Ann. Limnol. - Int. J. Lim. 2020, 56, 7
© EDP Sciences, 2020
https://doi.org/10.1051/limn/2020005

Available online at:
www.limnology-journal.org

RESEARCH ARTICLE

Cladocera (Crustacea: Branchiopoda) from the state of Mato Grosso, Brazil

Biodiversity of Cladocera (Crustacea: Branchiopoda) from the state of Mato Grosso, Brazil: new records and species richness in hydrographic regions

Maiara Tábatha da Silva Brito[1,*], Leidiane Pereira Diniz[2], Ully M. Pozzobom[1], Victor Lemes Landeiro[3] and Francisco Diogo R. Sousa[4,5]

[1] Programa de Pós-Graduação em Ecologia e Conservação da Biodiversidade, Departamento de Botânica e Ecologia, Instituto de Biociências, Universidade Federal de Mato Grosso, Cuiabá, MT, Brazil
[2] Programa de Pós-Graduação em Ecologia de Ambientes Aquáticos Continentais, Laboratório Zooplâncton, Núcleo de Pesquisa em Limnologia, Ictiologia e Aquicultura (Nupélia), Universidade Estadual de Maringá, PR, Brazil
[3] Departamento de Botânica e Ecologia, Instituto de Biociências, Universidade Federal de Mato Grosso, Cuiabá, MT, Brazil
[4] Laboratório de Taxonomia Animal, Unidade Acadêmica Especial de Ciências Biológicas, Universidade Federal de Goiás – Regional Jataí, Jatai, GO, Brazil
[5] Programa de Pós-Graduação em Zoologia, Universidade de Brasília, Campus Darcy Ribeiro, Brasília, Brazil

Received: 19 October 2019; Accepted: 10 March 2020

Abstract – Studies on Cladocera biodiversity in Brazilian freshwater ecosystems are intensifying. However, the fauna of some hydrographic regions is still poorly known. We investigated the richness and species composition of cladocerans in lakes of the Pantanal from the state of Mato Grosso (Paraguay hydrographic region), Brazil. In addition, we cataloged the known cladoceran species in each hydrographic region of the state. Occurrence data were obtained from the literature and samples collected from 50 lakes in the northern Pantanal. We recorded 120 cladoceran species from eight families in the state of Mato Grosso. The occurrence of these species was recorded in the Amazon and Paraguay hydrographic regions. We are unaware of studies on cladocerans conducted in the Tocantins-Araguaia hydrographic region. We reported 17 new records in the Pantanal samples (Paraguay hydrographic region). Overall, richness estimates reveal that 72.6% of the state's cladoceran fauna is already known, while for the Paraguay hydrographic region this estimate is 72.2%. In general, the cladocerans from the Amazon and Paraguay regions did not differ. Our findings allow us to infer the need for further studies in the different hydrographic regions found in Mato Grosso in order to improve the knowledge of cladoceran biodiversity. We suggest a greater sampling effort, particularly in the littoral zone of aquatic ecosystems in this state, which can harbor great biodiversity.

Keywords: Cladoceran / check list / floodplain lakes / microcrustaceans / zooplankton

1 Introduction

Cladocera is a group of microcrustaceans that play an important ecological role in the energy transfer between trophic levels and represent a large portion of the secondary productivity of aquatic ecosystems (Allan, 1976; Elmoor-Loureiro and Soares, 2010). The importance of this group is related to its biological characteristics, such as parthenogenetic reproduction and dormancy of egg production (Allan, 1976). These characteristics are known to provide advantages to the group in the face of adverse environmental conditions (Santangelo *et al.*, 2011).

Recently, studies on freshwater cladoceran biodiversity from the Neotropical region have increased significantly (Kotov and Fuentes-Reines, 2014; Alonso and Kotov, 2017; Sousa and Elmoor-Loureiro, 2017). More than 700 species of cladocerans are currently known in the world, of which 186 species of the orders Anomopoda and Ctenopoda occur in the Neotropical region (Forró *et al.*, 2008; Kotov *et al.*, 2013). At the beginning of this century, 112 species were known in Brazil, according to the latest survey conducted by

*Corresponding author: maiaratabatha@hotmail.com

Elmoor-Loureiro (2000). This number has increased in recent years and currently the Cladocera fauna of Brazil is estimated to exceed 140 species. This estimate is based on recently published studies that included the description of new species, genera, and the elaboration of regional catalogs (Sinev and Elmoor-Loureiro, 2010; Soares and Elmoor-Loureiro, 2011; Elmoor-Loureiro, 2014; Zanata *et al.*, 2017; Sousa and Elmoor-Loureiro, 2019a,b).

Despite the evident progress in the investigations of the group, there are still some regions of Brazil where freshwater Cladocera biodiversity is not well known (Elmoor-Loureiro *et al.*, 2018), as is the case of the state of Mato Grosso. Located in Central Brazil, Mato Grosso has its territory divided into three distinct Hydrographic Regions (HR), Paraguay, Amazon and Tocantins-Araguaia (ANA, 2015). Mato Grosso could be considered the most diverse state in Brazil, where the Cerrado biodiversity hotspot (Myers *et al.*, 2000) meets the Pantanal and Amazon forest. At the same time, the state has a great diversity of aquatic habitats and, therefore, the region should be considered of high importance for biodiversity conservation of aquatic species.

Located in the Paraguay HR, the Pantanal is considered the largest floodplain in the world (Junk *et al.*, 2006). Nevertheless, information on the biodiversity of its aquatic fauna is incipient and scattered in a few publications, including unpublished academic data (Brandorff *et al.*, 2011). Specifically for cladocerans, only a few studies have been carried out in the Pantanal of Mato Grosso when compared to its southern portion, located in the state of Mato Grosso do Sul (Tab. 2), where 20 studies have already been published (Zanata *et al.*, 2017). In the north of Mato Grosso, where the Amazon HR is located, there are also few studies related to cladoceran fauna. Recently in the upper Xingu Basin, Sousa and Elmoor-Loureiro (2018) described a new genus and new species of the Chydoridae family, which reveals that this region represents high potential for the discovery of new species. Conversely, we unaware of studies that investigate the diversity of cladocerans in the Tocantins-Araguaia HR of Mato Grosso state.

Biogeographers have pointed out two main gaps that jeopardize macroecological studies of biodiversity. The Linnean shortfall concerns the many species there are still unknown to science, while the Wallacean shortfall concerns the problems of the lack of knowledge on species distribution (Lomolino *et al.*, 2010). Thus, in order to reduce the gaps in the knowledge of the group for the state, the aim of this study was to investigate the cladoceran richness and composition (Crustacea, Branchiopoda) in 50 lakes of the Pantanal of Mato Grosso state (Paraguay HR), Brazil. In addition, we sought to compile the information published on cladoceran species in each hydrographic region of the state, in order to digest the knowledge of cladoceran biodiversity and distribution in Brazil.

2 Material and methods

2.1 Collection, sorting and identification of cladocerans

This study was based on two sources, namely literature data and field sample collection. Data from the literature on cladocerans were obtained by searching Google Scholar, Web of Science and Scopus databases and with the help of the specialist Lourdes M. Abdu Elmoor-Loureiro's personal database. We considered only papers that include species lists, excluding monographs, theses and dissertations (and other gray literature).

We also added information on cladocerans that we sampled in 50 lakes distributed across of the Cuiabá river watercourse in the Pantanal region of Mato Grosso. In all lakes, the sampling was performed at a point of the littoral zone with high influence from macrophytes. The samples were obtained by filtering 600 liters of water in a 68 μm plankton net, with the aid of a graduated bucket. The presence of macrophytes in the littoral zone is known to provide greater heterogeneity and availability of niches for organisms, related to higher species richness (Choi *et al.*, 2014; Maloufi *et al.*, 2016). Due to this, the samples were always collected near the macrophyte beds which, in most of the studied lakes, was characterized by the presence of the species *Eichhornia azurea* (Sw.) Kunth, *E. crassipes* (Mart.) Solms, *Salvinia auriculata* Aubl., *Ludwigia helminthorrhiza* Mart., including other species from the floating group.

Afterwards, samples were preserved in a 4% formaldehyde solution buffered with calcium carbonate. In the laboratory, cladoceran samples were analyzed in a Sedgewick-Rafter chamber and the organisms were identified at the lowest possible taxonomic level by specialized literature (Korovchinsky, 1992; Elmoor-Loureiro, 1997). We performed quantitative analysis by counting a minimum of three subsamples, provided there was a minimum of 50 individuals (Bottrel *et al.*, 1976); if this proportion was not fulfilled, ten subsamples were counted. We counted in full all samples with few individuals.

2.2 Data analyses

The occurrence data of the species obtained by searching the literature and through analyzing the collected samples were used in the elaboration of a list of cladoceran species in each HR from the state of Mato Grosso. Extrapolation sampling curves for the entire state of Mato Grosso (literature data, $N = 12$), and only for Paraguay HR ($N = 50$) were performed using Hill numbers through the function "iNEXT" available at iNEXT package. We used $q = 0$ to estimate species richness (Hsieh *et al.*, 2019). The Hill numbers calculate theoretical species richness; that is, the asymptote in an infinite sample size from a known number of sample units. The maximum extrapolated size was double the reference sample size. This package used Chao2 (for incidence data) to estimate the number of undetected species in the reference sample.

We used a PERMANOVA analysis ("adonis" function) to test for differences in cladoceran assemblages between the two hydrographic regions (Pantanal and Amazon) (Anderson and Walsh, 2013). After that, we also analyzed which HR is more heterogeneous in terms of species composition (*i.e.* higher beta diversity) through a PERMDISP analysis (Anderson and Walsh, 2013) based on "Jaccard" dissimilarity. We also performed a Principal Coordinate Analysis (PCoA) to visualize the differences and dispersion of studies in the different hydrographic regions. All analyses were performed using the Vegan package (Oksanen *et al.*, 2018) in software R (R Core Team, 2018).

Table 1. Code of references and localization of studies carried out in the state of Mato Grosso, Brazil.

Code	References	Study area	Hydrographic Region
1	Sinev and Elmoor-Loureiro, 2010	Lagoon in MT060, Poconé municipality	Paraguay
2	Sousa and Elmoor-Loureiro, 2018	Upper Xingu River Basin	Amazon
3	Green, 1972	Lakes in Suiá Missú River	Amazon
4	Neves *et al.*, 2003	Souza Lima and Atalaia Park Lakes, Cuiabá and Várzea Grande municipality	Paraguay
5	Branco *et al.*, 2018	Channel of the Upper Paraguay River, Cáceres municipality	Paraguay
6	Elmoor-Loureiro and Soares 2010	Baia Soca-Soca and Baia do Luiz, Vila Bela da Santíssima Trindade municipality	Amazon
7	Sousa *et al.*, 2015c	Vinicity of Poconé and Santo Antônio do Leverger municipality	Paraguay
8	Heckman 1998	Pantanal in Poconé municipality	Paraguay
9	Lima *et al.*, 2012	Lakes and Cuiabá River in Poconé municipality	Paraguay
10	Kotov and Elmoor-Loureiro 2008	Floodplain in S. Antônio do Leverger and Poconé municipality	Paraguay
11	Padovesi-Fonseca *et al.*, 2016	Vinicity of Vila Bela da Santissima Trindade	Amazon
12	Sousa *et al.*, 2018	Chapada dos Guimarães National Park	Paraguay

3 Results

Table 1 lists the studies about the cladoceran fauna conducted in the state of Mato Grosso, followed by a numerical identification code and study location. The Paraguay HR was the one that presented the largest number of studies on cladoceran fauna, followed by the Amazon HR. No study was found in the portion of the Tocantins-Araguaia HR located in Mato Grosso (Fig. 1; Tab. 1).

In total, considering all the data obtained from the literature, and the samples collected in the 50 lakes of the Pantanal, 120 cladoceran species are known in Mato Grosso state, distributed in eight families: Bosminidae, Chydoridae, Daphniidae, Ilyocryptidae, Macrothricidae, Moinidae, Holopedidae and Sididae (Tab. 2). The sampling of the 50 Pantanal lakes allowed us to identify 17 species considered new records for Mato Grosso, such as *Coronatella paulinae* Sousa, Elmoor-Loureiro & Santos, 2015, *Dunhevedia crassa* King, 1853, *D. odontoplax* Sars, 1901, *D. colombiensis* Stingelin, 1913, *Nicsmirnovius paggii* Sousa & Elmoor-Loureiro, 2017, *Pseudochydorus globosus* (Baird, 1850), among others (Tab. 2).

The sample-size-based extrapolation curves estimated a higher richness than observed, both for the Paraguay HR and for all of Mato Grosso state (Fig. 2A and B). The estimated richness obtained from twice the known sampling units was 146 for the Paraguay HR and 166 species for Mato Grosso. In other words, considering only the Paraguay HR, the observed richness represented 72.6% of the estimated richness, while all studies performed in the state allowed the estimated knowledge of 72.2% of cladoceran richness.

Species composition did not differ between Paraguay and Amazon HRs (Pseudo-$F = 0.77$; $p = 0.73$) but there are differences in the assemblage variability between the two regions ($F = 5.8$; $p = 0.03$; Fig. 3). The species that most contributed to the similarity between the two HRs, according to SIMPER analysis, were *Macrothrix elegans* Sars, 1901 ($p = 0.009$), *Chydorus eurynotus* Sars, 1901 ($p = 0.02$) and *Karualona muelleri* (Richard, 1897) ($p = 0.02$).

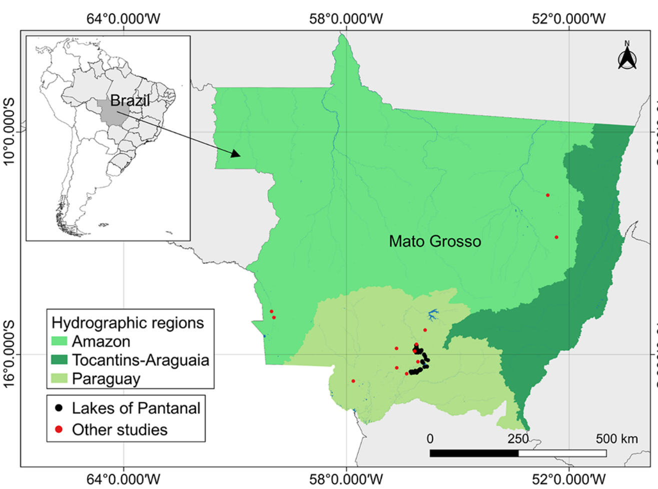

Fig. 1. Map of the state of Mato Grosso, Brazil. Highlight to the division of the territory into hydrographic regions (Amazon, Paraguay and Tocantins-Araguaia) and the approximate location where cladoceran biodiversity studies were conducted (samples collected for this study in the Pantanal, corresponding to only one study, and location of the other studies).

4 Discussion

Our study revealed that despite the increase in recent years (*i.e.* Padovesi-Fonseca *et al.*, 2016; Branco *et al.*, 2018; Elmoor-Loureiro *et al.*, 2018), there are still few studies focused on better understanding the biodiversity of cladocerans in the state of Mato Grosso (Tab. 1). The search allowed us to estimate a total richness of 166 species for the state and 146 for the region of Paraguay. An estimated high richness was already expected, as only thirteen studies were carried out throughout the state and only four in the Amazon HR. Possibly these study numbers were not enough to cover all aquatic ecosystems and access all the cladoceran biodiversity of the region. It is also possible that this result was influenced by the lack of sampling in the Tocantins-Araguaia HR. In this

Table 2. List of species of cladocerans, by hydrographic region, from the state of Mato Grosso, Brazil. Numeric codes refer to the study in which the species was cited (see Table 1). *asterisks represent new occurrences for the state.

Cladocerans	Original citation	Hydrographic region		
		Paraguay		Amazon
		Present study	Code	
Bosminidae				
Bosmina hagmanni Stingelin, 1904		X	4, 5	3
Bosmina tubicen Brehm, 1953		X	4, 5	
Bosmina longirostris (O. F. Muller, 1785)			5, 8	11
Bosminopsis deitersi Richard, 1895		X	4, 5	3, 6
Bosminopsis negrensis Brandorff, 1976			5	
Chydoridae				
Acroperus tupinamba Sinev & Elmoor-Loureiro, 2010			1, 12	2, 11
Acroperus sp.			9	
Alona affinis (Leydig, 1986)			4	3
Alona intermedia Sars, 1862			4, 5	
Alona ossiani Sinev, 1998		X	12	2, 6
Alona broaensis Smirnov & Matsumura-Tundisi, 1984			5	
Alona cf. *guttata*			5	
Alona guttata (Sars, 1862)		X	12	2
Alona isabellae Sousa, Elmoor-Loureiro & Santos 2016			12	
Anthalona verrucosa (Sars, 1901)	*Alona verrucosa*	X	5, 7	3
Anthalona neotropica Sousa, Elmoor-Loureiro & Debastiani-Júnior, 2015			12	2
Anthalona acuta Van Damme, Sinev & Dumont, 2011			7	
Anthalona sp.				11
Alonella dadayi Birge, 1910		X	4, 5, 12	2, 6, 11
Alonella clathratula Sars, 1896		X	12	2
Chydorus eurynotus Sars, 1901		X	4, 5	2, 3, 6
Chydorus nitidulus (Sars, 1901)		X	4	
Chydorus parvireticulatus Frey, 1987		X	4	
Chydorus pubescens Sars, 1901		X	4	3, 6
Chydorus cf. *sphericus* (O. F. Müller, 1776)			5	
Chydorus sphaericus (O. F. Müller, 1776)				11
Chydorus dentifer Daday, 1905		X	12	2
Chydorus spp.			5, 8	
Camptocercus australis Sars, 1896		X	5	
Camptocercus dadayi Stingelin, 1913				2
Coronatella cf. *rectangula* (Sars, 1861)	*Alona rectangula*			3
Coronatella monacantha (Sars, 1901)	*Alona monacantha*	X	4	
Coronatella poppei (Richard, 1897)			5	
Coronatella paulinae Sousa, Elmoor-Loureiro & Santos, 2015		X*		
Dadaya macrops (Daday, 1898)		X	5	
Disparalona hamata (Birge, 1879)	*Alonella hamulata*			3
Disparalona leptorhyncha Smirnov, 1996		X		2
Dunhevedia crassa King, 1853		X*		
Dunhevedia odontoplax Sars, 1901		X*		
Dunhevedia colombiensis Stingelin, 1913		X*		
Ephemeroporus barroisi (Richard, 1894)	*Chydorus barroisi*		5	2, 3
Ephemeroporus hybridus (Daday, 1905)	*Chydorus hybridus*	X	4	3
Ephemeroporus tridentatus (Bergamin, 1931)		X	4	
Euryalona orientalis (Daday, 1898)	*Euryalona occidentalis*	X	4, 5	3, 6
Euryalona brasiliensis Brehm & Thomsen, 1936		X	5	
Flavalona iheringula (Kotov & Sinev, 2004)	*Alona iheringi*		12	2, 11
Flavalona asymetrica Sousa et Elmoor-Loureiro, 2018			12	
Flavalona sp.			8	
Graptoleberis occidentalis Sars, 1901	*Graptoleberis testudinaria*	X	5	3, 6
Karualona muelleri (Richard, 1897)	*Alona karua*	X	4, 5	2, 3, 6
Kurzia polyspina Hudec, 2000	*Kurzia latissima*	X	5, 9	6
Kisakiellus aweti Sousa & Elmoor-Loureiro, 2018				2
Leberis davidi (Richard, 1895)	*Alona diaphana*			3
Leydigia striata Berabén, 1939	*Leydigia ciliata*		5	3
Leydigia sp.			5	
Leydigiopsis ornata Daday, 1905				6

Table 2. (continued).

Cladocerans	Original citation	Hydrographic region		
		Paraguay		Amazon
		Present study	Code	
Leydigiopsis brevirostris Brehm, 1938			5	11
Leydigiopsis curvirostris Sars, 1901		X*		
Magnospina dentifera (Sars, 1901)	*Alona dentifera*	X	5	11
Notoalona sculpta (Sars, 1901)		X		6
Nicsmirnovius paggii Sousa & Elmoor-Loureiro, 2017		X*		
Ovalona glabra (Sars, 1901)	*Alona pulchella*		5	3
Ovalona kaingang (Sousa, Elmoor-Loureiro & Santos, 2015)		X*		
Oxyurella ciliata Bergamin, 1939		X	5	
Oxyurella longicaudis (Birge, 1910)		X*		
Parvalona parva (Daday, 1905)		X	5	
Picripleuroxus cf. *similis* (Vávra, 1900)			5	
Picripleuroxus cf. *denticulatus (*Birge, 1877)			5	
Picripleuroxus similis (Vávra, 1900)				11
Pleuroxus aduncus (Jurine, 1820)				3
Pseudochydorus globosus (Baird, 1850)		X*		
Daphniidae				
Ceriodaphnia cornuta Sars, 1886		X	4, 5, 8	3, 6, 11
Ceriodaphnia silvestri Sars, 1901			5	
Ceriodaphnia sp.			5,9	
Daphnia ambigua Scourfield, 1947			4	
Daphnia gessneri Herbst, 1967		X*		
Simocephalus acutirostratus King, 1853	*Simocephalus acutirostris*	X	4	
Simocephalus latirostris Stingelin, 1906		X*		
Simocephalus serrulatus (Koch, 1841)			4, 5, 8	
Simocephalus iheringi Richard, 1897		X	5	
Simocephalus cf. *semiserratus* Sars 1901		X*		
Simocephalus sp.			5	
Scapholeberis armata freyi Dumont & Pensaert, 1983		X	5	
Ilyocryptidae				
Ilyocryptus sordidus (Liévin 1848)			4	
Ilyocryptus spinifer Herrick, 1882			4, 5, 8, 10	2, 3, 6
Ilyocryptus sarsi Stingelin, 1913			5	
Ilyocryptus sp.		X		
Macrothricidae				
Macrothrix brandorffi Kotov and Hollwedel, 2004				6
Macrothrix elegans Sars, 1901	*Macrothrix triserialis*	X		2, 3, 6
Macrothrix laticornis Jurine, 1820				3
Macrothrix paulensis (Sars,1901)		X	4	
Macrothrix squamosa Sars, 1901				6
Macrothrix spinosa King, 1853		X	5	
Macrothrix superaculata (Smirnov, 1992)		X	4, 5	
Macrothrix cf. *laticornis* Jurine, 1820			5	
Macrothrix sp.			5	
Grimaldina brazzai Richard, 1892		X*		
Guernella raphaelis Richard, 1892		X		6
Onchobunops tuberculatus Fryer & Paggi, 1972		X*		
Streblocerus pygmaeus Sars, 1901		X*		
Moinidae				
Moina minuta Hansen, 1899		X	4, 5	6
Moina reticulata (Daday, 1905)		X	5	6
Moina micrura Kurz, 1874		X	8	
Moina rostrata McNair,1980		X*		
Moina sp.		X	9	
Moinodaphnia macleayi (King, 1853)		X	5	6
Sididae				
Diaphanosoma birgei Korineck, 1981	*Diaphanosoma brachyurum*	X	4, 5, 8	3, 6
Diaphanosoma brevireme Sars, 1901		X	4	6
Diaphanosoma fluviatile Hansen, 1899		X	4, 5	
Diaphanosoma spinulosum Herbst, 1967	*Diaphanosoma sarsi*	X	4, 5, 9	3, 6

Table 2. (continued).

Cladocerans	Original citation	Hydrographic region		
		Paraguay		Amazon
		Present study	Code	
Diaphanosoma polyspina Korovchinsky, 1982			5	
Diaphanosoma sp.		X	5,9	
Sida crystallina (O. F. Müller, 1776)			8	
Latonopsis australis Sars,1888		X	4	
Pseudosida bidentata Herrick, 1884		X		3
Pseudosida ramosa (Daday, 1904)		X	4	6
Sarsilatona behningi Korovchinsky 1985			5	6
Sarsilatona serricauda (Sars, 1901)		X*		
Sarsilatona sp.		X		
Holopedidae				
Holopedium amazonicum Stingelin 1904				3
Total		69	82	54

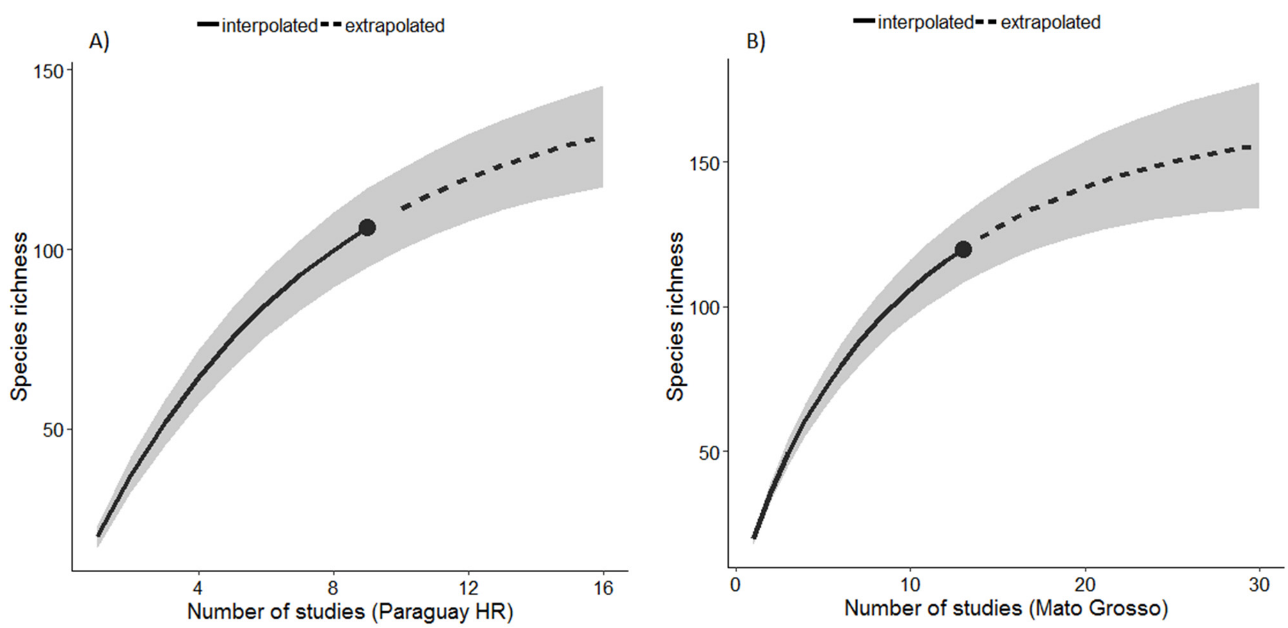

Fig. 2. Sample-size-based rarefaction (solid line) and extrapolation (dashed lines) for Hill numbers ($q = 0$, species richness) from cladoceran species considering (A) the Paraguay hydrographic region ($N = 9$) and (B) state of Mato Grosso ($N = 13$). The 95% confidence intervals were obtained by a bootstrap method.

scenario, even with the increase of new records obtained from the collections performed in the Pantanal in this study (Paraguay HR), the rarefaction curve showed no asymptotic tendency for the State (Fig. 2B). Overall, in biodiversity studies, there is no sampling or method capable of accessing the total species richness of an ecosystem and, according to Williams *et al.*, (2007), the adequacy of the inventory is dependent on obtaining more than 50% of the estimated number of species.

Despite being far from reaching the richness estimated, the richness observed for Mato Grosso can still be considered higher than that recorded for other states: Mato Grosso do Sul (101 spp), Minas Gerais (94 spp), São Paulo (84 spp) and Pernambuco (32 spp) (Santos-Wisniewski *et al.*, 2011; Rocha *et al.*, 2011; Soares and Elmoor-Loureiro, 2011; Zanata *et al.*, 2017). Among the registered families, the Chydoridae family presented the highest species richness considering the data analyzed together or only for the Paraguay HR (Tab. 2). This is a relatively common pattern in inventories of cladoceran fauna and is related to the self-ecological characteristics of the species that compose the family (Santos-Wisniewski *et al.*, 2011; Soares and Elmoor-Loureiro, 2011; Zanata *et al.*, 2017). For example, members of the Chydoridae family have reduced swimming capacity, but have specialized appendices for locomotion under substrates and for scraping organic material (Sousa and Elmoor-Loureiro, 2008; Sousa *et al.*, 2017). These characteristics allow this group to present greater abundance and diversity associated with macrophytes in littoral regions

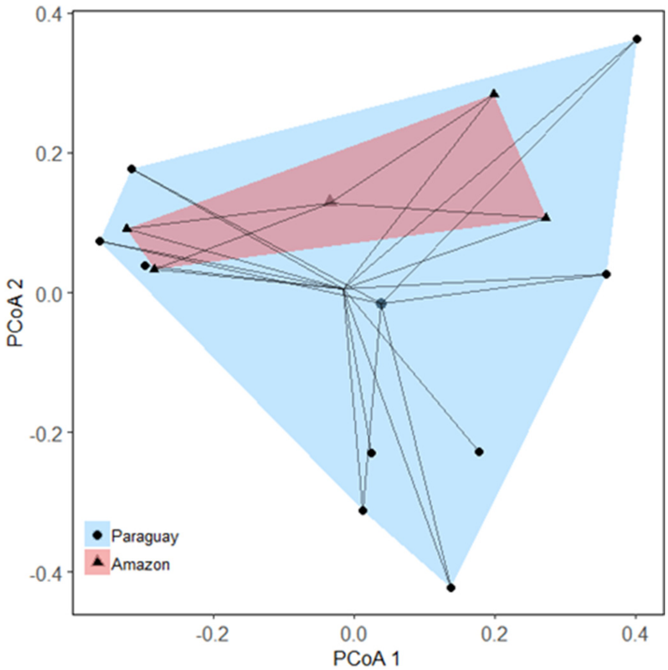

Fig. 3. Dispersion of studies conducted in the state of Mato Grosso obtained through the PCoA (Principal Coordinate Analysis) for each of the hydrographic regions.

(Castilho-Noll *et al.*, 2010) and water bodies with high vegetation cover. The relevance of Chydoridae in this study becomes even more evident when we observe the high number of new records for Mato Grosso (Tab. 2).

However, of all Chydoridae registered for the state, five species found have a delicate taxonomic context and some information should be taken into consideration when analyzing this species list: In Brazil, the only species of the *affinis*-group is *Alona ossiani*. Therefore, it is likely that *Alona affinis* records belong to its Neotropical congeners (Sousa and Elmoor-Loureiro, 2019b). The occurrence of *Alona broaensis* was also recorded; however, this species was considered by Van Damme *et al.* (2010) to be a junior synonym of *Alona dentifera.* After the creation of the genus *Magnospina*, which includes the *dentifera*-group, Sousa *et al.* (2016) confirmed the status suggested by Van Damme *et al.* (2010) for *Alona broaensis*. *Coronatella rectangula* has restricted distribution in the Palearctic region. In the Neotropical region, the name may have been attributed to different species such as *C. paulinae*, *C. undata*, *C. poppei* and *C. monacantha* or even to *Ovalona kaingang* (Sousa *et al.*, 2015a, b). Finally, *Chydorus sphaericus* was cited as a valid species in Elmoor-Loureiro (1997). This species is currently known to have Holarctic distribution (Smirnov, 1996) and records outside this region are related to cryptic diversity. On the other hand, it may represent a biological invasion process, as already described in Australia (Sharma and Kotov, 2014). Both possibilities must be tested in the future.

Similarly to some species of Chydoridae, *Ilyocryptus sordidus* and *Grimaldina brazzai* have some indications regarding taxonomic status. The first species also has a Palearctic distribution, and records in Brazil probably belong to *Ilyocryptus sarsi* (Sousa and Elmoor-Loureiro, 2019a). Recently, the genus *Grimaldina*, previously considered cosmopolitan, has been revised using material from different continents, including the South American (Neretina and Kotov, 2017). The main result of this work indicates that the *G. brazzai* species does not occur in the Neotropics and, therefore, the records possibly belong to *Grimaldina freyi* Nerentina & Kotov, 2017.

The Sididae were also prominent in relation to species richness, considering all studies conducted in the state. A similar result was found by Rocha *et al.*, (2011) in the state of São Paulo. On the other hand, the low richness observed in Moinidae and Daphniidae is related to the fact that they are groups consisting of typically planktonic species, found most predominantly in the pelagic region of aquatic ecosystems (Elmoor-Loureiro, 1997).

The similarity between the regions was marked by the species: *Macrothrix elegans,* one of the most common anomopod species in the Neotropics (Kotov *et al.*, 2004); *Chydorus eurynotus,* most frequently observed in vegetated regions (Battauz *et al.*, 2017); and *Karualona muelleri*, a common species in shallow lakes with low dissolved oxygen (Panarelli *et al.*, 2019). Despite this similarity, the few studies ever conducted for the state showed that the cladoceran community of the Amazon HR can be considered a subset of the Paraguay HR, whose species showed the highest variance (Fig. 3). These results should be evaluated, taking into account the effect of sampling, since there is a large difference in the number of literature studies for each hydrographic region, which is reflected in the species richness (Tabs. 1 and 2). Considering only the four studies found for the Amazon HR, we cannot rule out the possibility of distinct communities in relation to other hydrographic regions, due to the potential for high diversity. For example, a single inventory of a few water bodies in the Upper Xingu Basin revealed a new genus and new species of Chydoridae for the Amazon HR (Sousa and Elmoor-Loureiro, 2018). Therefore, we consider it necessary to carry out further studies in the different hydrographic regions found in Mato Grosso in order to improve the knowledge of cladoceran biodiversity.

Finally, even with the high number of species observed in the Paraguay HR influenced by the sampling of 50 lakes in the Pantanal, we can conclude that the state's aquatic ecosystems are still poorly studied. We therefore suggest a greater sampling effort in the Mato Grosso ecosystems, especially in areas of the Amazon and Tocantins-Araguaia HRs. This sampling should take particular account of the littoral zones of aquatic ecosystems, as such regions are marked by the presence of macrophyte beds, where aquatic invertebrate biodiversity tends to be higher due to increased resource availability (Choi *et al.*, 2014).

Acknowledgements. We thank the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES) – Finance Code 001. We also thank CAPES for a doctoral scholarship awarded to the first author. The authors thank Dr. Lourdes M. A. Elmoor-Loureiro for permission to use the Brazilian Cladocera database and Enezio Francisco and co-workers for help with fieldwork. We thank the Fundação de Amparo à Pesquisa do Estado de Mato Grosso (FAPEMAT) for the financial support through Edital N° 037/2016–Redes de Pesquisa em Mato Grosso. VLL is supported by a research fellowship from CNPq, process 307961/2017-6.

References

Allan JD. 1976. Life history patterns in zooplankton. *Am Natural* 110: 165–180.

Alonso M, Kotov AA. 2017. A new species of Alonella Sars, 1862 (Crustacea: Cladocera: Chydoridae) from the Ecuadorian Andes. *Zootaxa* 4290: 1–11.

ANA. 2015. Conjuntura dos recursos hídricos no Brasil: regiões hidrográficas brasileiras – Edição Especial. – Brasília: Agência Nacional das Águas (ANA). Available at http://www.snirh.gov.br/portal/snirh/centrais-de-conteudos/conjuntura-dos-recursos-hidricos/regioeshidrograficas2014.pdf (accessed November, 2018).

Anderson MJ, Walsh DC. 2013. PERMANOVA, ANOSIM, and the Mantel test in the face of heterogeneous dispersions: what null hypothesis are you testing? *Ecol Monogr* 83: 557–574.

Battauz YS, de Paggi SBJ, Paggi JC. 2017. Macrophytes as dispersal vectors of zooplankton resting stages in a subtropical riverine floodplain. *Aquat Ecol* 51: 191–201.

Bottrell H, Duncan A, Gliwicz ZM, *et al.*, 1976. Review of some problems in zooplankton production studies. *Norweg J Zool* 24: 419–456.

Branco CWC, Silveira RDML, Marinho MM. 2018. Flood pulse acting on a zooplankton community in a tropical river (Upper Paraguay River, Northern Pantanal, Brazil). *Fund Appl Limnol/Arch Hydrobiol* 192: 23–42.

Brandorff GO, Pinto-Silva V, Morini AET. 2011. Zooplankton: species diversity, abundance and community development. In: Junk WJ, Silva C, Cunha CN, Wantzen KM (Eds.), The Pantanal: Ecology, biodiversity and sustainable management of a large Neotropical seasonal wetland. Pensoft Publishers: Sofia/Moscow, 355–391.

Castilho-Noll MSM, Câmara CF, Chicone MF, Shibata EH. 2010. Pelagic and littoral cladocerans (Crustacea, Anomopoda and Ctenopoda) from reservoirs of the Northwest of São Paulo State, Brazil. *Biota Neotrop* 10: 21–30.

Choi JY, Jeong KS, Kim SK, La GH, Chang KH, Joo GJ. 2014. Role of macrophytes as microhabitats for zooplankton community in lentic freshwater ecosystems of South Korea. *Ecol Inf* 24: 177–185.

Elmoor-Loureiro LMA. 1997. Manual de identificação de cladoceros límnicos do Brasil. Brasília. Ed. Universitária, 156 p.

Elmoor-Loureiro LMA. 2000. Brazilian cladoceran studies: where do we stand? *Nauplius* 8: 117–131.

Elmoor-Loureiro LMA. 2014. *Ephemeroporus quasimodo* sp. nov. (Crustacea: Cladocera: Chydoridae), a new species from the Brazilian Cerrado. *Zootaxa* 3821: 88–100.

Elmoor-Loureiro LMA, Soares CEA. 2010. Cladocerans from gut content of fishes from Guaporé River Basin, MT, Brazil. *Acta Limnol Brasilien* 22: 46–49.

Elmoor-Loureiro LMA, Sousa FDR, Rocha GM, *et al.*, 2018. A new record of *Kisakiellus aweti Sousa* & Elmoor-Loureiro, 2018 (Cladocera, Chydoridae) from the Amazon region. *Nauplius* 26.

Forró L, Korovchinsky NM, Kotov AA, Petrusek A. 2008. Global diversity of cladocerans (Cladocera; Crustacea) in freshwater. *Hydrobiologia* 595: 177–184.

Green J. 1972. Freshwater ecology in the Mato Grosso, Central Brazil. *J Nat History* 6: 215–227.

Heckman CW. 1998. The seasonal succession of biotic communities in wetlands of the tropical wet-and-dry climatic zone: V. Aquatic invertebrate communities in the Pantanal of Mato Grosso, Brazil. *Int Rev Hydrobiol* 83: 31–63.

Hsieh TC, Ma KH, Anne C. 2019. iNEXT: iNterpolation and EXTrapolation for species diversity. R package version 2.0.19. Available at http://chao.stat.nthu.edu.tw/blog/software-download/

Junk WJ, Da Cunha CN, Wantzen KM. *et al.*, 2006. Biodiversity and its conservation in the Pantanal of Mato Grosso, Brazil. *Aquat Sci* 68: 278–309.

Korovchinsky NM. 1992. Sididae & Holopediidae. Guides to the identification of the microinvertebrates of the continental waters of the world, SPB, The Hague, 82 p.

Kotov AA, Garfias-Espejo T, Elías-Gutiérrez M. 2004. Separation of two Neotropical species: *Macrothrix superaculeata* (SMIRNOV, 1982) versus M. elegans SARS, 1901 (Macrothricidae, Anomopoda, Cladocera). *Hydrobiologia* 517: 61–88.

Kotov AA, Fuentes-Reines JM. 2014. A new species of *Leydigia* Kurz, 1875 (Cladocera: Chydoridae) from Colombia. *Zootaxa* 3814: 399–408.

Kotov A, Forró L, Korovchinsky NM, Petrusek A. 2013. World checklist of freshwater Cladocera species. World Wide Web electronic publication. Available in: http://fada.biodiversity.be/group/show/17

Kotov AA, Elmoor-Loureiro LM. 2008. Revision of *Ilyocryptus* Sars, 1862 (Cladocera: Ilyocryptidae) of Brazil with description of two new subspecies. *Zootaxa* 1962: 49–64.

Lima PV, Oliveira SML, de Carvalho Silva M, Oliveira VA. 2012. Variação na riqueza das espécies zooplanctônicas em lagoas marginais do rio Cuiabá (Pantanal-MT). *Biodiversidade* 11.

Lomolino MV, Riddle BR, Whittaker RJ, Brown JH. 2010. Biogeography, 4th edn. Sinauer, Sunderland.

Maloufi S, Catherine A, Mouillot D, *et al.*, 2016. Environmental heterogeneity among lakes promotes hyper β-diversity across phytoplankton communities. *Freshwater Biol.* 61: 633–645.

Myers N, Mittermeier RA, Mittermeier CG, Fonseca GAB, Kent J. 2000. Biodiversity hotspots for conservation priorities. *Nature* 403: 853–858.

Neretina AN, Kotov AA. 2017. Old World-New World differentiation of so-called "circumtropical" taxa: the case of rare genus *Grimaldina* Richard, 1892 (Branchiopoda: Cladocera: Macrothricidae). *Zootaxa* 4291: 295–323.

Neves IF, Rocha O, Roche KF, Pinto AA. 2003. Zooplankton community structure of two marginal lakes of the River Cuiaba (Mato Grosso, Brazil) with analysis of Rotifera and Cladocera diversity. *Braz J Biol* 63: 329–343.

Oksanen J, Blanchet FG, Friendly M, *et al.*, 2018. *vegan: Community Ecology Package*. R package version 2.5-3. Available at https://CRAN.R-project.org/package=vegan

Padovesi-Fonseca C, Saraiva MF, Fernandes CLDS. 2016. First record of cladocerans from the headwaters of the Cerrado–Amazon boundary, central Brazil. *Biodiversity* 17: 90–92.

Panarelli EA, Kawamura HA, Elmoor-Loureiro LM, *et al.*, 2019. Life history of *Karualona Muelleri* (Richard, 1897) (Chydoridae, Aloninae). jlimnol [Internet]. 26 Jul. 2019 [cited 30 Sep. 2019]. Available at https://www.jlimnol.it/index.php/jlimnol/article/view/jlimnol.2019.1848

R Core Team. 2018. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Available at https://www.R-project.org/

Rocha O, Santos-Wisniewski MJ, Matsumura-Tundisi T. 2011. Checklist de Cladocera de água doce do Estado de São Paulo. *Biota Neotrop* 11: 1–22.

Santangelo JM, Araújo LR, Esteves FA, Manca M, Bozelli RL. 2011. Method for hatching resting eggs from tropical zooplankton: effects of drying or exposing to low temperatures before incubation. *Acta Limnol Bras* 23: 42–47.

Santos-Wisniewski MJ, Matsumura-Tundisi T, Negreiros NF, *et al.*, 2011. O estado atual do conhecimento da diversidade dos Cladocera (Crustacea, Branchiopoda) nas águas doces do estado de Minas Gerais. *Biota Neotrop* 11: 287–301.

Sharma P, Kotov AA. 2014. Establishment of *Chydorus sphaericus* (O.F. Muller, 1785) (Crustacea: Cladocera) in Australia: consequences of mass fish stocking from Northern Europe? *J Limnol* 74: 225–233.

Sinev AY, Elmoor-Loureiro LM. 2010. Three new species of chydorid cladocerans of subfamily Aloninae (Branchipoda: Anomopoda: Chydoridae) from Brazil. *Zootaxa* 2390: 1–25.

Smirnov NN. 1996. Cladocera: The Chydorinae and Sayciinae (Chydoridae) of the world. Amsterdam: SPB Academic Publishing, 197 p.

Soares CEA, Elmoor-Loureiro LMA. 2011. Uma atualização da lista de Cladocera Cladocera (Crustacea, Branchiopoda) do Estado de Pernambuco, Brasil. *Biota Neotrop* 11: 409–414.

Sousa FDR, Elmoor-Loureiro LMA. 2008. Cladóceros fitófilos (Crustacea, Branchiopoda) do Parque Nacional das Emas, estado de Goiás. *Biota neotropica* 8: 159–166.

Sousa FDR, Elmoor-Loureiro LMA. 2017. Zip Code matters: *Nicsmirnovius paggii*, a new species from fitzpatricki-complex (Cladocera: Chydoridae) does not co-occur with *Nicsmirnovius incredibilis*. *Ann Limnol* 51: 2247–2270.

Sousa FDR, Elmoor-Loureiro LMA, Santos S. 2015a. *Alona kaingang* (Crustacea, Cladocera, aloninae): a new species of the pulchella group, with identification key to neotropical species. *Zoolog Stud* 54: 48.

Sousa FDR, Elmoor-Loureiro LMA, Santos S. 2015b. Redescription of Coronatella poppei (Richard, 1897) (Crustacea, Branchiopoda, Chydoridae) and a revision of the genus in Brazil, with descriptions of new taxa. *Zootaxa* 3955: 211–244.

Sousa FDR, Elmoor-Loureiro LM, Debastiani-Júnior JR, Mugnai R, Senna A. 2015c. New records of Anthalona acuta Van Damme, Sinev & Dumont 2011 and *Anthalona brandorffi* (Sinev & Hollwedel, 2002) in Brazil, with description of a new species of the simplex-branch (Crustacea: Cladocera: Chydoridae). *Zootaxa* 4044: 224–240.

Sousa FDR, Elmoor-Loureiro LMA, Santos S. 2016. Position of the dentifera-group in the Coronatella-branch and its relocation to a new genus: Magnospina gen. n. (Crustacea, Chydoridae, Aloninae). *ZooKeys* 586: 95–119.

Sousa FDR, Elmoor-Loureiro LM, Panarelli EA. 2017. The Amazing diversity of the genus Monospilus Sars, 1862 (Crustacea: Branchiopoda: Aloninae) in South America. *Zootaxa* 4242: 467–492.

Sousa FDR, Elmoor-Loureiro LMA. 2018. Cladocera from the Upper Xingu River Basin with the description of a new genus of the Chydoridae (Crustacea: Branchiopoda: Anomopoda). *Zootaxa* 4418: 545–561.

Sousa FDR, Elmoor-Loureiro LMA, Mendonça-Galvão L, Panarelli EA, Arruda TF, Fagundes BG. 2018. Cladoceran (Crustacea: Branchiopoda) biodiversity of protected areas in a Brazilian hotspot. *Inverteb Zool* 15: 309–322.

Sousa FDR, Elmoor-Loureiro LMA. 2019a. Identification key for the Brazilian species and subspecies of the family Ilyocryptidae (Crustacea, Branchiopoda, Anomopoda). *Pap Avulsos Zool* 59.

Sousa FDR, Elmoor-Loureiro LMA. 2019b. Identification key for the Brazilian genera and species of Aloninae (Crustacea, Branchiopoda, Anomopoda, Chydoridae). *Papéis Avulsos de Zoologia* 59.

Van Damme K, Kotov AA, Dumont HJ. 2010. A checklist of names in Alona Baird 1843 (Crustacea: Cladocera: Chydoridae) and their current status: an analysis of the taxonomy of a lump genus. *Zootaxa* 2330: 1–63.

Williams VL, Witkowski ETF, Balkwill K. 2007. The use of incidence-based species richness estimators, species accumulation curves and similarity measures to appraise ethnobotanical inventories from South Africa. *Biodiv Conserv* 16: 2495–2513.

Zanata LH, Güntzel AM, Rodrigues TAR, *et al.*, 2017. Checklist de Cladocera (Crustacea, Branchiopoda) do Estado de Mato Grosso do Sul, Brasil. *Iheringia Sér Zool* 107: e2017113.

Cite this article as: Brito MTS, Diniz LP, Pozzobom UM, Landeiro VL, Sousa FDR. 2020. Cladocera (Crustacea: Branchiopoda) from the state of Mato Grosso, Brazil. *Ann. Limnol. - Int. J. Lim.* 56: 7