Parasites in Loricariidae from Brazil: checklist and new records for fish from the Brazilian Amazon

William Felix Borges¹, Marcos Sidney Brito de Oliveira², Gracienhe Gomes Santos³ and Marcos Tavares-Dias²,4*

¹Universidade do Estado do Amapá, Macapá, Amapá, Brazil.  ²Universidade Federal do Amapá, Macapá, Amapá, Brazil.  ³Faculdade de Macapá, Macapá, Amapá, Brazil.  4Empresa Brasileira de Pesquisa Agropecuária, Rod. Juscelino Kubitschek, Km 5, 2600, 68903-419, Macapá, Amapá, Brazil.  *Author for correspondence. E-mail: marcos.tavares@embrapa.br

ABSTRACT. The aim of this study was to investigate the parasites fauna of *Ancistrus leucostictus*, *Hypostomus ventromaculatus*, *Ancistrus* sp. and *Hemiancistrus* sp. from the Igarapé Fortaleza River (Amapá State, Brazil), besides making a checklist of the parasite species in Loricariidae from Brazil. A total of 53 fishes were collected from November 2013 to August 2014. In the hosts, a total of 1,559 parasites of seven taxa were collected: *Unilatus unilatus*, *Trinigyrus mourei*, undetermined metacercariae, *Genarchella gernachella*, *Raphidascaris* (*Sprentascaris*) sp., *Gorythocephalus elongorchis* and *Proteocephalus* sp. Ectoparasite species were frequent in the examined Loricariidae species, which also had larval stages of endoparasites. The hosts with the highest sampled number, *H. ventromaculatus* and *Ancistrus* sp., had the highest parasite species richness. Loricariidae species from Brazil are parasitized by species of Protozoa, Monogenea, Nematoda, Digenea, Acantocephala, Cestoda, Crustacea and Hirudinea, but monogeneans, digeneans and nematodes were the predominant taxa.

Keywords: armored catfish ectoparasites; freshwater fish; Loricariidae.

Parasitos de Loricariidae do Brasil: checklist e novos registros para peixes da Amazônia brasileira

RESUMO. O objetivo deste estudo foi descrever a fauna parasitária de *Ancistrus leucostictus*, *Hypostomus ventromaculatus*, *Ancistrus* sp. e *Hemiancistrus* sp. da bacia Igarapé Fortaleza (Estado do Amapá, Brasil), além de fazer um checklist das espécies de parasitos em Loricariidae do Brasil. Foram coletados 53 peixes de novembro de 2013 a agosto de 2014. Nos hospedeiros foram coletados um total de 1.559 parasitos distribuídos em sete táxons: *Unilatus unilatus*, *Trinigyrus mourei*, metacercárias não identificadas, *Genarchella gernachella*, *Raphidascaris* (*Sprentascaris*) sp., *Gorythocephalus elongorchis* e *Proteocephalus* sp. Espécies de ectoparasitos foram frequentes nas espécies de Loricariidae examinadas, que também apresentaram estágios larvais de endoparasitos. Hospedeiros com maior número amostral, *H. ventromaculatus* e *Ancistrus* sp., apresentaram maior riqueza de espécies de parasitos. Espécies de Loricariidae do Brasil são parasitados por espécies de Protozoa, Monogenea, Nematoda, Digenea, Acantocehala, Cestoda, Crustacea e Hirudinea, mas monogeneas, digenea e nematoides são os táxons predominantes.

Palavras-chave: cascudos; ectoparasitos; peixes de água doce; Loricariidae.

Introduction

Loricariidae is the most species-rich of freshwater fishes, with more than 915 valid species, distributed in 106 genera and six subfamilies (Lithogeneinae, Neoplecostominae, Ancistriniae, Hypoptopomatinae, Hypostominae and Loricariinae) and occurs in Costa Rica, Panama and South America (Alonso, Terán, Aguilera, & Miranda, 2016; Nelson, Grande, & Wilson, 2016). However, the highest occurrence of Loricariidae species is in the Amazon River basin system (Soares et al., 2011). Fish species of this family have size ranging from 2.5 to 61.0 cm and detritivorous feeding habit, since they feed on debris, algae and invertebrates associated with the sediments of water bodies (Soares et al., 2011). Some species of Loricariidae such as *Ancistrus leucostictus* Günther, 1864; *Ancistrus Rafinesque, 1815*, *Hypostomus ventromaculatus* Boeseman, 1968 and *Hemiancistrus* Bleeker, 1862 are known for the Igarapé Fortaleza, a tributary of the Amazon River in the State of Amapá, eastern Amazon region (Brazil), the locality of this study. Loricariid species are fish that occupy a lower position in the food chain (Soares et al., 2011), thus they have a low parasitic fauna (Gonçalves, Oliveira, Santos, & Tavares-Dias, 2014).
Parasites play an important role in ecosystems, since they can regulate the abundance of host fish populations, destabilize food chains and alter the structure of communities of hosts (Luque & Poulin, 2007; Lagrue, Kelly, Hicks, & Poulin, 2011; Cardoso, Oliveira, Neves & Tavares-Dias, 2017; Baia, Florentino, Silva & Tavares-Dias, 2018). As parasites are components of most ecosystems, occurring in all food webs and at all trophic levels, several vertebrate and invertebrate species serve as hosts for one or more species of parasites (Lagrue et al., 2011; Cardoso et al., 2017; Baia et al., 2018). In wild fish populations, parasite communities differ in richness and diversity according to their behavior, diet of hosts and the parasite life cycle. The different species of fish living in sympatry may present a similar pattern of parasites when compared to species living in allopatry (Cardoso et al., 2017). Thus, this study compared the parasite fauna in A. leucostictus, H. ventromaculatus, Ancistrus sp. and Hemiancistrus sp. from the Igarapé Fortaleza River, and presented a checklist of the parasite species in Loricariidae from Brazil.

Material and methods

Study area, fish and locality of collection

The Igarapé Fortaleza basin, located in the municipalities of Macapá and Santana (AP), is formed by a main channel and an extensive area of floodplains that suffer periodic flooding and is strongly influenced by the high rainfall of the Amazon region and the daily tides of the Amazon River, thus providing shelter and feeding for different species of fish. The regional vegetation is composed of plants with characteristics of flooded forests and herbaceous fields, and several species of macrophytes (Thomaz, Costa-Neto, & Tostes, 2004; Tavares-Dias, Oliveira, Gonçalves, & Silva, 2014).

From November 2013 to August 2014, fifty three specimens of A. leucostictus, H. ventromaculatus, Ancistrus sp. and Hemiancistrus sp. were collected in Igarapé Fortaleza River, municipality of Macapá, State of Amapá, Brazil (Figure 1). All fish were collected with gill nets of different mesh sizes, for parasitological analysis.

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, fixed in formalin 5% and analyzed with the aid of a microscope. To quantify metazoan parasites, each viscera was dissected separately and washed with sodium chloride solution (0.85%) and examined under a stereomicroscope. Previously described techniques were used to collect, count, fix, preserve, and stain the parasites for identification (Eiras, Takemoto, & Pavanelli, 2006; Boeger & Viana, 2006). To analyze the parasites, the ecological terms used were those recommended by Bush, Lafferty, Lotz & Shostak (1997).

A review on the parasites of Loricariidae species in Brazil was performed by searching databases (SciELO, ISI, Scopus, Science Direct, Zoological Records, CAB Abstracts databases and Google Scholar), and available data regarding the parasitic fauna were added to Table 1.

Results

Species of Protozoa, Monogenea, Nematoda, Digenea, Acantocephala, Cestoda, Crustacea and Hirudinea were found parasitizing species of Loricariidae from Brazil, but the most frequent taxonomic groups are Monogenea, Digenea and Nematoda (Table 1). However, the greatest species richness is for Monogenea (Figure 2).

The weight, total length and number of examined hosts are listed in Table 2.

A total of 1,559 parasites were collected from 53 fish specimens, which infected gills and gut of hosts. Unilatus unilatus Mizelle et Kritsky, 1967 and Trinigyrus mourei Boeger and Bemont-Jégu, 1994 were the most frequent parasites, infecting four host species, followed by Genarchella gernachella Travassos 1928 and larvae of Raphidascaris (Sprentascaris) Peter and Cassone, 1984. Larvae of Proteocephalus Weinland, 1858 occurred only in one host species. Hypostomus ventromaculatus harbored the highest diversity of parasites, followed by Ancistrus sp. (Table 3).
Figure 1. Collection site of the Loricariidae species in Igarapé Fortaleza basin in the Amapá State (Brazil).
| Species of parasites | Species of hosts | Locality | References |
|----------------------|------------------|----------|------------|
| Sporocryptus sp.     | Hartia shumardi  | Igarapé Fortaleza River | Gonçalves et al. (2014) |
| Ichthyophthirius multifiliis | Igarapé Fortaleza River | Gonçalves et al. (2014) |
| Squidiforma emarginata | Igarapé Fortaleza River | Gonçalves et al. (2014) |
| Hypodentomus beringii | Chavantes Reservoir (SP) | Zica et al. (2012) |
| Hypodentomus regani | Chavantes Reservoir (SP) | Zica et al. (2012) |
| Unilatus unilatus     | Pedotheia broensis | Igarapé Fortaleza River | Cardoso et al. (2017) |
| Hypodentomus strigiceps | Chavantes Reservoir (SP) | Zica et al. (2012) |
| Pterygoplichthys pardalis | Igarapé Fortaleza River | Cardoso et al. (2017) |
| Unilatus itae         | Leporaamphilus galaxias | Guamá River (PA) | Branches & Domingues (2014) |
| Unilatus sp.          | Pterygoplichthys pardalis | Manaus (AM) | Porto et al. (2012) |
| Phanerometopus harrii | Hypodentomus sp. | Tocantins River (TO) | Kritsky, Vianna, & Boeger (2007) |
| Phanerometopus spinatoides | Hypodentomus plecostomus | Manaus (AM) | Kritsky & Boeger (1991) |
| Phanerometopus deipropodum | Hypodentomus punctatus | Guandu River (RJ) | Boeger, Kritsky, & Belmon-Jegu (1994) |
| Phanerometopus spinatidum | Hypodentomus regani | Rio das Almas (SP) | Kritsky et al. (2007) |
| Phanerometopus aequitobi | Hypodentomus affinis | Tocantins River (TO) | Kritsky et al. (2007) |
| Nothobranchiatus clavatus | Hypodentomus affinis | Guandu River (RJ) | Azevedo, Abdallah, & Luque (2010); Azevedo, Abdallah, & Luque (2011) |
| Nothobranchiatus amazonicus | Anictus sp. | Manaus (AM) | Kritsky & Boeger (1991) |
| Nothobranchiatus placentaticus | Anictus sp. | Manaus (AM) | Kritsky & Boeger (1991) |
| Nothobranchiatus sp. | Pedotheia broensis | Igarapé Fortaleza River (AP) | Cardoso et al. (2017) |
| Onychodentomus hyaliscus | Anictus multipinnis | Salto Morato River (PR) | Kritsky et al. (2007) |
| Onychodentomus salidus | Salto Morato River (PR) | Kritsky et al. (2007) |
| Oxydentomus farlowellae | Farlowella amazoon | Manaus (AM) | Kritsky & Boeger (1991) |
| Trinigynus mouri | Squidiforma emarginata | Igarapé Fortaleza River (AP) | Gonçalves et al. (2014) |
| Trinigynus hypotenatus | Hypodentomus affinis | Guandu River (RJ) | Azevedo et al. (2010); Azevedo et al. (2011) |
| Hyperellipsella malbombei | Hypodentomus affinis | Guandu River (RJ) | Azevedo et al. (2010); Azevedo et al. (2011) |
| Aglaspygodentomus salebrosus | Hypodentomus affinis | Guandu River (RJ) | Azevedo et al. (2010); Azevedo et al. (2011) |
| Aglaspygodentomus conei | Panorhaphis parula | Patos River (PR) | Kritsky et al. (2007) |
| Aglaspygodentomus ternatus | Panorhaphis parula | Patos River (PR) | Kritsky et al. (2007) |
| Aglaspygodentomus fishipani | Kromichthys lacera | Salto Morato River (PR) | Kritsky et al. (2007) |
| Aglaspygodentomus pechinocellatus | Himenes sp. | Dois de Fevereiro River (PR) | Kritsky et al. (2007) |
| Aglaspygodentomus calamus | Schizolepis guntheri | Várzea River (PR) | Kritsky & Boeger (2007) |
| Aglaspygodentomus fischeroides | Hypodentomus sp. | Pará River (PR) | Kohn, Bapista-Farias, & Cohen (2000) |
| Panorhaphis laquei | Rhinelepis aerea | Pará River (PR) | Kohn et al. (2000) |
| Hyperellipsella malbombei | Rhinelepis aerea | Paraquequara River (AM) | Boeger et al. (1994) |
| Demidesperum paranaiense | Loricariichthys platynematopon | Paraná River (PR) | Ferrari-Hoeninghaus, Bellay, Takemoto, & Pavanelli (2010) |
| Demidesperum spinocellus | Loricariichthys prolifica | Batalha River | Pelegrin, Jamâuri, Azevedo & Abdallah et al. (2018); Franceschini et al. (2018) |
| Demidesperum anau | Loricariichthys platynematopon | Paraná River | Franceschini et al. (2018) |
| Demidesperum prozus | Loricariichthys prolifica | Sapucaí-Mirim River | Franceschini et al. (2018) |
| Demidesperum rheolae | Rhinelepis aerea | Pará River (PR) | Acosta, Scholz, Blasco-Costa & Silva (2018) |
| Demidesperum sp. | Loricariichthys cataractae | Guandu River (RJ) | Azevedo et al. (2010); Azevedo et al. (2011) |
| Heteropteriulius sp. | Pterygoplichthys pardalis | Manaus (AM) | Porto et al. (2012) |
| Panocellaria pisicola | Hypodentomus affinis | Guandu River (RJ) | Azevedo et al. (2010); Azevedo et al. (2011) |
| Hypodentomus albopunctatus | Hypodentomus commersoni | Pará River (PR) | Moravec, Kohn, & Fernandes (1990) |
| Hypodentomus derbyi | Hypodentomus derbyi | Pará River (PR) | Moravec et al. (1990) |
| Ancistrus cirrhous | Hypodentomus derbyi | Pará River (PR) | Moravec et al. (1990) |
| Hypodentomus sp. | Pará River (PR) | Kohn et al. (2011) |
| Raphidascaris (Sprentascaris) hypostomi | Pará River (PR) | Kohn et al. (2011) |
| Loricariichthys platynematopon | Pará River (PR) | Takemoto et al. (2009); Kohn et al. (2011) |
| Loricariichthys platynematopon | Pará River (PR) | Pará River (PR) | Moravec et al. (1990); Kohn et al. (2011) |
| Paradoichadon laticeps | Pará River (PR) | Kohn et al. (2011) |
| Loricariichthys sp. | Pará River (PR) | Kohn et al. (2011) |
| Species of parasites | Species of hosts | Locality | References |
|----------------------|------------------|----------|------------|
| Rhabdochona bidleri  | Loricaria prolife | Batalla River | Pelegrini et al. (2018) |
| Rhabdochona sp.      | Loricaria prolife | Batalla River | Pelegrini et al. (2018) |
| Oxyuriasis coronatus | Laisiancistrus sancti | Guamá River (PA) | Rodrigues, Santos, Furtado, & Melo (2017) |
| Oxyuriasis hexapinatus| Laisiancistrus sancti | Guamá River (PA) | Rodrigues et al. (2017) |
| Caudianus (Cacaulanus) pinmai | Loricaria sp. | Parana River (PR) | Kohn et al. (2011) |
| Ichthyolaimus brevicaudatus | Loricaria prolife | Batalla River | Pelegrini et al. (2018) |
| Procannallus (Procannallus) annipeterae | Hypostomus sp. | Parana River (PR) | Kohn et al. (2011) |
| Guandu River (RJ) | Azevedo et al. (2010); Azevedo et al. (2011) | | |
| Genarchella tropica | Oligobdella | Parana River (PR) | Kohn et al. (2011) |
| Manaus (AM) Porto et al. (2012) | | | |
| Solimões River (AM) Vital et al. (2016) | | | |
| Parapanema River (SP) | | | |
| Solimões River (AM) Vital, Moreira, Pereira, & Pavanelli (2008) | | | |
| Janauacá Lake (AM) Thatcher (1979) | | | |
| Paraná River (PR) Kohn et al. (2011) | | | |
| Batalha River Pelegrini et al. (2018) | | | |
| Batalha River Pelegrini et al. (2018) | | | |
| Manaus (AM) Porto et al. (2012) | | | |
| Manaus (AM) Porto et al. (2012) | | | |
| Igarapé Fortaleza River | | | |
| Acta Scientiarum. Biological Sciences, v. 40, e40621, 2018
### Table 3. Parasitic indices four Loricariidae species from the Igarapé Fortaleza River, Amapá State, Brazil.

| Species of parasites | *Unilatus unilatus* and *Trinigyrus mourei* | *Unilatus unilatus* | Undetermined metacercariae | *Genarchella gernachella* | *Raphidascaris* (Sprentascaris sp.) | *Gorythocephalus elongorchis* | *Proteocephalus* sp. |
|---------------------|---------------------------------------------|---------------------|---------------------------|---------------------------|---------------------------------|----------------------------|---------------------|
| P (%)               | 75.0                                        | 0                   | 0                         | 25.0                      | 25.0                            | 0                          | 0                   |
| MI                  | 43.0                                        | 0                   | 0                         | 34.0                      | 24.0                            | 0                          | 0                   |
| MA ± SD             | 32.3 ± 37.4                                 | 0                   | 0                         | 8.5 ± 17.0                | 6.0 ± 12.0                      | 0                          | 0                   |
| Range               | 13.0-85.0                                   | 0                   | 0                         | 34                        | 24                              | 0                          | 0                   |
| Ancistrus leucostictus | 129                                        | 0                   | 0                         | 22                        | 1                               | 0                          | 0                   |
| SI Gills            | 64.3                                        | 0                   | 0                         | 15.0                      | 5.0                             | 0                          | 0                   |
| MI Gills            | 141.4                                       | 0                   | 0                         | 7.5                       | 1                               | 0                          | 0                   |
| MA ± SD Gills       | 90.9 ± 201.4                                | 0                   | 0                         | 1.1 ± 3.9                 | 0.1 ± 0.2                       | 0                          | 0                   |
| Range Gills         | 1.0-748.0                                   | 0                   | 0                         | -                         | -                               | 0                          | 0                   |
| TNP 1273            | 0                                            | 0                   | 0                         | 22                        | 1                               | 0                          | 0                   |

| Species of parasites | *Ancistrus* sp. | *Hemiancistrus* sp. | *Hypostomus ventromaculatus* | *Hemiancistrus* sp. |
|---------------------|----------------|---------------------|-------------------------------|---------------------|
| P (%)               | 64.3           | 28.6                | 31.2                          | 25.0                |
| SI Gills            | 0              | 100                 | 100                           | 100                 |
| MI Gills            | 0              | 0.2                 | 0.2                           | 0.2                 |
| MA ± SD Gills       | 0              | 2.0 ± 0.0           | 2.0                           | 2.0                 |
| Range Gills         | 0              | -                   | -                             | -                   |
| TNP 1273            | 0              | 4                   | 2                             | 2                   |
| SI Gills            | 28.6           | 119.5               | 34.1 ± 89.9                   | 34.1 ± 89.9         |
| MI                  | 0              | 0                   | 0                             | 0                   |
| MA ± SD             | 34.1 ± 89.9    | 0                   | 0                             | 0                   |
| Range               | 1.0-238.0      | 0                   | 0                             | 0                   |
| TNP 1273            | 239            | 0                   | 0                             | 0                   |

P: Prevalence, MI: Mean intensity, MA: Mean abundance, SD: Standart deviation, TNP: Total number of parasites, SI: Site of infection.

### Discussion

Some patterns of composition and structure of the parasite community in Loricariidae from Brazil were detected: (a) presence of ectoparasites (Protozoa, Monogenea, Crustacea and Hirudinea) and endoparasites (Nematoda, Digenea, Acantocephala and Cestoda); (b) dominance of *Austrodiplostomum compactum* Lutz, 1928; (c) infracommunities of ectoparasites richer and more diverse than endoparasites; (d) the presence of endoparasites at the larval stage with high prevalence and low abundance; (e) overdispersion of parasites and (f) interspecific associations of parasite infracommunities (Table 1). There are few studies on parasites in Loricariidae species in the Igarapé Fortaleza basin (Gonçalves et al., 2014; Cardoso et al., 2017). However, this was the first study for *A. leucostictus*, *H. ventromaculatus*, *Ancistrus* sp. and *Hemiancistrus* sp.

In wild fish populations, the parasitic fauna depend on internal and external factors such as: seasonal variations, habitat, limnological characteristics, water body depth, local biota, biological and physiological characteristics of the hosts, trophic level of host population and geography of region (Dogiel, 1961; Lagrué et al., 2011; Cardoso et al., 2017; Baia et al., 2018). The parasites, including monogeneans, can then be positively or negatively influenced by environmental stressors, mainly by anthropic actions that favor the eutrophication of water bodies, altering the parasites abundance in polluted environments (Takemoto et al., 2009).

Monogenea has life cycle in a single host and, in general, of a same family of fish, such as Loricariidae, which are commonly parasitized by species of *Demidospermus*, *Paranella*, *Trinigyrus* and *Unilatus* (Boeger & Vianna, 2006; Braga, Aráujo, & Boeger, 2014). In general, monogeneans are found in low prevalence and abundance in wild fish...
populations, when the environmental characteristics do not facilitate the reproduction of these ectoparasites (Tavares-Dias, Rigó, Pinheiro, Oliveira, & Marinho, 2013). *Unilatus unilatus* and *T. mourei* have been reported infecting diverse Loricariidae species from Brazil (Table 1), and now also *A. leucostictus*, *Ancistrus* sp., *H. ventromaculatus* and *Hemiancistrus* sp., which are new hosts for such monogeneans.

Digeneans are parasites of different host species and have mollusks as primary intermediate hosts, and fish can be intermediate, paratenic or definitive hosts (Ferrari-Hoeinghaus et al., 2007; Cardoso et al., 2017). *Genarchella gernachella* does not have host specificity, since it infects several Characiformes and Siluriformes fish from Brazil, which can be definitive hosts for this digenean specie (Cardoso et al., 2017). Undetermined metacercariae and *G. gernachella* were found in *A. leucostictus*, *Ancistrus* sp. and *H. ventromaculatus*, but the greatest prevalence occurred in intestine of *H. ventromaculatus*. This was the first report of *G. gernachella* for *Ancistrus* sp., *A. leucostictus* and *H. ventromaculatus*.

Species of *Raphidascaris* (*Sprentascaris*) are nematodes with little known life cycle, but require fish and aquatic crustaceans as intermediate hosts; in addition amphibians, aquatic insects, zooplankton, etc. which are less likely to be intermediate or paratenic hosts (Moravec, 1998). For *A. leucostictus*, *Ancistrus* sp. and *Hemiancistrus* sp., there were varied infection levels of *Raphidascaris* (*Sprentascaris*) sp. *Raphidascaris* (S.) *hipostomi* Peter and Cassone, 1984 and *Raphidascaris* (S.) *mahmerti* Peter and Cassone, 1984 (Table 1) are known infecting Loricariidae species, but this was the first record of *Raphidascaris* (*Sprentascaris*) sp. for *A. leucostictus*, *Ancistrus* sp. and *Hemiancistrus* sp.

Acanthocephalans are endoparasites of fish, birds and mammal (Cardoso et al., 2017). *Goryteles elongorchi* Thatcher (1979), a parasite of Loricariidae species (Table 1), was found only in *H. ventromaculatus*, which are new hosts for this acanthocephalan. Species of *Proteocephalus* are common cestodes of Siluriformes, which consume planktonic crustaceans (Copepoda and Cyclopoida) that serve as intermediate hosts. Thus, some species of Siluriformes can be definitive hosts, with direct infection after consuming microcrustaceans (Scholz, 1999; Cardoso et al., 2017). Plerocercoids of *Proteocephalus* sp. were found only in *H. ventromaculatus*, which can be secondary intermediate host for this endoparasite. In addition, *H. ventromaculatus* is a new host for *Proteocephalus* sp.

### Conclusion

Ectoparasites were predominant in the examined Loricariidae species, which also had species of endoparasites at the larval stage. The hosts with the highest number of collected samples (*H. ventromaculatus* and *Ancistrus* sp.) had a higher richness of parasite species. The species of Loricariidae from Brazil present ecto- and endoparasites, but the predominance is of ectoparasites. Species of monogeneans, digeneans and nematodes are the most diversified parasites in Brazilian Loricariidae.

### Acknowledgements

Dr. M. Tavares-Dias receives a Research Fellowship (# 303013/2015-0) from the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq, Brazil).

### References

Acosta, A. A., Scholz, T., Blasco-Costa, I., Alves, P. V., & Silva, R. J. (2018). A new genus and two new species of dactylogyrid monogeneans from gills of Neotropical catfishes (Siluriformes: Doradidae and Loricariidae). *Parasitology International*, 67(1), 4-12. doi: 10.1016/j.parint.2017.09.012

Alonso, F., Terán, G. E, Aguilera, G., & Mirande, J. M. (2016). First record of *Hypostomus boulengeri* (Siluriformes: Loricariidae) from Bermejo River basin. *Revista del Museo Argentino Ciencias Naturales*, 18(1), 85-88.

Azevedo, R. K., Abdallah, V. D., & Luque, J. L. (2010). Acanthocephala, Annelida, Arthropoda, Myxozoa, Nematoda and Platyhelminthes parasites of fishes from the Guandu River, Rio de Janeiro, Brazil. *Check List*, 6(4), 659-667. doi: 10.15560/6.4.659

Azevedo, R. K., Abdallah, V. D., & Luque, J. L. (2011). Biodiversity of fish parasites from Guandu River, southeastern Brazil: an ecological approach. *Neotropical Helminthology*, 5(2), 185-199.

Baia, R. R. J., Florentino, A. C., Silva, L. M. A., & Tavares-Dias, M. (2018). Patterns of the parasite communities in a fish assemblage of a river in the Brazilian Amazon region. *Acta Parasitologica*, 63(2), 304-316. doi: 10.1515/ap-2018-0035

Boeger, W. A, & Viana, R. T. (2006). Monogenoidea. In V. E. Thatcher (ed.), *Amazon fish parasites* (p. 42-116). Sofía, BUL: Pensoft Publishers.

Baier, W. A., & Viana, R. T. (2006). Monogenoidea. In: *Thatcher V. E. (ed.). Amazon fish parasites* (p. 42-116). Sofía, BUL: Pensoft Publishers.

Boeger, W. A., Kritsky D. C., & Belmont-Jégu, E. (1994). Monogenoidea. In: *Helminthology of Brazilian Loricariidae*. 34-44.

Biodiversity of fish parasites from Guandu River, southeastern Brazil: an ecological approach. *Neotropical Helminthology*, 5(2), 185-199.
Brances, B., & Domingues, M. V. (2014). A new species of Unilatus (Platyhelminthes: Monogeneoida) from the gills of Leponoanthias galaxis Isbrücker et Nijsen (Siluriformes: Loricariidae) from Brazil. *Acta Parasiologia*, 59(1), 91-97. doi: 10.2478/s11686-014-0213-7.

Braga, M. P., Araújo, S. B. L., & Boeger, W. A. (2014). Patterns of interaction between Neotropical freshwater fishes and their gill Monogeneoida (Platyhelminthes). *Acta Parasiologia*, 113(2), 481-490. doi: 10.1007/s00436-013-3677-8.

Bush, A. O., LaFerty, K. D., Lotz, J. M., & Shostak, W. (1997). Parasitology meets ecology on its own terms: Margolis et al. Revisited. *Journal of Parasitology*, 83(4), 575-583. doi: 10.2307/3284227.

Cardoso, A. C. F., Oliveira, M. S. B., Neves, L. R., & Tavares-Dias, M. (2017). Metazoan fauna parasitizing *Plektothilus braueri* and *Pterygodrilliis paralis* (Loricariidae) catfishes from the northeastern Brazilian Amazon. *Acta Amazonica*, 47(2), 147-154. doi: 10.1590/1809-43922016013232.

Dias, M. L. G. G., Mine-Ver, C. V. Eiras, J. C., Machado, M. H., Souza G. T. R., Pavanelli, G. C. (2006). Ecology of *Clinostomum complanatum* Rudolphi, 1814 (Trematoda: Clinostomidae) infecting fish from the floodplain of the high Paraná River, Brazil. *Parasitology Research*, 99, 675-681. doi: 10.1007/s00436-006-0205-0.

Dogiel, V. A. (1961). Ecology of the parasites of freshwater fishes. In V. A. Dogiel, G. K. Petrushevsky, and Y. I. Poliansky (Eds.), *Parasitology of fishes* (p. 1-47). Leningrad, RUS: University Press. Russian Soviet Federative Socialist Republic.

Eiras, J. C., Dias, M. L. G. G., Pavanelli G. C., & Machado M. H. (1999). Histological studies on the effects of *Clinostomum marginatum* (Digenea, Clinostomidae) in its second intermediate host *Loricariichthys platymetopon* (Osteichthyes, Loricariidae) of the upper Paraná River, Brazil. *Acta Scientiaria, Biological Sciences*, 21(2), 237-241. doi: 10.4025/actascibiolsci.v21i2.4416.

Eiras, J. C., Takemoto, R. M., & Pavanelli, G.C. (2006). *Métodos de estudos e técnicas laboratoriais em parasitologia de peixes*. Maringá, PR: Eduem.

Ferrari-Hoeinghaus, A. P., Takemoto, R. M., & Pavanelli, G. C. (2007). Digenean trematode parasites of *Loricariichthys platymetopon* (Loricariidae, Siluriformes) of the upper Paraná River floodplain, Brazil. *Acta Scientiaria, Biological Sciences*, 29(3), 327-329. doi: 10.4025/actascibiolsci.v29i3.508.

Ferrari-Hoeinghaus, A. P., Bellay, S., Takemoto, R. M., & Pavanelli, G. C. (2010). A new species of *Demidospermus* Suriano, 1983 (Monogenea, Dactylogyridae) parasitic on *Loricariichthys platymetopon* Isbrücker et Nijsen (Loricariidae, Siluriformes) from the upper Paraná River floodplain, Brazil. *Acta Parasiologia*, 55(1), 16-19. doi:10.2478/s11686-010-0007-5.

Franceschini, L., Zago, A. C., Müller, M. I., Francisco, C. J., Takemoto, R. M., & Silva, R. J. (2018). Morphology and molecular characterization of *Demidospermus spirophallus* n. sp., *D. prolulus* n. sp. (Monogenea: Dactylogyridae) and a redescription of *D. anus* in siluriform catfish from Brazil. *Journal of Helminthology*, 92(2), 228-243. doi:10.1017/S0002149X17000256.

Gonçalves, R. A., Oliveira, M. S. B., Santos, E. F., & Tavares-Dias, M. (2014). Aspectos ecológicos da comunidade de parasitos em duas espécies de Loricariidae da bacia Igarapé Fortaleza, estado do Amapá, Brasil. *Biotota Amazonica*, 4(1), 15-21. doi: 10.18561/2179-5746/biototaamazonica.v4i1p15-21.

Kohn, A., Baptista-Farias, M. F. D., & Cohen S. C. (2000). *Paranaella luquet* gen. et sp. n. (Monogenea: Microcotylidae), a new parasite of Brazilian catfishes. *Folia Parasiologia*, 47(4), 279-283. doi: 10.1411/fp.2000.048.

Kohn, A., Moravec, F., Cohen, S. C., Canzi, C., Takemoto, R. M., & Fernandes, B. M. M. (2011). Helminths of freshwater fishes in the reservoir of the Hydroelectric Power Station of Itaipu, Paraná, Brazil. *Check List*, 7(5), 681-690. doi: 10.15560/7.5.681.

Kritsky, D. C., & Boeger, W. A. (1991). Neotropical Monogenea. 16. New species of oviparous Gyrodactylidea with proposal of *Nothogyrodactylus* gen. n. (Oogryodactylidae). *Journal of the Helminthological Society of Washington*, 58(1), 7-15.

Kritsky, D. C., Vianna, R. T., & Boeger, W. A. (2007). Neotropical Monogeneoida. 50. Oviparous gyrodactylids from loricariid and pimelodid catfishes in Brazil, with the proposal of *Phanerotheicotides* n. g., *Onychogyrodactylus* n. g. and *Aglathyrodactylus* n. g. (Polyonchoinea: Gyrodactylidea). *Systematic Parasitology*, 66(1), 1-34. doi: 10.1007/s11230-006-9053-7.

Lagre, C., Kelly, D. W., Hicks, A., & Poulin, R. (2011). Factors influencing infection patterns of trophically transmitted parasites among a fish community: host diet, host-parasite compatibility or both? *Journal of Fish Biology*, 79(2), 466-485. doi: 10.1111/j.1095-8649.2011.03041.x.

Luque, J. L., & Poulin R. (2007). Metazoan parasite species richness in Neotropical fishes: hotspots and the geography of biodiversity. *Parasitology*, 134(6), 865-878. doi:10.1017/S0031182007002272.

Moravec, F., Kohn, A., Fernandes, B. M. M. (1990). First record of *Raphidascaris* (Sprentascaridae) *hypostomi* (Petter et Cassone, 1984) comb. n. and *S. mahneri* (Petter et Cassone, 1984) comb. n. (Nematoda: Anisakidae) from Brazil with remarks on the taxonomic status of the genus *Sprentascaris* Petter et Cassone, 1984. *Folia Parasitologica*, 37(2), 131-140.

Moravec, F. (1998). *Nematodes of freshwater fish of the Neotropical region*. Praha, CZ: Academia of Sciences of the Czech Republic.

Nelson, J. S, Grande, T. C., & Wilson, M. V. H. (2016). *Fishes of the world* (5th) New Jersey, EUA: John Wiley & Sons, Inc., Hoboken.

Oda, F. H., Graça, R. J., Tencatt, L. F. C., Tavares, L. E. R., Froehlich O., & Takemoto R. M. (2015). The...
poorly known Rígia acuticaudata (Crustacea: Isopoda) parasitizing Ancistrus sp. (Siluriformes: Loricariidae) from the Paraguay River basin, Brazil, with comments on its reproductive biology. Comparative Parasitology, 82(1), 25-28. doi: 10.1654/4738.1

Paraguassú, A. R., & Luque J. L. (2007). Metazoários parasitos de seis espécies de peixes do reservatório de Lajes, Estado do Rio de Janeiro, Brasil. Revista Brasileira de Parasitologia Veterinária, 16(3), 121-128. doi: 10.1590/S1984-29612007000300002.

Pelegriti, L. S., Januário, F. F., Azevedo, R. K., & Abdallah, V. D. (2018). Biodiversity and ecology of the parasitic infracommunities of Loricaria prolifica (Siluriformes: Loricariidae) from the Tietê-Balatla Basin, SP, Brazil. Acta Scientiarum. Biological Sciences, 40(1), e36294. doi: 10.4025/actascibiolsci.v40i1.36294.

Porto, D. B., Vital, J. F., Santos, A. K. S., Morais, A. M., Varella, A. M. B., Malta, J. C. O. (2012). Metazoários parasitos de Pterygophylchys pardalis (Castelnau, 1855) (Siluriformes: Loricariidae) da Amazônia central, Brasil. Revista Brasileira de Zoológicas, 14 (1-3): 35-40.

Rodrigues, A. R. O., Santos, J. N., Furtado, A. P., & Melo, F. T. V. (2017). Osyrias cassis corurus n. gen. n. sp. and O. hexapinatus n. sp. (Okyridida: Pharyngodonidae): parasites of Lasiancistrus saetiger (Siluriformes: Loricariidae) in freshwater rivers of the Brazilian Amazon. Journal of Parasitology, 103(4), 390-398. doi: 10.1645/16-138.

Scholz, T. (1999). Life cycles of species of Proteocephalus, parasites of fishes in the Palearctic region: a review. Journal of Helminthology, 73(1), 1-19. doi: 10.1017/S0022149X99000013.

Soares, M. G. M., Costa E. L., Siqueira-Souza, F. K., Anjos, H. D. B., Yamamoto K. C., & Freitas, C. E. C. (2011). Peixes de lagos do médio Rio Solimões (2 ed.). Manaus, AM: Instituto Patam.

Takemoto, R. M., Pavanelli, G. C., Lacerda, A. C. F., Yamada, F. H., Moreira, L. H. A., ... Bellay, S. (2009). Diversity of parasites of fish from the upper Paraná River floodplain, Brazil. Brazilian Journal of Biology, 69(2), 691-705. doi: 10.1590/S1519-69842009000300023.

Tavares-Dias, M., Rigôr, L. N., Pinheiro, D. A., Oliveira, M. S. B., & Marinho, R. G. B. (2013). Parasites in Curimata cyprinoides (Characiformes: Curimatidae) from eastern Amazon, Brazil. Acta Scientiarum. Biological Sciences, 35(4), 595-601. doi: 10.4025/actascibiolsci.v35i4.19649.

Tavares-Dias, M., Oliveira, M. S. B., Gonçalves, R., Silva, L. M. A. (2014). Ecology and seasonal variation of parasites in wild Aequidens tetramerus, a Cichlidae from the Amazon. Acta Parasitologica, 59(1), 158-164. doi: 10.2478/a11686-014-0225-3.

Thatcher, V. E. (1979). Uma nova espécie de Gortyacephalus Nickel e Thatcher, 1971 (Acanthocephala: Neochinorhynchidae) do acari bodó (Pisces: Loricariidae) da Amazônia, Brasil Acta Amazonica, 9(1), 199-202. doi: 10.1590/1809-4392197901199.

Thatcher, V. E., & Varella, A. B. (1981). Duas novas espécies de Megadocidum Szidat, 1954 (Trematoda: Heploporidae), parasitas estomacais de peixes da Amazônia Brasileira, com uma definição do gênero. Acta Amazonica, 11(2), 285-289. doi: 10.1590/1809-43921981112285.

Thomaz, D. O., Costa-Neto, S. V., Tostes L. C. L. (2004). Inventário florístico das ressacas das bacias do Igarapé do Lago. In Takiyama, L. R., & Silva, A. Q. Diagnostico de ressacas do estado do Amapá: bacias do Igarapé da Fortaleza e do Rio Curiauí (p. 13-32). Macapá, AP: IEPA.

Vital, J. F., Morey, G. A. M., Pereira, N. B., & Malta, J. C. O. (2016). Metacercárias de Austrodiplostomum compactum (Lutz, 1928) em peixes de lagos de várzea da Amazônia brasileira. Folia Amazônica, 25(2), 153-158. doi: 10.24841/fui252.399.

Yamada, F. H., Moreira, L. H. A., Ceschini, T. L., Takemoto, R. M., Pavanelli, G. C. (2008). Novas ocorrências de metacercária de Austrodiplostomum compactum (Lutz, 1928) (Platyhelminthes: Digenea) para o estado do Rio Pararã. Revista Brasileira de Parasitologia Veterinária, 17(3), 163-166. doi:10.1590/S1984-29612008000300010.

Zica, E. O. P., Santos, K. R., Ramos, I. P., Zanatta, A. S., Carvalho, E. D., & Silva, R. J. (2009). First case of an infection of the metacercariae of Austrodiplostomum compactum (Lutz, 1928) (Digenea, Diplostomidae) in Hypostomus regani (Ihering, 1905) (Siluriformes: Loricariidae). Pan-American Journal of Aquatic Sciences, 4(1), 35-38.

Zica, E. O. P., Brandão, H., Zawadzki, C. H., Nobile, A. B., Carvalho E. D., & Silva, R. J. (2011). The occurrence of Austrodiplostomum compactum (Lutz, 1928) (Digenea: Diplostomidae) metacercariae in the eyes of loricariid fish (Siluriformes: Osteichthyes: Loricariidae). Brazilian Journal of Biology, 81(1), 73-79. doi:10.1590/S1519-698420090000300023.

Zica, E. O. P., Abdallah, V. D., Azevedo R. K., Wunderlich A. C., Carvalho E. D., & Silva R. J. (2009). First case of an infection of the metacercariae of Austrodiplostomum compactum (Lutz, 1928) (Digenea, Diplostomidae) in Hypostomus regani (Ihering, 1905) (Siluriformes: Loricariidae). Pan-American Journal of Aquatic Sciences, 4(1), 35-38.

Received on November 28, 2017.
Accepted on May 7, 2018.

License information: This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Acta Scientiarum. Biological Sciences, v. 40, e40621, 2018.