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Scientific Note

HELMINTHIC ENDOFAUNA OF FOUR SPECIES OF FISH FROM LOWER JARI RIVER, A TRIBUTARY OF THE AMAZON BASIN IN BRAZIL

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ABSTRACT

Studies on parasites of wild fish populations are important for knowledge of biodiversity, since parasites represent a great fraction of the planet's biodiversity. The present study investigated the helminths fauna of *Leporinus friderici*, *Mylossoma duriventre*, *Hoplerythrinus unitaeniatus* and *Osteoglossum bicirrhosum* collected from the lower Jari River, in the state of Amapá in the eastern Amazon region, Brazil. These fish, which have varying eating habits, were caught using gill nets with different mesh sizes for analysis of helminths, using standard methodologies. The helminths collected from these hosts were: *Procamallanus* (*Spirocamallnus*) *inopinatus*, *Guyanema seriei seriei*, *Contracaecum* sp., *Eustrongylides* sp. (Nematoda), *Clinostomum marginatum*, *Dadaytrema oxycephala*, *Caballerotrema aruanense*, *Posthodiplostomum* sp. (Digenea), *Quadrigyrus nickoli* and *Neoechinorhynchus* sp. (Acanthocephala). *Hoplerythrinus unitaeniatus* presented the highest prevalence, intensity and mean abundance of *C. marginatum,* while *M. duriventre* was the host with lowest level of this parasite. The greatest diversity was of *Contracaecum* sp., sole helminth found in all species of fish studied. The presence of larvae of endoparasites indicates that these fish are intermediate hosts in the Jari River basin.

Key words: Amazon; parasites; freshwater fish; hosts.

ENDOFAUNA HELMÍNTICA DE QUATRO ESPÉCIES DE PEIXES DO BAIXO RIO JARI, AFLUENTE DA BACIA AMAZÔNICA NO BRASIL

RESUMO

Os estudos sobre parasitos de populações naturais de peixes são importantes para o conhecimento da biodiversidade, uma vez que os parasitos representam uma grande fração da biodiversidade do planeta. Este estudo investigou a fauna de endohelmintos de *Leporinus friderici*, *Mylossoma duriventre*, *Hoplerythrinus unitaeniatus* e *Osteoglossum bicirrhosum* coletados no médio Rio Jari, no estado do Amapá, Amazônia oriental, Brasil. Peixes com diferentes hábitos alimentares, foram capturados com redes de espera de diferentes tamanhos de malha para a análises dos endohelmintos, usando metodologias usuais. Os endohelmintos encontrados nesses hospedeiros foram: *Procamallanus* (*Spirocamallnus*) *inopinatus*, *Guyanema seriei seriei*, *Contracaecum* sp., *Eustrongylides* sp. (Nematoda), *Clinostomum marginatum*, *Dadaytrema oxycephala*, *Caballerotrema aruanense*, *Posthodiplostomum* sp. (Digenea), *Quadrigyrus nickoli* e *Neoechinorhynchus* sp. (Acanthocephala). *Hoplerythrinus unitaeniatus* apresentou os maiores níveis de prevalência, intensidade e abundância de *C. marginatum*, enquanto *M. duriventre* apresentou os menores níveis desse parasito. A maior diversidade foi de *Contracaecum* sp., único helminto encontrado em todas as espécies de hospedeiros estudadas. A presença de estágios larvais de endoparasitos indica que esses peixes são hospedeiros intermediários para esses parasitos na bacia do Rio Jari.

Palavras-chave: Amazônia; parasitos; peixes de água doce; hospedeiros.

INTRODUCTION

The Jari River basin, an important tributary of the Amazon River, has its source in the Parque Montanhas Tumucumaque (the Tumucumaque Mountain Park), on the border between Brazil and Surinam, and empties into the Amazon River in the south of the state of Amapá. The basin is divided between the states of Amapá and Pará in the north of Brazil, and covers the municipal districts of Vitória do Jari, Laranjal do Jari, Mazagão (State Amapá) and Almeirim (State Pará), covering a total area of approximately

119,540 km^2 (Epe, 2010; Epe, 2011; Amapá, 2012; Oliveira et al., 2017). The basin is directly influenced by the daily tides of the Amazon River at its mouth and has white water downstream and black water upstream, causing the amount of suspended organic matter to vary (Epe, 2011; Abreu and Cunha, 2015).

The fish fauna of the Jari River basin consist of several species of Characiformes, Siluriformes, Cichliformes and Osteoglossiformes, with about 238 species being recorded for this region (Ambiental, 2013; Oliveira et al., 2015), including *Leporinus friderici* Bloch, 1794 (Anostomidae), *Mylossoma duriventre* Cuvier, 1818 (Serrasalmidae), *Hoplerythrinus unitaeniatus* Agassiz, 1829 (Erythrinidae) and *Osteoglossum bicirrhosum* Cuvier, 1829 (Osteoglossidae), the object species of this study. These fish are important sources of animal protein for Amazon riverine populations (Santos et al., 2006; Soares et al., 2011).

For *L. friderici* from the Amazon basin (State Amapá) the helminths fauna is constituted by species of digenean, nematodes and acanthocephalan (Oliveira et al., 2017) and in Paraná River basin (State Paraná) by species of digeneans, nematodes and cestodes (Guidelli et al., 2006; Takemoto et al., 2009). For *M. duriventre* from the Solimões River basin (State Amazonas) is constituted by species of nematodes (Silva and Tavares-Dias, 2012). In *O. bicirrhosum* from the Solimões basin (State Amazonas) the helminths fauna is not composed by species of endoparasites (Tavares-Dias et al., 2014) and in *H. unitaeniatus* from the Tapajós River basin (Benigno et al., 2012) and the Igarapé Fortaleza (the Fortaleza Stream), state of Amapá (Alcântara and Tavares-Dias, 2015) by species of nematodes, digeneans, acanthocephalan and cestode. So how is the helminths fauna of *L. friderici*, *M. duriventre*, *H. unitaeniatus* and *O. bicirrhosum* from the Jari River basin, which have different feeding habits, constituted?

Studies of the helminths community of fish can reveal information about aspects of the diet of the hosts, their trophic level in the food chain and their participation in the life cycle of parasites (Benigno et al., 2012; Tavares-Dias et al., 2014; Oliveira et al., 2015; Oliveira and Tavares-Dias, 2016; Oliveira et al., 2017). Some helminth species from fish have zoonotic potential for humans (Barros et al., 2006; Benigno et al., 2012). Therefore, the present study investigated the helminths fauna parasitizing *L. friderici*, *M. duriventre*, *H. unitaeniatus* and *O. bicirrhosum* from the Jari River basin region, in the eastern Amazon region, Brazil.

MATERIAL AND METHODS

Species of *L. friderici*, *M. duriventre*, *H. unitaeniatus* and *O. bicirrhosum* were collected in December 2014 from the lower Jari River, near the Jarilândia community in the state of Amapá, in the north of Brazil (Figure 1).

The fish were captured using gill nets with different mesh sizes. The standard length (cm) and body weight (g) of the fish collected were measured. Each fish was then subjected to necropsy, and

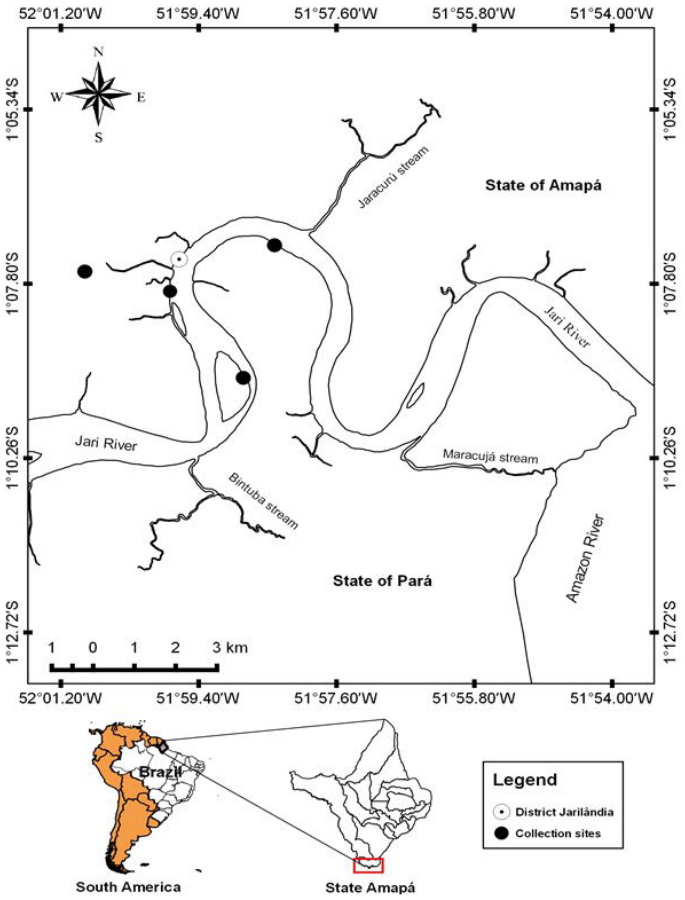

Figure 1. Location of the collection sites of the fish species in the lower Jari River, a tributary of the Amazon River in northern Brazil.

the gastrointestinal tract and viscera were examined with the aid of a stereomicroscope and microscope to collect endohelminths. This work was carried out in accordance with the principles of the Colégio Brasileiro de Experimento Animal (the Brazilian College of Animal Experimentation/COBEA). All the fish were collected pursuant to a collection authorization granted by IBAMA/ICMBio - Nº 27447-1/2011.

The collection, fixation, preservation and preparation of the parasites for identification followed the recommendations of Eiras et al. (2006). The species of the parasites were identified in accordance with Schmidt and Hugghins (1973), Petter (1974), Thatcher (1980, 2006), Moravec (1998) and Caffara et al. (2011). The ecological terms used were adopted from those recommended by Rohde et al. (1995) and Bush et al. (1997).

RESULTS

A total of 55 fish of four species from hosts such as *L. friderici* (16.2 ± 2.1 cm and 141.1 ± 53.8 g), *M. duriventre* (21.9 ± 1.7 cm and 350.7 ± 59.7 g), *H. unitaeniatus* (20.3 ± 1.3 cm and 219.3 ± 65.2 g)

Table 1. Species of helminths for four hosts from the lower Jari River, a tributary of the Amazon River, northern Brazil. P: Prevalence, MI: Mean intensity of infection, MA: Mean abundance, IS: Infection site, TNP: Total number of parasites.

Host species	Parasites species	P (%)	MI	MA	IS	TNP
Leporinus friderici (n = 14)	*Procamallanus* (*Spirocamallnus*) *inopinatus*	42.9	2.5	1.0	Intestine	15
	Procamallanus (*Spirocamallnus*) *inopinatus*	35.7	2.8	1.0	Caecum	14
	Contracaecum sp. (larvae)	14.3	1.0	0.1	Mesentery	2
	Neoechinorhynchus sp. (larvae)	14.3	1.5	0.2	Intestine	3
	Neoechinorhynchus sp. (larvae)	7.1	2.0	0.1	Mesentery	2
Mylossoma duriventre (n = 15)	*Procamallanus* (*Spirocamallnus*) *inopinatus*	13.3	1.0	0.1	Caecum	2
	Contracaecum sp. (larvae)	6.7	1.0	0.07	Mesentery	1
	Contracaecum sp. (larvae)	13.3	4.0	0.5	Intestine	8
	Dadaytrema oxycephala	6.7	2.0	0.1	Intestine	2
Hoplerythrinus unitaeniatus (n = 14)	*Procamallanus* (*Spirocamallnus*) *inopinatus*	35.7	1.6	0.6	Intestine	8
	Procamallanus (*Spirocamallnus*) *inopinatus*	7.1	1.0	0.07	Caecum	1
	Contracaecum sp. (larvae)	7.1	1.0	0.07	Intestine	1
	Contracaecum sp. (larvae)	71.4	2.4	1.7	Mesentery	24
	Eustrongylides sp. (larvae)	21.4	1.0	0.2	Mesentery	3
	Eustrongylides sp. (larvae)	50.0	4.7	2.3	Musculature	33
	Eustrongylides sp. (larvae)	7.1	2.0	0.1	Liver	2
	Guyanema seriei seriei	28.6	2.0	0.6	Mesentery	8
	Clinostomum marginatum (metacercariae)	7.1	3.0	0.2	Intestine	3
	Clinostomum marginatum (metacercariae)	100	17.1	17.1	Mesentery	240
	Clinostomum marginatum (metacercariae)	7.1	2.0	0.1	Caecum	2
	Posthodiplostomum sp. (metacercariae)	7.1	1.0	0.07	Mesentery	1
	Quadrigyrus nickoli (larvae)	42.9	2.7	1.1	Intestine	16
	Quadrigyrus nickoli (larvae)	21.4	4.3	1.1	Mesentery	16
Osteoglossum bicirrhosum (n = 12)	*Eustrongylides* sp. (larvae)	8.33	1.0	0.08	Musculature	1
	Contracaecum sp. (larvae)	50.00	1.3	0.7	Mesentery	8
	Caballerotrema aruanense	25.0	5.0	1.2	Intestine	15
	Caballerotrema aruanense	8.33	2.0	0.2	Mesentery	2

and *O. bicirrhosum* (39.2 ± 9.9 cm and 549.2 ± 382.6 g) were necropsied. Of this total, 60% were parasitized by one or more species of helminthes, and a total of 433 parasites from nine taxa was collected. Among the species o helminthes collected, larvae of *Contracaecum* sp. were found in all the hosts, but *Procamallanus* (*Spirocamallnus*) *inopinatus* Travassos, Artigas & Pereira, 1928 do not occurred only in *O. bicirrhosum*. *Hoplerythrinus unitaeniatus* was the host with the greatest parasitic prevalence, intensity and abundance of *Clinostomum marginatum* Rudolphi, 1819, while *M. duriventre* was the least parasitized by this endoparasite (Table 1).

All host species had endoparasites in the larval stages (Table 2). In the four hosts, the number of parasites ranged from one to six, but infection by zero or one parasite predominated. *Hoplerythrinus unitaeniatus* had the greatest richness of helminths species (Figure 2).

DISCUSSION

Four species of nematodes, three digeneans and two acanthocephalans were found in *L. friderici*, *M. duriventre*, *H. unitaeniatus* and *O. bicirrhosum*, and with larval stages. However, for *L. friderici*

Table 2. Component community of the helminths for four hosts from the lower Jari River, a tributary of the Amazon River, northern Brazil.

Characteristics	*Leporinus friderici*	*Mylossoma duriventre*	*Osteoglossum bicirrhosum*	*Hoplerythrinus unitaeniatus*
Number of hosts examined	14	15	12	14
Number of parasitized hosts	8	4	7	14
Prevalence (%) of parasites	71.4	26.7	58.3	100
Total number of parasites	46	13	26	358
Helminths species number	3	3	3	7
Helminths species (adults) number	2	2	1	3
Helminths species (larvae) number	2	1	2	5

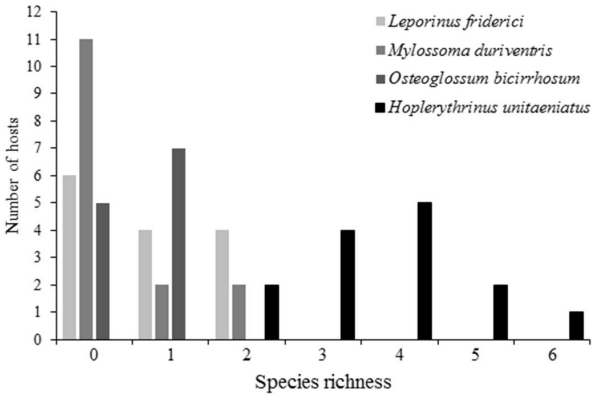

Figure 2. Richness of helminths species for four host species from the lower Jari River, tributary of the Amazon River, northern Brazil.

from the Amazon basin the endohelminths fauna is constituted by one species of digenean, two nematodes and one acanthocephalan (Oliveira et al., 2017) and in Paraná River basin by 11 species of digeneans, 12 nematodes, two acanthocephalans and one cestode (Guidelli et al., 2006; Takemoto et al., 2009). In *M. duriventre* from the Solimões River basin was reported one species of nematode (Silva and Tavares-Dias, 2012), while in *O. bicirrhosum* from the Solimões no species of endohelminth was reported (Tavares-Dias et al., 2014). The endohelminths fauna of *H. unitaeniatus* from the Tapajós River basin (Benigno et al., 2012) and Igarapé Fortaleza River (Alcântara and Tavares-Dias, 2015) was composed by three species of nematodes, one digenean, one acanthocephalan and one cestode. Therefore, fish can act as paratenic, intermediate or definitive hosts for the different species of endohelminths found (Dias et al., 2003; Moravec, 2004; Thatcher, 2006; Lizama et al., 2008; Martins et al., 2009; Benigno et al., 2012; Alcântara and Tavares-Dias, 2015; Oliveira and Tavares-Dias, 2016; Oliveira et al., 2017). Larvae of *Contracaecum* sp., which have zoonotic potential (Benigno et al., 2012), were found in low abundance in *L. friderici*, *M. duriventre*, *H. unitaeniatus* and *O. bicirrhosum* when compared to *H. unitaeniatus and Hoplias malabaricus* Bloch, 1794 of Igarapé Fortaleza basin (Alcântara and Tavares-Dias, 2015). Larvae of *Contracaecum* sp. were found also on musculature of *H. unitaeniatus* and *O. bicirrhosum*, due to migration into host. This nematode has a low host parasitic specificity, being a common anisakid in freshwater fish from Brazil, mainly in carnivorous hosts (Luque et al., 2011; Benigno et al., 2012; Alcântara and Tavares-Dias, 2015; Oliveira and Tavares-Dias, 2016; Oliveira et al., 2017). The greatest prevalence of *Contracaecum* sp. occurred in *H. unitaeniatus* and *O. bicirrhosum*, both of which are carnivorous hosts that feed on insects, crustaceans, mollusks and small fish (Soares et al., 2011; Benigno et al., 2012; Froese and Pauly, 2017; Oliveira et al., 2017). These fish are secondary intermediary hosts for this anisakid which uses species of crustaceans as primary intermediate hosts (Moreira et al., 2009; Moravec, 2009; Oliveira et al., 2017) and birds and fish-eating mammals to complete its life cycle (Navone et al., 2000; Barros et al., 2006; Moreira et al., 2009). This is the first record *Contracaecum* sp. for *M. duriventre*.

Larvae and adults of *P.* (*S.*) *inopinatus* infected *L. friderici*, *M. duriventre* and *H. unitaeniatus*, with moderate prevalence and low abundance. These finding indicates that that these omnivorous fish (*L. friderici*, *M. duriventre* and *H. unitaeniatus*) are definitive hosts of this nematode that uses chironomids as intermediate hosts (Moreira et al., 2009; Oliveira et al., 2017). Larvae of *Eustrongylides* sp. were found in low abundance only in *H. unitaeniatus* and *O. bicirrhosum*, both carnivorous hosts. However, the greatest prevalence was in *H. unitaeniatus*. Therefore, *H. unitaeniatus* and *O. bicirrhosum* acts as secondary intermediate hosts for *Eustrongylides* sp., a nematode that uses species of earthworms as primary intermediate hosts (Martins et al., 2009) and reaches its adult phase in piscivorous birds (Barros et al., 2006; Martins et al., 2009; Benigno et al., 2012; Meneguetti et al., 2013). Larvae of *Eustrongylides* sp. has been reported in varied infection levels in different species of fish from several hydrographic basins in Brazil (Vicente and Pinto, 1999; Luque et al., 2011), but the species have not been identified. Low levels of infection by *Guyanema seriei seriei* Petter, 1974 were found in the mesentery of *H. unitaeniatus* as reported for this same host of the Vila Nova River basin (Oliveira et al., 2018). Petter (1974) described this nematode Dracunculoidea superfamily in the same host from Guyana. The life story of this nematode is unknown, but species of Dracunculoidea have a life

cycle involving aquatic crustaceans such as copepods, ostracods or branchiurans as intermediate hosts, and aquatic vertebrates as definitive hosts (Moravec, 2004). This is the first report of *Eustrongylides* sp. for *O. bicirrhosum* and widens the distribution of this nematode and of *G. seriei seriei* for the Jari River basin, in the eastern Amazon region.

Dadaytrema oxycephala Diesing, 1836 Travassos, 1931 infects species of Characidae, Serrasalmidae and Doradidae from the Brazil (Kohn et al., 2007). Low levels of infection by *D. oxycephala* were found in *M. duriventre* when compared to *Piaractus brachypomus* Cuvier, 1818 from the lower Amazonas River (Oliveira and Tavares-Dias, 2016). This was the first report of *D. oxycephala* for *M. duriventre*. In *H. unitaeniatus*, the prevalence and abundance of metacercariae of *Posthodiplostomum* sp. were low, but there was a greater prevalence of *C. marginatum*. On the other hand, the levels of infection by *C. marginatum* were least that in *H. unitaeniatus* reported by Alcântara and Tavares-Dias (2015). Mollusk species are the primary intermediate hosts of the *Posthodiplostomum* and *C. marginatum* species, fish are the secondary intermediate hosts and fish-eating birds are the definitive hosts (Klaas, 1963; Ritossa et al., 2013). This is the first report of *Posthodiplostomum* sp. for *H. unitaeniatus*. Adults of *Caballerotrema aruanense* Thatcher, 1980 were found infecting only *O. bicirrhosum*, due to its host specificity. While the life cycle of this digenean is still unknown, it appears to use *O. bicirrhosum* as a definitive host. However, such levels of infection by digenean species are related to the life habits of these hosts, which in the ambient of the present study ingest mollusks containing infective forms.

Acanthocephalans Neoechinorhynchidae Ward, 1917 and Quadrigyridae Van Cleve, 1920 have amphipods, ostracods, isopods and copepods as their intermediate hosts, while fish are their paratenic hosts (Schmidt, 1985; Taraschewski, 2008). In *H. unitaeniatus*, levels of infection by *Quadrigyrus nickoli* Schmidt and Hugghins, 1973 were greater than those of *Neoechinorhynchus* sp. for *L. friderici*. Contrastingly, the levels of *Q. nickoli* in *H. unitaeniatus* were lower than those described for *Hyphessobrycon eques* (Fujimoto et al., 2013). Therefore, when arthropod species containing acanthella are swallowed by fish, this stage continues until the cystacanth stage.

CONCLUSIONS

The parasites community of *L. friderici*, *M. duriventre*, *H. unitaeniatus* and *O. bicirrhosum* was composed mainly by endoparasites in larval stages due to the feeding habits of these intermediate hosts, which can serve of food for definitive hosts. Furthermore, it was characterized by species with moderate prevalence and low abundance. There was little interspecies variation of parasites among the different hosts. The diversity of endoparasites using different organs of *H. unitaeniatus* indicates that species can coexist in the same fish because they occupy different sites in the host.

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REFERENCES

Abreu, C.H.M.; Cunha, A.C. 2015. Qualidade da água em ecossistemas aquáticos tropicais sob impactos ambientais no baixo Rio Jari-AP: Revisão descritiva. Biota Amazônia, 5(2): 119-131. http://dx.doi.org/10.18561/2179-5746/biotaamazonia.v5n2p119-131.

Alcântara, N.M.; Tavares-Dias, M. 2015. Structure of the parasites communities in two Erythrinidae fish from Amazon River system (Brazil). Revista Brasileira de Parasitologia Veterinária, 24(2): 183-190. http://dx.doi.org/10.1590/S1984-29612015039.

Amapá 2012. Áreas protegidas do Estado do Amapá. Macapá: CGTIA. 113p.

Ambiental 2013. Programa de Monitoramento da Ictiofauna. Ahe Santo Antônio do Jari. Consultoria, Estudos e Projetos Ltda; 199 p.

Barros, L.A.; Filho, J.M.; Oliveira, R.L. 2006. Nematóides com potencial zoonótico em peixes com importância econômica provenientes do rio Cuiabá. Revista Brasileira de Ciência Veterinária, 13(1): 55-57. http://dx.doi.org/10.22409/rbcv.v13i1.453.

Benigno, R.N.M.; São Clemente, S.C.; Matos, E.R.; Pinto, R.M.; Gomes, D.C.; Knoff, M. 2012. Nematodes in *Hoplerytrinus unitaeniatus, Hoplias malabaricus* and *Pygocentrus nattereri* (Pisces, Characiformes) in Marajó Island, Brazil. Revista Brasileira de Parasitologia Veterinária, 21(2): 165-170. http://dx.doi.org/10.1590/S1984-29612012000200018.

Bush, A.O.; Lafferty, K.D.; Lotz, J.M.; Shostak, W. 1997. Parasitology meets ecology on its own terms: Margolis et al. revisited. The Journal of Parasitology, 83(4): 575-583. http://dx.doi.org/10.2307/3284227.

Caffara, M.; Locke, S.A.; Gustinelli, A.; Marcogliese, D.J.; Fioravanti, M.L. 2011. Morphological and molecular differentiation of *Clinostomum complanatum* and *Clinostomum marginatum* (Digenea: Clinostomidae) metacercariae end adults. The Journal of Parasitology, 97(5): 884-891. http://dx.doi.org/10.1645/GE-2781.1.

Dias, M.L.G.G.; Eiras, J.C.; Machado, M.H.; Souza, G.T.R.; Pavanelli, G.C. 2003. The life cycle of *Clinostomum complanatum* Rudolphi, 1814 (Digenea, Clinostomidae) on the floodplain of the high Paraná river, Brazil. Parasitology Research, 89(6): 506-508. http://dx.doi.org/10.1007/s00436-002-0796-z.

Eiras, J.C.; Takemoto, R.M.; Pavanelli, G.C. 2006. Métodos de estudo e técnicas laboratoriais em parasitologia de peixes. Maringá: Ed. EDUEM; 171p.

Epe 2010. Bacia hidrográfica do Rio Jari / PA-AP: Estudos de inventário hidrelétrico. vol. 8/9. Empresa de Pesquisa Energética; 302 p.

Epe 2011. Estudo de inventário hidrelétrico/Relatório final: Avaliação ambiental integrada. vol. 1/2. Empresa de Pesquisa Energética; 302 p.

Froese, R.; Pauly, D. 2017. FishBase. [online] URL: <www.fishbase.org>.

Fujimoto, R.Y.; Barros, Z.M.N.; Diniz, D.G.; Marinho-Filho, A.N.; Eiras, J.C. 2013. First occurrence of *Quadrigyrus nickoli* (Acanthocephala) in the ornamental fish *Hyphessobrycon eques*. Revista Brasileira de Parasitologia Veterinária, 22(1): 110-113. http://dx.doi.org/10.1590/S1984-29612013000100020.

Guidelli, G.; Tavechio, W.L.G.; Takemoto, R.M.; Pavanelli, G.C. 2006. Fauna parasitária de *Leporinus lacustris* e *Leporinus friderici* (Characiformes, Anostomidae) da planície de inundação do alto Rio Paraná, Brasil. Acta Scientiarum. Biological Sciences, 28(3): 281-290. http://dx.doi.org/10.4025/actascibiolsci.v28i3.228.

Klaas, E.E. 1963. Ecology of the trematode *Clinostomum marginatum*, and its hosts in eastern Kansas. Transactions of the Kansas Academy of Science, 66(3): 519-538. http://dx.doi.org/10.2307/3626552.

Kohn, A.; Fernandes, B.M.M.; Cohen, S. 2007. South American trematodes parasites of fishes. Rio de Janeiro: Oficina de Livros. 318p.

Lizama, M.A.P.; Takemoto, R.M.; Pavanelli, G. 2008. Ecological aspects of metazoan parasites of *Astyanax altiparanae* Garutti & Britski, 2000 (Characidae) of the upper Paraná river floodplain, Brazil. Boletim do Instituto de Pesca, 34(4): 527-533.

Luque, J.L.; Aguiar, J.C.; Vieira, F.M.; Gibson, D.I.; Santos, C.P. 2011. Checklist of Nematoda associated with the fishes of Brazil. Zootaxa, 3082(10): 1-88.

Martins, M.L.; Santos, R.S.; Marengoni, N.G.; Takahashi, H.K.; Onaka, E.M. 2009. Seasonality of *Eustrongylides* sp. (Nematoda: Dioctophymatidae) larvae in fishes from Paraná river, South-Estern Brazil. Boletim do Instituto de Pesca, 35(1): 29-37.

Meneguetti, D.U.O.; Laray, M.P.O.; Camargo, L.M.A. 2013. Primeiro relato de larvas de *Eustrongylides* sp. (Nematoda: Dioctophymatidae) em *Hoplias malabaricus* (Characiformes: Erythrinidae) no Estado de Rondônia, Amazônia Ocidental, Brasil. Revista Pan-Amazônica de Saúde, 4(3): 55-58. http://dx.doi.org/10.5123/S2176-62232013000300008.

Moravec, F. 1998. Nematodes of freshwater fishes of the Neotropical region. Academia: Praha. 64 p.

Moravec, F. 2004. Some aspects of the taxonomy and biology of dracunculoid nematodes parasitic in fishes: a review. Folia Parasitologica, 51(1): 1-13. http://dx.doi.org/10.14411/fp.2004.001.

Moravec, F. 2009. Experimental studies on the development of *Contracaecum rudolphii* (Nematoda: Anisakidae) in copepod and fish paratenic hosts. Folia Parasitologica, 56(3): 185-193. http://dx.doi.org/10.14411/fp.2009.023.

Moreira, L.H.A.; Takemoto, R.M.; Yamada, F.H.; Ceschini, T.L.; Pavanelli, G.C. 2009. Ecological aspects of metazoan endoparasites of *Metynnis lippincottianus* (Cope, 1870) (Characidae) from upper Paraná River floodplain, Brazil. Helminthologia, 46(4): 214-219. http://dx.doi.org/10.2478/s11687-009-0040-9.

Navone, G.T.; Etchegoin, J.A.; Cremonte, F. 2000. *Contracaecum multipapillatum* (Nematoda: Anisakidae) from *Egretta alba* (Aves: Ardeidae) and comments on other species of this genus in Argentina. The Journal of Parasitology, 86(4): 807-810. http://dx.doi.org/10.1645/0022-3395(2000)086[0807:CMNAFE]2.0.CO;2.

Oliveira, M.S.B.; Corrêa, L.L.; Prestes, L.; Neves, L.R.; Brasiliense, A.R.P.; Ferreira, D.O.; Tavares-Dias, M. 2018. Comparison of the endoparasite fauna of *Hoplias malabaricus* and *Hoplerythrinus unitaeniatus* (Erythrinidae), sympatric hosts in the eastern Amazon region (Brazil). Helminthologia, 55(2): 157-165. http://dx.doi.org/10.2478/helm-2018-0003.

Oliveira, M.S.B.; Gonçalves, R.A.; Neves, L.R.; Tavares-Dias, M. 2015. Endohelmintos parasitos de *Metynnis hypsauchen* (Characidae) da bacia do Rio Jari, Amazônia brasileira. Neotropical Helminthology, 9(2): 235-242.

Oliveira, M.S.B.; Gonçalves, R.A.; Ferreira, D.O.; Pinheiro, D.A.; Neves, L.R.; Dias, M.K.R.; Tavares-Dias, M. 2017. Metazoan parasite communities of wild *Leporinus friderici* (Characiformes: Anostomidae) from Amazon River system in Brazil. Studies on Neotropical Fauna and Environment, 52(2): 146-156. http://dx.doi.org/10.1080/01650521.2017.1312776.

Oliveira, M.S.B.; Tavares-Dias, M. 2016. Communities of parasite metazoans in *Piaractus brachypomus* (Pisces, Serrasalmidae) in the lower Amazon River (Brazil). Revista Brasileira de Parasitologia Veterinária, 25(2): 151-157. http://dx.doi.org/10.1590/S1984-29612016022.

Petter, A.J. 1974. *Hoplerythrinus unitaeniatus* (Characidac, Cypriniformes) en Guyane; création d'une nouvelle famille: les Guyanemidae (Dracunculoidea). Zoologie, 156(7): 803-812.

Ritossa, L.; Flores, V.R.; Viozzi, G. 2013. Life cycle of a *Posthodiplostomum* species (Digenea: Diplostomidae) in Patagonia, Argentina. The Journal of Parasitology, 99(5): 777-780. http://dx.doi.org/10.1645/12-170.1.

Rohde, K.; Hayward, C.; Heap, M. 1995. Aspects of the ecology of metazoan ectoparasites of marine fishes. International Journal for Parasitology, 25(8): 945-970. http://dx.doi.org/10.1016/0020-7519(95)00015-T.

Santos, G.M.; Ferreira, E.J.G.; Zuanon, J.A.S. 2006. Peixes comerciais de Manaus. Manaus: Ibama/AM-PróVárzea, 144 p.

Schmidt, G.D. 1985 Development and Life Cycles. In: Crompton, D.W.T.; Nickol, B.B. Biology of the Acanthocephala. Cambridge: University Press. [online] Disponível em:: http://digitalcommons.unl.edu/parasitologyfacpubs/504 Acesso em: 18 de março de 2018

Schmidt, G.D.; Hugghins, E.J. 1973. Acanthocephala of South American Fishes. Part I, Eoacanthocephala. The Journal of Parasitology, 59(5): 829-835. http://dx.doi.org/10.2307/3278417.

Silva, E.F.; Tavares-Dias, M. 2012. Infection by helminths in *Mylossoma duriventre* Cuvier, 1817, a characid from the central Amazon, Brazil. Neotropical Helminthology, 6(1): 67-73.

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. 2nd ed. Manaus: Instituto Piatam: 160 p.

Takemoto, R.M.; Pavanelli, G.C.; Lizama, M.A.P.; Lacerda, A.C.F.; Yamada, F.H.; Moreira, L.H.A. 2009. Diversity of parasites of fish from the Upper Paraná River floodplain, Brazil. Brazilian Journal of Biology = Revista Brasileira de Biologia, 69(2, suppl.): 691-705. http://dx.doi.org/10.1590/S1519-69842009000300023.

Taraschewski, H. 2008. *Acanthocephala*. In: Eiras, J.C.; Segner, H.; Wahli, T.; Kapoor, B.G. Fish diseases. Enfield: Science Publishers. p. 1025-1062.

Tavares-Dias, M.; Sousa, T.J.S.M.; Neves, L.R. 2014. Parasitic Infections in two benthopelagic fish from Amazon: The Arowana *Osteoglossum bicirrhosum* (Osteoglossidae) and Oscar *Astronotus ocellatus* (Cichlidae). Bioscience Journal, 30(2): 546-555.

Thatcher, V.E. 1980. Duas novas espécies de *Caballerotrema* (Trematoda: Echinostomatidae) do pirarucu e aruanã (Osteoglossidae), com uma redefinição do gênero e uma redescrição de *Caballerotrema brasiliense* Prudhoe, 1960. Acta Amazonica, 10(2): 419-423. http://dx.doi.org/10.1590/1809-43921980102419.

Thatcher, V.E. 2006. Amazon fish parasites. 2nd ed. Moscow: Sofia. 507p.

Vicente, J.J.; Pinto, R.M. 1999. Nematoides do Brasil. Nematoides de peixes Atualização: 1985-1998. Revista Brasileira de Zoologia, 16(3): 561-610. http://dx.doi.org/10.1590/S0101-81751999000300001.