Diversity of ectoparasites and endoparasites infecting *Brachyplatystoma vaillantii* (Siluriformes: Pimelodidae), a large migratory catfish from the Amazon

Ivanildo Amanajás BRITO-JUNIOR¹, Marcos TAVARES-DIAS²*

¹Faculdade de Macapá (FAMA), Macapá, AP, Brazil
²Embrapa Amapá, Macapá, AP, Brazil

* Corresponding author: marcos.tavares@embrapa.br; https://orcid.org/0000-0002-8376-1846

ABSTRACT

*Brachyplatystoma vaillantii* is a large migratory catfish widely distributed in the Amazon basin, but its parasitic fauna is still poorly known. As it is an important fishery resource in the region of the Amazonas River estuary, the aim of this study was to investigate the parasite community in *B. vaillantii* from a tributary of the Amazonas River estuary system, in Brazil. We examined 31 juvenile fish, of which 80.6% were parasitized, and a total of 586 parasites were collected. We identified *Dermidospermus brachyplastystimae* and *Dermidospermus araguiensis* (Monogenea), *Genarchella genarchella* (Digenea), *Harriscolex piramutab* (Cestoda), *Pseudoterranova* sp. (Nematoda), *Ergasilus xinguensis* (Crustacea) and mites (Acarina). The dominance was of *Pseudoterranova* sp. larvae. The parasite community of *B. vaillantii* was composed of low values of species richness (2.0 ± 1.4), evenness (0.18 ± 0.21) and diversity (0.32 ± 0.37), with predominance of ectoparasite species with low prevalence, low abundance and overdispersion. Host body weight was the main correlate of parasite diversity and abundance, and a diet rich in crustaceans and other invertebrates may be important in structuring the parasite community of *B. vaillantii*. This is the first report of *Dermidospermus brachyplastystimae* and *D. araguiensis*, *Pseudoterranova* sp. and *G. genarchella* for *B. vaillantii*.

KEYWORDS: fish, parasites, Laulao catfish, helminths, crustaceans, mites

INTRODUCTION

*Brachyplatystoma vaillantii* Valenciennes, 1840 (Siluriformes), is a Pimelodidae fish native to northern South America, known as piramutaba or laulao catfish, which is an important fishing resource in the region of the Amazonian estuary. It is one of the large migratory catfishes with wide distribution in the Amazonas and Orinoco river basins, as well as river basins from the Guianas (Soares et al. 2011; Froese and Pauly 2019). This benthic species inhabits the channel of the Amazon River and its major tributaries. The young consume crustaceans (mainly prawns) and insects, and the adults are piscivorous.
and can reach up to 1.5 m in total length and weigh 10 kg. It performs annual migrations between its feeding grounds in the Amazonas basin and its reproduction grounds near the Brazil-Peru-Colombia border region. Females reach sexual maturity with 42 cm of length and, after spawning, larvae and juveniles drift until reaching the Amazonas estuary, which is the main growth environment for this fish. *Brachyplatystoma vaillantii* is heavily exploited by the artisanal and industrial fishery at the mouth of the Amazonas River (Soares et al. 2011; Barthem et al. 2015; Jimenez et al. 2017; Froese and Pauly 2019).

Despite the wide distribution of *B. vaillantii* in the Amazonas basin, there are only a few studies on its parasites, mostly on taxonomy. Studies on community aspects of its parasite fauna, however, are lacking, despite their interest related to the complexity of the life history and distribution of this fish. Studies on the diversity of fish parasites are important due to the role of parasites as indicators of environmental quality and ecosystem health, which are useful tools in the conservation and maintenance of local biodiversity (Cardoso et al. 2017; Oliveira et al. 2017; Leite et al. 2018). Parasites can change the composition and structure of the host community due to alterations in the environment that influence the functioning and stability of the ecosystems (Vasconcelos and Tavares-Dias 2016; Santos and Tavares-Dias 2017; Cardoso et al. 2017). Changes caused by parasites can lead to negative impacts on fishery production due to losses in quality and quantity of fish, reduction in body weight and injuries, which can result in the disposal of part of the catch (Cardoso et al. 2017) and reduce the potential economic benefits that fisheries may generate.

Reported parasites for *B. vaillantii* from the Brazilian Amazon are the cestodes *Pterobothrium crassicole* Diesing, 1850; *Goezeella siluri* Fuhrmann, 1916; *Amazotaenia yrettiae* Chambrier, 2001; *Amphoteromorphus ninoi* Carfora, Chambrier & Vaucher, 2003; *Harriscolex piramutab* (Woodland, 1933) Chambrier, Kuchta & Scholz, 2015; *Nomimosolex suspectus* Zehnder, Chambrier, Vaucher & Mariaux, 2000, and the coccidian *Calyptopsora* sp. (Rego 1984; Silva et al. 2012; Alves et al. 2017a,b). In the Peruvian Amazon, *B. vaillantii* was found to be infected with the cestodes *Chambriella sp.* and *H. piramutab*, and monogeneans of the genus *Demidiopterum* (Mendoza-Palmero et al. 2015; Chambrier et al. 2015). In Venezuela, the infection of *B. vaillantii* by *G. siluri* and *Harriscolex kapatari* (Woodland, 1935) Rego, 1987 (Alves et al. 2017a,b) was reported. To date, there has been no study reporting quantitative and qualitative descriptors of the parasite community in a wild *B. vaillantii* population. Therefore, the aim of this study was to describe the communities of ecto and endoparasites of *B. vaillantii* from a tributary of the Amazonas River estuary system, in the northern Brazilian, state of Amapá Region.

### MATERIAL AND METHODS

#### Study area and fish collection

Between November and December 2017, 31 specimens of *B. vaillantii* juveniles (152.5 ± 76.7 g and 21.5 ± 3.7 cm total length) were collected in the Igarapé Fortaleza River basin, in the municipality of Macapá, Amapá state, northern Brazil (Figure 1) for parasitological analyses. The fish were captured using gill nets with mesh sizes from 30 to 70 mm. This study was approved by the ethics committee in the use of animal of Embrapa Amapá (Protocol No 004/2016 CEUA/Embrapa Amapá) and authorized by SISBIO license # 23276-1 issued by Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA).

The Igarapé Fortaleza hydrographic basin (Figure 1) has an area of 195 km² which drains from the north into the estuary system of the Amazon River (Takiyama et al. 2004, Silva et al. 2009). It is a river system with extensive floodplains and is influenced by high rainfall and the daily tides of the Amazon River. During the rainy season, the waters are rich in nutrients due to the fast decomposition of plant and animal remains and the layer of forest humus from the inundated floodplain forests, leading to the increase of vegetation and invertebrate biomass (insects, crustaceans and mollusks), which are used as food by fish (Takiyama et al. 2004). The margins of the floodplain are vegetated by species of diverse vegetation species, along with macrophytes of Cabombaceae, Lentibulariaceae, Salviniaceae and Cyperaceae (Thomas et al. 2004). The area of the basin is under pressure from urban land occupation and buffalo ranching, associated with deforestation, burning of vegetation and solid waste dumping. The pH of the water varies from 5.5 to 7.5 and the oxygen levels from 2.5 to 6.0 mg/L, depending on the area of the basin and the season (Takiyama et al. 2004).

#### Collection and analysis of parasites

The collected fish were weighed (g) and measured in total length (cm) and necropsied for parasitological analysis. We examined the mouth, opercula, gills, viscera and gastrointestinal tract of each fish. Gills were removed for collection of ectoparasites, and the gastrointestinal tract and viscera were removed and examined for endoparasites under a stereomicroscope (Zeiss). The collection, fixation, preservation, counting and staining of the parasites for identification followed Eiras et al. (2006). The identification of parasites was according to Moravec (1998) and Thatcher (2006). Voucher specimens were deposited at Instituto de Pesquisas Científicas e Tecnológicas do Estado do Amapá (IEPA), Macapá, Amapá, Brazil, in the Scientific Collection Curation Office for the Fauna of Amapá, under accession number IEPA 160-165P.

We calculated the ecological indices (prevalence, mean intensity and mean abundance) host) following Bush et al. (1997). We used the Diversity software (Pisces Conservation...
to calculate the following descriptors for the parasite component community: species richness of parasites, the Brillouin diversity index ($H_B$), evenness ($E$) in association with the diversity index, and the dominance frequency (percentage of the infracommunities in which a parasite species is numerically dominant) (Rohde et al. 1995; Magurran 2004). In order to detect the distribution pattern of the parasite infracommunities (Rózsa et al. 2000), the index of dispersion (ID) and the Poulin discrepancy index (D) were calculated for species with prevalence >10 % using the Quantitative Parasitology 3.0 software. The ID significance for each infracommunity was tested using the $d$-statistics (Ludwig and Reynolds 1988). The correlation of parasite abundance with the length and weight of hosts, as well as with species richness and the Brillouin diversity index was analyzed using the Spearman correlation coefficient (Zar 2010).

**RESULTS**

Overall, 80.6% of the 31 fish were parasitized. Parasites belonged to two species of Monogenea, one Digenea, one Nematoda, one Cestoda, one Crustacea and one unidentified species of Acarina (Table 1). A total of 586 individual parasites were collected, of which 71.4% were ectoparasites, and 28.6% endoparasites, thus the component community was dominated by ectoparasites, that were characterized by low prevalence, low abundance and overdispersion (Tables 1; Table 2). The monogeneans were identified to genus level (*Dermidospermus*) by standard stereomicroscopic examination,
and a partial microscopic examination of the sample revealed the presence of *Dermidospermus brachyplastystimae* Cepeda & Luque, 2016 and *Dermidospermus araguiensis* Cepeda & Luque. As not all individuals were identified to species level, we used the pooled sample of *Dermidospermus* sp. for analysis and parameter calculation. The dominant species was *Pseudoterranova* sp. (Nematoda) and all individuals were larvae (Table 1). The parasites presented an aggregate dispersion, except for *Ergasilus xinguensis* Taborda, Paschoal & Luque, 2016 (Crustacea), which showed random dispersion (Table 2). There was a predominance of hosts with one and three species of parasites (Figure 2).

The species richness of parasites per host was 2.0 ± 1.4 (0-5), the Brillouin diversity index was 0.32 ± 0.37 (0 - 1.21) and the evenness was 0.18 ± 0.21 (0 - 0.68). The Brillouin index showed no correlation with the length of hosts (*r* = 0.31, *p* = 0.09, *n* = 31), while species richness of parasites showed a weak positive correlation with host length (*r* = 0.38, *p* = 0.03, *n* = 31). Host weight was positively correlated with the Brillouin diversity (*r* = 0.43, *p* = 0.01, *n* = 31) and the species richness of parasites (*r* = 0.50, *p* = 0.004, *n* = 31).

The abundance of *Dermidospermus* spp. was positively correlated with the length of hosts (*r* = 0.43, *p* = 0.02, *n* = 31). There was no correlation between the length of hosts and the abundance of the crustacean *E. xinguensis* (*r* = 0.27, *p* = 0.14, *n* = 31), the digenean *Genarchella genarchella* Travassos, Artigas & Pereira, 1928 (*r* = 0.20, *p* = 0.27, *n* = 31) and the nematode *Pseudoterranova* sp. (*r* = -0.18, *p* = 0.32, *n* = 31). The abundance of *Dermidospermus* spp. also presented a positive correlation (*r* = 0.59, *p* = 0.0005, *n* = 31) with the weight of hosts, while the abundance of *E. xinguensis* was weakly positively correlated with host weight (*r* = 0.36, *p* = 0.04, *n* = 31). The abundance of *G. genarchella* (*r* = 0.18, *p* = 0.31, *n* = 31) and of *Pseudoterranova* sp. (*r* = -0.19, *p* = 0.31, *n* = 31) presented no correlation with the length of hosts.

![Figure 2](image_url)

**Figure 2.** Species richness of parasites found in 31 individuals of *Brachyplatystoma vaillanti* (Pimelodidae) in the Igarapé Fortaleza river basin, a tributary of the Amazonas River estuary system, in Brazil.

### Table 1
Parasites of *Brachyplatystoma vaillanti* (*n* = 31) from the Igarapé Fortaleza basin, on the northern margin of the Amazonas River estuary system, in Brazil. *P* = prevalence; *MI* = mean intensity; *MA* = mean abundance; *FD* = frequency of dominance; *TNP* = total number of parasites. Values for *MA* are the mean followed by the standard deviation.

| Parasites                      | P (%) | MI  | MA  | Range | TNP | FD (%) | Infection site |
|-------------------------------|-------|-----|-----|-------|-----|--------|----------------|
| Monogenea                     |       |     |     |       |     |        |                |
| *Dermidospermus* spp.*        | 48.4  | 4.8 | 2.3 ± 3.4 | 1-11 | 72  | 12.0   | Gills          |
| Digenea                       |       |     |     |       |     |        |                |
| *Genarchella genarchella* (metacercariae) | 16.1  | 3.2 | 0.5 ± 1.6 | 1-8  | 16  | 3.0    | Gills          |
| Nematoda                      |       |     |     |       |     |        |                |
| *Pseudoterranova* sp. (larvae) | 54.8  | 27.2| 14.9 ± 24.0 | 1-78 | 462 | 79.0   | Intestine      |
| Cestoda                       |       |     |     |       |     |        |                |
| *Harriscolex piramutab* (larvae) | 9.7   | 2.3 | 0.2 ± 0.9 | 1-78 | 7   | 1.0    | Intestine      |
| Crustacea                     |       |     |     |       |     |        |                |
| *Ergasilus xinguensis*        | 38.7  | 2.3 | 0.8 ± 1.5 | 1-7  | 27  | 5.0    | Gills          |
| Acarina                       |       |     |     |       |     |        |                |
| *Acarina gen. sp.*            | 3.2   | 1.0 | 0.03 ± 0.18 | 1-1  | 1   | 0.2    | Gills          |

* The sample includes *Dermidospermus brachyplastystimae* and *D. araguiensis*

### Table 2
Dispersion index (ID), *d*-statistics and discrepancy index (*D*) for the parasites in *Brachyplatystoma vaillanti* (*n* = 31) from the Igarapé Fortaleza basin, on the northern margin of the Amazonas River estuary system, in Brazil.

| Species                      | ID    | d    | *D*  | Dispersion type |
|------------------------------|-------|------|------|-----------------|
| *Dermidospermus* spp.*       | 2.065 | 3.32 | 0.631| Aggregated      |
| *Genarchella genarchella**   | 1.881 | 2.81 | 0.847| Aggregated      |
| *Pseudoterranova* sp.        | 2.425 | 4.25 | 0.601| Aggregated      |
| *Ergasilus xinguensis*       | 1.416 | 1.41 | 0.676| Random          |

* The sample includes *Dermidospermus brachyplastystimae* and *D. araguiensis*
** metacercariae
DISCUSSION

In wild populations of fish, species richness of parasites is considered a reflection of the number of host species present in the environment and the local capacity for transmission and infection of intermediate and definitive hosts (Bellay et al. 2013; Santos and Tavares-Dias 2017; Oliveira et al. 2017; Cardoso et al. 2017). Abundance and diversity of invertebrates that act as intermediate hosts to parasites are key components in the composition of endoparasite communities in wild fish populations (Luque et al. 2013; Bellay et al. 2013; Cardoso et al. 2017; Santos and Tavares-Dias 2017; Oliveira et al. 2017). The B. vaillantii of Igarapé Fortaleza examined in this study had low parasite species richness and diversity for ecto and endoparasites, probably due to the low availability of invertebrates that act as intermediate hosts for the endoparasites. All diversity indices and evenness had low values, indicating an uneven distribution of parasite species diversity across the host sample and specific species dominance in abundance (Pseudoterranova sp. in our sample). This is a common pattern in communities of fish parasites with a relatively low species diversity, but with low abundance (Cardoso et al. 2017; Oliveira et al. 2017; Santos and Tavares-Dias 2017; Leite et al. 2018).

The aggregated distribution pattern of parasite observed in B. vaillantii followed the same pattern reported for other freshwater host species (Guidelli et al. 2003; Vasconcelos and Tavares-Dias 2016; Cardoso et al. 2017; Oliveira et al. 2017; Santos and Tavares-Dias 2017; Leite et al. 2018). This pattern is related to random environmental variables, such as heterogeneity in host susceptibility to infections, direct reproduction of the parasite within the host and heterogeneity in the host ability to eliminate parasites by immunological response (Guidelli et al. 2003; Santos and Tavares-Dias 2017; Oliveira et al. 2017; Leite et al. 2018). The random distribution of E. xinguensis in B. vaillantii has also been reported for the congeneric Eragasilus turucuyus Malta & Varella, 1996 in Acestrobrachyurus falciformis Cuvier, 1819 and for Escorallana berbicensis Boone, 1918 in Serrasalmus gibbus Castelnau, 1855 (Vasconcelos and Tavares-Dias 2016). The random dispersion pattern may be related to a reduced opportunity to colonize this host in the environment (Guidelli et al. 2003; Vasconcelos and Tavares-Dias 2016).

The parasite fauna of B. vaillantii consisted mainly of ectoparasites, particularly monogeneans. The lentic environment inhabited by the examined fishes favors dispersal and reproduction of ectoparasites with free-living stages during some phases of its direct life cycle (Santos and Tavares-Dias 2017; Leite et al. 2018). Monogeneans are helminths with a high host specificity when compared to other groups of helminths, occurring only on one host, or a few hosts that are phylogenetically very closely related. Hence, the structuring of their communities is related to both ecological and historical constraints (Braga et al. 2014; Santos and Tavares-Dias 2017). Dermidiospermus brachyplatystymae and D. araguiensis, both parasites of Brachyplatystoma filamentosum Lichtenstein, 1819 (Cepeda and Luque 2010) were also found in gills of B. vaillantii. This is the first report of D. brachyplatystymae and D. araguiensis for B. vaillantii.

Young individuals of B. vaillantii, which composed our sample, consume crustaceans and insects (Soares et al. 2011; Barthem et al. 2015; Jimenez et al. 2017; Froese and Pauly 2019), the environment from Igarapé Fortaleza basin with diversity of several invertebrate species (Takiyama et al. 2004; Thomaz et al. 2004) play an important role by providing feeding grounds. At the same time, these factors increase the possibilities that this host population will acquire endoparasites, as G. genarchella, Harriscolex piramutab (Woodland, 1933) Chambrier, Kuchta & Scholz, 2015 and Pseudoterranova sp. Digeneans were found for the first time parasitizing the gills of B. vaillantii in this study. Digeneans are parasites with complex life cycle, generally involving two or three hosts (Martorelli 1989; Poulin and Cribb 2002; Cardoso et al. 2017). Genarchella genarchella normally has a snail as intermediate host and a fish as definitive host (Martorelli 1989; Poulin and Cribb 2002). The level of infection by metacercariae of G. genarchella in the gills of B. vaillantii was low when compared to Triportheus rotundatus Jardine, 1841 (Santos and Tavares-Dias 2017), which seem be a paratenic host for this species of digenean.

This is the first report of Pseudoterranova sp. parasitizing B. vaillantii. This nematode, which can be a serious threat to human health, had a higher prevalence in B. vaillantii than that reported in B. filamentosum from the state of Pará, Brazil (Rodrigues et al. 2015). Pseudoterranova are nematodes that infect different marine and freshwater fish species (McClelland 2002; Hernández-Orts et al. 2013; Rodrigues et al. 2015). Marine Pseudoterranova species have invertebrates (e.g., polychaetes, decapods, copepods, mysids, isopods, etc.) as primary hosts, while fish species are secondary hosts and mammals are definitive hosts (McClelland 2002; Hernández-Orts et al. 2013). The life cycle of these endoparasites in freshwater fish is yet unknown but considering what is known of their life cycle in marine environments, the prevalence of Pseudoterranova sp. in B. vaillantii may be related to the benthonic habitat of this fish, and the fact that crustaceans, mainly prawns, and insects (Soares et al. 2011; Barthem et al. 2015; Froese and Pauly 2019) are part of its juvenile diet.

South American catfishes, of the order Siluriformes, are definitive hosts of a vast diversity of Proteocephalidae Cestoda species (Alves et al. 2017a,b). Hence, Cestoda is the endohelminth taxon most known for infecting B. vaillantii (Rego 1984; Alves et al. 2017a,b). The prevalence of H. piramutab in B. vaillantii was lower than that reported by Chambrier et al. (2015) for this same host from the Peruvian
Amazon, and the species also occurred in low mean abundance and intensity in our sample. Our study expands the occurrence of *H. piramutab* to the eastern Amazon.

Ergasilidae is one of the largest families of Cyclopoida, and most species are found on freshwater fish (Tavares-Dias et al. 2015). Only adult females of ergasilids are parasites on gills, fins, the interior nasal fossae, or embedded in host tissues or in the urinary bladder of teleost fish species, and rarely on the gills of elasmobranchs and bivalve mollusks (Taborda et al. 2016). *Ergasilus xinguensis* was described initially on the cichlids *Geophagus argyroctistus* Kullander, 1991 and *Geophagus altifrons* Heckel, 1840 from the western Amazon (Taborda et al. 2016). Its record, albeit at low infection levels, in gills of *B. vaillantii*, indicates that this crustacean ectoparasite has no host specificity.

Mites (Acarina) are usually found on the gills, integument and digestive tract of fish (Olmeda et al. 2011; Lizama et al. 2013). The habitat and behavior of fish do not contribute to mite infestation, and some authors consider mites to be unusual parasites of fish, whereas for others, mites are not fish parasites at all (Olmeda et al. 2011; Lizama et al. 2013). Under certain environmental conditions, however, mites may proliferate and colonize weak or stressed fish causing serious damage. Several genera of mites have been isolated from fish species in Europe, Australia, and North America, in some cases associated with high host mortality (Olmeda et al. 2011; Lizama et al. 2013).

Species richness of parasites and the abundance of *Dermidiospermus* spp. in the gills increased with fish weight and length in our study, in agreement with the general pattern described for parasites in fish (Cardoso et al. 2017; Oliveira et al. 2017; Santos and Tavares-Dias 2017). In wild fish populations, body size is correlated with age, which has been considered a determinant of parasite abundance and species richness in fish, explaining in part the variation of parasitic infracommunities (Poulin 2001; Poulin 2004; Cardoso et al. 2017; Oliveira et al. 2017; Santos and Tavares-Dias 2017).

Larger fish provide parasites with more diverse niches and larger colonization areas, allowing larger hosts to harbor a higher species richness and load of parasites (Poulin 2001; Poulin 2004; Oliveira et al. 2017), mainly ectoparasites such as monogeneans, as observed in this study.

CONCLUSIONS

This was the first study on parasite communities in *B. vaillantii* and revealed a low species richness and diversity of parasites in juvenile fish in a northern tributary of the Amazonas River estuary system. The parasite component community consisted predominantly of ectoparasite species with low prevalence, low abundance and overdispersion distribution. Species richness and diversity of parasites was more strongly correlated to host weight than to host length. Only the abundance of *Dermidiospermus* spp. was strongly correlated with fish size. Our findings increase the knowledge on the parasite diversity in the Amazon system.

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