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Diversity and similarity in parasitic infracommunities of *Mylossoma aureum* and *Mylossoma duriventre* (Characiformes, Serrasalmidae) from the Middle Madeira River Basin, Southern Amazonas, Brazil

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Abstract

A total of 30 specimens of *Mylossoma aureum* and 30 of *Mylossoma duriventre* from the Middle Madeira River Basin were examined between October 2020 to March 2021. Eight species of parasites were identified. About 65% of the hosts were parasitized. A total of 386 parasites was collected in *M. aureum* and 436 in *M. duriventre*. Species accumulation curves in *M. aureum* did not reach the asymptote, while in *M. duriventre* the curves showed tendency to stabilization. *Contracaecum* sp. larvae was the only endoparasite found. *Anacanthorus paraspathulatus* was the dominant species in *M. aureum*. In *M. duriventre*, the core species with highest parasite indexes was *Mymarothecium* sp. 3. Margalef's and Shannon's diversity indexes were higher in *M. aureum*. Most of the parasites showed an aggregated distribution pattern. *Mymarothecium* sp. 1, *Mymarothecium* sp. 2 and the parasite richness showed a significant positive correlation between its abundance and host length and between *Mymarothecium* sp. 1 abundance and host weight in *M. aureum*. All parasites are the first records for the Southern Amazonas. Except *A. paraspathulatus*, all *M. aureum* parasites are mentioned for the first time in this host. The three morphotypes of *Mymarothecium* spp. are probably new species that are in the process of taxonomic description.

Keywords: Parasite diversity; Small-scale fisheries; Pacu; Amazon fish parasites; Freshwater fish; Amazonia.

Diversidade e similaridade em infracomunidades parasitárias de *Mylossoma aureum* e *Mylossoma duriventre* (Characiformes, Serrasalmidae) da Bacia do Médio Rio Madeira, sul do Amazonas, Brasil

Resumo

O total de 30 espécimes de *Mylossoma aureum* e 30 de *Mylossoma duriventre* da Bacia do Médio Rio Madeira foi examinado entre outubro de 2020 e março de 2021. Oito espécies de parasitos foram identificadas, e 65% dos peixes analisados estavam parasitados. Foram coletados 386 parasitos em *M. aureum* e 436 em *M. duriventre*. As curvas de acumulação de espécies em *M. aureum* não atingiram a assíntota, enquanto em *M. duriventre* as curvas tenderam à estabilização. *Contracaecum* sp. foi o único endoparasito encontrado. *Anacanthorus paraspathulatus* foi central e dominante em *M. aureum*. Em *M. duriventre*, a espécie central com maiores índices parasitários foi *Mymarothecium* sp. 3. Os índices de Margalef e Shannon foram maiores em *M. aureum*. A maioria dos parasitos apresentou padrão de distribuição agregado. *Mymarothecium* sp. 1, *Mymarothecium* sp. 2 e a riqueza parasitária mostraram correlação positiva significativa entre sua abundância e o comprimento de *M. aureum* e entre abundância de *Mymarothecium* sp. 1 e peso de *M. aureum*. Todos os parasitos são primeiros registros para o sul do Amazonas. Exceto *A. paraspathulatus*, todos os parasitos de *M. aureum* são mencionados pela primeira vez nesse hospedeiro. Os três morfotipos de *Mymarothecium* spp. são espécies novas que estão em processo de descrição taxonômica.

Palavras-chave: Diversidade parasitária; Pesca artesanal; Pacu; Parasitos de peixes amazônicos; Peixes continentais; Amazônia.

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INTRODUCTION

The Amazon basin has the largest and most diverse ichthyofauna on the planet, with estimates ranging from 1,500 and 3,000 species and representatives of practically all orders of freshwater fish (Reis et al., 2003; 2016). Proportionally to this biodiversity, it is possible to say that the diversity of its associated parasites is also quite expressive in the Amazon region, but with studies carried out only in some of its sub-basins (Eiras et al., 2010).

The main socio-economic activity in the Middle Madeira River region is small-scale artisanal fishing (Lima et al., 2016). Historically, Characiformes fish have great relevance in regional fishing landings, with emphasis on Serrasalmidae species (Doria and Lima, 2008; Doria et al., 2012; Ramos et al., 2021). *Mylossoma aureum* (Spix & Agassiz, 1829) and *Mylossoma duriventre* (Cuvier, 1818), known as *pacu*, are the most common and consumed fish species by the regional population. They are distributed in the Amazon, Orinoco, and Paraguai-Paraná River basins (Jégu, 2003) and are small- to medium-sized, reaching up to 25 cm in total length and 500 g in body mass. These fish are benthopelagic, migratory, diurnal, with an herbivorous diet tending to omnivory and with ontogenic variations in feeding (Soares et al., 2008).

Studies on parasitic fauna in natural populations of *M. duriventre* and *M. aureum* were carried out by Travassos et al. (1928), Kritsky et al. (1992), Azevedo et al. (2011), Silva and Tavares-Dias (2012), Braga et al. (2015), Gomes (2018), and Oliveira et al. (2019). Among them, only a few involved the distribution and diversity of parasites.

These two *Mylossoma* species account for about 15% of fisheries production in the Middle Madeira, Middle Solimões and Juruá rivers (Soares et al., 2008; Alcântara et al., 2015; Lima et al., 2016). Considering the importance of these fish species and the few studies involving ecology of parasite communities in fish from Southeastern Amazon, the purpose of this study was to inventory the parasitic fauna of *M. duriventre* and *M. aureum* from artisanal fisheries in the Middle Madeira River, Amazonas, Brazil, as well as to present considerations on the composition and structure of the parasitic communities present in these fish species.

MATERIAL AND METHODS

Study area and fish collections

The Madeira River, one of the largest in the world, belongs to the group of Amazon tributaries and has a drainage area of around 1.3 million km^2 (1/5 of the total Amazon Basin) and an annual discharge of around 31,200 m^3*s^{-1}. It is still the main tributary of the Amazon River, with 3,352 km in length, considered geologically young because it is still "digging" its channel, which causes a high degree of surface erosion and, consequently, turbid waters with high amounts of suspended material, whose hydrochemistry is predominantly controlled by the Andean flanks (Gibbs, 1967).

Fish collections were carried out in four floodplain lakes connected to the Madeira River (Petrópolis 7°26'42.7"S 63°01'23.3"W, Mirari 7°39'54.4"S 62°56'29.1"W, Puruzinho 7°21'07.69"S 63°06'25.14"W, and Pupunha 7°23'52.60"S 62°56'38.96"W), and in the main channel of the river (Fig. 1). These collections took place between October 2020 and March 2021, respecting the closed season of the species. For each host species, 30 specimens were collected, totaling 60 fish.

The artisanal fishermen who assisted in the collection used gillnets with different types of mesh (sizes ranging from 30 to 70 mm alternating internodes). They are associated with the Fishermen's Colony Z-31 Dr. Renato Pereira Gonçalves, in the municipality of Humaitá, Amazonas. The collections followed the guidelines of the scientific fishing license under the authorization of the Instituto Chico Mendes de Conservação da Biodiversidade, through the Biodiversity Authorization and Information System (authorization no. 29476-3).

The euthanasia methodologies of the host fish were developed under the principles adopted by the National Council of the Animal Experimentation Control. After collection, the hosts were stored individually in plastic bags so that the composition of the parasitic fauna of each specimen would not change. Then, they were frozen and taken for analysis at the Laboratório de Ictiologia e Ordenamento Pesqueiro do Vale do Rio Madeira, of the Universidade Federal do Amazonas, in Humaitá.

Biometric data (standard weight and length) of each host were obtained for subsequent necropsy and analysis of all the organs in a stereomicroscope. The parasites found were fixed, stored, stained, and mounted for light microscopy following the recommendations proposed by Eiras et al. (2006).

Specific bibliographies for each group were used for taxonomical identification of the parasites, with species identification keys. Representative specimens of all organisms (parasites and hosts) used in this study were deposited in the Zoological Collection of the Instituto Nacional de Pesquisas da Amazônia, in Manaus, Amazon, and in the Helminthological Collection of the Institute of Biosciences of the Universidade

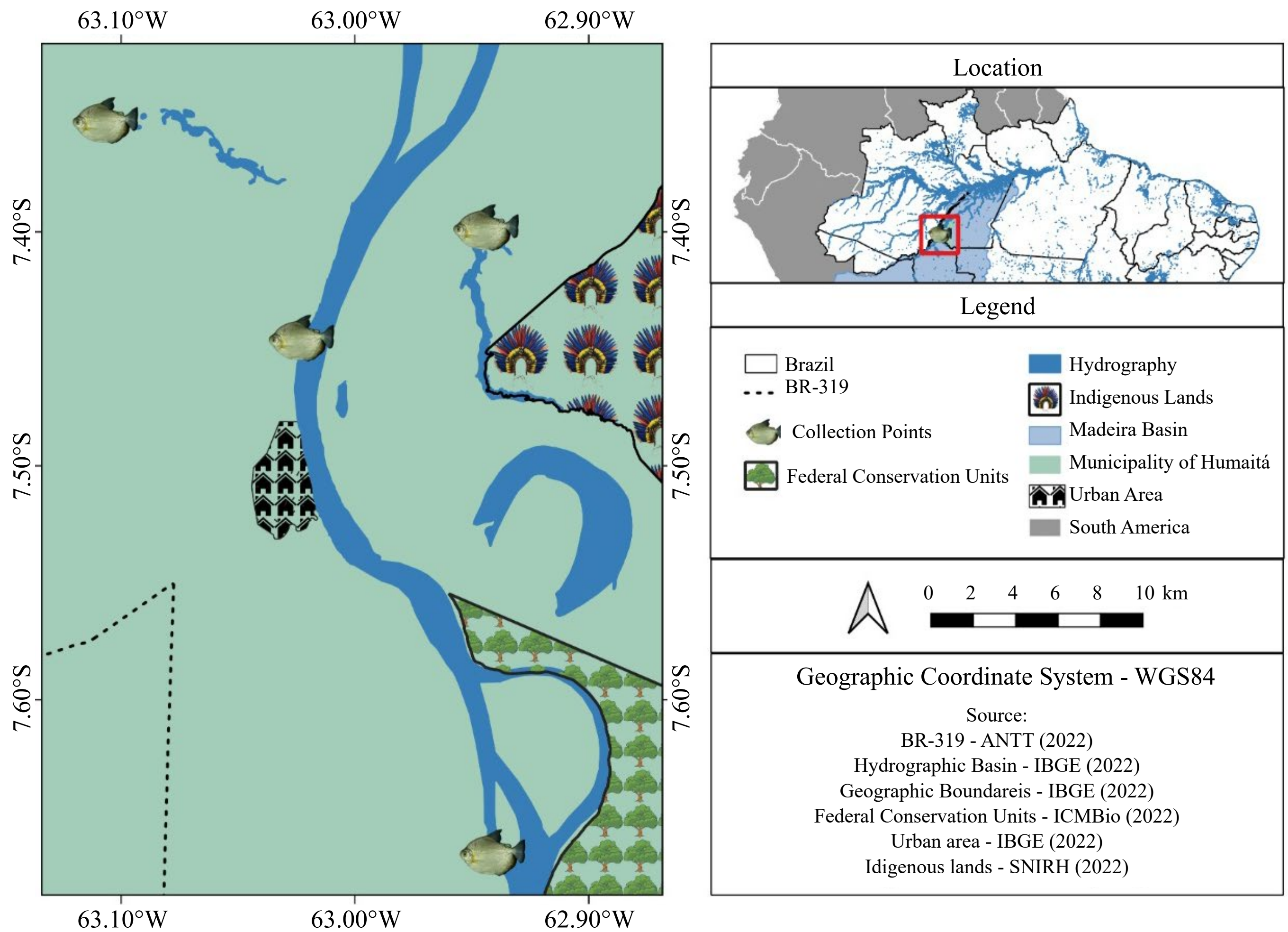

Figure 1. Sampling points of *Mylossoma aureum* and *Mylossoma duriventre* (Characiformes, Serrasalmidae) from small-scale fisheries in the Middle Madeira River, Southeastern Amazon, Brazil. The fish figures represent the four sample points of fish collections.

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Data analysis

The ecological terminology and the quantitative descriptors of parasitism (prevalence, mean intensity, mean abundance) were obtained according to Bush et al. (1997). Based on their prevalence within the studied sample, the parasites were classified as central, secondary or satellite species (Hanski, 1982; Bush and Holmes, 1986). The variance of mean ratio of parasite abundance, or dispersion index (DI), was used to determine spatial distribution patterns for each infrapopulation (Ludwig et al., 1988), and the *d*-statistic test was also calculated to assess their significance (Rabinovich, 1980). The green index (GI) was calculated to verify how much the infrapopulations are grouped (Ludwig et al., 1988).

The accumulation curve of identified species was defined to verify if the number of hosts collected included the highest proportion of parasitic species in the component community. This was compared with the curve of the first order Jackknife richness estimator, that was used to verify if the expected parasite richness was sufficient for the number of hosts analyzed (Magurran, 2013).

To characterize the composition of the parasite communities, the following descriptors were obtained: Shannon-Wiener diversity index (H) (Neperian logarithm Ln), Pielou's equitability index (J), Margalef specific richness index (D) (Magurran, 2013), Berger-Parker dominance index (D_{BP}), frequency of dominance, and relative dominance of each parasite species (Rohde et al., 1995). The Shapiro-Wilk's normality test was applied to verify if the distribution of data obtained could be approximated by the normal distribution. One-way analysis of variance test was then performed to verify if there were significant differences between the values of the diversity, equitability, and richness indexes among the host species analyzed (Ayres et al., 2007).

Sorensen's coefficient similarity index was used to calculate a similarity quotient between the component parasitic communities of the two host species based on the number of species in each community and the number of species in common (Wagner and Harper, 2000).

The Spearman's rank correlation coefficient (*rs*) was used to verify possible correlations between the host's biometric data (mass and standard length) and parasitic abundance, species richness, and total abundance (Zar, 2010).

Statistical Package for the Social Sciences Statistics and PRIMER 6 software (version 6.1.6) were used for data analysis. The tests mentioned were applied only to parasite species with prevalence over 10% (Bush et al., 1997). The results were considered significant when $p < 0.05$.

RESULTS

Eight species of parasites were identified in the two *Mylossoma* species analyzed, including monogeneans, nematodes, and crustaceans. They parasitized the external surface, gills, and digestive tract of *pacus*. About 65% of the analyzed fish were parasitized by at least one species of parasite, in the larval or adult phase. The total number of parasites collected was 822 parasitic metazoans, 386 in *M. aureum* and 436 in *M. duriventre* (total mean abundance 13.70 ± 16.74 for *M. aureum* and 13.70 ± 16.74 for *M. duriventre*). The richness of each infracommunity ranged from one to five species of parasites in *M. aureum* and from one to six species in *M. duriventre* (Table 1).

The maximum expected number of parasite species collected was very close to the observed value for the two analyzed host species, according to the first order Jackknife richness estimator. Both the observed species curve and the Jackknife estimator curve were not stable for *M. aureum*, with the tendency to increase species richness in the case of a greater sampling of these hosts. On the other hand, the curves of *M. duriventre* showed a tendency towards stabilization (Figs. 2a and 2b).

Mylossoma aureum was parasitized only by monogeneans ectoparasites. *Contracaecum* sp. larvae was the only endoparasite species found in this study and parasitized the intestine of *M. duriventre. Anacanthorus paraspathulatus* was the only species considered central in *M. aureum* and also showed higher values of quantitative parasitism descriptors in this host. As for *M. duriventre*, the highest parasite indexes were obtained for *Mymarothecium* sp. 3. *Amplexibranchius bryconis* was the unique crustacean species found in the gills of *M. duriventre* (Table 1).

Statistically, the values of the Pielou equitability index (J) were identical for the two species of *Mylossoma* spp. ($p = 0.55$). However, for the other pairs involving Margalef's richness (D) and Shannon's diversity (H) indexes, there was a statistically significant difference ($p < 0.05$), with higher values obtained in *M. aureum* (Table 2). The parasitic communities of *M. aureum* and *M. duriventre* presented Sorensen's coefficient similarity index (Cs) of 66.7%.

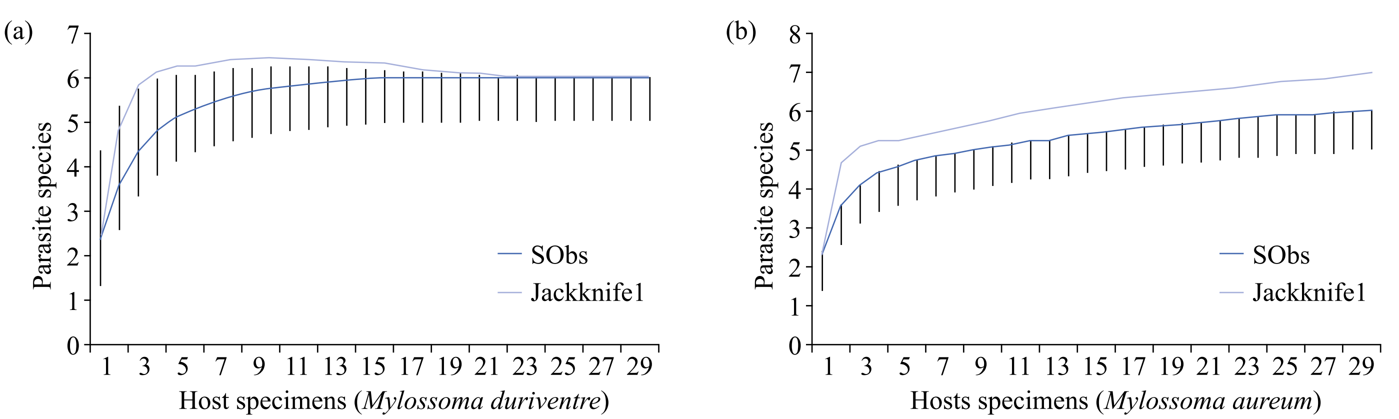

Figure 2. Species accumulation curves [first order Jackknife estimator (Jackknife 1) and Species Observed (SObs)] of parasites of (a) *Mylossoma aureum;* and (b) *Mylossoma duriventre* (Characiformes, Serrasalmidae) from small-scale fisheries in the Middle Madeira River, southeastern Amazon, Brazil.

As commonly observed in communities of parasitic organisms, in the present study most of the parasites showed an aggregated distribution pattern (except for *A. bryconis* in *M. duriventre*). *Anacanthorus paraspathulatus* dominated the *M. aureum* infracommunities and also presented the highest degree of aggregation among species (GI = 0.24). *Mymarothecium* sp. 3 was the dominant species in *M. duriventre* ($D_{BP} = 0.50$) (Table 3).

Mymarothecium sp. 1, *Mymarothecium* sp. 2, and the parasite richness showed significant positive correlation between its abundance and standard length of *M. aureum*, while *Mymarothecium* sp. 1 had significant positive correlation between its abundance and the host weight. The parasites of *M. duriventre* did not present significant correlations with the biometric data of this host (Table 4).

Table 1. Quantitative descriptors, degree of importance within the infracommunity, and fixation sites of parasites in *Mylossoma aureum* and *Mylossoma duriventre* (Characiformes, Serrasalmidae) from small-scale fisheries in the Middle Madeira River, Southeastern Amazon, Brazil*.

Parasite species	Prevalence (%)	Mean abundance ± standard error	Mean intensity ± standard error	Variation Range	Community status	Infection/ infestation site
Mylossoma aureum						
Monogenea						
Anacanthorus cladophallus Van Every & Kritsky, 1992	3.33	0.10 ± 0.55	3.00 ± 1.00	1–3	Satellite	Gills
Anacanthorus paraspathulatus Kritsky, Boeger & Van Every, 1992	66.67	4.30 ± 6.13	6.45 ± 6.35	1–25	Central	Gills, Body surface
Mymarothecium sp. 1	53.33	2.27 ± 2.59	4.25 ± 2.57	1–10	Secondary	Gills, Body surface
Mymarothecium sp. 2	56.67	2.47 ± 4.21	4.35 ± 4.86	1–18	Secondary	Gills, Body surface
Mymarothecium sp. 3	63.33	3.57 ± 4.47	5.63 ± 4.46	1–14	Secondary	Gills, Body surface
Notozothecium minus Boeger & Kritsky, 1988	10.00	0.17 ± 0.53	1.67 ± 0.58	1–2	Satellite	Gills
Mylossoma duriventre						
Monogenea						
Anacanthorus paraspathulatus	53.33	4.30 ± 6.83	8.06 ± 7.60	1–28	Secondary	Gills, Body surface
Mymarothecium sp. 1	46.67	2.23 ± 3.18	4.79 ± 3.07	1–12	Secondary	Gills, Body surface
Mymarothecium sp. 2	46.67	2.97 ± 4.16	6.36 ± 3.91	2–16	Secondary	Gills, Body surface
Mymarothecium sp. 3	56.67	4.60 ± 5.42	8.12 ± 4.79	1–19	Secondary	Gills, Body surface
Nematoda						
Contracaecum sp.	13.33	0.27 ± 0.94	2.00 ± 2.00	1–5	Satellite	Intestine
Copepoda						
Amplexibranchius bryconis Thatcher & Paredes, 1985	16.67	0.17 ± 0.38	1.00	1	Satellite	Gills

*Mean values followed by ± standard deviation.

Table 2. Body measures and characteristics of the component community of the parasites in *Mylossoma aureum* and *Mylossoma duriventre* (Characiformes, Serrasalmidae) from small-scale fisheries in the Middle Madeira River, Southeastern Amazon, Brazil*.

Parameters	*Mylossoma aureum*	*Mylossoma duriventre*
Weight (g)	151.73 ± 30.64 (103.00–198.00)	138.27 ± 36.72 (84.00–268.00)
Standard length (cm)	14.43 ± 1.16 (12.00–17.00)	15.13 ± 1.27 (13.50–18.00)
Parasite species richness	2.53 ± 1.98 (1.00–5.00)	3.68 ± 1.20 (1.00–6.00)
Margalef index (D)	1.05 ± 0.40 (0.68–1.74)	0.95 ± 0.37 (0.51–1.56)
Shannon diversity index (H)	1.21 ± 0.21 (0.69–1.57)	1.11 ± 0.42 (0.41–1.63)
Pielou equitability index (J)	0.89 ± 0.06 (0.74–1.00)**	0.84 ± 0.23 (0.59–1.00)**
Berger-Parker dominance (D_{BP})	0.47 ± 0.15 (0.29–1.00)	0.50 ± 0.19 (0.32–1.00)
Total parasite number	386 (1–66)	436 (1–68)
Total parasite species	6	6
Endoparasites species	0	1
Ectoparasites species	6	5
Exclusive species	2	2
Adult stage	6	5
Larval stage	0	1

*Mean values followed by standard error and minimum and maximum values in parentheses; **statistically equal values.

Table 3. Dispersion index, *d*-statistic, aggregation index, dispersion pattern, dominance frequency, and relative dominance for the parasite infracommunities of *Mylossoma aureum* and *Mylossoma duriventre* (Characiformes, Serrasalmidae) from artisanal fisheries in the middle Madeira River, southeastern Amazon, Brazil.

Parasite species	Dispersion index	d	Aggregation index	Dispersion	Dominance frequency (%)	Relative dominance
Mylossoma aureum						
Anacanthorus paraspathulatus	8.06	14.07	0.24	Aggregated	43.33	0.36
Mymarothecium sp. 1	3.46	6.61	0.08	Aggregated	3.33	0.15
Mymarothecium sp. 2	7.27	12.99	0.22	Aggregated	13.33	0.19
Mymarothecium sp. 3	5.60	10.47	0.16	Aggregated	10.00	0.28
Notozothecium sp.	1.69	2.35	0.02	Aggregated	0.00	0.01
Mylossoma duriventre						
Anacanthorus paraspathulatus	10.84	17.53	0.34	Aggregated	23.33	0.30
Mymarothecium sp. 1	4.53	8.66	0.12	Aggregated	0.00	0.15
Mymarothecium sp. 2	5.82	10.83	0.17	Aggregated	0.00	0.20
Mymarothecium sp. 3	6.40	11.71	0.19	Aggregated	36.67	0.32
Contracaecum sp.	3.34	6.38	0.08	Aggregated	0.00	0.02
Amplexibranchius bryconis	0.86	-0.48	0.00	Uniform	0.00	0.01

DISCUSSION

The parasitic infracommunities of the analyzed hosts were dominated by ectoparasites, the monogeneans were the most frequent parasites, and part of these species were shared between *M. aureum* and *M. duriventre*. Serrasalmidae fish species can be parasitized by many species of Monogenea and tend to share their parasites with species of the same or close genus (Thatcher, 2006; Braga et al., 2014). In the present study, this panorama

Table 4. Spearman's rank correlation coefficient (*rs*) of *Mylossoma aureum* and *Mylossoma duriventre* (Characiformes, Serrasalmidae) from artisanal fisheries in the Middle Madeira River, southeastern Amazon, Brazil.

Parasite species	Standard length		Weight	
	rs	p-value	rs	p-value
Mylossoma aureum				
Anacanthorus paraspathulatus	0.20	0.29	0.23	0.22
Mymarothecium sp. 1	0.40	0.03*	0.36	0.05*
Mymarothecium sp. 2	0.39	0.03*	0.31	0.10
Mymarothecium sp. 3	0.24	0.19	0.18	0.33
Notozothecium minor	0.16	0.40	0.32	0.09
Parasite species richness	0.41	0.02*	0.30	0.11
Total abundance	0.30	0.11	0.29	0.13
Mylossoma duriventre				
Anacanthorus paraspathulatus	0.12	0.52	0.22	0.24
Mymarothecium sp. 1	0.19	0.30	0.07	0.72
Mymarothecium sp. 2	0.21	0.26	0.05	0.81
Mymarothecium sp. 3	0.25	0.19	0.15	0.43
Contracaecum sp.	0.05	0.79	0.14	0.47
Amplexibranchius bryconis	0.19	0.32	0.16	0.41
Parasite species richness	0.17	0.36	0.11	0.57
Total abundance	0.28	0.14	0.23	0.22

*$p < 0.05$.

was observed, although the richness was not very expressive in the two hosts.

Mymarothecium sp. 1, *Mymarothecium* sp. 2, *Mymarothecium* sp. 3, and *A. paraspathulatus* were parasites common to both fish. Gomes (2018), in his study with parasitological biodiversity of Characiformes fish including *M. duriventre*, also found *Mymarothecium* (Kritsky, Boeger & Jégu, 1998) and *Anacanthorus* (Mizelle & Price, 1965) in this host, with relative abundance. However, these parasites were only present in the gills, whereas in the present study these monogeneans were found in the gills and also on the external surface of the host. The prevalence of Monogenea in the present study can be explained by the gregarious behavior of the studied hosts, which swim and hunt in shoals, increasing intraspecific contact between them, which facilitates the transmission of the parasites (Morey, 2017; Moreira et al., 2019).

The only endoparasites found in the present study were *Contracaecum* sp. larvae in the intestines of *M. duriventre*. This parasite had already been recorded in this host (Oliveira et al., 2019), and, like the present study, it will not be possible to determine it at a specific level. *Contracaecum* spp. has a wide geographic distribution and has been observed in wild fish and in culture systems, having been found parasitizing more than 70 species of Brazilian continental fish (Pavanelli et al., 2015), showing no parasitic specificity. These nematodes use free-living copepods as primary intermediate hosts, fish as secondary or paratenic intermediate hosts, and fish-eating birds as definitive hosts (Meneguetti et al., 2013; Pinheiro et al., 2019; Sousa et al., 2019). *Mylossoma aureum* and *M. duriventre* feed on fruits, leaves, and occasionally small invertebrates (Abelha et al., 2001; Soares et al., 2008). The ingestion of potential intermediate hosts determines the presence of endoparasites transmitted through the food web (Pavanelli et al., 2013).

Contracaecum sp. are economically important parasites with zoonotic significance. Human infection with *Contracaecum* larvae has been reported in several countries after the consumption of raw or undercooked contaminated fish (Shamsi et al., 2018). Other Anisakidae nematodes are frequently found in commercially important Brazilian fish. Brazilian Health Ministry classified the biological risk of infection by Anisakidae as belonging to Risk Class 2, as they are parasites of moderate risk and limited risk of transmission (Brasil, 2010).

Amplexibranchius bryconis was described from the gill filaments of *Brycon amazonicus* (Spix & Agassiz, 1829) from Iquitos, Peru (Thatcher and Paredes, 1985). Gomes (2018) also identified these copepods in *M. duriventre* collected in floodplain lakes in the Solimões River. Other studies involving different hosts have also reported parasitism by *A. bryconis* in fish from the floodplains of the Negro, Solimões and Purus rivers (Dumbo, 2014; Morey et al., 2015; Morey, 2017; Vital, 2018).

The richness and the composition of parasite species in the infracommunities analyzed in the present study differ from other studies carried out with *M. duriventre* in the Amazon region (Silva and Tavares-Dias, 2012; Gomes, 2018; Oliveira et al., 2019). In relation to *M. aureum*, there are no studies involving the parasite infracommunities from this host.

Pielou's equitability was statistically equal between *M. aureum* and *M. duriventre* and presented high values, close to 1 (0.89 and 0.84, respectively), which indicates that almost 90% of the maximum theoretical diversity was obtained through the sampling performed and that parasitic infracommunities tend to be uniform. However, as some parasites were not very prevalent, the distribution of most species was considered aggregated, according to the dispersion index. The analyses by Gomes (2018) with *M. duriventre* parasites showed lower values of Shannon (H), Pielou (J) and Margalef (D) indices (H = 0.45–056; J = 0.28–0.35; D = 0.53–0.79) when compared to the present study (H = 1.11; J = 0.84; D = 0.95). For more accurate conclusions, the comparison of diversity indices should consider the respective sampling areas of the hosts and their equivalences. Otherwise, data rarefaction should be adopted to carry out an appropriate comparative analysis (Magurran, 2013).

In general, parasite infracommunities are distributed in an aggregated manner among hosts, regardless of whether the communities have high species richness (McVinish and Lester, 2020). This means that most fish hosts will have few parasites, while a higher concentration of parasites will infest or infect few hosts. The aggregate pattern allows for greater encounter between parasite specimens, favoring their reproduction (Pelegrini et al., 2022), in addition to allowing the coexistence of different species. Therefore, more parasite species can coexist in the same host population (Salgado-Maldonado et al., 2019). In contrast, uniform distribution is a pattern that is almost impossible to observe in natural populations of parasite species (McVinish and Lester, 2020). The result obtained in the present study follows the aggregate distribution pattern, with one case of uniform distribution (in *A. bryconis*). However, this parasite showed low prevalence and abundance in *M. duriventre*, which influenced this result.

In the present study, the abundance of *Mymarothecium* sp. 1, *Mymarothecium* sp. 2, and the parasite richness increased with fish length (*M. aureum*) and between the abundance of *Mymarothecium* sp. 1 and fish weight (*M. aureum*), according to the general pattern observed in fish parasites, especially in wild fish populations (Poulin, 2013). The host body size is correlated with its age, which has been considered a determinant of parasite abundance and species richness in fish, explaining in part the variation of parasitic infracommunities (Poulin, 2001; 2004; Cardoso et al., 2017; Oliveira et al., 2017; Santos et al., 2018). Larger fish provide parasites with more diverse niches and larger colonization areas, allowing larger hosts to harbor more parasites, especially ectoparasites such as Monogenea (Poulin, 2004; Oliveira et al., 2017).

CONCLUSIONS

Considering the ubiquity of parasitic organisms at all trophic levels and in almost all environments and their importance in ecological processes, studies like this are necessary to understand the population dynamics of these organisms. In addition to being indicators of local biodiversity, parasites can indicate various aspects of the biology of their hosts, such as diet, migration, population disaggregation, and phylogeny, as well as aspects of the environment where they are inserted.

The Southeastern Amazon and its watersheds are important ecosystems for maintaining biodiversity and are constantly on the alert for anthropic changes that harm the integrity of their aquatic environments. This study is the first one to describe the structure of populations and communities of fish parasites in Southern Amazonas. Future studies involving these parasites as bioindicators can be carried out in the region, mainly considering the increase in the gold mining and the construction of hydroelectric dams.

All the parasites found are the first records for the region. Except *A. paraspathulatus*, all parasites in *M. aureum* are mentioned for the first time in this host. As for *M. duriventre*, all identified parasites have already been mentioned in the literature. The three morphotypes of *Mymarothecium* spp. are probably new species that are in the process of taxonomic description by the authors of the present study.

CONFLICT OF INTEREST

Nothing to declare.

DATA AVAILABILITY STATEMENT

The data will be available upon request.

AUTHORS' CONTRIBUTION

Conceptualization: Pelegrini, L.S.; **Formal Analysis:** Pelegrini, L.S.; **Investigation:** Ramos, K.S; **Resources:** Silva, R.; Anjos, M.R.; **Supervision:** Anjos, M.R.; **Validation:** Pelegrini, L.S.; Silva, R.; Anjos, M.R.; **Data curation:** Ramos, K.S; **Writing – original draft:** Pelegrini, L.S.; **Writing – review & editing:** Pelegrini, L.S.; Silva, R.; Anjos, M.R.

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