UFSM

CIÊNCIA e NATURA

ISSN 2179-460X
OPEN ACCESS

Ci. e Nat., Santa Maria, v. 48, e91106, 2026 • https://doi.org/10.5902/2179460X91106
Submitted: 03/08/2025 • Approved: 11/25/2025 • Published: 07/28/2026

Biology-Zoology

Metazoan parasites in *Biotodoma cupido* (Cichliformes: Cichlidae) from the Jari River basin, in Brazilian eastern Amazon region

Parasitas metazoários em *Biotodoma cupido* (Cichliformes: Cichlidae) da bacia do Rio Jari, na região da Amazônia oriental brasileira

Leonardo de Oliveira Mota-Júnior[I], Paulo Venicius Nascimento Santos[II], David Sales Sousa Valentim[I], Marcos Sidney Brito Oliveira[I,II], Marcos Tavares-Dias[I,III]

[I] Universidade Federal do Amapá, Macapá, AP, Brazil
[II] Universidade Estadual do Amapá, Macapá, AP, Brazil
[III] Empresa Brasileira de Pesquisa Agropecuária (Embrapa Amapá), Macapá, AP, Brazil

ABSTRACT

The aim of this study was to evaluate the community and infracommunities of metazoan parasites in *Biotodoma cupido* from the Jari River basin, in Brazilian Amazon. All fish (100%) were parasitized by one or more species, but hosts infected by three or four metazoan species predominated. A total of 3,052 parasites were recovered, comprising the following: *Biotodomella mirospinata*, *Procamallanus spiculastriatus*, larvae of *Spirocamallanus* sp., *Hysterothylacium* sp., *Ascocotyle* sp., Diplostomidae gen. sp. and *Genarchella genarchella*; and also, *Dolops geayi*, *Ergasilus* sp., *Therodamas* and Acarina gen. sp. However, the predominant finding was larvae of *Ascocotyle* sp. in the gills and the majority of the helminths found were larvae. Only *P. spiculastriatus* presented a random dispersion pattern, while the other species of metazoan parasites showed aggregated dispersion. The parasite species richness was 3.52 ± 0.76, Brillouin diversity index 0.48 ± 0.25, Berger-Parker dominance 0.83 ± 0.12, and evenness 0.22 ± 0.12; values that were considered low. Moreover, only the hosts' body weight showed a positive correlation with the species richness of metazoan parasites. There was a negative correlation between the abundance of *P. spiculastriatus* and host weight and length, while there were positive correlations between the abundance of *Ergasilus* sp. and *Therodamas* sp. and their hosts' weight and length. This first study on the community and infracommunities of parasites in *B. cupido* from eastern Amazon suggests that this cichlid is an intermediate host for some species of helminths, and possibly a definitive host for *P. spiculastriatus* in the ecosystem studied.

Keywords: Aggregation; Freshwater fish; Host; Parasitic infection

RESUMO

O objetivo deste estudo foi avaliar a comunidade e infracomunidades de parasitas metazoários em *Biotodoma cupido* da bacia do Rio Jari, na Amazônia brasileira. Todos os peixes (100%) estavam parasitados por uma ou mais espécies, mas hospedeiros infectados por três ou quatro espécies de metazoários predominaram. Um total de 3.052 parasitas foram recuperados, compreendendo os seguintes: *Biotodomella mirospinata*, *Procamallanus spiculastriatus*, larvas de *Spirocamallanus* sp., *Hysterothylacium* sp., *Ascocotyle* sp., Diplostomidae gen. sp. e *Genarchella genarchella*; e também *Dolops geayi*, *Ergasilus* sp., *Therodamas* sp. e Acarina gen. sp. No entanto, o achado predominante foi larvas de *Ascocotyle* sp. nas brânquias e a maioria dos helmintos encontrados eram larvas. Apenas *P. spiculastriatus* apresentou um padrão de dispersão aleatório, enquanto as outras espécies de parasitas metazoários apresentaram dispersão agregada. A riqueza de espécies de parasitas foi de 3,52 ± 0,76, índice de diversidade de Brillouin de 0,48 ± 0,25, dominância de Berger-Parker de 0,83 ± 0,12 e uniformidade de 0,22 ± 0,12; valores considerados baixos. Além disso, apenas o peso corporal dos hospedeiros apresentou correlação positiva com a riqueza de espécies de parasitas metazoários. Houve correlação negativa entre a abundância de *P. spiculastriatus* e o peso e comprimento do hospedeiro, enquanto houve correlações positivas entre a abundância de *Ergasilus* sp. e *Therodamas* sp. e o peso e comprimento de seus hospedeiros. Este primeiro estudo sobre a comunidade e infracomunidades de parasitas em *B. cupido* da Amazônia oriental sugere que este ciclídeo é um hospedeiro intermediário para algumas espécies de helmintos, e possivelmente um hospedeiro definitivo para *P. spiculastriatus* no ecossistema estudado.

Palavras-chave: Agregação; Peixe de água doce; Hospedeiro; Infecção parasitária

1 INTRODUCTION

Cichlidae are one of the most abundant fish families in a variety of aquatic ecosystems and have diversified morphology. This richness, diversity and wide distribution occur particularly in Brazil and other countries of the Amazon basin (Borges et al., 2018; Oliveira & Graça, 2024). Cichlidae are the third most species-rich family in the Neotropical region, and this region accounts for 571 valid species out of the total of 1749 in the family. In general, cichlid species have high diversification of color patterns, feeding habits, breeding and other behavioral characteristics (Oliveira & Graça, 2024).

Among the South American cichlids, the cupid cichlid *Biotodoma cupido* (Heckel 1840) (= *Geophagus cupido*) is distributed throughout the Amazon River basin (Peru, Bolivia and Brazil) and the Essequibo River, in Guyana; and Tocantins drainage basins, which flows into the Atlantic Ocean alongside the Amazon Delta (Cichocki, 1977; Kullander, 2003; Froese & Pauly, 2025). *Biotodoma cupido* is a

benthopelagic fish of around 12 cm in length and omnivorous feeding habit. It mainly consumes algae and aquatic invertebrates. It lays its eggs in stages and becomes sexually mature when it reaches 6 cm in length (Cichocki, 1977; Santos et al., 2004; Froese & Pauly, 2025). Like in other cichlid species, males of *B. cupido* that are of reproductive age are generally larger than females of this age (Santos et al., 2004). Couples with offspring present aggressive protective behavior against predatory fish (Cichocki, 1977). The feeding habit of host fish can favor the presence of metazoan parasite species and patterns of infections. In food web, trophically transmitted helminth parasites use predator-prey links for their transfer from intermediate hosts, in which they occur as larval or juvenile stages, as well as to predatory definitive hosts, in which they reach adult phase (Poulin & Leung, 2011; Mota-Júnior et al., 2024).

Since little is known about the biology of *B. cupido*, this fish does not appear on the International Union for Conservation of Nature (IUCN) list. In addition, few studies have been investigated the parasite fauna of *B. cupido*, which were concentrated in the Brazilian western Amazon (Virgilio et al., 2021, 2022; Souza-Neto et al., 2023; Lima et al., 2024), while taxonomic studies have reported two new monogenean species for this host fish from the Peruvian Amazon (Morey et al., 2019, 2024). From these reports previously cited, the parasites in *B. cupido* comprise some species of Acanthocephala, Digenea, Monopisthocotyla and Nematoda. Therefore, there is a need for additional studies covering other Amazon ecosystems, in order to expand our knowledge of the diversity and ecology of parasites infesting *B. cupido*.

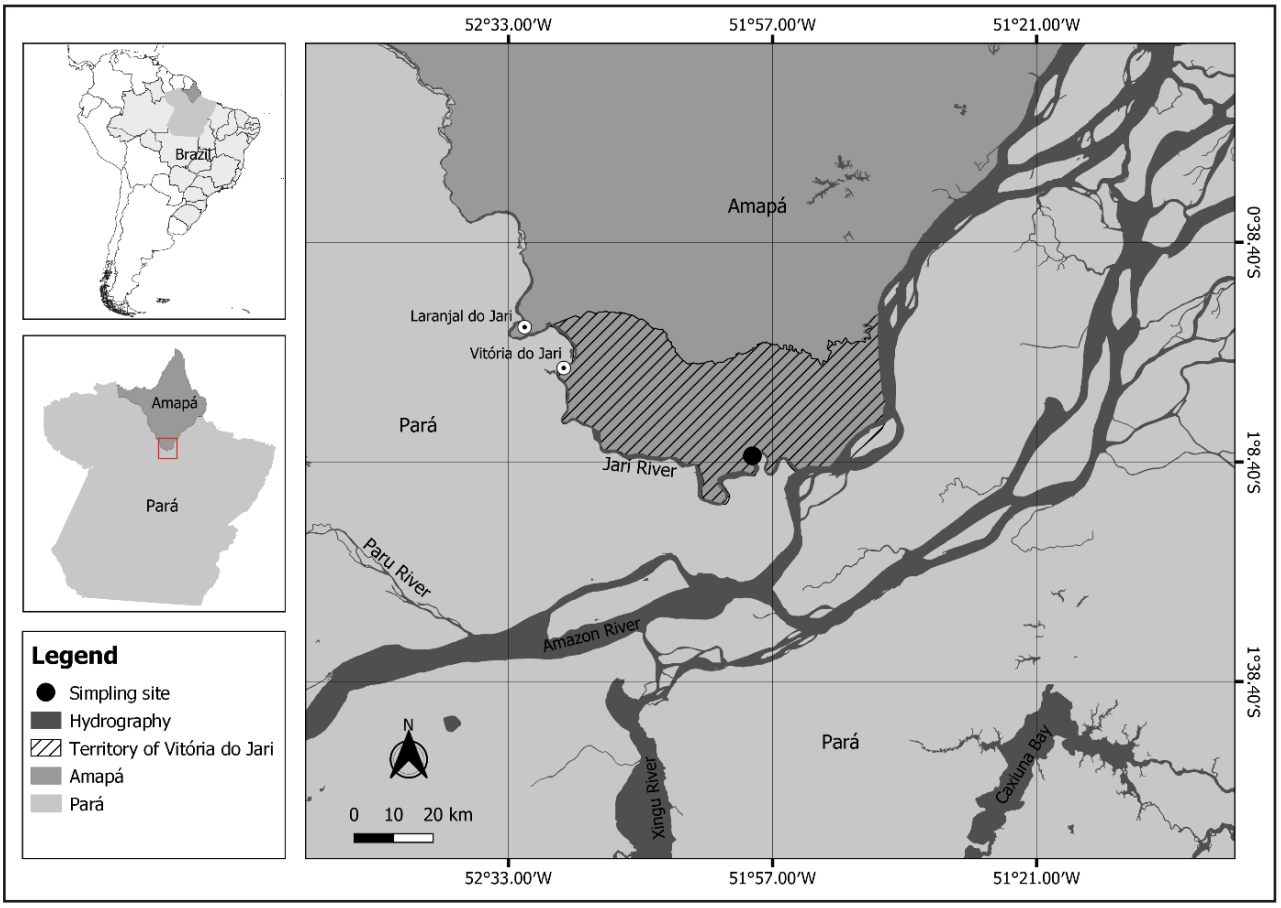
In different host fish populations, the distribution of parasites may be affected by diverse factors such as seasonality, age of host, size, diet, social behavior, physiology, density of fish, etc. (Felizardo et al., 2009; Borges et al., 2018; Timi & Poulin, 2020; Bissagio et al., 2023; Amaral et al., 2023, Mota-Júnior et al., 2024). Among vertebrates, fish are organisms that present high rates of parasitism due to characteristics of aquatic environments that are favorable to development of

the life cycles of different host species (e.g., fish and aquatic invertebrates) with various means of transmission that relate to a variety of aspects of these host populations (Guidelli et al., 2003; Timi & Poulin, 2020; Virgilio et al., 2022; Bissagio et al., 2024; Mota-Júnior et al., 2024). Consequently, these organisms can be used to complement important studies on the composition of the communities and infracommunities of wild fish populations, and they also form indirect indicators of the diversity of free-living invertebrates that make up the biological cycles of these fish populations in their ecosystems (Borges et al., 2018; Timi & Poulin, 2020; Bissagio et al., 2023; Mota-Júnior et al., 2024). Furthermore, the abundance of metazoan parasites is also dependent on the population densities of intermediate and definitive hosts present in aquatic ecosystems, as well as on predator-prey interactions that can influence the parasitic infection levels in populations of wild fish (Amaral et al., 2023; Mota-Júnior et al., 2024). Thus, the aim of this study was to evaluate the community and infracommunities of metazoan parasites in *B. cupido* from the Jari River basin, in the eastern Amazon region of Brazil.

2 MATERIALS AND METHODS

Thirty-one specimens of *B. cupido* were collected from the lower reaches of the Jari River, in the region of the Jarilândia District, municipality of Vitória do Jari, in the state of Amapá, Brazil (Figure 1), during rainy season. The Jari River is an important tributary of the Amazon River in the eastern Amazon region of Brazil. It originates from the Tumucumaque mountains, on the border between Brazil, Suriname and French Guiana, and goes through several municipalities in the state of Amapá (Lucas et al., 2010; Borges et al., 2019; Mota-Junior et al., 2024). The Jari River basin is delimited to the north by Suriname and French Guiana, to the south by the Amazon River, to the east by the state of Amapá and to the west by the state of Pará. This river is strongly influenced by the daily tides of the Amazon River.

Figure 1 – Sampling site of *Biotodoma cupido* in Jari River basin, in region from the eastern Amazon (Brazil)



Source: Authors (2025)

Because of its location, the Jari River basin faces major natural environmental vulnerability, such as overflows and urban flooding. The influence of riverbank settlements is among the causes of these adverse environmental effects, given that these have caused alignment changes to the main bed of the Jari River, along with sanitary problems (Lucas et al., 2010; Mota-Júnior et al., 2024). These effects may in the future intensify the adverse implications of extreme natural events, as has occurred in the past, which may have diversified and intensified the environmental and sanitary problems of this hydrographic basin (Lucas et al., 2010; Oliveira & Cunha, 2015). In addition, while the vegetation along its riverbanks consists of tropical rainforest, the southern part of the basin has become subject to anthropic actions, through which the original vegetation cover has given way to agricultural activities and silvicultural farms (Borges et al., 2019; Mota-Júnior et al., 2024).

The fish of this study were collected using nets with mesh sizes of 25 and 30 mm between knots. Each fish was weighed (g) and a standardized length measurement (cm) was made. The fish were then necropsied for parasitological analyses. The mouth, gills, opercula and fins were examined to ascertain any presence of ectoparasites, while the viscera and gastrointestinal tract were examined for any presence of endoparasites. The collection, fixing, conservation and preparation of the parasites for identification followed previous recommendations (Eiras et al., 2006; Thatcher, 2006). The ecological terms used (prevalence, mean intensity and mean abundance) were as described by Bush et al. (1997). The parasites were identified in accordance with the recommendations of Thatcher (2006), Kohn et al. (2007), Pinheiro et al. (2018) and Morey et al. (2019) using a microscope (Leica DM 5500B).

The following were determined: Brillouin diversity index (*HB*), evenness (*E*), Berger-Parker dominance index (*d*), parasite species richness (Magurran, 2004) and frequency of dominance, i.e., the percentage of the infracommunities in which a given parasite is numerically dominant (Rohde et al., 1995; Magurran, 2004). The diversity index was assessed using the Diversity software (Pisces Conservation Ltd, UK).

The dispersion index (DI) and Poulin discrepancy index (D) were calculated using the Quantitative Parasitology 4.0 software (web version), to detect the distribution pattern of the metazoan parasite infracommunities (Reiczigel et al., 2019) for species with prevalence >10%. The significance of the DI was calculated for each infracommunity using the *d*-statistical test (Ludwig and Reynolds, 1988). Spearman's correlation coefficient (*rs*) was used to determine possible correlations between parasite abundance and host length, host weight, Brillouin diversity index and parasite species richness, among the hosts examined (Zar, 2010).

This study was authorized by the Ethic Committee for the Use of Animals of Embrapa Amapá (Protocol No. 014/2018-CPAFAP). Ethics approval for obtaining access to genetic heritage was authorized by the Brazilian Ministry of the Environment (SISBio No. 73550-1 and SisGen No. A604361).

3 RESULTS

Fish of both sexes were fish examined and presented mean weight of 38.5 ± 14.4 g (11.3-68.5) and mean length of 12.3 ± 2.0 cm (8.0-16.5).

All the fish examined were parasitized (100%) by one or more metazoan species, and a total of 3,052 parasites were collected, comprising the following taxa: *Biotodomella mirospinata* Morey, Arimuya & Boeger 2019 (Dactylogyridae); *Procamallanus spiculastriatus* Pinheiro, Melo, Monks, Santos & Giese 2018 (Camallanidae); *Spirocamallanus* Olsen 1952 (Camallanidae); *Hysterothylacium* Ward & Magath 1917 (Raphidascarididae); *Ascocotyle* Looss 1899 (Heterophyidae); Diplostomidae gen. sp.; *Genarchella genarchella* Travassos, Artigas & Pereira 1928 (Derogenidae); *Dolops geayi* Bouvier 1897 (Argulidae); *Ergasilus* Nordmann 1832, *Therodamas* Krøyer 1863 (Ergasilidae); and Acarina gen. sp. However, the metazoan parasite community was dominated by larvae of *Ascocotyle* sp. on the hosts' gills (Table 1).

Table 1 – Metazoan parasites in *Biotodoma cupido* (N = 31) from the Jari River basin, in eastern Amazon region (Brazil)

Species of parasites	P (%)	MI	MA	FD (%)	NTP	SI
Biotodomella mirospinata	90.3	9.4	7.8 ± 7.9	8.6	262	Gills
Procamallanus spiculastriatus	61.3	4.4	3.0 ± 3.4	3.0	92	Intestine
Spirocamallus sp. (larvae)	6.5	1.0	0.06 ± 0.2	0.07	2	Intestine
Hysterothylacium sp. (larvae)	9.7	3.7	0.4 ± 1.2	0.4	11	Intestine
Ascocotyle sp. (larvae)	100	84.6	84.6 ± 53.0	85.9	2623	Gills
Displostomidae gen. sp. (larvae)	9.7	1.3	0.1 ± 0.4	0.1	4	Gills
Genarchella genarchella (larvae)	9.7	0.1	0.1 ± 0.1	0.1	3	Gills
Dolops geayi	3.2	0.3	0.3 ± 0.2	0.3	1	Gills
Ergasilus sp.	25.8	3.5	0.9 ± 1.7	0.9	28	Gills
Therodamas sp.	22.6	2.6	0.7 ± 1.5	0.8	23	Gills
Acarina gen. sp.	6.5	0.1	0.1 ± 0.1	0.1	3	Gills

P: Prevalence, MI: Mean intensity, AM: Mean abundance, FD: Frequency of dominance, TNP: Total number of parasites, SI: Site of infection.
Source: Authors (2025)

The parasites of *B. cupido* presented an aggregated dispersion pattern, but for *Ergasilus* sp. and *Therodamas* sp. this pattern was high, while for *P. spiculastriatus* the dispersion pattern was random (Table 2).

Table 2 – Dispersion index (DI), *d*-statistic and discrepancy index (D) for the metazoan parasite infracommunities of *Biotodoma cupido* (N=31) from the Jari River basin, in eastern Amazon region (Brazil)

Species of parasites	DI	D	*d*	Dispersion type
Biotodomella mirospinata	1.81	0.33	2.74	Aggregated
Procamallanus spiculastriatus	1.23	0.50	0.91	Random
Ascocotyle sp.	2.61	0.32	4.83	Aggregated
Ergasilus sp.	1.66	0.75	2.30	Aggregated
Therodamas sp.	2.04	0.79	3.38	Aggregated

Source: Authors (2025)

The parasite species richness ranged from 2 to 5, Brillouin diversity index 0.11 to 0.95, Berger-Parker dominance index 0.53 to 0.97, and evenness 0.06 to 0.46 (Table 3).

Table 3 – Diversity descriptors for the metazoan parasite community in *Biotodoma cupido* (N=31) from the Jari River basin, in eastern Amazon region (Brazil)

Diversity indices	Mean ± SD	Ranges
Species richness	3.52 ± 0.76	2-5
Brillouin diversity index (*HB*)	0.48 ± 0.25	0.11-0.95
Berger-Parker dominance index	0.83 ± 0.12	0.53-0.97
Evenness (*E*)	0.22 ± 0.12	0.06-0.46

SD: Standard deviation.
Source: Authors (2025)

The correlation between the Brillouin diversity index (*rs* = 0.038, p = 0.84) and host fish length was not significant, nor was the correlation with body weight (*rs* = 0.05, p = 0.77). Parasite species richness (*rs* = 0.338, p = 0.06) also did not show any correlation with fish weight, but it showed a positive correlation (*rs* = 0.41, 0.02) with host weight.

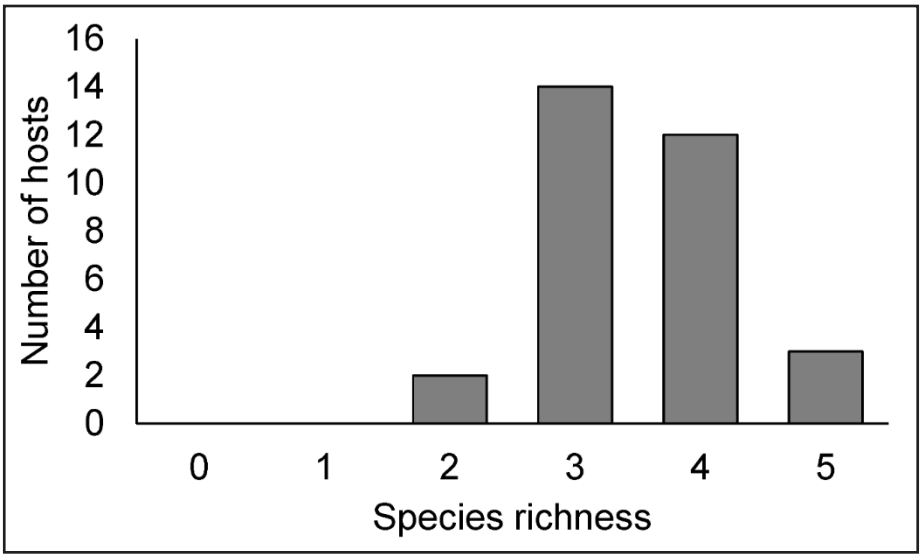
There was a significant negative correlation between the abundance of *P. spiculastriatus* and the weight and body length of the hosts. There was a significant positive correlation between the abundance of *Ergasilus* sp. and the weight and length of the fish examined, and also a positive correlation between the abundance of *Therodamas* sp. and host weight and length (Table 4). There was a predominance of hosts parasitized by three or four species (Figure 2).

Table 4 – Spearman's correlation coefficient (*rs*) of metazoan parasite abundance with body length and weight of *Biotodoma cupido* (N = 31) from the Jari River basin, eastern Amazon region (Brazil)

Body parameters	**Weight (g)**		**Length (cm)**	
Species of parasites	***rs***	***p***	***rs***	***p***
Biotodomella mirospinata	0.192	0.301	0.172	0.353
Procamallanus spiculastriatus	**- 0.551**	0.001	**-0.533**	0.002
Ascocotyle sp.	0.220	0.221	0.211	0.255
Ergasilus sp.	**0.535**	0.001	**0.491**	0.005
Therodamas sp.	**0.620**	0.002	**0.630**	0.001

Source: Authors (2025)

Figure 2 – Species richness of metazoan parasites in Biotodoma cupido from the Jari River basin, in the eastern Amazon (Brazil)



Source: Authors (2025)

4 DISCUSSION

Biotodoma cupido from the Jari River were all parasitized (100%), with hosts presented one or more metazoan species, and the parasites found were: *P. spiculastriatus*, *Hysterothylacium* sp., *Ascocotyle* sp., *G. genarchella*, *D. geayi*, *Ergasilus* sp., *Therodamas* sp. and Acarina gen. sp. These are all metazoan parasites described here for the first time, and presented varying levels of infection. However, the levels of Acarina gen. sp. were lower than those reported for *Aequidens tetramerus* Heckel 1840 (Borges et al., 2019) and for *Crenicichla strigata* Günther, 1862 (Mota-Júnior et al., 2024), both cichlid species from the same basin of this study. In addition, this was the first report of *B. mirospinata* for *B. cupido* from Brazil, because Morey et al. (2019) proposed this new to accommodate this monogenean species, which was found infecting the gills of this same host from the Nanay River, in Peru. However, the prevalence and mean intensity of infection by *B. mirospinata* reported by Morey et al. (2019) were lower than in the *B. cupido* gills of the present study. Recently, Morey et al. (2024) described *Sciadicleithrum amazoniensis* Morey, Dávila, Arimuya, Sousa, Cruces & Chero of the *B. cupido* gills collected from the Tanshi creek, Loreto region, Peru; nonetheless, we not found this species of monogenean in the hosts examined here.

For *B. cupido*, other species of metazoan parasites that were not found in the hosts examined from the Jari River have been reported. Among these parasites are *Neoechinorhynchus* sp.; *Crassicutis cichlasomae* Manter, 1936; *Genarchella isabellae* Lamothe-Argumedo, 1977; *Thometrema* sp.; *Sciadicleithrum* sp.; Nematoda gen. sp.; *Contracaecum* sp.; *Cosmoxynemoides aguirrei* Travassos, 1949; *Spirocamallanus peraccuratus* Pinto, Fábio, Noronha & Rolas, 1976; *Spirocamallanus inopinatus* Travassos, Artigas & Pereira, 1928; *Spirocamallanus pimelodus* Pinto, Fábio, Noronha & Rolas, 1974 and *Pseudoproleptus* sp. (Virgilio et al., 2021, 2022; Souza-Neto et al., 2023; Santillán et al., 2024; Lima et al., 2024). Most of these species of metazoan parasites are helminths reported for *B. cupido* of different rivers in the state of Acre, western Amazon region,

in Brazil. Therefore, these distinct results for *B. cupido* can be attributed to differences in the environment in which this Amazonian cichlid species was examined.

Infections in the gills of *B. cupido* by *B. mirospinata*, *Ergasilus* sp., *Therodamas* and *Ascocotyle* sp. showed pattern of aggregated dispersion; while intestinal nematode *P. spiculastriatus* presented random dispersion pattern, which may be associated with diminished opportunity for colonizing this host population or may be due to its pathogenicity (Guidelli et al., 2003). Similarly, pattern of random dispersion has been also reported for species of monogeneans, nematodes and digenean of *C. strigata* (Mota-Júnior et al., 2024). Aggregated dispersion pattern has been the more frequent in different wild freshwater fish populations (Guidelli et al., 2003; Borges et al., 2019; Neves et al., 2020; Bissagio et al., 2023; Mota-Júnior et al., 2024). This pattern may increase the stability of the parasite-host relationship, given that regulatory mechanisms for parasite populations (e.g., mortality and reduction of fecundity and survival, which are dependent on population density, etc.) may influence a large proportion of these populations (Guidelli et al., 2003; Poulin, 2013; Timi and Poulin, 2020). Moreover, aggregated dispersion may also be related to environmental, behavioral and genetic factors of the host population, and to its immunological susceptibility to parasitic infections; factors that may control the size of parasite and host populations in natural ecosystems (Poulin, 2013; Borges et al., 2019; Mota-Júnior et al., 2024).

In *B. cupido* from the Jari River, ectoparasites predominated over endoparasites, especially at the larval stage on the gills. This may indicate the existence of an accumulative effect among helminth species during this initial stage of their development, as reported for *Hemisorubim platyrhynchos* Valenciennes, 1840 from the Paraná River (Guidelli et al., 2003). On the other hand, for *C. strigata* from Jari River, similar pattern in the occurrence of ectoparasites and endoparasites in larval and adult stage has been reported (Mota-Júnior et al., 2024). Furthermore, this presence of larval stage of helminth species in the population of *B. cupido* from the Jari River

indicates that this host fish constitutes an important link in the transmission of these parasites within the trophic network; occupying, therefore a lower position in the food web (Bissagio et al., 2023; Mota-Júnior et al., 2024).

In *B. cupido* from the Jari River, diversity index of Brillouin was lower that reported for this same host from the Juruá River, in the Brazilian western Amazon, while the Berger-Parker dominance index was similar to reported by Lima et al. (2024). However, Lima et al. (2024) determined the parasite species richness using the total number of species found in this host population, which made comparison with our results impossible regarding this diversity descriptor.

The genus *Procamallanus* Baylis, 1923, comprises numerous nematode species that can infect marine and freshwater fish species. These species are widely distributed in several zoogeographical regions (Pinheiro et al., 2018; Ailán-Choke et al., 2018; Amaral et al., 2023). They generally do not cause much damage to their host fish, except when the host's health status is compromised by environmental stress, which increases the host's susceptibility to parasites and leads to high levels of infection (Amaral et al., 2023). *Procamallanus spiculastriatus* is a nematode that was described for the first time infecting the intestine of the cichlids *Astronotus ocellatus* Agassiz 1831, coming from a lake in the Botanical Garden of the capital of the state of Pará, Brazil (Pinheiro et al., 2018). Thus, the present study provides the second report of *P. spiculastriatus*, which had prevalence similar to that *of A. ocellatus*, while mean intensity and mean abundance were lower than reported by Pinheiro et al. (2018). Although the life cycle of *P. spiculastriatus* is yet unknown, studies on other species of the genus *Procamallanus* have suggested that different copepod species are intermediate hosts for these Camallanidae. After ingestion by copepods, the first-stage larvae of *Procamallanus* spp. penetrate the hemocele of these intermediate hosts (e.g., *Mesocyclops* spp. and *Diaptomus* spp.) and reach the infective stage. Fish are definitive hosts and acquire species of these camallanids by feeding on copepods containing infective stages of these nematodes (Neves et al., 2020).

Larvae of *Hysterothylacium* have been reported in several species of freshwater and marine fish (Felizardo et al., 2009; Khammassi et al., 2020; Cárdenas et al., 2021), and some species may present zoonotic potential for humans (Cárdenas et al., 2021), in addition histopathological alterations in host fish populations (Felizardo et al., 2009). Recently, Khammassi et al. (2020) studying morphological and molecular aspects of *Hysterothylacium* larvae in marine fish from Tunisian coast, cited that this genus includes about 101 marine and freshwater species. *Biotodoma cupido* from the Jari River had low levels of infection by larvae of *Hysterothylacium* sp. compared with 11 specimens of *Hypophthalmus marginatus* Valenciennes 1840 from the Tocantins River (Brazil), which presented ranges of 4-321 nematodes/fish, with a total of 1,606 larvae recovered (Cárdenas et al., 2021). Larvae of *Hysterothylacium* use invertebrates as an intermediate host, and the definitive hosts include fish, birds, reptiles or marine mammals. Studies on the mollusk *Diplodon suavidicus* Lea, 1856 from the Brazilian Amazon basin demonstrated the occurrence of *Hysterothylacium* larvae parasitizing the pericardial cavity of this host. These results suggest that this mollusk species may act as an intermediate host for *Hysterothylacium* larvae in the ecosystem studied (Lopes et al., 2011). Therefore, considering that aquatic invertebrates are a component of the diet of *B. cupido* (Cichocki, 1977; Santos et al., 2004); larvae of *Hysterothylacium* sp. found in the intestine of this fish suggest it may be ingesting small mollusks infected with larvae of this nematode, acting thus as a second intermediate host. However, this still requires further investigations.

In general, digenean species requires different host organisms to complete their life cycle. Fish can act as intermediate and/or definitive hosts for digeneans and generally form links in the food web of aquatic ecosystems. These trophically transmitted parasites are central elements in most aquatic food webs and influence host community and food web structures while infecting diverse groups of invertebrate and vertebrate hosts. Parasites with a complex life cycle have a strong impact on ecosystems and food webs. Thus, these parasites have effects on fish populations at both community and ecosystem levels (Guerrero et al., 2019; Kandambeth et al., 2023; Mota-Júnior et

al., 2024). Species of *Ascocotyle* are common digeneans found in the adult stage in fish-eating birds and mammals. Their metacercariae can become encysted in the body musculature, heart, stomach, liver, kidney, spleen, gonads, mesentery, intestine or gills of fresh, brackish and marine-water fish (Guerrero et al., 2019; Santos and Borges, 2020). On the gills of *B. cupido* from the Jari River, metacercariae of *Ascocotyle* were found at higher infection levels than reported for the gills of *Odontesthes argentinensis* Valenciennes, 1835 from La Plata River, Argentina and Uruguay region (Guerrero et al., 2019). Thatcher (2006) demonstrated tumorous growth in the gill filaments of fish infected by a single metacercaria of *Ascocotyle* sp. In addition, the levels of infection by metacercariae of Diplostomidae gen. sp. in the gills of *B. cupido* were similar to those found for metacercariae of *G. genarchella*. Therefore, the consumes aquatic invertebrates by *B. cupido* may have favor the presence of these helminth species and infection levels found in the population of hosts, because all these parasites are trophically transmitted, using predator-prey interaction.

Crustaceans are important components of the invertebrate aquatic fauna of several environments. These species of ectoparasites include some representatives that are free-living, while others have a parasitic lifestyle (Oliveira et al., 2021) that only needs a single host fish. We found *Therodamas* sp. on gills of *B. cupido* from the Jari River, which is a new species of this Ergasilidae. In *B. cupido*, levels of infection by *Therodamas* sp. were similar to what was previously reported for *Leporinus fasciatus* Bloch, 1794 from the Jari River infected by *Therodamas longicollum* Oliveira, Corrêa, Adriano & Tavares-Dias, 2021 (Oliveira et al., 2021). However, the infection levels were higher than the reported for *Pterygoplichthys pardalis* Castelnau, 1855 from the Manaus city, in state of Amazonas, Brazil infected by *Therodamas elongatus* Thatcher, 1986 (Caracciolo et al., 2023). Nonetheless, as few species of these ergasilids have been described, its interaction with host fish populations is yet unknown.

Dolops geayi was also found in the gills of *B. cupido* from the Jari River, but at infection levels lower than reported for *Hoplias malabaricus* Bloch, 1794 from Janauacá

Lake, state of Amazonas, Brazil (Malta 1982). Low levels of infection by *D. geayi* were also found by Mota-Júnior et al. (2024) for *C. strigata* from the Jari River. Furthermore, low levels of infection by *Ergasilus* sp. in the *B. cupido* gills from the Jari River were also found.

Body size (weight and length) of host fish plays an important role in susceptibility to parasitism, growth and development of the parasitic community. Consequently, it has major implications regard dynamics of infections and for parasite-host interactions (Guidelli et al., 2003; Borges et al., 2019; Amaral et al., 2023; Mota-Júnior et al., 2024). Larger fish, are older and provide larger surface areas which parasites to attach and are considered to habitats that are more stable for them (Amaral et al., 2023; Bisaggio et al., 2023; Mota-Júnior et al., 2024). Parasites that present greater longevity living usually in smaller-sized fish, which offer less habitat for attachment, even though those parasites need their hosts for its survival (Amaral et al., 2023; Bisaggio et al., 2023). For *B. cupido* from the Jari River, the abundance of *P. spiculastriatus* decreased with growth in weight and body length, while the abundance of *Ergasilus* sp. and *Therodamas* sp. increased with growth in weight and body length of the hosts. Similarly, positive or negative correlations with the abundance of different species of metazoan parasites were previously reported for *H. platyrhynchos* (Guidelli et al., 2003), for *Gymnogeophagus balzanii* Perugia, 1891 (Bisaggio et al., 2023) and *C. strigata* (Mota-Júnior et al., 2024. In contrast, for *A. tetramerus* was not demonstrate any correlation between the abundance of parasite species and the body size of the hosts examined (Borges et al., 2019). Thus, body size may or may not influence the abundance of parasites in host fish population, because correlation of parasite abundance with both body parameters is not universal (Poulin, 2004; Poulin & Leung, 2011).

6 CONCLUSIONS

This first study on the community and infracommunities of parasites in *B. cupido* showed that there was low species richness, a low diversity index and low evenness, with predominance of *Ascocotyle* sp. on the gills, which is the infection site with highest

occurrence among metazoan parasites. The presence of larvae and adult stages of helminths, indicate that this fish is an intermediate and definitive host. Host size did not have a predominant effect on the diversity and species richness of metazoan parasites. The body size of *B. cupido* partly explains the occurrence of metazoan parasites found, because its feeding behavior and the availability of infectious stages of metazoans were also factors structuring of the community and infracommunities of these parasites. Lastly, with these current knowledges on metazoan parasites that *B. cupido* harbors and anthropic interferences caused by the industrial and urban activities in the Jari River basin, future studies must be carried out for understanding and evaluating the possible effects of these impacts in the parasite ecology of this host fish.

ACKNOWLEDGEMENTS

The authors thank the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) for the productivity research grant awarded to xxx (Grant No. 301911/2022-3) and for the Master's scholarship awarded to the first author (No. 162203/2022-5).

CONFLICT OF INTEREST

The authors manifest not having any type of conflict of interest.

REFERENCES

Ailán-Choke, L. G., Ramallo, G., & Davies, D. (2018). Further study on *Procamallanus* (*Spirocamallanus*) *pintoi* (Kohn et Fernandes, 1988) (Nematoda: Camallanidae) in *Corydoras paleatus* and *Corydoras micracanthus* (Siluriformes: Callichthyidae) from Salta, Argentina, with a key to congeneric species from Neotropical Realm. Acta Parasitol., 63: 595–604. https://doi: 10.1515/ap-2018-0068

Amaral, R. B., Leão, G.R., Campos, T. N. S., Borges, K. M., Grano-Maldonado, M. I., Lino, C. N. R, Takemoto, R. M., Rocha, T. L., & Damacena-Silva, L. (2023). Abundance of *Procamallanus* (*Spirocamallanus*) *inopinatus* (Nematoda: Camallanidae) in Characiformes fish and associated factors in Midwest Brazil. An. Acad. Bras. Cienc. 95(Suppl. 2): e20220978. https://doi.org/10.1590/0001-3765202320220978

Bisaggio, F. P., Malta, L. S., Paiva, F., Elisei, C., & Tavares, L. E. R. (2023). First assessment of the metazoan parasite community of *Gymnogeophagus balzanii* (Cichliformes: Cichlidae) from Pantanal wetlands, state of Mato Grosso do Sul, Brazil. J. Natural Hist. 57(1-4): 130-141. https://doi.org/10.1080 /00222933.2022.2161965

Borges, W. F., Santos, G. G., Oliveira, M. S. B., & Tavares-Dias, M. (2019). Parasites in gills of *Aequidens tetramerus*, cichlid from the lower Jari River, a tributary of the Amazon River, northern Brazil. Bol. Inst. Pesca 45(1):e.485. https:// doi.org/10.20950/1678-2305.2019.45.1.485DOI: 10.20950/1678-2305.2019.45.1.485

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

Caracciolo, M. E., Porto, D. B., Mourão, M. P.G., Malta, J. C. O. M., & Souza, W. (2023). Fauna of metazoan parasites of *Pterygoplichthys pardalis* (Castelnau, 1855) sold at fairs in the city of Manaus, state of Amazonas, Brazil. Acta Sci. Biol. Sci. 45: e68798. https://doi.org/10.4025/ actascibiolsci.v45i1.68798.

Cárdenas, M. Q., Justo, M. C. N., Viana, D. C., & Cohen, SC. (2021). New host record and geographical distribution of Nematoda parasitizing *Hypophthalmus marginatus* Valenciennes (Siluriformes) from the Tocantins River, Brazil. Acta Acta Sci. Biol. Sci. 43: e58014. https://doi.org/10.4025/actascibiolsci. v43i1.5801

Cichocki, F.P. (1977). Tidal cycling and parental behavior of the cichlid fish, *Biotodoma cupido*. Env. Biol. Fish 2: 159-169. https://doi.org/10.1007/ BF00000407

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

Felizardo, N. N., Menezes, R. C., Tortelly, R., Knoff, M., Pinto, R. M., & Gomes, D. C. (2009). Larvae of *Hysterothylacium* sp. (Nematoda: Anisakidae) in the sole fish *Paralichthys isosceles* Jordan, 1890 (Pisces: Teleostei) from the littoral of the state of Rio de Janeiro, Brazil. Vet. Parasitol., 166:175-177. https://doi.org/ 10.1016/j.vetpar. 2009.08.004

Froese, R. and D. Pauly. Editors. (2025). FishBase. World Wide Web electronic publication. Available in: www.fishbase.org, version (04/2025).

Guerrero, D.C., Di Falco, O. C., Tourné, M. L., & Noschesi, A.P. (2019). Spatial distribution of two digenea metacercariae in gills of the silverside *Odontesthes argentinensis* (Atheriniformes) from de La Plata River (Uruguay, southwestern Atlantic Ocean). Neotrop. Helminthol. 13(1): 41-47.

Guidelli, G. M., Isaac, A., Takemoto, R. M., & Pavanelli, G.C. (2003). Endoparasite infracommunities of *Hemisorubim platyrhynchos* (Valenciennes, 1840) (Pisces: Pimelodidae) of the Baía River, Upper Paraná River floodplain, Brazil: specific composition and ecological aspects. Braz. J. Biol., 63: 261-268. https://doi.org/ 10.1590/S1519-69842003000200011

Kandambeth, P. P., Veettil, N. P., Janardhanan, J. P., & Chacko, S. (2023). Checklist of digenean fauna infecting fishes of Kerala region, India. J. Parasit. Dis. 47(3):566–590. https://doi.org/10.1007/ s12639-023-01589-4

Khammassi, M., Bahri, S., & Pekmezci, G.Z. (2020). Morphological and molecular identification of *Hysterothylacium* larvae (Nematoda: Raphidascarididae) in marine fish from Tunisian Mediterranean coasts. Parasitol. Res., 119:3285–3296. https://doi.org/10.1007/ s00436-020 -06848-4

Kohn, A., Fernandes, B. M. M., & Cohen, S. C. (2007). *South American Trematodes parasites of fishes.* Rio de Janeiro: Imprinta Express.

Kullander, S. O. (2003). Family Cichlidae. *In*: Reis, R. E., Kullander, S. O., & Ferraris, C. J. Jr, (Eds). *Check list of the freshwater fishes of South and Central America* (pp. 605-654). Porto Alegre: Edipucrs.

Lima, F. S., Silva, A. L. C., & Virgílio, L. R. (2024). Endofauna parasitária de cinco espécies da família Cichlidae em uma região na Amazônia Ocidental. Sci. Natur., 6: 17-27. https:// doi.org/ 10.v 29327/269504.6.1-2

Lopes, L. P. C., Pimpão, D. M., Takemoto, R. M., Malta, J. C. O., & Varella, A. M. B. (2011). *Hysterothylacium* larvae (Nematoda, Anisakidae) in the freshwater mussel *Diplodon suavidicus* (Lea, 1856) (Mollusca, Unioniformes, Hyriidae) in Aripuanã River, Amazon, Brazil. J. Invertebr. Pathol., 106: 357-359. https://doi. org/10.1016/j.jip.2010.12.002

Lucas, E. W. M., Barreto, N. J. C., & Cunha, A.C. (2010). Variabilidade hidrológica da bacia do Rio Jari (AP). *In*: Cunha AC, Souza, EB, Cunha HFA (Org.). *Tempo, clima e recursos hídricos: resultados do projeto REMETAP no estado do Amapá* (pp. 119-134). Macapá: IEPA.

Ludwig, J. A., Quartet, L., Reynolds, J. F., & Reynolds. J. S. (1988). *Statistical ecology: a primer in methods and computing*. New York: John Wiley & Sons.

Magurran, A. E. (2004). *Measuring biological diversity*. Australia: Blackwell Science.

Malta, J. C. O. (1982). Os Argulídeos (Crustacea: Branchiura) da Amazônia brasileira. 2. Aspectos da ecologia de *Dolops geayi* Bouvier, 1897 e *Argulus juparanaensis* Castro, 1950. Acta Amaz. 12(4): 701-705. https://doi.org/10.1590/1809-43921982124701

Morey, G. A. M., Arimuya, M. V., & Boeger, W.A. (2019). Neotropical Monogenoidea 62. *Biotodomella mirospinata* gen. nov., sp. nov. (Polyonchoinea: Dactylogyridae): a parasite of the gills of *Biotodoma cupido* (Cichliformes: Cichlidae), from the Peruvian Amazon. Zoologia 36: e38455. https://doi.org/ 10.3897/zoologia. 36.e38455

Morey, G. A. M., Dávila, H. A., Arimuya, M. V., Sousa, A. L, Cruces, C. L., & Chero, J. D. (2024). Three new species of *Sciadicleithrum* (Monogenoidea, Dactylogyridae) parasitizing cichlid fishes (Cichliformes: Cichlidae) in the northeastern Peru. Acta Parasitol. 69:1674-1681. https://doi.org/10.1007/ s11686-024-00895-y

Mota-Júnior, L. O., Santos, P. V. N., Valentim, D. S. S., Oliveira, M. S. B., & Tavares-Dias, M. (2014). First study on the metazoan parasite community of *Crenicichla strigata* (Cichliformes: Cichlidae). Braz. J. Vet. Parasitol., 33(3): e012724. https://doi.org/ 10.1590/ S1984-29612024063

Neves, L. R., Silva, L. M. A., Florentino, A. C., & Tavares-Dias, M. (2020). Distribution patterns of *Procamallanus* (*Spirocamallanus*) *inopinatus* (Nematoda: Camallanidae) and its interactions with freshwater fish in Brazil. Rev. Bras. Parasitol. Vet., 29(4): 1-15. https://doi.org/10.1590/S1984-29612020092

Oliveira, A. M., & Cunha, A. C. (2015). Análise de risco como medida preventiva de inundações na Amazônia: estudo de caso de enchente de 2000 em Laranjal do Jari-AP, Brasil. Ciênc. Nat., 37: 110-118. https://doi.org/10.5902/217 9460X16224

Oliveira, M. S. B., Corrêa, L. L., Adriano, E. A., Tavares-Dias, M. (2021). Integrative taxonomy of a new species of *Therodamas* (Ergasilidae) infecting the Amazonian freshwater fish *Leporinus fasciatus* (Anostomidae). Parasitol. Res. 120:3137-3147. https://doi.org/10.1007/s00436-021-07256-y

Oliveira, R. C., & Graça, W. J. (2014). Evolutionary trends in encephalic morphology among Geophagini cichlid fish: phylogenetic insights and associations with ecological and behavioral traits. Hydrobiologia 851:3711-3734. https://doi. org/ 10. 1007/s10750-024-05531-4

Pinheiro, R. H. S., Melo, F. T. V., Monks, S., Santos, J. N., & Giese, E. G. (2018). A new species of *Procamallanus* Baylis, 1923 (Nematoda, Camallanidae) from *Astronotus ocellatus* (Agassiz, 1831) (Perciformes, Cichlidae) in Brazil. ZooKeys 790: 21-33. https://doi.org/10.3897/zookeys.790.24745

Poulin, R. (2004). Macroecological patterns of species richness in parasite assemblages. Basic. Appl. Ecol., 5: 423–434. https://doi.org/10.1016/j.baae. 2004.08.003

Poulin, R. (2013). Explaining variability in parasite aggregation levels among host samples. Parasitology 140:541–546. https://doi.org/10.1017/S00311820 12002053

Poulin, R., & Leung, T. L. F. (2011). Body size, trophic level, and the use of fish as transmission routes by parasites. Oecologia166: 731-738. https://doi.org/10. 1007/s 00442-011-1906-3

Reiczigel, J., Marozzi, M., Fabian, I., & Rozsa, L. (2019).Biostatistics for parasitologists - a primer to Quantitative Parasitology. Trends Parasitol. 35(4): 277-281. https://doi.org/ 10.1016/ j.pt.2019.01.003

Rohde, K., Hayward, C., & Heap, M. (1995). Aspects of the ecology of metazoan ectoparasites of marine fishes. Inter. J. Parasitol., 25: 945-70. https://doi.org/10.1016/ 0020-7519(95)00015-T

Santillán, L. A., Cruces, C. L., Sáez, G. M., Martínez-Rojas, R., Mondragón-Martínez, A., Morey, G. A. M., Quinones, M., Luque, J. L., & Chero, J. D. (2024). An annotated checklist of monogeneans (Platyhelminthes, Monogenea) from aquatic vertebrates in Peru: a review of diversity, hosts and geographical distribution. Animals 14: 1542. https://doi.org/10.3390/ ani14111542

Santos, C. P., & Borges, J.N. (2020). Current knowledge of small flukes (Digenea: Heterophyidae) from South America. Korean J. Parasitol., 58: 373-386. https://doi.org/10.3347/kjp.2020. 58.4.373

Santos, G. M., Mérona, B., Juras, A. A., & Jégu, M. (2004). *Peixes do baixo Tocantins 20 anos depois da Usina Hidrelétrica Tucuruí*. Brasília: Eletronorte.

Souza-Neto, A. G., Virgilio, L. R., & Nóbrega, M. I. L. S. (2023). Nematodas de peixes do Vale do Juruá, Amazônia Ocidental. Neotrop. Helminthol. 17: 25-36. https://dx.doi.org/10.24039/rnh 20231711465

Thatcher, V. E. (2006). *Amazon fish parasites*. Second Edition. Sofia-Moscow.

Timi, J. T., & Poulin, R. (2020). Why ignoring parasites in fish ecology is a mistake? Int. J. Parasitol., 50: 755-761. http://doi.org/10.1016/j. ijpara.2020.04.007

Virgilio, L. R., Lima, F. S., Takemoto, R. M., Camargo, L. M. A., & Meneguetti, D. U. (2021). Endofauna of helminth parasites of fish in the Amazon basin. SAJEBTT 8(1):102–11.

Virgilio, L. R., Martins, W. M. O., Lima, F. S., Takemoto, R. M., Camargo, L. M. A., & Meneguetti, D. U. O. (2022). Endoparasite fauna of freshwater fish from the upper Juruá River in the Western Amazon, Brazil. J. Helminthol., 96:e55,1–27. https://doi.org/10.1017/S0022 149X22 00027X

Zar, J. H. (2010). *Biostatistical analysis*. 5th ed. New Jersey: Prentice Hall.

Authorship contribution

1 – Leonardo de Oliveira Mota-Júnior

Graduated in Biology and Master in Tropical Biodiversity (UNIFAP).
https://orcid.org/0009-0005-7414-5303. leonardooliveira.j@gmail.com
Contribution: Methodology, Investigation, Writing – original draft.

2 - Paulo Venicius Nascimento Santos

Graduated in Fisheries Engineering (UEAP).
https://orcid.org/0009-0004-7778-7291. pauloveniciusnds52@gmail.com
Contribution: Methodology, Investigation.

3 - David Sales Sousa Valentim

Graduated in Chemistry, and Master in Tropical Biodiversity (UNIFAP).
https://orcid.org/0009-0000-3003-4365. davidsalesvalentim@gmail.com
Contribution: Methodology, Investigation.

4 – Marcos Sidney Brito de Oliveira

Graduated in Fisheries Engineering, Master and Doctor in Tropical Biodiversity (UNIFAP).
https://orcid.org/0000-0002-4421-9608.marcosidney2012@hotmail.com
Contribution: Software, Writing – review & editing.

5 - Marcos Tavares-Dias

Graduated in Biology and Master and Doctor in Continental water aquaculture, UNESP Aquaculture Center
https://orcid.org/0000-0002-8376-1846, marcos.tavares@embrapa.br
Contribution: Conceptualization, Data curation, Supervision, Funding acquisition, Writing – review & editing.

How to quote this article

Mota-Júnior, L. O., Santos, P. V. N., Valentim, D. S. S., Oliveira, M. S. B. & Tavares-Dias, M. (2026). Metazoan parasites in *Biotodoma cupido* (Cichliformes: Cichlidae) from the Jari River basin, Brazilian eastern Amazon region. *Ciência e Natura*, Santa Maria, v. 48, e91106. DOI: https://doi.org/10.5902/217946091106.