Abundance of zooplankton from different zones (pelagic and littoral) and time periods (morning and night) in two Amazonian meandering lakes

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ABSTRACT. The abundance of zooplankton in two lakes of Southwest Amazonia was studied for 10 months in different regions and at different periods of the day. The lakes were *Lago Amapá*, located at 10°02'36"S, 67°50'24"W, and *Lago Pirapora*, at 9°27'21"S, 67°31'39". Both lakes are characterized as oxbow lakes. The aim of this study was to compare the pelagic and littoral regions, as well as to determine differences in the distribution of zooplankton in the water column in the morning and at night. Collections were made by filtering water through a 55μm zooplankton net into a 5L Van Dorn bottle, collecting 4L from the top and 5L from the middle and bottom layers, totaling 14L of water for each sampling location. In addition, physical and chemical parameters were measured, including transparency, temperature, pH, dissolved oxygen, electrical conductivity and turbidity. Anova (analysis of variance) and Tukey's test were used. There was no statistically significant difference between the regions studied, nor between the two time periods examined. The results of the Pearson correlation ($p<0.05$) demonstrated that the physical and chemical characteristics of the water correlated with the cladocerans *Moina* spp. (represented by *M. minuta* and *M. reticulata*) and *Ceriodaphnia cornuta*, and that *Daphnia gessneri* was associated with Chaoboridae.

Key words: zooplankton, abandoned meander, pelagic and littoral regions.

RESUMO. Abundância do zooplâncton em diferentes zonas (pelágica e litorânea) e horários (manhã e noite) em dois lagos meândricos amazônicos. Durante 10 meses foi estudada a abundância do zooplâncton em dois lagos da Amazônia Sul-Ocidental, situados respectivamente nas coordenadas 10°02'36"S; 67°50'24"W (Lago Amapá) e 9°27'21"S; 67°31'39"W (Lago Pirapora). Ambos os lagos caracterizam-se como de meandro abandonado. O objetivo desse estudo foi comparar as regiões pelágica e litorânea, com base na abundäncia da comunidade zooplanctönica, bem como observar diferenças da distribuição dessa comunidade na coluna da água no período da manhã e noite. As coletas foram realizadas com filtragem em rede de zooplâncton (55μm) e posterior passagem em garrafa de Van Dorn de 5L. Coletou-se 4L na superfície e 5L nas camadas do meio e fundo, totalizando 14L de água para cada estação de coleta. Adicionalmente, foram medidos parâmetros físicos e químicos como transparência, temperatura, pH, oxigênio dissolvido, condutividade elétrica e turbidez. Anova (análise de variância) e teste de Tukey foram usados. Não houve diferença estatística significativa nem para as regiões estudadas como também para os diferentes horários observados. Os resultados dos coeficientes de correlação de Pearson ($p<0.05$) demonstraram que as características físicas e químicas foram correlacionadas com os cladóceros *Moina* spp. (representados por *Moina minuta* e *Moina reticulata*) e *Ceriodaphnia reticulata*. *Daphnia gessneri* também apresentou correlação com Chaoboridae.

Palavras-chave: zooplãncton, meandro abandonado, regiões pelágica e litorãnea.

Introduction

Meandering abandoned or oxbow lakes are common in Southwest Amazonia. According to Sioli (1984), meanders migrate down rivers; old ones are cut off and transformed into oxbow lakes, new ones are formed, and the whole land adjacent to the rivers is in a constant and rapid dismantling and rebuilding process, which can be observed in a few decades. According to Camargo and Esteves (1995), diverse ecological mechanisms are at work in this environmental process: (i) directly by entrance of richer waters from a lotic ecosystem; (ii) through the action of turbulence and resuspension of lacustrine sediments, either related to wind action or to the influx of river water; (iii) by decomposition of littoral vegetation after submergence, and (iv) by entrance in rainwater and runoff.

In these ecosystems, unfortunately, almost nothing is known about the limnology of the rivers of western and southwestern Amazonia, with their turbid waters, unstable beds and their oxbow lakes, except for some aspects of their fish fauna and fisheries (Luling, 1975). Little is know about environmental effects on the abundance of zooplankton. This aspect is better known for the floodplains in Central Amazonia from the studies of Brandorff and Andrade (1978), Hardy (1980), Carvalho (1983), Hardy *et al*. (1984), and Robertson and Hardy (1984).

The timing and extent of the maximum abundances of zooplankton varies from lake to lake, on account of differences in parameters such as lake morphology, depth and, very important for Amazonian lakes, the type (temporary or permanent) and length (long or short) of the channel which links the lake to its major river source. The timing of the maximum and minimum densities of zooplankton also varies from year to year due to differences in the intensity and duration of the high-water and low-water periods (Robertson and Hardy, 1984).

Regardin the zooplankton distribution in lakes, these organisms display vertical migration behavior in response to low food availability (Wetzel, 1981; Johnsen and Jakobsen, 1987) or as a defense against invertebrate and fish predation (Wetzel, 1981; Neill, 1990; Levy, 1990; Tjossem, 1990). The only work dealing on the distribution of zooplankton at different times in Amazonia was a study in the Lago Calado by Fisher *et al*. (1983).

The main aim of this study was to analyze the abundance of zooplankton during morning and night in two lakes located in Southwest Amazonia, to determine if there is any influence of the time period on the zooplankton community structure in the pelagic and littoral regions. In addition, the abundance of common zooplankton species present was studied to see if there was any correlation with physical and chemical parameters and Chaoboridae.

Material and methods

Study Area

In the areas of the Amazonia lowlands, the character of the Andean rivers develop strong lateral incisions instead of showing depth erosion, resulting in meandering. After passing their cones of coarse rubble, deposited when leaving the mountainous section of their courses, the rivers carry a bottom-load of sand which forms sandbanks, and their water becomes turbid, because of their load of fine suspended particles. The meanders migrate down the rivers, old ones are cut off and transformed into oxbow lakes, new ones are formed, and the whole land adjacent to the rivers is in a constant and rapid process of dismantling and rebuilding, a process which can be observed on a time scale of a few decades (Sioli, 1984). The lakes studied are environments situated in the Amazon Basin. *Lago Amapá* is situated in the Municipality of *Rio Branco*, and *Lago Pirapora* is located in Porto Acre, in the State of *Amazonas*, with geographic coordinates 10°02'36"S 67°50'24"W and 9°27'21"S 67°31'39"W, respectively (Figure 1). Both meander lakes are affluents of the Acre river, characterized according Sioli (1984) as whitewater rivers with turbid, more or less ochre-colored water; this type of river is well marked in the pre-Andean zone as southwestern. One of the main characteristics of the lakes studied is the fluctuation of the water level, which is distinguished by two phases: high water and low water. They are directly influenced by the hydrological regime of *rio Acre*, especially during high water periods. These lakes are abandoned meanders. The minimum and maximum depths for *Lago Amapá* are respectively 2.7 and 4.5m and for Pirapora 4.5 and 13m.

According to Salati *et al*. (1978), the Amazon basin hydrologic complex is formed by thousands of small rivers and probably has been, together with the exuberant forest, in dynamic equilibrium for millenia. Figure 2 shows the rainfall during the study period. The lakes studied are situated south of the equator, beyond parallel 65°W, and have a minimum amount of precipitation in June/July (Sioli, 1984).

Being in the hydrographic basin of the Acre river, to which they are permanently linked, *Lago Amapá* and *Lago Pirapora* are considered whitewater lakes according to Sioli (1968). The lakes are surrounded by forest, which is flooded during high water, and as consequence, there is a great input of organic matter from the forest into the lake.

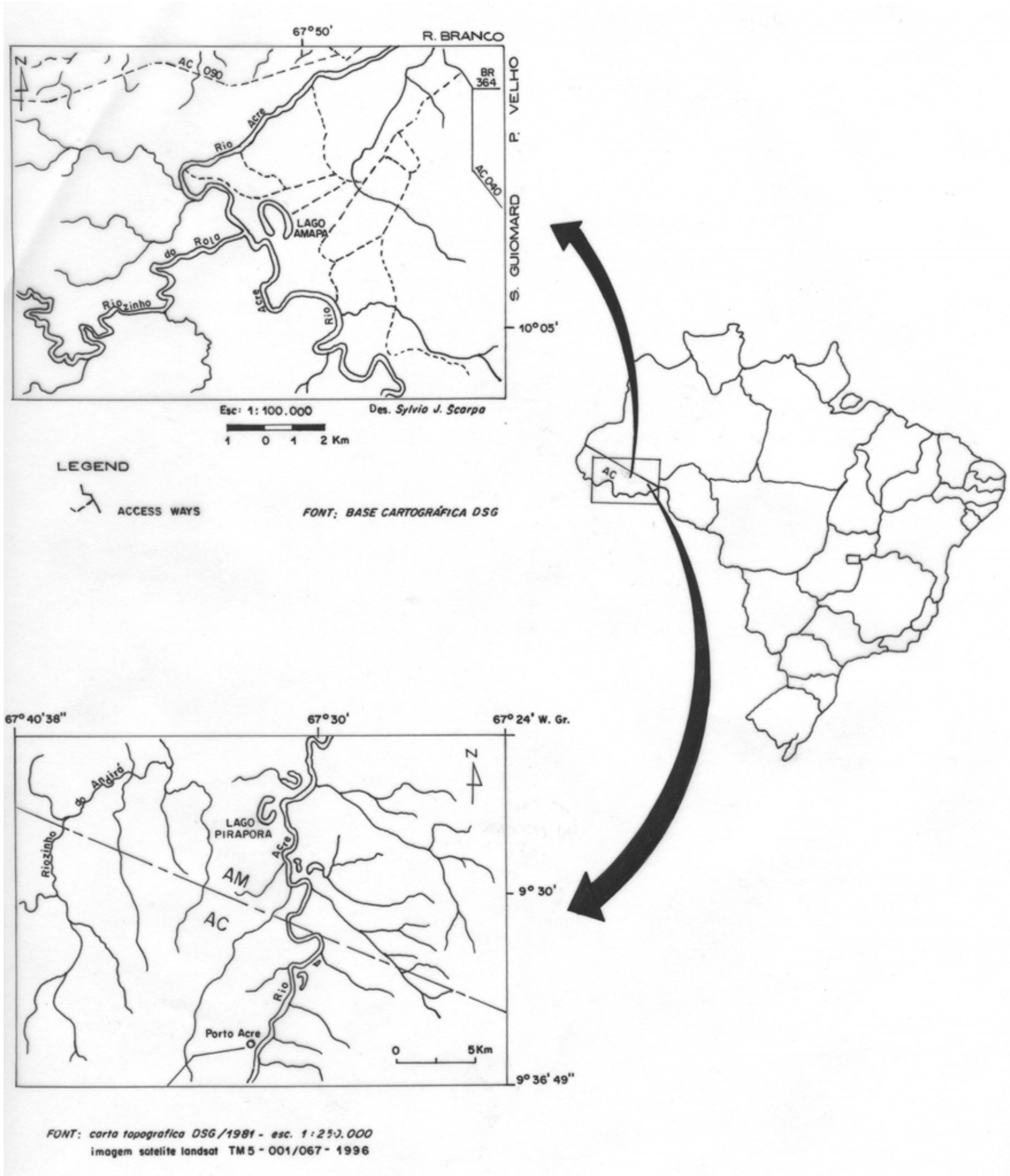

Figure 1. Area studied.

Samplings of zooplankton were carried out over a period of ten months, including the dry and rainy seasons, from April, 2000 through February, 2001, along with the measurement of physical, chemical and biological parameters. The samplings and measurements were conducted at the two sampling stations, in the pelagic and littoral regions, for the top, middle and bottom layers of the water column. Abundance was estimated by counting at least 100 individuals per sampling (ind.m^3) of the whole water column, including juvenile forms of Copepoda (nauplii and copepodites).

The zooplankton organisms were collected with a Van Dorn bottle, using a conical net (55-μm mesh) to filter 14 liters of water at different depths. The samples were preserved in a solution of 4% formaldehyde. The determination of physical, chemical and biological parameters, that is, water temperature (°C), transparency and depth of the water column (m), electrical conductivity (μS.cm^{-1}), turbidity (NTU), and dissolved oxygen (mg.L^{-1}) was according to Golterman (1978), including a modification of the assay for dissolved oxygen using sodium azide (Golterman, 1969).

The determination of the physical, chemical and biological parameters in the above reference was limited to the surface and the average of the pelagic and littoral zones. However, Marques-Lopes (in prep.) carried out a more detailed study, especially regarding the surface, middle and bottom levels for the pelagic and littoral zones. The levels of rainfall used in this paper were provided by the Meteorological Station of the Federal University of Acre (Figure 2).

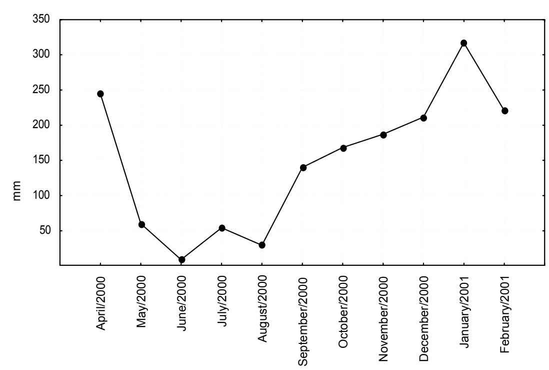

Figure 2. Rainfall during the period of April, 2000 to February, 2001.

Statistical analyses

The Statistical Analyses System (vs. 5; SAS Institute, 1988) was utilized. Anova and Tukey's test were performed to assess if there was any difference in abundance between zones, and between morning and night. The difference in densities was significant if $p<0.05$. Assumptions for Anova were verified. In each case of variance analysis, the data were standardized by eliminating extreme values and zeros (outliers) and by logarithmic transformation (log). Tukey's test was used for the comparison of means. Pearson's correlation between densities of abundant individuals and of the environmental variables measured with STATISTICA (vs. 5; Tulsa, 1994) were also determined. Correlations were considered significant if $p<0.05$.

Results and discussion

Table 1 presents data for certain limnological characteristics of the lakes (according to Marques-Lopes, in prep.). The minimum temperature was 22.65°C in June, and the maximum was 30.40°C, in Lago Amapá. Higher transparency levels occurred during the low-water period. The transparency levels varied during this period, from 0.30m in August to 1.40m in September, in Lago Amapá. For Lago Pirapora, the transparency level varied from 0.30m in September/October to 0.60m in May. For dissolved oxygen, the minimum was 3.15mg.L^{-1} during the low-water period in March, while the maximum was 11.96mg.L^{-1}, both for *Lago Amapá*. The values for electrical conductivity oscillated for *Lago Amapá* between 28.83 and 56.73μS.cm^{-1}, and for *Lago Pirapora* 35.90-140μS.cm^{-1}. The minimum value for turbidity was 13.40NTU during the low-water period (*Lago Amapá*) and the maximum 88.30 NTU (*Lago Pirapora*).

Table 2 lists the zooplankton taxa whose density was quantitatively calculated. Figure 3 shows the density (ind.m^{-3}) of zooplankton in the top, middle and bottom zones, for samples collected during the morning and night periods. It shows that cladocerans and copepods were more frequently present than rotifers at the bottom of lakes.

Table 1. Values for abiotic and biotic variables obtained during the period of April, 2000 to February, 2001 in the *Lago Amapá* and *Lago Pirapora*. A=*Lago Amapá* and P=*Lago Pirapora*; Secchi= water transparency; Temp = temperature; DO= dissolved oxygen; Cond.= conductivity; Turb.= turbidity. (Marques-Lopes, in prep).

	Secchi (m)		Temp. (°C)		pH		DO (mg/L^{-1})		Cond.(μS.cm^{-1})		Turb. (NTU)	
	A	P	A	P	A	P	A	P	A	P	A	P
April/2000	0.40	0.50	28.45	28.30	6.18	4.88	4.67	4.88	36.65	83.34	28.60	30.10
May/2000	0.50	0.60	27.00	26.50	6.19	6.14	5.32	4.66	36.56	83.35	31.10	30.50
June/2000	0.50	0.50	22.65	24.90	5.69	5.51	5.12	4.77	41.67	83.34	26.00	30.20
July/2000	0.35	0.50	24.20	24.10	4.88	5.60	4.21	3.79	54.40	77.70	30.80	35.20
August/2000	0.30	0.40	28.20	28.00	7.39	6.12	5.59	4.69	28.83	140.75	27.80	35.20
September/2000	1.40	0.30	28.95	29.56	7.37	7.34	10.46	4.47	50.59	111.31	12.70	53.20
November/2000	0.70	0.25	29.35	29.25	7.95	6.98	11.33	5.00	53.50	94.98	14.70	68.30
December/2000	0.50	0.20	30.00	28.25	7.24	6.77	11.96	5.93	49.83	73.69	22.40	88.30
January/2001	0.50	0.25	27.60	27.60	6.81	6.54	7.55	4.03	37.78	50.12	31.20	68.99
February/2001	0.30	0.30	28.40	26.56	6.62	6.51	3.33	4.86	41.16	35.90	35.70	61.30

Table 2. Zooplankton taxa recorded at the sampling stations of Lago Amapá and Lago Pirapora between April, 2000 and February, 2001.

ROTIFERA	*Filinia* cf. *terminalis*	*Diaphanosoma spinulosum*
Anuraeopsis spp.	*Filinia opoliensis*	*Moina minuta*
Ascomorpha spp.	*Filinia pjeleri*	*Moina reticulata*
Asplanchna sieboldi	*Filinia longiseta*	**COPEPODA**
Asplanchna brightwelli	*Hexarthra intermedia braziliensis*	**CYCLOPOIDA**
Brachionus falcatus	*Hexarthra* sp.	*Mesocyclops meridianus*
Brachionus caudatus	*Lecane curvicornis*	*Microcyclops* spp.
Brachionus dolabratus	*Lecane elsa*	*Thermocyclops* spp.
Brachionus calicyflorus	*Lecane lunaris*	*Neutrocyclops brevifurca*
Brachionus calicyflorus fa. *anuraeformis*	*Lepadella* sp.	**CALANOIDA**
Brachionus havanaensis	*Polyarthra* sp.	*Calodiaptomus perelegans*
Brachionus mirus fa. *reductus*	*Polyarthra vulgaris*	*Calodiaptomus* spp.
Brachionus quadridentatus	*Trichocerca bicristata*	*Notodiaptomus coniferoides*
Cephalodella gibba	*Trichocerca similis*	Ostracoda
Keratella americana	*Trichocerca* spp.	Insect larvae
Keratella cochlearis	*Testudinella patina*	Chaoboridae
Keratella cochlearis var. cf. *hispida*	*Testudinella* sp.	*Chaoborus* spp.
Platyonus patulus fa. *macrodactyla*	**CLADOCERA**	
Trochosphaera aequatorialis	*Bosminopsis deitersi*	
Epiphanes macrourus	*Ceriodaphnia cornuta*	
Epiphanes spp.	*Daphnia gessneri*	
Filinia limnetica	*Diaphanosoma brachiurum*	

The results obtained, evaluated by Anova and Tukey's test, did not show any statistically significant difference between the pelagic and littoral regions, as well as between the morning and night periods (Tables 3 and 4).

The results of the Pearson correlation demonstrated that the physical and chemical parameters correlated with the cladocerans *Moina* spp. (represented by *M. minuta* and *M. reticulata*) and *Ceriodaphnia cornuta*, and that *Daphnia gessneri* was associated with Chaoboridae (Figure 4).

The pH showed a negative correlation with *Moina* spp. (r=-0.6827) and *Ceriodaphnia cornuta* (r=-0.8756), respectively in *Lago Amapá* and *Lago Pirapora*.

This cladoceran also showed a negative correlation with dissolved oxygen (r=-0.7508) in Lago Amapá. Turbidity and electrical conductivity were parameters that correlated with *Moina* spp., respectively in *Lago Amapá* (r=-0.8595) and *Lago Pirapora* (r=0.8357).

The pelagic and littoral zones of the two studied lakes (Lago Amapá and Lago Pirapora) did not show any statistically significant difference. According to Thomaz *et al*. (1997), cycles of inundation exert a homogenizing effect on the aquatic environments influenced, for example, in the Paraná river. A meandering lake, for the major part of the year, is isolated from the main channel. This situation is perpetuated without the occurrence of any differences in species abundance between the pelagic and littoral regions. In environments less than 3.5m deep, during low water, there is, for example, a resuspension of sediment caused by wind or water circulation. This disturbance promotes an increase in nutrients derived from self-fertilization from the sediment, a greater relative extension of the euphotic zone and also diurnal circulation of the water column. This variability of factors, brought about by cycles of inundation, influences the abundance of species.

The vegetation that predominates along the edges of abandoned meanders can be aquatic weeds, such as colonizing grasses, or larger vegetation, adapted to environments less "water-logged" (Silva and Latrobesse, 2002). Keppeler (1999) found abundant vegetation along the edges of *Lago Amapá*, represented by these two types of vegetation. The normal foraging of decaying plants possibly provides meander lakes with homogeneity, making the pelagic and littoral zones similar with respect to the abundance of zooplankton species.

The factors that are most likely to be of importance in natural populations are food, temperature, oxygen content of the water, and population density. Copepods were found to be dominant in the lakes studied. According to Robertson and Hardy (1984), Amazonian zooplankton communities are characterized by rotifers tending to show the greatest species diversity, but copepods often being the more abundant. The latter is due primarily to the presence of young nauplii and copepodite stages rather than adult animals. Rotifers also were abundant. Hardy *et al*. (1984) found a relative abundance of the three main groups of zooplankton occurring in *Lago Camaleão (Amazonia*, Brazil), with rotifers being the dominant group, often contributing with more than 70% of the standing stock. In contrast to the rotifers, the crustacean fauna, Cladocera and Copepoda showed approximately 30%, that is, a lower number, in *Lago Amapá* and *Lago Pirapora* as well. Chaoboridae showed a high biomass, reaching 4 ind.L^{-1}, in *Lago*

Amapá, while in *Pirapora* it was 20 ind.L^{-1}, especially abundant during the night period. Arcifa (1997) examined the seasonal variations in the water column at night, finding increased densities (maximum of 4 ind.L^{-1} for Chaoborus) during the wet-warm season. Chaoboridae was also positively associated with *Daphnia gessneri.* According to Kvam and Kleiven (1995), laboratory experiments showed that this predador has a higher capture efficiency for juvenile daphnids in light compared to darkness, and that *Daphnia* exhibits a behavioral response to water that has previously contained Chaoboridae. The investigators concluded that predation from Chaoboridae can be an important factor affecting the distribution patterns of *Daphnia* in lakes. Nonetheless, the populations of cladocerans were larger during the night period, explaining the positive correlation between Chaoboridae and *Daphnia gessneri*, serving as a strategy against predation. This is probably due to a lack of visualization.

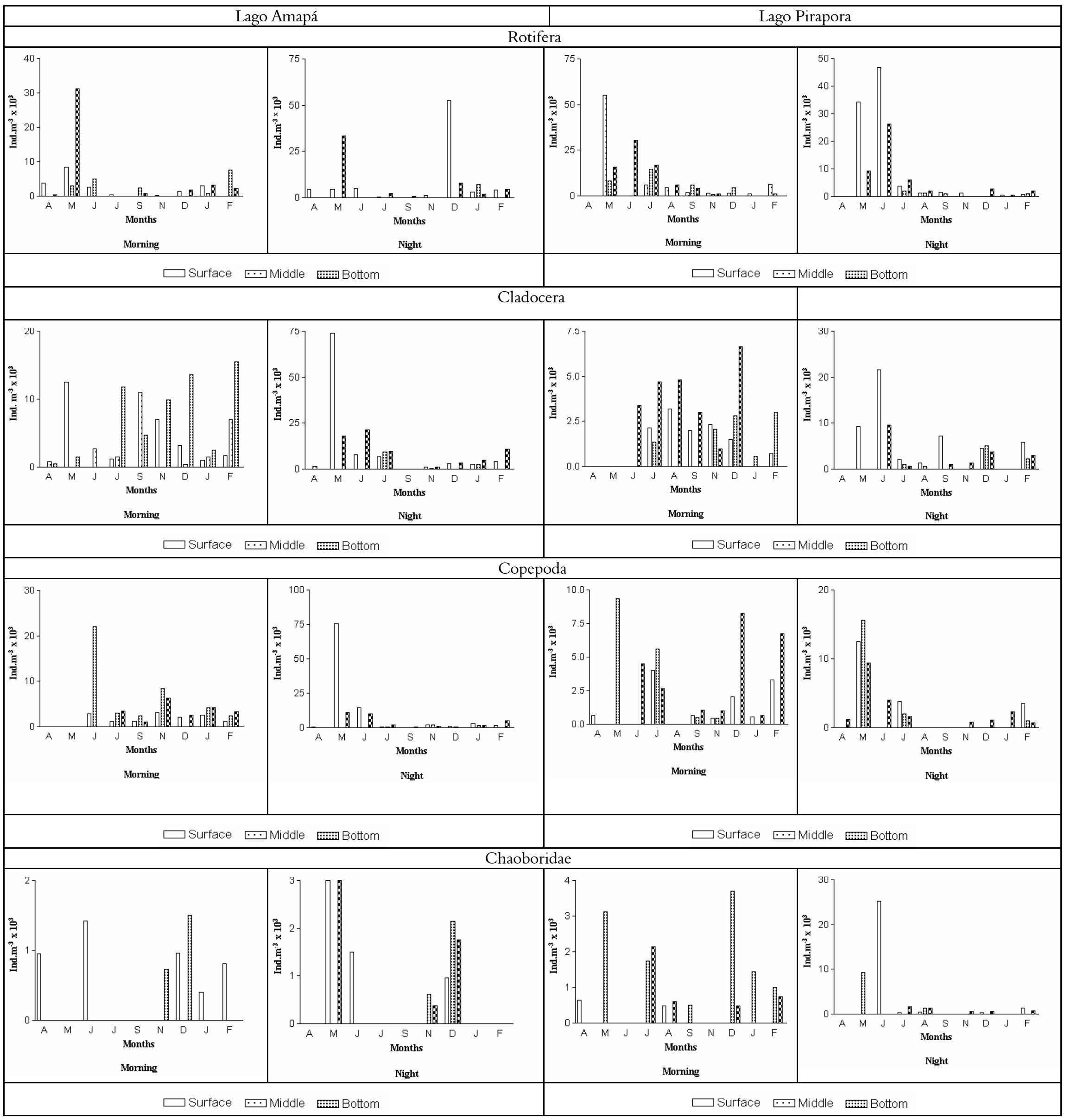

Figure 3. Density (ind.m-3) of zooplankton groups at the surface, middle and bottom layers during the morning and night periods in lakes studied.

Table 3. Anova of the data for the pelagic and littoral regions and for the morning and night periods, for the studied lakes.

Groups studied	Lago Amapá						Lago Pirapora					
	Pelagic/littoral			Morning/night			Pelagic/Littoral			Morning/night		
	F	p	CV	F	p	CV	F	p	CV	F	p	CV
Rotifera	3.59	0.07	16.89	0.09	0.77	18.19	2.25	0.15	12.53	0.46	0.50	14.33
Cladocera	-	-	-	0.14	0.71	12.31	1.53	0.23	9.52	0.72	0.41	11.42
Copepoda	0.03	0.85	13.88	1.38	0.26	14.44	0.00	0.98	15.22	0.08	0.78	14.86
Ostracoda	-	-	-	0.06	0.80	13.81	3.81	0.09	14.16	-	-	-
Chaoboridae	0.07	0.80	11.47	4.79	0.06	10.23	0.17	0.68	16.01	0.83	0.37	14.21

Table 4. Tukey's test of the data for the pelagic and littoral regions and for the morning and night periods, for the lakes studied.

Groups studied	Lago Amapá	Lago Pirapora
	Pelagic/Littoral	Morning/Night
	Mean	Mean
Cladocera	13705^{A}	
	7923^{A}	
Ostracoda	4016^{A}	578^{A}
	2594^{A}	2435^{A}

The factors that are most likely to be of importance in natural populations are food, temperature, oxygen content of the water, and population density. Copepods were found to be dominant in the lakes studied. According to Robertson and Hardy (1984), Amazonian zooplankton communities are characterized by rotifers tending to show the greatest species diversity, but copepods often being the more abundant. The latter is due primarily to the presence of young nauplii and copepodite stages rather than adult animals. Rotifers also were abundant. Hardy *et al*. (1984) found a relative abundance of the three main groups of zooplankton occurring in *Lago Camaleão (Amazonia*, Brazil), with rotifers being the dominant group, often contributing with more than 70% of the standing stock. In contrast to the rotifers, the crustacean fauna, Cladocera and Copepoda showed approximately 30%, that is, a lower number, in *Lago Amapá* and *Lago Pirapora* as well. Chaoboridae showed a high biomass, reaching 4 ind.L^{-1}, in *Lago Amapá*, while in *Pirapora* it was 20 ind.L^{-1}, especially abundant during the night period. Arcifa (1997) examined the seasonal variations in the water column at night, finding increased densities (maximum of 4 ind.L^{-1} for *Chaoborus*) during the wet-warm season. Chaoboridae was also positively associated with *Daphnia gessneri*. According to Kvam and Kleiven (1995), laboratory experiments showed that this predador has a higher capture efficiency for juvenile daphnids in light compared to darkness, and that *Daphnia* exhibits a behavioral response to water that has previously contained Chaoboridae. The investigators concluded that predation from Chaoboridae can be an important factor affecting the distribution patterns of *Daphnia* in lakes. Nonetheless, the populations of cladocerans were larger during the night period, explaining the positive correlation between Chaoboridae and *Daphnia gessneri*, serving as a strategy against predation. This is probably due to a lack of visualization.

Moreover, this species has spines on its head, which could represent a type of defense for the species, as seen with other organisms. For example, it has been shown that dragonfly (*Leucorrhinia dubia*) larvae, in the presence of fish predators, develop elongated abdominal spines which serve to reduce mortality risk (Johansson and Wahlstrom, 2002).

Ceriodaphnia cornuta and *Moina* spp. were the species that showed correlations with physical-chemical parameters (Figure 4). *Ceriodaphnia cornuta* showed a negative correlation with pH in Lago Pirapora. Vijverberg *et al*. (1996) also found for daphnids a decreased egg viability at elevated pH, resulting in a diminution of natural populations. For *Moina* spp., there was also a negative correlation of this parameter with the presence of their populations. Basic pH levels could favor the development of these species; thus, *Moina* spp., as other species, show a tolerable threshold. Vijverberg *et al*. (1996) demonstrated that high pH can substantially reduce egg viability. pH is also a limiting factor for other zooplankton such as *Ceriodaphnia* spp., *Bosmina longirostris* and others, leading to the notion that an increase in pH may increase the dominance of cyanophytes (Beklioglu and Moss, 1995), very common in *Lago Amapá*.

Moina spp. (*Moina minuta* and *Moina reticulata*) had the best correlation with physical-chemical parameters, showing negative correlation with pH and electrical conductivity, while positive correlation with turbidity. This positive influence by turbidity had also been observed by others in *Moina minuta* (Bozelli, 1998), *Moina micrura* (Hart, 1999) and *Moina reticulata* (Hardy, 1992). In the latter study, Hardy (1992) had already shown that in *Lago Jacaretinga* this shift was associated with the annual flooding of the Amazon River, when water carrying a large amount of fine suspended particles entered into the lake. This species may be more efficient at exploiting unconventional food resources such as silt-adsorbed, dissolved organic matter in *Lago Jacaretinga's* turbid waters.

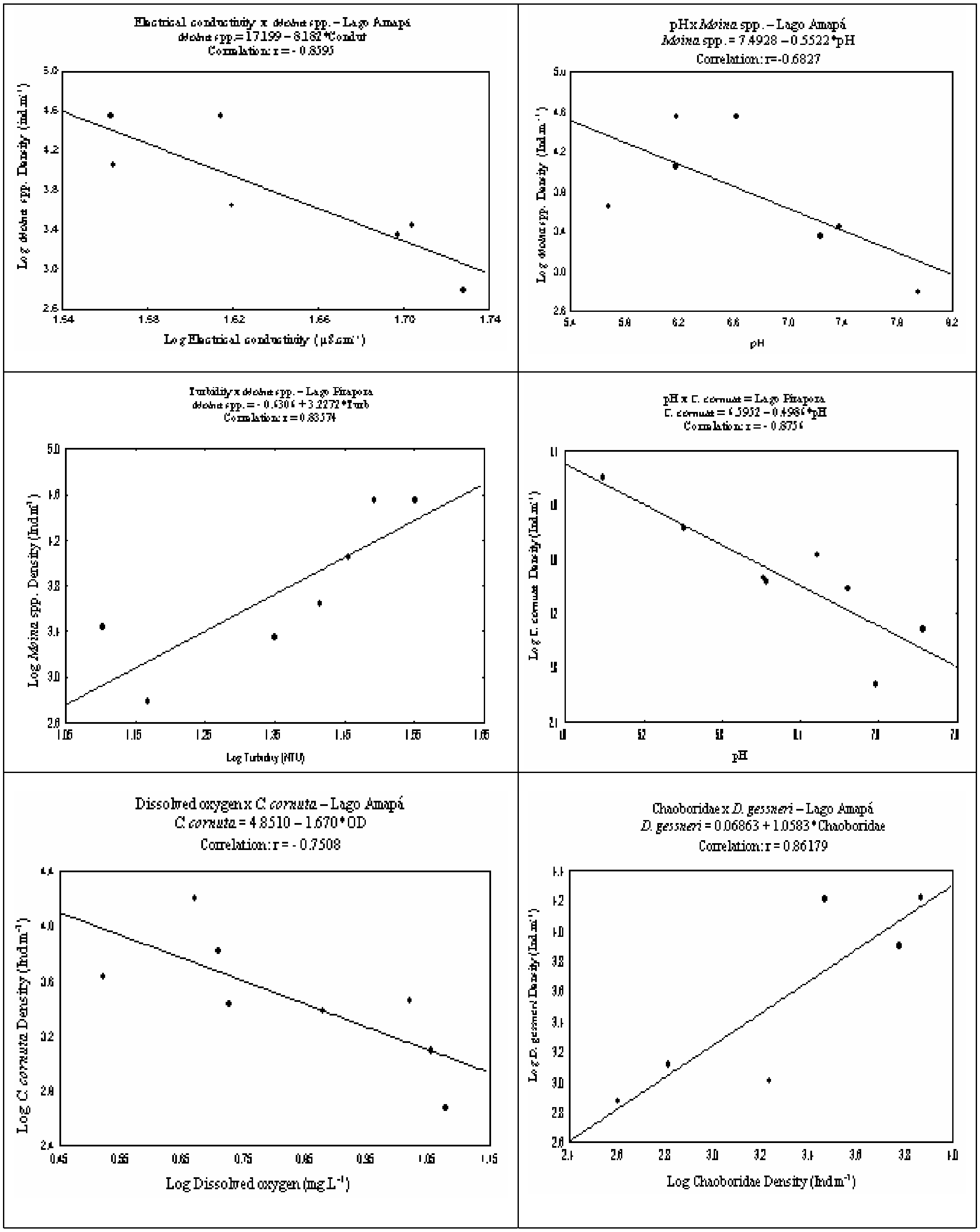

Figure 4. Pearson correlation coefficients ($p < 0.05$) among the abundant species and the physical and chemical variables in Lago Amapá and Lago Pirapora.

Besides pH, electrical conductivity and turbidity, another limiting factor for the success and establishment of populations is dissolved oxygen, which in our study affected the distribution of *Ceriodaphnia cornuta* in *Lago Amapá*. Hardy *et al*. (1984) found that the extremely low standing-stock observed during the high-water period was attributed to prevailing poor oxygen conditions in

Lago Camaleão as well, a Central Amazonian varzea lake. Food could be the main factor influencing zooplankton depression (Arcifa *et al*., 1992). High water results in a greater dilution of food, making it less available to the zooplankton community. According to Hardy (1992), the dependence of the aquatic invertebrates distribution on oxygen concentration is thought to be critical and has been described by several authors, such as Junk (1973), Brandorff (1977) and Fisher *et al*. (1983) for Amazon lakes and reservoirs. Fisher *et al*. (1983) found that in *Lago Calado*, at a depht of 9 meters, with the water level slowly rising, the water below 4 meters was anoxic. Virtually all of the zooplankton was in the oxygenated layer. Adult and juvenile *Daphnia gessneri*, the most abundant crustacean species, were found between 0.5 and 4.5 meters. Copepod nauplii tended to occur nearer to the surface, in the 0-2 meter stratum. No clear vertical migration was observed.

There was no correlation between rotifer species and environmental variables. Paggi (1995) also did not find such relation in a study, showing no direct effect on the distribution of rotifers, indicating that rotifers do not seem to be affected by low oxygen content. Bonecker and Lansac-Tôha (1996) found a strong relation, for example, with water temperature and dissolved oxygen.

Light is the main stimulus for vertical migration (Wells, 1960; Siebeck, 1960; Ringelberg, 1964 cited by Wetzel, 1981). These movements vary considerably, according to conditions of the lake, including such characteristics as luminosity, season, and age, among other factors. In general, predation from fish and other predators is a process guided by vision that requires good conditions of illumination. Therefore, ascending movement up to the trophic zone in periods of obscurity or low light would allow zooplankton, for the most part, to elude this predation pressure (Wetzel, 1981), as a defense against invertebrate and fish predation (Wetzel, 1981; Neill, 1990; Levy, 1990; Tjossem, 1990). Zooplankton exhibit vertical migration behavior in response to low food availability (Johnsen and Jakobsen, 1987). In addition, the quality of the waters, as with food, shows a diurnal rhythm, whereby carbohydrate synthesis occurs during the light period, while protein synthesis reaches a maximum during the night, coinciding with the maximum pressure for consumption for animals. The advantages of adaptation are related to the low pressure of predation and the greater quality of noctural food, compared to the light period (Wetzel, 1981).

In general, it has been observed, in cladocerans as well as copepods, that the migration of juvenile individuals is more extensive than for adults (Wetzel, 1981). The biomass of copepods, in our study, comprised mostly juvenile individuals. The water column was observed to be homogeneous for this group. Larger zooplankton are less heterogeneously distributed than small zooplankton (Pinel-Alloul *et al*., 1988; Pinel-Alloul, 1995). Greater spatial aggregation may allow small zooplankton to evade predators and locate mates, while reduced spatial heterogeneity in large species may decrease competition (Pinel-Alloul, 1995). Also, the vertical distribution of Rotifera showed a relatively uniform distribution throughout the water column in this study. This pattern of distribution was maintained during the year and did not show variations for Rotifera in relation to hydrologic phases of inundation and isolation of the lake in Laguna El Tigrem, floodplain lakes of the Middle *Paraná* River (Paggi, 1995).

The community structure of Ostracoda in distinct littoral zones of "*Lagoa do Gentil*," a northern coastal lagoon in Rio Grande do Sul state (Albertoni and Wurding, 1996), was also found to be extensive as observed in the study.

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