Comparison of the endoparasite fauna of *Hoplias malabaricus* and *Hoplerythrinus unitaeniatus* (Erythrinidae), sympatric hosts in the eastern Amazon region (Brazil)

M. S. B. OLIVEIRA1,5*, L. LIMA CORRÊA2, L. PRESTES3, L. R. NEVES4,5, A. R. P. BRASILIENSE1,5, D. O. FERREIRA5, M. TAVARES-DIAS1,4,5

1Postgraduate Program in Tropical Biodiversity - PPGBIO, Universidade Federal do Amapá - UNIFAP, Rod. Juscelino Kubitschek, KM-02, CEP 68.903-419, Jardim Marco Zero, Macapá, Amapá, Brazil, *E-mail: marcosidney2012@hotmail.com; 2Universidade Federal do Oeste do Pará - UFOPA, Av. Mendonça Furtado, n° 2946, Fátima, CEP 68040-470, Instituto de Ciências e Tecnologia das Águas - ICTA, Santarém, Pará, Brazil, E-mail: lincore@gmail.com; 3Postgraduate Program in Aquatic Ecology and Fisheries - PPGEA, Universidade Federal Rural da Amazônia - UFRA. Av. Presidente Tancredo Neves, n° 2501, Terra Firme, CEP 66077-830, Belém, Pará, Brazil and Universidade do Estado do Amapá - UEAP, Av. Presidente Vargas n° 100, CEP 66077-830, Central, Macapá, Amapá, Brazil, E-mail: luliprestes@gmail.com; 4Postgraduate Program in the Biodiversity and Biotechnology of the Legal Amazon - PPGBIONORTE - AP, Universidade Federal do Amapá - UNIFAP, Rod. Juscelino Kubitschek, KM-02, CEP 68.903-419, Jardim Marco Zero, Macapá, Amapá, Brazil. E-mail: liahirgor@hotmail.com; 5Embrapa Amapá, Rodovia Juscelino Kubitschek, Km 5, n° 2600, Universidade, CEP 68903-419, Macapá, Amapá, Brazil, E-mail: driellyferreira2015@outlook.com; marcos.tavares@embrapa.br

**Summary**

*Hoplias malabaricus* and *Hoplerythrinus unitaeniatus* are Erythrinidae family widely distributed in the Amazon River system of great value to both commercial and subsistence fishing for riverine populations. As such, the objective of the present study was to investigate the endoparasite communities of *H. malabaricus* and *H. unitaeniatus* of a tributary of the Amazon River in the north of Brazil. The endoparasite communities of *H. unitaeniatus* and *H. malabaricus* were taxonomically similar (85%) and consisted of *Clinostomum marginatum*, *Contracaecum sp.*, *Guyanema seriei seriei*, *Procamalmanus* (*Spirocamallanus* *inopinatus*, *Pseudoproleptus* sp. and *Gorytocephalus spectabilis*, although the dominant endoparasite was *C. marginatum*, which was the most prevalent and abundant. All the specimens of both *H. malabaricus* and *H. unitaeniatus* were parasitized, with a total of 1237 helminths collected in the former host and 1151 helminths collected in the latter. *Hoplerythrinus unitaeniatus* possessed greater parasite species richness. Both hosts had an aggregate dispersion of parasites, and the abundance of *C. marginatum*, *Contracaecum* sp. and *G. spectabilis* correlated positively with the weight and length of the hosts. The condition factor was not affected by parasitism, but the abundance of *C. marginatum* and *Contracaecum* sp. increased when the condition factor of the hosts decreased. This is the first report of *G. seriei seriei* for *H. malabaricus* and *Pseudoproleptus* sp. for *H. unitaeniatus*.

**Keywords:** Amazon; Vila Nova River; Erythrinidae; helminth parasites

**Introduction**

The state of Amapá has 34 hydrographic basins, including the Vila Nova River basin, which is one of the largest in the state (Zee, 1997; Silva et al., 2006), and covers the municipalities of Santana and Mazagão, flowing into the Amazon River near Santana. The Vila Nova is a white-water river with a pH of 5-7 (Cunha, 2003). Besides being important for navigation and water supply (Silva et al., 2006), it is home to several species of fish, including the Erythrinidae family (including *Hoplias malabaricus* Bloch, 1794 and *Hop-
_Hoplias malabaricus_ and _H. unitaeniatus_ are common Erythrinidae from the Amazon River system, and are important for commercial and subsistence fishing (Santos et al., 2006; Soares et al., 2011; Gonçalves et al., 2016). Both fish inhabit rivers, lakes and flooded forests (Mattox et al., 2006). The young of _H. malabaricus_ and _H. unitaeniatus_ feed on plankton such as microcrustaceans and insects, while adults feed mainly on fish and shrimp. They can tolerate low concentrations of dissolved oxygen in the water and take care of their offspring (Santos et al., 2006; Soares et al., 2011). The occurrence of _H. malabaricus_ and _H. unitaeniatus_ can be observed in various environments, and their carnivorous diet and elevated position in the food chain, makes them good host models in parasitic ecology (Alcântara & Tavares-Dias, 2015; Gonçalves et al., 2016).

In the Amazon region of South America, the parasite fauna of _H. malabaricus_ and _H. unitaeniatus_ consists of 17 species, of which seven are endoparasites of _H. unitaeniatus_ and ten are endoparasites of _H. malabaricus_ (Alcântara & Tavares-Dias, 2015; Gonçalves et al., 2016). The rainy and dry seasons create variations in the availability of food in Amazon habitats, leading to fluctuations in the infracommunities of the parasites of the two hosts (Gonçalves et al., 2016). However, the size of these two hosts has no relation to the abundance of parasites (Alcântara & Tavares-Dias, 2015; Gonçalves et al., 2016).

The relationship between parasites and hosts can be regulated by the host mortality induced by parasites. Abundant hosts generally tend to harbor richer parasite fauna, but if the host species are less numerous, their parasite fauna may become less rich (Moro-Zińska-Gogol, 2015). As _H. malabaricus_ and _H. unitaeniatus_ are abundant hosts in the floodplain area of the Amazon River system and have a similar life history, will they present a similar community of endoparasites? Populations of hosts with a similar life history that live in the same geographical area and are exposed to the same infection stages may present a qualitatively and quantitatively similar community of endoparasites when they ingest similar quantities and types of prey. In this manner, overlapping in the same area of occurrence may have an important effect on endoparasite communities in phylogenetically related hosts (Alarcos & Timi, 2012; Alcântara & Tavares-Dias, 2015; Hoshino et al., 2016; Oliveira et al., 2016).

Parasites can regulate the growth of host fish populations, reducing fertility and affecting the swimming, feeding and behavior of these animals (Corrêa et al., 2014; Machado et al., 2013; Hoshino et al., 2016). Knowledge of the parasites of natural populations can be important for decision-making regarding the monitoring of fish stocks, as they generate information about the physical conditions of fish (Corrêa et al., 2013). As such, the objective of this study was to compare the endoparasites fauna of _H. malabaricus_ and _H. unitaeniatus_ in a floodplain area of the basin of the Vila Nova River, a tributary of the Amazon River, Northern Brazil.

**Materials and Methods**

**Fish and collection location**

In October 2015 (dry season), 30 specimens of _H. unitaeniatus_ and 30 specimens of _H. malabaricus_ were captured in the floodplain region of the Vila Nova River in the municipality of Mazagão, a tributary of the Amazon River, in the state of Amapá, Brazil (Fig. 1), for parasitological analysis. Gill nets were used to capture the fish (30 and 35 mm between knots). The fish were transported in boxes with ice to the Laboratory of Aquaculture and Fishery from Embrapa Amapá.

![Fig. 1. Geographic location of collection site of Hoplias malabaricus and Hoplerythrinus unitaeniatus in the Vila Nova River basin, eastern Amazon region (Brazil).](image-url)
The Vila Nova River and its floodplain areas are strongly influenced by tides through the Amazon River, and in the rainy season fish enter the floodplain areas in search of food. In dry seasons, however, these areas are reduced and have a low dissolved oxygen level (Silva et al., 2006).

Collection, fixation and identification procedures of parasites
After collection, the fish were euthanized by the spinal cord transection method and weighed (g) and measured for standard length (cm). The fish were then necropsied for parasitological analysis. This work was carried out in accordance with the principles adopted by the Colégio Brasileiro de Experimento Animal (Brazilian College of Animal Experimentation -Cobea) with the authorization from Ethics Committee in the Use of Animals of Embrapa Amapá (#.004 - CEUA/CPAFAP).

After necropsy, the gastrointestinal tract and viscera were analyzed using a stereomicroscope and a light microscope to collect endoparasites. The methodology used to fix, preserve, quantify and stain the parasites for identification was that recommended by Eiras et al. (2006). The parasites were identified in accordance with Petter (1975), Moravec (1998), Moravec & Santos (2009), Vincente & Pinto (1999), Thatcher (2006) and Caffara et al. (2011). The ecological terms proposed by Rohde et al. (1995) and Bush et al. (1997) were used.

Data analysis
The Brillouin diversity index (HB), uniformity (E), Berger-Parker dominance index (d) and species richness of the parasites (Magurran, 2004) was calculated to evaluate the endoparasite component community using the Diversity software package (P scoffs Conservation Ltd, UK). The index of dispersion (ID) and discrepancy index (D) were calculated using Quantitative Parasitology 3.0 software to detect the distribution pattern of the parasite infracommunities (Rózska et al., 2000) for species with a prevalence of > 10 %. The significance of the (ID), for each infracommunity, was tested using the d-statistics test (Ludwig & Reynolds, 1988). The Jaccard index (J) and Bray-Curtis index (B) were used to measure similarity in parasite abundance between *H. unitaeniatus* and *H. malabaricus*. These take into account the differences in abundance between the shared parasite species (Ludwig & Reynolds, 1988; Magurran, 2004). These similarity indices were calculated using the Past software (Hammer et al., 2001). Principal component analysis (PCA) was carried out to compare the ways in which body size and diversity influenced the parasite communities of *H. unitaeniatus* and *H. malabaricus*. This analysis was performed using the Past software (Hammer et al., 2001).

The total weight (g) and standard length (cm) of the fish were used to calculate the relative condition factor (Kn) of the hosts and the weight-length ratio using the equation W = a.L^b, where W is the total weight (g) and L is the standard length (cm), a and b are con-

### Table 1. Helminth parasites of two Erythrinidae species from the Vila Nova River basin, eastern Amazon region (Brazil).

<table>
<thead>
<tr>
<th>Fish species</th>
<th>Hoploerythrus unitaeniatus (N = 30)</th>
<th>Hoplias malabaricus (N = 30)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parasites</td>
<td>P (%)</td>
<td>MI</td>
</tr>
<tr>
<td>Clinostomum marginatum (larvae)</td>
<td>76.7</td>
<td>29.6</td>
</tr>
<tr>
<td>Clinostomum marginatum (larvae)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Clinostomum marginatum (larvae)</td>
<td>6.7</td>
<td>1.5</td>
</tr>
<tr>
<td>Pseudoproleptus sp. (larvae)</td>
<td>33.3</td>
<td>4.9</td>
</tr>
<tr>
<td>Pseudoproleptus sp. (larvae)</td>
<td>26.7</td>
<td>6.8</td>
</tr>
<tr>
<td>Pseudoproleptus sp. (larvae)</td>
<td>13.3</td>
<td>1.8</td>
</tr>
<tr>
<td>Pseudoproleptus sp. (larvae)</td>
<td>66.7</td>
<td>5.3</td>
</tr>
<tr>
<td>Contracaeum sp. (larvae)</td>
<td>83.3</td>
<td>3.4</td>
</tr>
<tr>
<td>Contracaeum sp. (larvae)</td>
<td>10.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Contracaeum sp. (larvae)</td>
<td>10.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Contracaeum sp. (larvae)</td>
<td>3.3</td>
<td>1.0</td>
</tr>
<tr>
<td>Procamallanus (S.) inopinatus</td>
<td>26.7</td>
<td>1.4</td>
</tr>
<tr>
<td>Procamallanus (S.) inopinatus</td>
<td>63.3</td>
<td>3.8</td>
</tr>
<tr>
<td>Guyanema seriei seriei</td>
<td>3.3</td>
<td>2.0</td>
</tr>
<tr>
<td>Gorytocephalus spectabilis</td>
<td>60.0</td>
<td>3.5</td>
</tr>
<tr>
<td>Gorytocephalus spectabilis</td>
<td>3.3</td>
<td>4.0</td>
</tr>
<tr>
<td>Gorytocephalus spectabilis</td>
<td>30.0</td>
<td>3.6</td>
</tr>
<tr>
<td>Gorytocephalus spectabilis</td>
<td>6.67</td>
<td>2.0</td>
</tr>
</tbody>
</table>
The Spearman coefficient ($r_s$) was used to determine the possible correlations between parasite abundance and host length, body weight and Kn, as well as to correlate host length with species richness and $HB$. The Mann-Whitney ($U$) test was used to compare the mean intensity, mean abundance, species richness, $HB$, E and Berger-Parker dominance of both host species (Zar, 2010).

**Ethical Approval and/or Informed Consent**

This work was carried out in accordance with the principles adopted by the Brazilian College of Animal Experimentation (Cobea) with the authorization from Ethics Committee in the Use of Animals of Embrapa Amapá (#:004 - CEUA/CPAFAF).

**Results**

Thirty specimens of *H. unitaeniatus* measuring $x = 21.5 \pm 2.0$ cm and $x = 245.3 \pm 65.6$ g, and 30 specimens of *H. malabaricus* with $x = 24.9 \pm 7.7$ cm and $x = 242.3 \pm 75.0$ g were analyzed.

Of the specimens of *H. unitaeniatus* and *H. malabaricus* examined, 100% were parasitized by one or more species of helminth. It was observed that there was similar dominance of the digenean *Clinostomum marginatum* Rudolphi, 1819, in *H. malabaricus* and

![Species richness of parasitic helminths of two species of Erythrinidae from the Vila Nova River basin, eastern Amazon region (Brazil).](image-url)
H. unitaeniatus, followed by Contracaecum sp. for both hosts. A total of 1151 helminths were collected in H. unitaeniatus and 1237 in H. malabaricus, making a total of 2,388 helminths. These parasites were distributed among the following taxa: Clinostomum marginatum (Trematoda), Guyanema seriei seriei Petter, 1975, Procamallanus (Spirocamallanus) inopinatus Travassos, Artigas & Pereira, 1928, Pseudoproleptus Khera, 1955, Contracaecum Railliet & Henry, 1912 (Nematoda) and Gorytocephalus spectabilis Machado, 1959 (Acanthocephala) (Table 1). These parasites presented aggregated dispersion, except P. (S.) inopinatus in the pyloric cecum of H. unitaeniatus that exhibited a random dispersion (Table 2).

Berger-Parker diversity index and evenness were similar for both fish species, but the Brillouin index ($HB$) and species richness of the parasites were higher for H. unitaeniatus (Table 3), and there was no difference between the abundance ($U = 430.5, p = 0.309$) and parasitic intensity ($U = 430.5, p = 0.309$) in the two fish species. In H. malabaricus there was a predominance of individuals harboring three species of helminths, whereas in H. unitaeniatus the predominance was four species of helminths (Fig. 2).

The H. unitaeniatus and H. malabaricus populations exhibited low parasite community similarity, as described by the Jaccard index ($J = 0.66$) and the Bray-Curtis index ($B = 0.15$). Multivariate analysis based on the parasite communities of H. unitaeniatus and H. malabaricus revealed a difference between these host populations, caused by C. marginatum and Pseudoproleptus sp. (Fig. 3).

For H. malabaricus, the abundance of C. marginatum correlated positively with the length and negatively with the Kn of the hosts. In the same manner, the abundance of Contracaecum sp. correlated positively with host size and negatively with Kn. For H. unitaeniatus, there was a negative correlation between the abundance of G. spectabilis and host length, while the abundance of C. marginatum correlated positively with host length and body weight. The abundance of Contracaecum sp. also exhibited a positive correlation with host length (Table 4).

The condition factor of the parasitized H. malabaricus (Kn = 0.999 ± 0.063) did not differ (t = -0.062; p = 0.951) from the standard (Kn = 1.00), and the same was true for H. unitaeniatus (Kn = 1.00 ± 0.017) (t = 0.003, p = 0.997). The equation describing the growth of
**Table 4. Spearman correlation coefficient (rs) of abundance of parasites with standard length, body weight and Kn for the infracomunities of parasite helminths of two species of Erythrinidae from the Vila Nova River basin, eastern Amazon region (Brazil).**

<table>
<thead>
<tr>
<th>Hosts fish</th>
<th><em>Hoplias malabaricus</em></th>
<th><em>Hoplerythrus unitaeniatus</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Parasites</td>
<td>Length</td>
<td>Weight</td>
</tr>
<tr>
<td><strong>Pseudopropleptus sp.</strong></td>
<td>0.284</td>
<td>0.127</td>
</tr>
<tr>
<td><strong>Gorytocephalus spectabilis</strong></td>
<td>-0.159</td>
<td>0.400</td>
</tr>
<tr>
<td><strong>Clinostomum marginatum</strong></td>
<td>0.467</td>
<td>0.001</td>
</tr>
<tr>
<td><strong>Contracaecum sp.</strong></td>
<td>0.545</td>
<td>0.001</td>
</tr>
<tr>
<td><strong>Procamallanus (S.) inopinatus</strong></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Guyanema s. seriei</strong></td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

*H. malabaricus* was $W = 0.0891L^{2.507}; r^2 = 0.898$, while for *H. unitaeniatus* it was $W = 0.0327L^{2.887}; r^2 = 0.904$, which shows negative allometric type growth.

**Discussion**

The endoparasite fauna in *H. malabaricus* was composed by 1 species of Digenea, 4 Nematoda and 1 Acanthocephala, while in *H. unitaeniatus* it consisted of 1 species of Digenea, 2 Nematoda and 1 Acanthocephala. Thus, 66.6% of these taxa are known species for these hosts in the eastern Amazon region. The endoparasite communities of *H. unitaeniatus* and *H. malabaricus* were dissimilar (15%) and were mostly influenced by the amount of ingested prey. However, a certain degree of homogeneity can be expected in hosts living in the same environment that are phylogenetically related and have a similar ecology (Alarcos & Timi, 2012; Hoshino et al., 2016). The parasites of *H. unitaeniatus* and *H. malabaricus* presented aggregate dispersion, but *H. unitaeniatus* demonstrated greater species richness, a higher Brillouin index and lower Berger-Parker dominance. The greater species richness of endoparasites of *H. unitaeniatus* is an indication that their feeding is more diversified than *H. malabaricus* in the studied environment. This higher species richness of endoparasites in *H. unitaeniatus* can therefore result in a greater number of infected organs, thus causing a reduction in competition among endoparasites.

The parasite dispersion pattern in both *H. malabaricus* and *H. unitaeniatus* was aggregated, a pattern registered for other freshwater fish in Brazil (Luque et al., 2003; Guidelli et al., 2003; Tavares-Dias et al., 2014a,b; Oliveira et al., 2016, 2017). This pattern is mainly influenced by the breadth of the ecological niche dimension, environmental heterogeneity and host immunology (Anderson & Gordon, 1982; Guidelli et al., 2003; Tavares-Dias et al., 2013; Oliveira et al., 2016). However, the infection by *P. (S.) inopinatus* in the pyloric cecum of *H. unitaeniatus* had a random dispersion, similar to the infection of this nematode in the pyloric cecum of *T. angulatus* from the Amazon River system (Oliveira et al., 2016). The random dispersion pattern is common in larvae and species of parasites with a high degree of pathogenicity, and that have a reduced possibility of colonizing hosts (Guidelli et al., 2003). Therefore, such parasite dispersion patterns may vary depending on the colonization strategies of the parasite species.

The growth type of *H. malabaricus* and *H. unitaeniatus* was negative allometric, indicating a greater increase in length than in body mass. In both *H. malabaricus* and *H. unitaeniatus*, there was a positive correlation between the abundance of *C. marginatum* and *Contracaecum sp.* and the size of the hosts. This is a strong indicator of the accumulation of these endoparasites throughout the life of these hosts, influenced mainly by the greater possibility of intermediate host ingestion, and a longer time of exposure to parasitic infections (Guidelli et al., 2003; Bicudo et al., 2005; Bellay et al., 2012). However, *H. malabaricus* and *H. unitaeniatus*, which are fish of sedentary habits (Santos et al., 2006, Soares et al., 2011), exhibited differences in the number of prey containing infective forms of the endoparasites found, thus demonstrating a relative overlap in the same environment investigated. The negative correlation between the abundance of *C. marginatum* and *Contracaecum sp.* and the size of *H. malabaricus* and the condition factor, indicates that larger fish have lower body conditions despite feeding more, and thus support lower levels of endoparasitic infection (Oliveira et al., 2016). However, a high abundance of parasites can compromise the body conditions of natural populations (Lizama et al., 2007; Morozhiska-Gogol, 2015).

The digenean *C. marginatum*, a parasite with low parasitic specificity (Gonçalves et al., 2016), which occurred at similar levels of infection in *H. malabaricus* and *H. unitaeniatus* in the present study, was the dominant helminth in the community. The transmission of digenean species is directly related to the food habits of the host, since these endoparasites need more than one host to complete their biological cycle (Pinto et al., 2015; Oliveira et al., 2016, 2017). In Brazil, in general, metaceraria of *Clinostomum* spp. use *Biomphalaria* spp. mollusks as primary intermediate hosts (Dias et al., 2003; Pinto et al., 2015), and the *H. malabaricus* and *H. unitaeniatus* of the present study are the secondary intermediate hosts of this endoparasite, with piscivorous birds the definitive hosts (Dias et al., 2003; Pinto et al., 2015).
The acanthocephalan *G. spectabilis* was found in the intestine, liver, pyloric cecum and mesentery of *H. unitaeniatus*, as well as in the mesentery of *H. malabaricus*, with varying rates of prevalence. However, its greatest abundance occurred in *H. unitaeniatus*, which showed levels of infection similar to those described for this same host from another basin of the Amazon River system (Alcântara & Tavares-Dias, 2015; Gonçalves et al., 2016). The life cycle of acanthocephalans involves vertebrate species as definitive hosts and microcrustaceans (amphipods, copepods, isopods and ostracods) as intermediate hosts (Huys & Bodin, 1997). Fish become infected when they prey on microcrustaceans containing acanthella, which can reach the cystacanth and adult stages in *H. unitaeniatus* and *H. malabaricus* in the environment of this study, corroborating the results of Alcântara & Tavares-Dias (2015), for these same host species. Low levels of infection by *G. s. seriéi* were found in *H. unitaeniatus*, indicating that this fish acts as definitive host for this nematode. This species of endoparasite was originally described from *H. unitaeniatus* from French Guiana (Petter, 1975), indicating that these nematodes have a restricted relationship with *H. unitaeniatus*, while *H. malabaricus* is parasitized by Guyanema baudii (Weiblen & Brandão, 1992). However, *G. s. seriéi* and *G. baudii* use different species of fish as primary and secondary intermediate hosts. This study extends the distribution of *G. s. seriéi* to the basin of the Vila Nova River. A high prevalence but low abundance of larvae of *Contracaecum* sp. was found in *H. unitaeniatus* and *H. malabaricus*, although the latter host was less parasitized. However, there was a higher level of *Contracaecum* sp. infection of *H. malabaricus* than *H. unitaeniatus* in another basin in the Amazon River system, due to a larger range of items present in the diet of *H. malabaricus* in the studied environment (Alcântara & Tavares-Dias, 2015; Gonçalves et al., 2016). In general, nematodes use microcrustacean species as primary intermediate hosts, while fish may be paratenic, secondary or definitive intermediate hosts (Moravec, 2009; Moreira et al., 2009). *Contracaecum* species use piscivorous birds as definitive hosts (Moravec, 2009; Tavares-Dias et al., 2014a).

*Procamallanus* (S.) *inopinatus*, a nematode with no parasitic specificity and with wide distribution in Brazil, uses fish species as definitive hosts and species of chironomids as intermediate hosts (Moravec, 1998; Moreira et al., 2009; Tavares-Dias et al., 2014b; Oliveira et al., 2015; Oliveira et al., 2016). This nematode was found only in *H. unitaeniatus* and with lower infection levels than those reported for this same host from the Igarapé Fortaleza basin, a tributary of the Amazon River (Alcântara & Tavares-Dias, 2015; Gonçalves et al., 2016), a finding probably influenced by the lower availability of intermediate hosts in the environment. However, *H. unitaeniatus* and *H. malabaricus* are the definitive hosts for this endoparasite (Alcântara & Tavares-Dias, 2015). This study extends the distribution of *P. (S.) inopinatus* to the basin studied. A high prevalence of *Pseudoproleptus* sp. occurred in *H. unitaeniatus* and *H. malabaricus*, but the highest levels of infection were found in *H. malabaricus*. In the Eastern Amazon region, the larvae of *Pseudoproleptus* sp. were also reported in *Satanoperca jurupari* (Melo et al., 2011) and *Aequidens tetramerus* (Tavares-Dias et al., 2014a), as cichlid species are possibly part of the diet of *H. malabaricus* and *H. unitaeniatus*, which makes the transmission and development of this nematode even more efficient. *Pseudoproleptus* sp. uses larvae of ephemeral insects and crustaceans as the first intermediate hosts (Moravec, 2007; Moravec & Santos, 2009) while some species of fish act as second intermediate hosts (Moravec and Santos, 2009, Melo et al., 2011, Tavares-Dias et al., 2014a) and even as a definitive host, such as *H. malabaricus* (Melo et al., 2011). This is the first record of *Pseudoproleptus* sp. for *H. unitaeniatus* and extends its geographic distribution to the basin of the Vila Nova River.

In summary, the endoparasites community of *H. malabaricus* and *H. unitaeniatus* was characterized by the predominance of larvae, indicating that these fish are intermediate hosts for most of the parasite species found here. Therefore, these two hosts occupy a central position in the food chain. Finally, the high similarity between the community of endoparasites of *H. malabaricus* and *H. unitaeniatus* indicate a high overlap in environment. There also does not appear to be interspecific competition between the parasites, as they occupy several sites in the host.

**Conflict of Interest**

Authors state no conflict of interest.

**Acknowledgements**

The authors would like to thank the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (Coordination for the Improvement of Higher Level Education Personnel) (Capes) for the doctorate grant awarded to Oliveira, M.B.O and Neves, L.R. and master’s grant awarded to Brasiliense, A.R.P. and to the Conselho Nacional de Desenvolvimento Científico (the National Scientific Development Council) (CNPq) for the productivity grant awarded to Tavares-Dias, M., and to Mr. José C.C. Pinto for the availability of the area for collection and help in fishing.

**References**


Paraná River


tol., 54(4): 239 – 257. DOI: 10.14411/fp.2007.033


Moraèc, F., Santos, P. (2009): Larval Pseudoproetus sp. (Nem-
atoda: Cystidicolidae) found in the Amazon River Prawn Macrobrachium amazonicum (Decapoda: Palaemonidae) in Brazil. J. Parasi-
tol., 95(3): 634 – 638. DOI: 10.1645/GE-1887.1

Moreira, L.H.A., Takimoto, R.M., Yamada, F.H., Ceschin, T.L., Pa-

Morozinska-Gogol, J. (2015): Changes in the parasite communities as one of the potential causes of decline in abundance of the three-spined sticklebacks in the Puck Bay. Oceanologia, 57(3): 280 – 287. DOI: 10.1016/j.oceano.2015.03.001

site communities of wild Leporinus friderici (Characiformes: Anosto-


Pinto, H.A., Caffara, M., Fioravanti, M.L., Melo, A.L. (2015): Experimental and molecular study of cercariae of Clíonostoma sp. (Trem-
atoda: Clíonostomidae) from Biomphalaria spp. (Mollusca: Planorbi-


Rózsa, L., Reiczigel, J., Majóros, G. (2000): Quantifying para-

eiais de Manaus [Commercial fish from Manaus]. Manaus, AM, Ibama/AM, PróVárzea, 144 pp. (In Portuguese)

tental ao Zoneamento Ecológico-Econômico Costeiro Participativo [Atlas of the Zone Coastal State of Amapá: from the socio-environ-


Tavares-Dias, M., Neves, L.R., Pinheiro, D.A., Oliveira, M.S.B., Marinho, R.G.B. (2013): Parasites in Curinita cyprinoides (Charachi-

tol., 59(1): 158 – 164. DOI: 10.2478/s11686-014-0225-3

Tavares-Dias, M., Souza, T.J.S., Neves, L.R. (2014b): Parasitic in-
factions in two benthopelagic fish from amazon, the arowana Os-


Vicente, J., Pinto, R.M. (1999): Nematoides do Brasil. Nema-

Zee - Zoneamento ECOLOGICO ECONÔMICO (1997): Primeira aproxi-
mãção do zoneamento ecológico econômico do Amapá. Repre-
semtação escala 1/1.000.000 [First approximation of the ecological ecological zoning of Amapá. Scale representation 1/1.000.000]. Macapá, AP, IEPA-ZEE, 106 pp. (In Portuguese)