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Composition, abundance, and diversity of limnetic cladocerans (Crustacea: Anomopoda and Ctenopoda) in a black-water lake in the Negro River basin, Amazonas State, Brazil

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Abstract

For the past 10 years, studies have contributed greatly to knowledge regarding the composition and distribution of the planktonic cladocerans of Tupé Lake in Amazonas State, Brazil, but comparisons between these studies have not been made, and this would increase the comprehension of the ecology of these organisms and their environment. Periodically the hydrological conditions in Tupé Lake change, due to its connecting channel with the Negro River. The purpose of this study was to determine the composition, abundance and diversity of cladocerans in the limnetic zone of Tupé Lake and compare the results with previous studies performed there. Samples were taken in April, June, September, October, November/08 and February/09 in 4 stations located in different areas of the lake. *Ceriodaphnia cornuta* G.O. Sars, 1886, *Bosminopsis deitersi* Richard, 1895 and *Bosmina* cf. *longirostris* (O.F. Müller, 1785) were the most abundant and frequent species of cladocerans among the 25 recorded species. Higher abundance and richness were observed during the low water phase (October/08). A relationship between the number of samples taken, as well as the type of sampling gear used, and the species richness was observed, when comparing this and previous studies performed in the lake.

Key words

Black-water lake, central Amazon, microcrustaceans, Neotropical region, pelagic zone.

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Introduction

Although they are traditionally associated with the plankton community, cladocerans can be found in different habitats such as flooded forest litter (Walker, 1985), underground water (Dumont, 1995), and in the limnetic and littoral zones of lakes and reservoirs (Elmoor-Loureiro, 2007; Castilho-Noll *et al.*, 2010). Cladocerans can also be associated with other organisms such as sponges (Ghidini and Santos Silva, 2011a) and bromeliads (Smirnov, 1988).

Many studies of the composition and abundance of cladocerans in the plankton community of the limnetic zone have been conducted in São Paulo State in Brazil (Rocha *et al.*, 1995; Rocha and Guntzel, 1999), and in the Paraná River (Lansac-Tôha *et al.*, 2004; Lansac-Tôha *et al.*, 2009) and Amazon River basins (Robertson and Hardy, 1984). Biological aspects of these organisms have also been studied, including reproduction (Crispim and Watanabe, 2001), vertical distribution (Lansac-Tôha et al., 1995; Matsumura-Tundisi, 1999), the influence of predation (Castilho-Noll and Arcifa, 2007), and the relationship with the phytoplankton community (Ferrão-Filho and Azevedo, 2003; Ghidini *et al.*, 2009).

Compared to other regions in Brazil, studies of cladocerans in the Amazon basin are rare (Elmoor-Loureiro, 2000), even though many areas of this region have been sampled. Robertson and Hardy (1984) found only 20 species of pelagic cladocerans in white- and black-water environments near Manaus. Robertson and Hardy (1984) and Brandorff (1978) observed similar differences in the two types of waters. Hardy (1980) observed lower diversity of cladocerans in black-water lakes than in white-water lakes, and Carvalho (1983) found that cladocerans do not have clear abundance patterns in the Amazon River floodplain during the fluvial regime, due to different feeding strategies of these organisms.

Most of the studies of the cladoceran community have been conducted in white-water lakes. However, Brandorff (1978) disputed the idea that black-water lakes have less diversity, and his statement was confirmed by later studies in the Tarumã-Mirim and Nhamundá rivers and Lake Cristalino (Hardy, 1980; Brandorff *et al.*, 1982).

Most studies involving cladocerans and the zooplankton community in black-water lakes have been performed in Tupé Lake, focusing on the spatial-temporal and vertical distribution, day/night variation, predatory fish, and biomass and reproductive aspects (Previattelli *et al.*, 2005; Brandorff and Hardy, 2010; Calixto et al., 2011; Ghidini and Santos-Silva, 2011b; Previattelli and Santos-Silva, 2011).

The cladoceran community in Tupé Lake has been studied for almost 10 years, using various approaches and methodologies, but neither a comparative study involving historical data, nor a structural pattern of this community was completed. What is known is that the periodic changes in the composition and abundance of cladocerans in the lake are related primarily to changes in the water level, predation and vertical migration (Brandorff and Hardy, 2010; Ghidini and Santos-Silva, 2011b).

The present study: (i) analyzes the composition, abundance and diversity of planktonic cladocerans in Tupé Lake during the fluvial cycle; (ii) compares the values of species richness, organism density and spatial-temporal variation of the planktonic cladoceran community from previous studies performed in this lake with this study; (iii) analyzes studies previously performed in the lake, to determine patterns in the temporal variation of these organisms according to the various tested methodologies.

Material and Methods

Study area

Located 25 km from Manaus in Amazonas State, Tupé Lake is part of a Sustainable Development Area. Because the lake is connected to the Negro River by a channel, its mean water volume ranges from 1,400,000 to 2,500,000 m^3 during the different periods of the fluvial regime.

During the low-water periods, the lake is characterized as dystrophic, with a maximum depth of 5 m and sandy margins. During the flood periods, the water invades the surrounding forest, and as the water volume increases (to a depth of 14.5 m), its conditions shift to oligotrophic (Aprile and Darwich, 2005; Darwich *et al.*, 2005).

Field work, sampling and data analyses

Sampling occurred in April, June, September, October and November 2008 and February 2009, with four sampling stations: two located in the main channel of the lake, one in the deeper central part, and the fourth in the secondary arm (Fig. 1). Samples were taken only in the limnetic zone, as previous studies in the lake were performed only in this zone.

To represent the entire water column, samples were collected with a motorized pump with which 50 l of water was taken, at each meter of depth, starting from the surface to the bottom of the lake. The sample volume at each station varied according to the season and depth of the station. The water was filtered in a conical plankton net (55 μm mesh size), with samples stored in polyethylene flasks and fixed in 4% buffered formalin.

Depth and water transparency were measured at each sampling station using a Secchi Disk. Dissolved-oxygen concentration, electrical conductivity and water temperature were measured in the surface water, using YSI 55 and YSI 30 multimeters (Yellow Springs Instruments).

Cladoceran species were identified based on specialized literature (Paggi, 1973, 1979; Elmoor-Loureiro, 1988, 1997; Korovchinsky, 1992; Alonso, 1996; Smirnov, 1996). Species quantification was done through subsamples of 5 ml, using a Stempel pipette and a stereoscopic microscope. The number of subsamples counted was determined by the count of 100 individuals of the most abundant species (Bottrel *et al.*, 1976).

Population densities were represented by the relative abundance of each species in each month and at each station. The consistency indices were also determined for each species, according to Dajoz (1973). Kruskal-Wallis ANOVA tests were performed to determine if there were significant differences in the richness and relative abundance of cladocerans among months and stations, as well as variations in the abiotic parameters. The species richness and Shannon-Wiener diversity index were determined based on

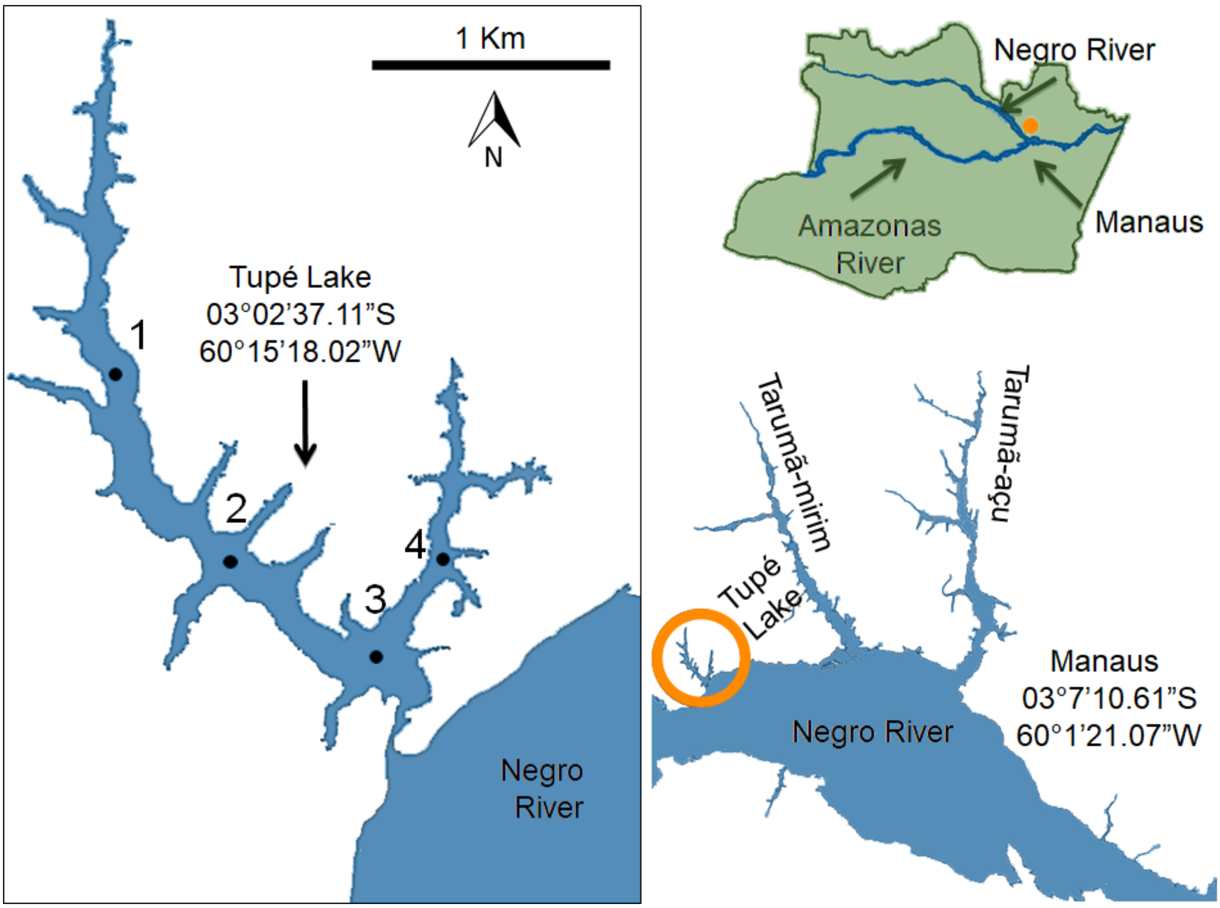

Figure 1. Map of Tupé Lake, Amazonas State, Brazil, indicating the study site and sampling stations.

the ecological attributes of the organisms, using the statistical software PAST (Hammer *et al.*, 2001).

Previous data from the cladoceran community of Tupé Lake were obtained from the studies of Previattelli *et al.* (2005), Brandorff and Hardy (2010), Ghidini and Santos-Silva (2011b), Previattelli and Santos-Silva (2011) and Calixto *et al.* (2011). Considering the scarcity of literature regarding the cladocerans of the lake, two unpublished studies (Ferreira, 2009; 2013) were included in the discussion, due to the importance of the data in these studies.

Results and Discussion

Variation of limnetic parameters

The depths of stations ranged from 1 to 14.5 m. The minimum depths were observed at station 1, located north of the main channel of the lake (ranging from less than 1 m to almost 10 m, during the high-water period), while the maximum depths were at station 3 in the most sloped region of the lake (ranging from 5 to 15 m depth). The minimum and maximum values of depth were observed in October/2008 and June/2008, corresponding to the periods of drought and flood-peak, respectively. This cycle was previously discussed by Aprile and Darwich (2005).

A small variation (2.5 to 3 m) was observed in the euphotic zone (LZE) throughout the study. Light penetration into the lake was slightly greater in July/2008; however, significant differences were not observed in the LZE monthly variation among the stations (Kruskal-Wallis test: H (N = 24) = 0.99, p = 0.87). In addition, because of the low volume of water in the lake during the low-water period (from September to November/2008), light penetrated the entire water column. This was at stations 1 and 4, located farthest from the Negro River. In October/2008, station 1 reached 0.7 m depth, similar to levels previously reported by Aprile and Darwich (2005).

Variations in the dissolved-oxygen concentration and electrical conductivity throughout the study period were observed, with maximum values recorded in April/2008 (5.1 $mgO_2.L^{-1}$ and 10 $\mu S.cm^{-1}$, respectively) and February/2009 (flooding period, 4.9 $mgO_2.L^{-1}$ and 9.1 $\mu S.cm^{-1}$, respectively) and minimum values during the low-water period, October and November/2008, 1.5 $mgO_2.L^{-1}$ and 6 $\mu S.cm^{-1}$, respectively.

No significant variation was recorded in the limnological parameters among the stations, similarly to previous studies (Darwich *et al.*, 2005; Ghidini and Santos-Silva, 2011b). The lake presented two profiles during the fluvial regime. It was shallow and stratified during the low-water period and homogeneous and oligotrophic during the high-water period, due mainly to the water flow from the Negro River into the lake. Darwich *et al.* (2005), Ghidini and Santos-Silva (2011b) and Calixto *et al.* (2011) previously reported this temporal and spatial pattern of variation in Tupé Lake.

Composition, abundance, diversity and richness of cladoceran species

Representatives from all the Neotropical families of cladocerans (Crustacea: Ctenopoda and Anomoda) were observed, and 25 species were recorded from April/2008 to February/2009 at all 4 stations (Tab. 1). Studies of the limnetic zone of lakes in other regions of

Table 1. Dajoz's constancy index and relative abundancy of the species of planktonic cladocerans (Crustacea: Anomopoda and Ctenopoda) in Tupé Lake, between April 2008 and February 2009.

Family	Species	Constancy
Daphniidae	*Ceriodaphnia cornuta* G.O. Sars, 1886	50% or more
Bosminidae	*Bosmina hagmanni* (Stingelin, 1904)	50% or more
	Bosmina cf. *longirostris* (O.F. Müller, 1785)	50% or more
	Bosmina tubicen Brehm, 1953	Between 25 and 50%
	Bosminopsis brandorffi Rey & Vásquez, 1989	25% or less
	Bosminopsis deitersi Richard, 1895	50% or more
	Bosminopsis negrensis Brandorff, 1976	25% or less
Holopedidae	*Holopedium amazonicum* Stingelin,1904	25% or less
Moinidae	*Moina minuta* Hansen, 1899	50% or more
	Moina reticulata (Daday, 1905)	25% or less
	Moina rostrata McNair,1980	Between 25 and 50%
Sididae	*Diaphanosoma birgei* Kořínek, 1981	25% or less
	Diaphanosoma polyspina Korovchinsky, 1982	50% or more
	Diaphanosoma spinulosum Herbst, 1967	25% or less
Ilyocryptidae	*Ilyocryptus spinifer* Herrick, 1882	25% or less
Macrothricidae	*Streblocerus pygmaeus* G.O. Sars, 1901	25% or less
	Magnospina dentifera (G.O. Sars, 1901)	25% or less
Chydoridae (Aloninae)	*Alona ossiani* Sinev, 1998	25% or less
	Coronatella monacantha (G.O. Sars, 1901)	25% or less
	Notoalona sculpta (G.O. Sars, 1901)	25% or less
Chydoridae (Chydorinae)	*Alonella clathratula* G.O. Sars, 1896	25% or less
	Alonella dadayi Birge, 1910	25% or less
	Alonella sp.	25% or less
	Disparalona hamata (Birge, 1879)	25% or less
	Ephemeroporus barroisi (Richard, 1894)	25% or less

25% or less | Between 25 and 50% | 50% or more

Brazil reported similar data to those observed in Tupé Lake (Santos-Wisniewski *et al.*, 2000; Serafim-Júnior *et al.*, 2005; Castilho-Noll *et al.*, 2010). Robertson and Hardy (1984) estimated an average of 20 species of cladocerans in the Amazonian environments.

The family Chydoridae showed the highest richness, but its records were accidental. This is the most species-rich family of cladocerans (Smirnov, 1996). Bosminidae was the second most species-rich family, followed by Moinidae and Sididae. For the families Daphniidae, Ilyocryptidae, Macrothricidae and Holopedidae, only one species of each was observed. Brandorff (1978) found that the most species-rich family in the Amazonian ecosystem was Bosminidae. Three Bosminidae species were observed, two of them endemic to the Amazon basin (Brandorff, 1976; Rey and Vásquez, 1989). Records of the genus *Bosmina* are common in many regions of Brazil, especially in reservoir environments (Paggi and José de Paggi, 1990; Lansac-Tôha *et al.*, 2004; Perbiche-Neves and Nogueira, 2010). Kotov *et al.* (2009) reinforced the idea that the genus *Bosmina* Baird, 1845 must undergo intensive revision, especially in the tropics, considering its complex taxonomy.

Ceriodaphnia cornuta G.O. Sars, 1886 was observed in all samples of this study, corresponding to the results in other Neotropical environments. This species is widely distributed and has high feeding adaptability (Villalobos and González, 2006). *Bosmina* cf. *longirostris* (O.F. Müller, 1785), *Bosmina deitersi* Richard, 1895, *Diaphanosoma polyspina* Korovchinsky, 1982 and *Moina minuta* Hansen, 1899 were frequent and their respective families were the most important, while *Moina rostrata* McNair,1980 and *Bosmina tubicen* Brehm, 1953 were not found as frequently. Occurrences of *Streblocerus pygmaeus* G.O. Sars, 1901 (Macrothricidae), *Ilyocryptus spinifer* Herrick, 1882 (Ilyocryptidae) and species of the family Chydoridae were accidental. Although most members of these families live associated with plants or buried in the substrate of littoral zones, they are commonly present in samples from the pelagic zone (Fryer, 1968; 1974; Smirnov, 1974).

A mean of seven species per station was recorded (minimum = 4, maximum = 9). Significant variations between months (KW-H(5;24) = 8.1126, p = 0.1501) and stations (KW-H(3;24) = 0.2277, p = 0.9730) were not observed. However, a discrepant maximum number of species was observed in October/2008, while in the following months we observed the minimum numbers of species at the stations.

The mean density of cladocerans was equal to 9,516 ind.m^{-3} (minimum 769 ind.m^{-3}, maximum 41,747 ind.m^{-3}). *Ceriodaphnia cornuta* was the most abundant during this study, representing 34.8% of the organisms in the limnetic zone (mean 3,315 ind.m^{-3}, minimum 0, maximum 15,707 ind.m^{-3}). *Bosminopsis deitersi* (19.58%), *B.* cf. *longirostris* (15.12%) and *D. polyspina* (11.81%) were the second, third and fourth most abundant species, respectively. Species with a relative abundance from 10 to 20% were considered accessory species.

High abundances of *C. cornuta* have been previously observed in Amazonian environments, especially in lakes associated with the Solimões River and Jacaretinga Lake (Hardy, 1992), Curuá-Una Reservoir (Robertson, 1981) and black-water lakes (Robertson and Hardy, 1984; Brandorff & Hardy, 2010).

Bosminopsis deitersi is one of the most common species in aquatic systems of the Neotropical region (Kotov, 1997). This species was recorded as the most abundant species in lakes Cristalino and Tarumã-Mirim (Hardy, 1980); Camaleão (Waichman *et al.*, 2002) and Batata (Maia-Barbosa and Bozelli, 2006).

The total density of cladocerans did not vary among stations. On the other hand, variation through the months was observed, with the maximum total density in October/2008 (low-water period). As a result, the total number of cladocerans in the lake varied seasonally (KW-H(5;24) = 11.21, p = 0.0474). Brandorff and Andrade (1978) and Carvalho (1983) also observed high densities of zooplankton organisms during low-water periods. However, assumptions cannot be made regarding patterns, because the variability of population density within a lake is higher than that observed between two or more different environments (Robertson and Hardy, 1984; Brandorff & Hardy, 2010).

No definite patterns of species distribution were observed during this study. However, *Holopedium amazonicum* Stingelin,1904 (Holopedidae), species from the family Bosminidae (especially *Bosmina* sp. and *B. deitersi*) and *M. minuta* were present mainly during the low-water periods (September, October and November/2008).

Species of the families Chydoridae and Macrothricidae were rarely observed in this study (relative abundance less than 1%) and only in the low-water periods. These species are benthic or phytophilous. Paggi and José de Paggi (1990) stated that their presence in open waters is probably due to their "pseudoplankton" behavior. Importantly, when the water starts to recede it flows from the littoral zone into the central area of the lake, possibly carrying these organisms.

The species of Sididae and Ilyocryptidae were most frequent in the samples in April and July/2008, during the high-water periods, but their maximum populations were observed in October/2008, when the highest density of cladocerans was also observed. *Ceriodaphnia cornuta* also had higher densities in April and June/2008, being mostly present during the flood-peak period. *Bosminopsis brandorffi* Rey & Vásquez, 1989, *Bosminopsis negrensis* Brandorff, 1976 and *M. rostrata* also were recorded during the flood-peak period.

Moina rostrata reached its population peak (approx. 5,000 ind.m^{-3}) in July/2008 at station 4 (secondary arm). Maia-Barbosa and Bozelli (2006) also observed the sporadic occurrence of *B. brandorffi* and *M. rostrata* in Batata Lake during high-water periods. *Bosminopsis negrensis* has a preference for acidic environments and is found associated with *B. deitersi* (Brandorff, 1976).

Analysis of the results for relative abundance and species richness reveals some spatial and temporal diversity patterns of the cladoceran community in Tupé Lake. The diversity of pelagic cladocerans (Shannon-Wiener index) was highest in October/2008 (1.49 bits) and at station 3 (1.31 bits). The lowest values were recorded in April/2008 (1.02 bits) and at station 1 (1.20 bits).

The diversity indices found in this study (minimum = 1.02 and maximum = 1.49 bits) are similar to studies in other regions of Brazil (Neves *et al.*, 2003; Serafim-Júnior *et al.*, 2005; Negreiros *et al.*, 2009; Castilho-Noll *et al.*, 2010). However, compared to other Amazonian lakes, the diversity in Tupé Lake is higher than in lakes Cristalino and Tarumã-Mirim (Hardy, 1980).

The observed values for abundance and richness of cladocerans in Tupé Lake followed a distribution pattern related to the fluvial regime. Both abundance and richness of species were higher during the low-water period, and consequently, diversity was also higher at that time. In addition, during most periods of the fluvial regime, *C. cornuta* and *B. deitersi* were dominant. Carvalho (1983) and Calixto *et al.* (2011) associated the dilution effect during the high-water phase as a factor affecting the density and diversity in the zooplankton community.

Comparison with previous studies from Tupé Lake

Differences in the results of the present and previous studies were observed. The number of recorded species ranged from 9 to 25, and only three studies had similar results for composition and richness of cladoceran species (Tab. 2). In one of these studies, Calixto *et al.* (2011) observed 25 species of cladocerans in 12 months between 2003 and 2004 at 11 sampling stations. Compared to the present study, only the species recorded were different (all from the family Chydoridae, with accidental occurrences). Similarly, these studies did not find significant differences for species richness between sampling stations. However, a temporal pattern was observed, especially when we compare low and high-water periods.

In addition, our results for specific richness and composition of the cladoceran community were similar to studies performed in the lake in 2005 and 2006 (Ghidini and Santos-Silva, 2011b). We observed a strong relationship between sampling effort and the number of observed taxa, considering that studies with more samples found higher values for species richness. An exception was the study of Brandorff and Hardy (2010). However, because of the method of free sampling used in that study, it was not possible to establish relationships among volume, areas of sampling, and species richness.

The mean population densities in the previous studies were similar, differing only for the dominant species. In the present study, *B. deitersi* reached its abundance peak (19,000 ind.m^{-3}) in October 2008 at station 4. For the same species, Calixto *et al.* (2011) observed 2,000,000 ind.m^{-3} in November 2003, while Ghidini and Santos-Silva (2011b) recorded an abundance peak of 24,000 ind.m^{-3} in June 2006. Population estimates are related to different behaviors of populations, and the species peaks might have an ecological explanation. However, because these three studies used varied methods and sampling equipment, it is possible that these differences might have caused these different results.

Bottrel *et al.* (1976) demonstrated that the analysis of samples collected by motorized pumps and nets gave different results. The author also affirmed that samples collected using motorized pumps have higher

Table 2. Results obtained in previous studies with cladocerans (Crustacea: Anomopoda and Ctenopoda) in Tupé Lake. N_{am} = number of samples taken; S_{tot} = total species richness, maximum and minimum; Dens. = mean population density (ind.m^{-3}); Freq. = most frequent species; Abund. = Most abundant species.

Study	Method	N_{am}	S_{tot}, max. and min.	Dens.	Freq.	Abund.
Previattelli *et al.* (2005)	Schindler-Patalas trap	40, at 1 site	10	N/A	N/A	1) *B. deitersi* 2) *B. longirostris* 3) *M. minuta*
Ferreira (2009)	Suction pump	90	12	N/A	1) *M. minuta, B. deitersi* 2) *C. cornuta*	1) *M. minuta* (17,000 ind.m^{-3}) 2) *B. deitersi* (8,664 ind.m^{-3}) 3) *C. cornuta* (8,008 ind.m^{-3})
Brandorff & Hardy (2010)	Vertical and horizontal pulls	2	18	N/A	1) *B. deitersi* 2) *M. minuta* 3) *C. cornuta*	1) *B. deitersi* 2) *M. minuta* 3) *C. cornuta*
Calixto *et al.* (2011)	Vertical pull	132, at 11 sites	total=25, max=16 (Mar/03), min=8 (Dec/03)	15,444 ind.m^{-3} (total)	1) *B. deitersi* 2) *C. cornuta* 3) *D. polyspina*	1) *B. deitersi* (2,000,000 ind.m^{-3})
Ghidini & Santos-Silva (2011)	Schindler-Patalas trap	114, at 1 site	total=20, max=12 (Jun/2006), min=1 (Jun/2006)	6,080 ind.m^{-3} (Nov/2005) 9118 ind.m^{-3} (Jun/2006)	1) *B. deitersi* 2) *M. minuta* 3) *C. cornuta*	1) *B. deitersi* 2) *C. cornuta* and *M. minuta* 3) *D. polyspina*
Previattelli & Santos-Silva (2011)	Stomach contents	24, at 1 site	11	? (1 to 11,887 ind.m^{-3})	N/A	1) *B. deitersi* 2) *M. minuta* 3) *D. polyspina*
Ferreira (2013)	Vertical pull	144	total=16, max=16 (Jun/11), min=13 (Nov/11)	N/A	1) *B. deitersi* 2) *M. minuta* 3) *C. cornuta rigaudi*	1) *B. deitersi* (1,029,626 ind. m^{-3})

species densities. In addition, he defended this method because of its smaller impact on the environment, efficiency in capturing fast-moving organisms, and collection of representative samples through a continuous rhythm of filtration.

Environment characteristics and the collection method (*e.g.*, the time to pull the net and control of the suction valve) can generate variations in the results. Consequently, these variations can also cause an under- or overestimation of a population or even the entire community (Bottrel *et al.*, 1976).

Ferreira (2009) analyzed the plankton community of cladocerans in a central station of Tupé Lake (equivalent to station 3 in the present study). In his study, samples were collected using both a conical plankton net and a motorized pump for vertical sampling of cladocerans. His results showed that samples collected with the motorized pump yielded higher values for organism density and species.

It is important to consider that the increase in the number of samples does not necessarily increase the number of species recorded. For example, although Ferreira (2013) collected the largest number of samples, his study did not find the largest number of species compared to other studies. Therefore, the collection equipment can better improve the quality of samples, rather than an increase of sampling effort.

Although applying different methods, all the studies in Tupé Lake in recent years have found the same most abundant species. *Bosminopsis deitersi*, *M. minuta* and *C. cornuta* were the most frequent cladoceran species in the limnetic zone, and their presence in all previous studies highlights their importance in the Amazon region. These species are also the most frequent in other environments in the Amazon basin (Robertson and Hardy, 1984; Robertson and Darwich, 2008).

In all the studies, *B. deitersi* was the dominant species during the low-water periods (from August to December), while *C. cornuta* was the most important species during the high-water periods (from January to July). *Holopedium amazonicum* was also observed during the low-water periods, while *M. rostrata*, *B. negrensis* and *B. brandorffi* were present only during the high-water periods. This pattern of species occurrence was present in all the studies in Tupé Lake. Possibly, specific environmental conditions can relate the occurrence of these species to specific periods of the fluvial regime. Ghidini and Santos-Silva (2011b) associated this occurrence with reproductive mechanisms and diapause adjusted to the cyclic modification in the environment.

The historical data indicate that the diversity of limnetic cladocerans in Tupé Lake is adapted to the fluvial regime and is affected by cyclic ecological changes. The present study and that of Calixto *et al.* (2011) show that the cladoceran community in the pelagic zone does not show a spatial pattern of distribution, but some parts of the community attributes vary temporally.

Previattelli *et al.* (2005), Ferreira (2009), and Ghidini and Santos-Silva (2011) highlighted the importance of a sampling methodology that can collect from the entire water column (from the surface to the bottom) during the nictemeral cycle, since daily fluctuation was observed in the ecological attributes.

Zones in the lake such as the littoral and aquatic macrophytes have not been explored. These zones support high organismal diversity, and it is necessary for future studies to show the importance of these habitats to the plankton community, especially relating to horizontal migration processes from and to the littoral zone, its causes (adaptation to predation or search for better food conditions), and the occurrence of aquatic species in the Amazon region.

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