castro, 1950	Integument	Marajó Island (PA)	Peralta et al. (1998)
	Argulus juparanaensis Lemos de Castro, 1950	Integument	Amazon River (PA)	Gama et al. (2015)

SI site of infestation, *AP* Amapá state, *PA* Pará state

ectoparasites in literature regarding fish populations in the eastern Amazon region.

Materials and methods

Characterization of the studied areas

The tributaries of the Amazon River system are responsible for forming large floodplain areas. Such floodplains have a fluvial physical system drained by freshwater, and are influenced by the high rainfall and tides of the Amazon River. Several fish species have been identified in these basins, as floodplain areas form a propitious environment for their development. In the rainy season, waters spread over the floodplain, creating favorable conditions that lead most fish to reproduce earlier in the season. This is the main period for feeding, growth and the accumulation of energy reserves used to support the reduced food supply during the dry season (Braga et al. 2011; Albert and Reis 2011). In both basins, regional vegetation consists of plants characteristic of floodplain forests and periodically flooded herbaceous fields, composed mainly of various macrophyte species.

Fish and sampling procedures

The fish were caught in 2015, in two locations, in the Jari River basin for parasitological analysis of crustaceans: one site was located near the Jarilândia community, in the municipality of Vitória do Jari, in the state of Amapá (S1°07′20.73″–W51°59′32.86″) and the other was situated near the Socorro of Jarí community in the Tapajós River basin in Santarém in the state of Pará (S02°20.043′–W54°52.568′). Cast and gill nets of different sizes, as well as hooks, were used to catch the fish. For each fish caught, the gills, mouth, opercula, integument, nostrils and anus were examined for the collection of crustaceans. The crustaceans found were fixed in alcohol (70 %) for 48 h, and then preserved in ethyl alcohol (70 %) with glycerin (10 %). The techniques used for staining the parasites were in accordance with previous recommendations (Eiras et al. 2006). The parasitological terminology used throughout the study followed that described by Bush et al. (1997). Parasite identification was performed in accordance with Van Name (1925), Lemos de Castro (1959, 1985), Thatcher (2006) and Luque et al. (2013). The present work was developed according to the principles adopted by the Brazilian College of Animal Experiments (COBEA) and with the authorization from Ethics Committee in the Use of Animal of the Embrapa Amapá (N° 004—CEUA/CPAFAP).

Results

In 2015 July, 1 specimen of *Arapaima gigas* (102.5 cm and 6800 g), 3 specimens of *Cichla monoculus* (27.7 ± 0.85 cm; 580 ± 51.9 g), 1 specimen of *Cichla ocellaris* (20.2 cm and 320 g), 5 specimens of *Cichla jariina* (33.5 ± 2.6 cm; 940 ± 227.2 g), 4 specimens of *Satanoperca jurupari* (14.5 ± 2.3 cm; and 140 ± 24.5 g), 1 specimen of *Leporinus friderici* (16.8 ± 2.5 cm; 153.3 ± 16.3 g), 1 specimen of *Leporinus fasciatus* (20.5 cm and 250 g), 1 specimen of *Hoplias malabaricus* (33.4 cm and 820 g), 2 specimens of *Phractocephalus hemioliopterus* (25.3 ± 3.5 cm and 440 ± 120 g), 1 specimen of *Serrasalmus altispinis* (11.5 cm and 57.2 g), 1 specimen of *Pseudoplatystoma tigrinum* (47.5 cm and 3580 g) and 4 specimens of *Potamotrygon motoro* (46 ± 9.3 cm 4940 ± 2149.8 g) were captured.

The Argulidae, Ergasilidae, Lernaeidae and Cymothoidae crustacean species have been recorded for different fish species in the eastern Amazon. However, *Ergasilus turucuyus* (Ergasilidae), *Braga patagonica* (Cymothoidea) and *Dolops longicauda* (Argulidae) have been the most frequently found parasites among these fish species (Table 1).

A total of 399 parasites were collected from 12 examined host species. *Argulus multicolor* (Argulidae) was the most frequently found species, infesting six host species. However, the highest intensity was of *Argulus juparanaensis* in the integument of *P. motoro* and *Dolops discoidalis* in the integument of *P. tigrinum*, *P. hemiliopterus* and *A. gigas* (Table 2).

Discussion

Many species of fish are infected by different parasitic crustacean species. Luque et al. (2013) listed 133 species of parasitic crustaceans that infect freshwater fish in Brazil. However, since then, more species have been described, providing further evidence of the richness of parasitic crustacean fauna in this country, especially in the Amazon region. In 10 host fish species from the Jari River basin 5 branchiurans, 2 Isopods and 1 undetermined copepods species were found in two host species of the Tapajós River basin in the state of Pará, while *A. multicolor* infested 58.3 % of the host fish species due to its low parasitic specificity. *Argulus multicolor* is widely distributed as it infects different fish species from the central Amazon (Malta 1984), Pantanal (Fontana et al. 2012) and Paraná River basins (Yamada and Takemoto 2013). However, this is the first recording of *A. multicolor* for *L. friderici*, *L. fasciatus*, *L. trifasciatus*, *S. jurupari*, *H. malabaricus*, *C. ocellaris* and *C. jariina*.

Table 2 Parasitic crustaceans on teleost fish and elasmobranch species of two localities from eastern Amazon region (Brazil)

Host species	Parasites species	Locality	SI	EF/PF	MI	MA	TNP
Arapaima gigas	*Dolops discoidalis* Bouvier, 1899	Pará state	Integument	1/1	142	142	142
Cichla monoculus	*Argulus elongatus* Heller, 1857	Amapá state	Mouth	3/2	3.0	2.0	6
Cichla ocellaris	*Argulus multicolor* Stekhoven, 1937	Amapá state	Gills	1/1	1.0	1.0	1
Cichla jariina	*Argulus multicolor* Stekhoven, 1937	Amapá state	Mouth	5/2	1.0	0.4	2
Leporinus fasciatus	*Argulus multicolor* Stekhoven, 1937	Amapá state	Mouth	1/1	1.0	1.0	1
Leporinus trifasciatus	*Argulus multicolor* Stekhoven, 1937	Amapá state	Mouth	1/1	1.0	1.0	1
Leporinus friderici	*Argulus multicolor* Stekhoven, 1937	Amapá state	Mouth	3/2	2.0	1.3	4
	Braga fluviatilis Richardson, 1911	Amapá state	Mouth	3/1	6.0	2.0	6
	Livoneca guianensis Van Name, 1925	Amapá state	Mouth	3/1	1.0	0.3	1
Potamotrygon motoro	*Argulus juparanaensis* Lemos de Castro, 1950	Amapá state	Mouth and Integument	4/4	38.0	38.0	152
Pseudoplatystoma tigrinum	*Argulus nattereri* Heller, 1857	Amapá state	Integument	1/1	1.0	1.0	1
	Dolops discoidalis Bouvier, 1899	Amapá state	Integument	1/1	1.0	1.0	1
	Dolops longicauda Heller, 1857	Pará state	Integument	2/1	1.0	6.5	13
	Dolops discoidalis Bouvier, 1899	Pará state	Integument	2/1	53.0	26.5	53
Phractocephalus hemiliopterus	*Dolops discoidalis* Bouvier, 1899	Amapá state	Integument	3/3	2.6	2.6	8
	Argulus nattereri Heller, 1857	Amapá state	Gills	3/1	1.0	0.3	1
	Lernaeidae gen. sp.	Amapá state	Mouth	3/1	1.0	0.3	1
Satanoperca jurupari	*Argulus multicolor* Stekhoven, 1937	Amapá state	Mouth	4/2	1.5	0.8	3
Serrasalmus altispinis	*Braga patagonica* Schiödte and Meinert, 1884	Amapá state	Mouth	1/1	1.0	1.0	1
	Argulus nattereri Heller, 1857	Amapá state	Integument	1/1	1.0	1.0	1
Hoplias malabaricus	*Argulus multicolor* Stekhoven, 1937	Amapá state	Mouth	1/1	1.0	1.0	1

EF examined fish, *PF* parasitized fish, *TNP* total number of parasites, *SI* site of infestation, *MI* mean intensity, *MA* mean abundance

Among the crustacean species of this study, only *B. patagonica* and *A. multicolor* have been reported in hosts from the eastern Amazon (Table 2). Recent studies suggest that the distribution patterns of parasitic crustaceans are the result of complex host-parasite interactions, compounded by factors that act in either direction. Furthermore, the biology of these parasites and hosts are ecological barriers, a factor that is of prime importance within these interactions (Tavares-Dias et al. 2015). However, factors determining infestation levels are typically complex and may be based on a variety of factors, including morphological, physiological, behavioral, immunological characteristics, or the nutritional conditions of the host (Walker et al. 2008).

Branchiurans are known for their frequent host switching and for having a lower host specificity than other parasitic groups. Among the factors that influence the infestation rates of these ectoparasites, the genetic similarities of the hosts and ecological factors may be involved to various degrees (Mamani et al. 2004; Thatcher 2006). *Argulus juparanaensis* was found to infest only *P. motoro* from the Jari River Basin. This argulid has been also reported in *P. motoro* from the Marajó Archipelago in the state of Pará (Peralta et al. 1998) and the mouth of the Amazon River, in the state of Amapá (Gama et al. 2015). This species of argulid also infected the Characidae, Doradidae, Pimelodidae, Sciaenidae (Luque et al. 2013) and Serrasalmidae (Carvalho et al. 2003) species in other Brazilian regions. However, this is the first record of *A. juparanaensis* for *P. motoro* from the Jari River basin. Moreover, in this study *A. nattereri* was collected from the integument of *P. tigrinum* and *P. hemiliopterus*. This parasite has been also reported in *Pseudoplatystoma corruscans*, *Pseudoplatystoma* sp., *Salminus brasiliensis* and *Salminus franciscanus* in the states of Mato Grosso do Sul, Paraná and São Paulo (Luque et al. 2013), as well as in *Pseudoplatystoma fasciatum* and *P. tigrinum* in Bolívia (Mamani et al. 2004). However, this is the first record of *A. nattereri* in *P. tigrinum* and *P. hemiliopterus* from the eastern Amazon.

Argulus elongatus infested only *C. monoculus* in the Jari River basin, though it also parasites Serrasalmidae such as *Pygocentrus nattereri*, *Serrasalmus marginatus* and *Serrasalmus spilopleura* from the Pantanal, Brazil (Carvalho et al. 2003). This is the first record of *A. elongatus* parasitizing *C. monoculus*. Moreover, the highest abundance of

parasites was of *A. juparanaensis* in the integument of *P. motoro*, and *D. discoidalis* in *A. gigas*, probably due to the larger body size of these hosts. Larger fish seem be more prone to a higher abundance of argulids, due to their greater body surface area (Malta 1984; Mamani et al. 2004; Walker et al. 2008). However, the abundance of *D. discoidalis* was high in some hosts, and it was collected only from *A. gigas*, *P. tigrinum* and *P. hemiliopterus*. *Dolops discoidalis* has infested other fish species from different Brazilian regions (Thatcher 2006; Luque et al. 2013; Tavares-Dias et al. 2015), but this is the first report of this argulid species in fish from the Jari River basin. (Thatcher 2006; Luque et al. 2013; Tavares-Dias et al. 2015), but this is the first report of this argulid species in the Jari River basin. *Dolops longicauda*, an argulid that infests the Characidae, Doradidae, Potamotrygonidae and Serrasalmidae species (Fontana et al. 2012; Thatcher 2006; Luque et al. 2013; Hoshino et al. 2014; Tavares-Dias et al. 2015) was found only in *P. tigrinum*. Moreover, this is the first report of *D. longicauda* found in *P. tigrinum*, and expands the distribution of this argulid species to the Jari River Basin, in eastern Amazon.

Isopods are crustaceans that can occur in almost all habitats; and are therefore a highly diverse group, with a great number of parasite species (Brasil-Lima and Barros 1998; Thatcher 2006; Tavares-Dias et al. 2014a). *Braga patagonic*a is the most common isopod infesting fish from the eastern and central Amazon (see Table 1, and Tavares-Dias et al. 2014a), but was only found in *S. altispinis* of the current study, and this is the first record for this host. However, *B. fluviatilis* is distributed in Argentina, Uruguay and Brazil (Lemos de Castro 1959; Brasil-Lima and Barros 1998). This isopod species parasitized only *L. friderici* in the present study, which is the first record of *B. fluviatilis* for this host, and for the Jari River Basin. Moreover, *L. guianensis* was first described for *L. fasciatus* and *Pimelodus clarias* in British Guyana (Van Name 1925) and was also found only in *L. friderici* from the Jari River basin, which is its first record for this host species.

In summary, 399 parasitic crustacean specimens were found from 12 hosts during this survey. *Argulus* species were the taxa richest in the community of these parasites. Moreover, the majority of fishes examined had a low abundance of parasites, except *A. gigas* and *P. tigrinum*, which were the most parasitized fish. Finally, this study reports new hosts for the crustacean species and describes the occurrence of a number of species in the Jari River basin.

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