Composition and abundance of Cladocera (Crustacea) assemblages associated with *Eichhornia azurea* (Swartz) Kunth stands in the Upper Paraná River floodplain

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ABSTRACT. The composition and abundance of cladocerans associated with *Eichhornia azurea* (Pontederiaceae) in different environments of the Upper Paraná River floodplain were achieved. Collecting was undertaken from March 1992 to February 1993, at eight stations, two river-lake floodplain systems, Baía and Ivinheima, and in the Cortado Channel, a Paraná River-associated system. Thirty-one species of cladocerans were identified. The greatest number of species and highest abundance values were registered in floodplain environments, probably due to a great number of habitats made up of aquatic macrophytes and to the high connectivity among different environments. In the Paraná system there are some great quantities of macrophytes on its banks, however a small number of cladocerans species occurs, contrastingly to the floodplain environments. This may happens due to the high speed of the river water that restricts the development of large cladoceran populations typical of the littoral region. The great number of plankton species in this system suggests that aquatic macrophytes are like a haven to these species since the vegetation greatly reduces the speed of the water current.

Key words: Cladocerans, macrophyte associated fauna, composition, abundance, floodplain, Paraná River.

RESUMO. Composição e abundância da assembléia de Cladocera (Crustacea) associada à macrófitas aquáticas (*Eichhornia azurea*) na planície de inundação do alto rio Paraná. Foram estudadas a composição e abundância da assembléia de cladóceros associados à *Eichhornia azurea* (Pontederiaceae) em distintos ambientes da planície de inundação do alto rio Paraná. As coletas foram realizadas durante o período de março/92 a fevereiro/93, em oito estações, localizadas em dois sistemas rio-lagoa, Baía e Ivinheima, caracterizados como sistemas de várzea, e em um sistema associado ao rio Paraná, o canal Cortado. Foram identificadas 31 espécies de cladóceros. O maior número de espécies bem como os mais elevados valores de abundância foram registrados nos ambientes de várzea, provavelmente devido a grande quantidade de hábitats formados pelas macrófitas aquáticas, além da grande conectividade existente entre os diferentes ambientes. Por outro lado, no sistema Paraná, embora ocorra uma grande quantidade de macrófitas em suas margens, não foi registrado um elevado número de espécies como o de ambientes de várzea, possivelmente devido a maior velocidade de corrente que limita o desenvolvimento de grandes populações de cladóceros típicos de região litorânea. A maior representatividade de espécies planctônicas nesse sistema sugere que as macrófitas aquáticas atuam como refúgio para essas espécies, tendo em vista que essa vegetação reduz substancialmente a velocidade de corrente.

Palavras-chave: Cladocera, fauna associada à macrófitas, composição, abundância, planície de inundação, rio Paraná.

Introduction

Cladocerans of the floodplain systems have been widely studied, although analyses have been mainly concentrated on plankton (Paggi and José de Paggi 1974, 1990; Lansac Tôha *et al.,* 1997; Sendacz 1997; Lima *et al.,* 1996, 1998).

Despite the small number of studies on associated fauna, the literature demonstrates that aquatic macrophytes support an abundant and diversified fauna of invertebrates that play an important role in the energy transference and nutrient cycling on aquatic food webs (Miura *et al.,* 1978; Junk and Robertson, 1997).

In South America few studies about the fauna associated with aquatic macrophytes include cladocerans. Researches involving the littoral region of Paca Lake, Peru (Valdívia and Zambrano, 1989) and the lentic and lotic environments of the Argentine stretch of Paraná River basin, is worth mentioning (Paporello de Amsler, 1983, 1987a, b; Poi de Neiff and Neiff, 1984; Poi de Neiff, 1986; Poi de Neiff and Bruquetas de Zozaya, 1989).

Researches in the floodplain of Upper Paraná River about the fauna associated with aquatic macrophytes, have included cladocerans only in the group level without references to the species abundance and composition (Lima *et al.,* 1998; Souza-Franco and Takeda, 2000).

This current research describes the spatial and temporal patterns of the cladoceran composition and abundance associated with *Eichhornia azurea* (Swartz) Kunth (Pontederiaceae), the most abundant macrophyte species in Paraná River floodplain.

Material and methods

Study area

Samples from associated fauna were obtained monthly, from March 1992 to February 1993, in the lentic and lotic environments of Upper Paraná River floodplain, in Mato Grosso do Sul and Paraná States (22º 47' - 22º 52' S; 53º 15' - 53º 35' W).

Eight sampling stations were established in three different systems of the floodplain: two stations located in the main channel of Paraná River, the Cortado Channel system, one of them in the right margin of Cortado Channel (P1) and the other in the lower section of this channel (P2); three stations in Baía River - Guaraná Lagoon system (B1, B2 and B3), and three in Ivinheima River - Patos Lagoon system (I1, I2 and I3). In each of these last two systems, inserted in the floodplain, a station was located at the margin of the lagoon (B1 and I1), the other station in the connection channel between the river and lagoon (B2 and I2), and the last one in the margin of the river (B3 and I3), (Figure 1).

Table 1 shows morphometric and hydrological characteristics of these systems.

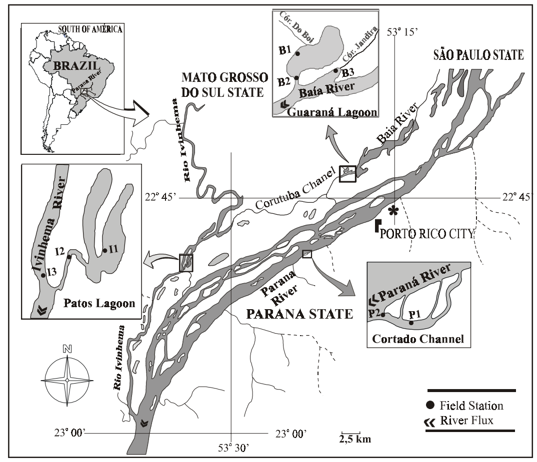

Figure 1. Study area and sampling stations

Table 1. Water speed, discharge (minimum and maximum), average depth and width of sampling sites

	Current speed (m/s)	Discharge (m^3/s)	Width (m)	Average depth (m)
Paraná River	0.87 - 0.98	8860 - 11401	1170	14
Ivinheima River	0.34 - 0.85	240 - 1006	86	6.3
Baia River	0.11 - 0.50	9.8 - 102	67	4.2
Cortado Channel	0.15 - 0.56	5.2 - 118	60	2.3
Guaraná Lake	Not detectable	Not detectable	No data	2.8
Patos Lake	Not detectable	Not detectable	No data	3.7

Sampling

Samples of the cladoceran fauna associated to *E. azurea* were obtained among pure stands of this macrophyte. Approximately one meter of stalk with roots and leaves of *E. azurea* was collected. This material was washed in a series of three pails, two containing formaldehyde 4% and the other containing water. The solution in the pails was filtered and the material was fixed in formaldehyde 4% buffered with calcium carbonate. Organisms were analyzed in the lab through a stereoscopic microscope for the cladoceran separation.

Species identification was based on Paggi (1972, 1973, 1975, 1976, 1978, 1979a, b, 1980, 1995), Fryer and Paggi (1972), Smirnov (1974, 1992), Korinek (1984), Korovchinsky (1992) and Elmoor-Loureiro (1997).

Organisms were then counted through an optic microscope in a Sedgwick-Rafter chamber. Plants were dried in an oven at 80°C, and weighted. Density of cladocerans is given as number of individuals/100 g of dry weight of plant.

Daily water levels of the Paraná River were given by the National Department for Water and Electric Energy (DNAEE).

Results

Water level

The water level of Paraná River oscillated between 2.52 and 6.64m during the period of March 1992 - February 1993, with two distinct hydrological instances: high water (March 1992 - May 1992 and November 1992 - February 1993) and low water (June 1992 - October 1992) periods; average levels of 4.23 - 2.98m respectively (Figure 2).

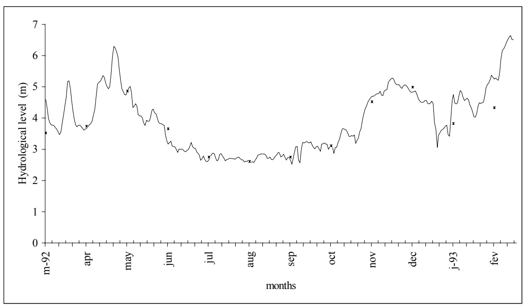

Figure 2. Variation of the water level of Paraná river from March/92 to February/93

Distribution of species richness and abundance

Thirty-one species of cladocerans belonging to seven families (Chydoridae, Ilyocryptidae, Macrothricidae, Bosminidae, Moinidae, Daphniidae and Sididae) were registered (Table 2).

Table 2. list of the cladocerans species recorded amongst Eichhornia azurea stands from the Upper Paraná River floodplain

Chydoridae	
Acroperus harpae (Baird, 1834)	*Dunhevedia odontoplax* Sars, 1901
Alona affinis (Leydig, 1986)	*Euryalona occidentalis* Sars, 1901
Alona eximia Kiser 1948	*Eurycercus lamellatus* (Müller, 1776)
Alona guttata Sars, 1862	*Graptoleberis testudinaria* (Fisher, 1848)
Camptocercus dadayi Stingelin, 1914	*Leydigiopsis curvirostris* Sars, 1901
Chydorus eurynotus Sars, 1901	*Notoalona globulosa* (Daday, 1898)
Chydorus parvireticulatus Frey, 1987	*Onchobunops tuberculatus* Fryer and Paggi, 1972
Dadaya macrops Sars, 1901	*Oxyurella longicauda* (Birge, 1910)
Disparalona cf *acutirostris* (Birge, 1879)	*Pseudochydorus globosus* (Baird, 1850)
Ilyocryptidae	
Ilyocryptus spinifer Herrick, 1884	
Macrothricidae	
Grimaldina brazzai Richard, 1892	*Macrothrix triserialis* (Brady, 1886)
Bosminidae	
Bosmina hagmanni Stingelin, 1904	
Oinidae	
Moina minuta Hansen, 1899	*Moinodaphnia macleayii* (King, 1853)
Daphniidae	
Ceriodaphnia cornuta Sars, 1886	*Simocephalus serrulatus* (Kock, 1841)
Daphnia gessneri Herbst, 1967	*Simocephalus* sp.
Sididae	
Diaphanosoma fluviatile Hansen, 1899	*Sarsilatona serricaudata* (Sars, 1901)
Diaphanosoma sp.	

The richest species family was Chydoridae (18 species). The other families were represented by a smaller number of species, varying from 4 (Daphniidae) to 1 species (Ilyocryptidae and Bosminidae).

The greatest number of cladoceran species was recorded in the Baía and Ivinheima systems (Figure 3).

In Paraná River system there was only a small difference in species richness during the year, although a slight increase was observed in the last months of the low water period (September and October). In the Ivinheima system a greater number of species was recorded in the beginning of the low water period (June and July). In the Baia system a clear pattern about the changes of the species richness was not observed, with High values registered in July, October, November and December (Figure 3).

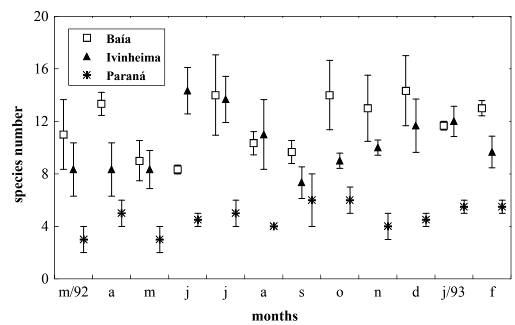

Figure 3. Seasonal variation in the number of cladoceran species associated with *E. azurea* in the three studied systems from March/92 to February/93. Points represent the mean and the bars represent the standard error

The greatest average abundance of cladocerans was also recorded in the Ivinheima and Baía systems mainly in the lagoons and the connection channels. The most abundant families were, in general, Chydoridae and Ilyocryptidae (Figure 4).

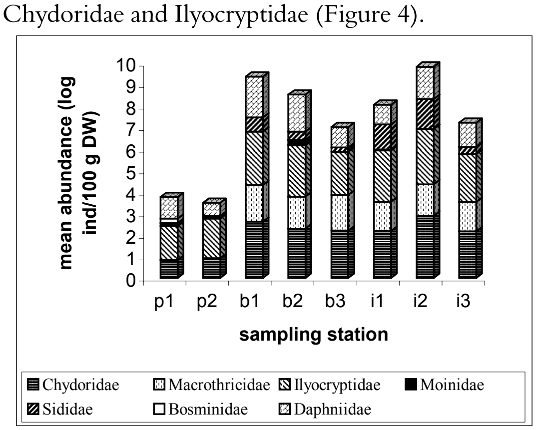

Figure 4. Mean abundance of cladoceran families in the different sampling station

Figure 5 shows the temporal variation of the most abundant species of Chydoridae associated with aquatic macrophytes in the various systems. *Alona affinis* had the greatest density in the Baía River stations, mainly between August and December; it was less abundant or even absent in the Ivinheima and Paraná systems. *Camptocercus dadayi* had the highest abundance between September and December in the Baía River too. *Chydorus eurynotus* had its highest density during the month of April in the Baía system, August in the Ivinheima system, and February in both systems. *Euryalona occidentalis* had high densities in the Ivinheima system especially during March, with smaller peaks between June and August. *A. globulosa* had its highest abundance in the Ivinheima system at the start and end of the period under analysis, with peaks in June and February; in the Baía system, chiefly in the end of the period, which the highest density was recorded in November and February. *L. curvirostris* was also a species registered in the Ivinheima system with two distinct abundance peaks in June and January (Figure 5).

The most abundant species of the other families were *Ilyocryptus spinifer*, *Macrothrix triserialis*, *Sarsilatona serricaudata*, *Simocephalus serrulatus, Moina minuta* and *Bosmina hagmanni* (Figure 6).

The first one had the highest abundance among the registered cladoceran species, at the three systems studied, with highest density peaks at the end of the period, in the Baía and Ivinheima systems. The second species was also abundant in two systems, it was not recorded in the Paraná system. Its highest density was recorded during June and January in the Ivinheima system and during November and December in the Baía system (Figure 6).

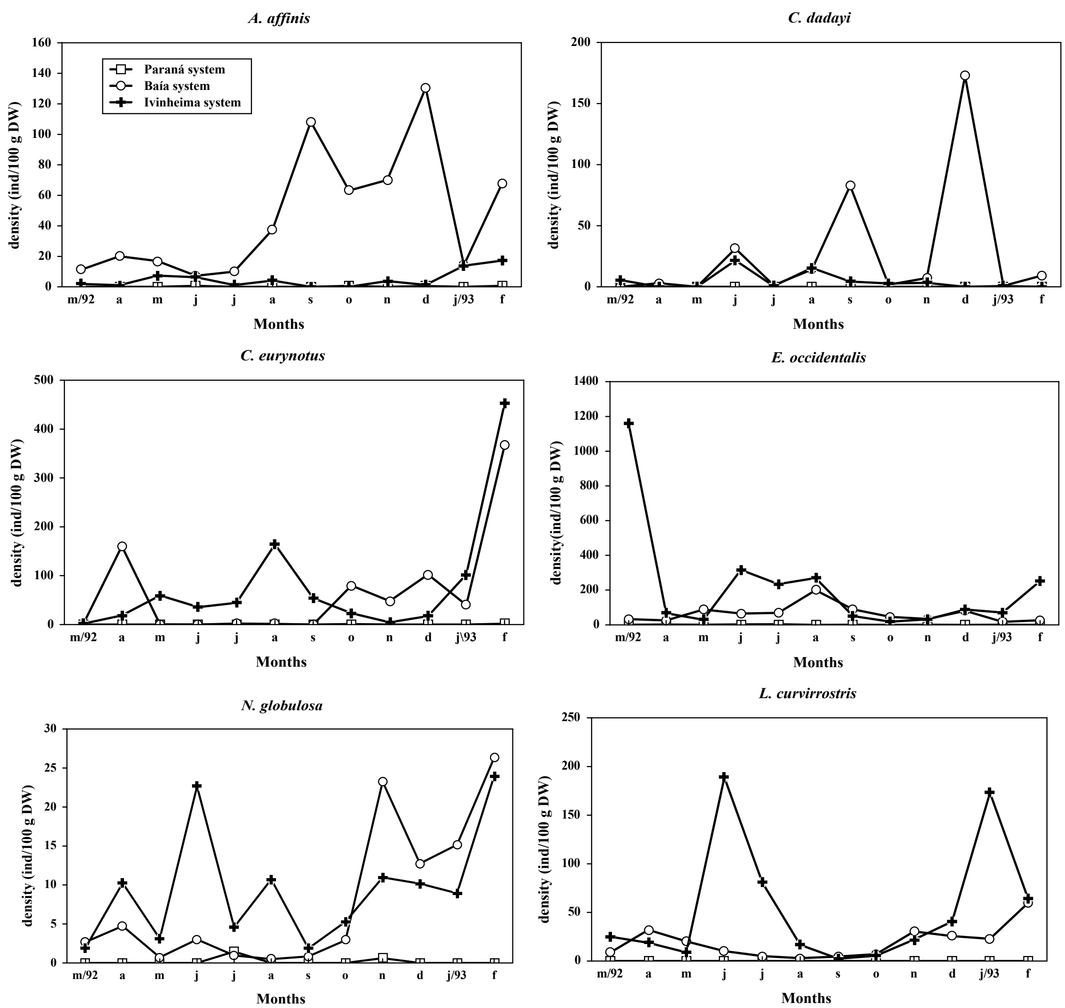

Figure 5. Seasonal variation of the six most abundant species of chydorid cladocerans in the studied systems, from March/92 to February/ 93

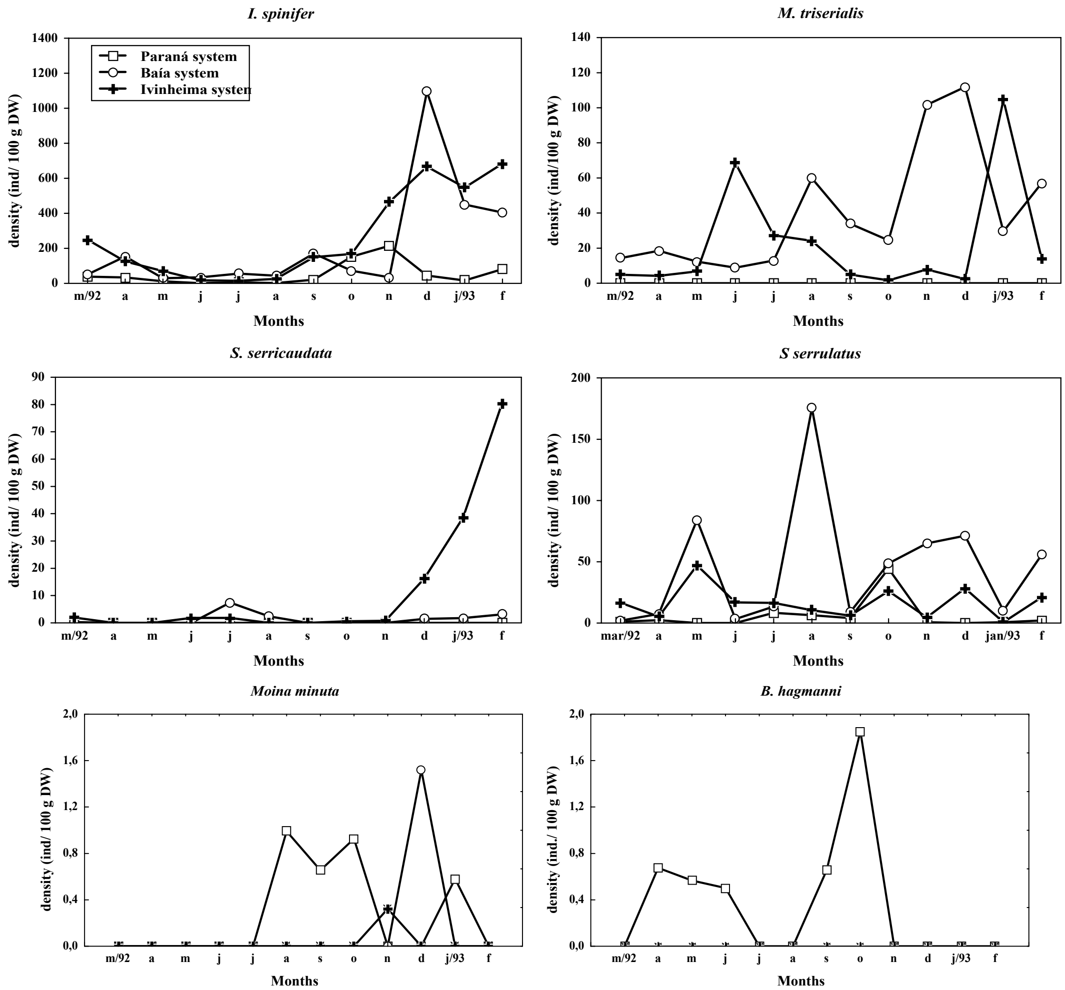

Figure 6. Seasonal variation of the most abundant species of Ilyocryptidae, Macrothricidae, Sididae, Daphniidae, Moinidae and Bosminidaae in the studied systems, from March/92 to February/ 93

Sarsilatona serricaudata was the most abundant species of the Sididae family. Its density was higher in the Ivinheima system, especially from December to February. *Simocephalus serrulatus* was particularly conspicuous in the Baía system, with its highest peak in August (Figure 6). Among the bosminids, *B. hagmanni* was the only representative species, occuring exclusively in the Paraná system. It was recorded between April and June and between September and October, with abundance peak in October. The Moinidae family was represented by *M. minuta*, mainly also registered in the Paraná system, although its abundance peak occurred during December in the Baía system.

Discussion

Eighty-three percent of the Cladoceran species registered in our research are species with typical littoral habits. This percentage is close to the one given by Valdivia and Zambrano (1989) for cladocerans associated with aquatic macrophytes in different regions of Paca Lake (Peru).

In this study we discovered that the greatest number of cladoceran species were representatives of the Chydoridae family. These results agree with those found by researchers studying the littoral zone and other macrophyte assemblages in the floodplain lagoons of the middle Paraná River, Argentina (Paporello de Amsler, 1983, 1987b) and in Paca Lake, Peru (Valdivia and Zambrano, 1989). These results have also been registered for assemblages of zooplankton cladocerans of the littoral region of certain environments of the Paraná River floodplain analyzed in this current study (Lima *et al.,* 1996; Serafim-Junior, 1997) and in flood areas of Venezuela (Zoppi de Roa *et al.,* 1985). Chydoridae, Macrothricidae and Ilyocryptidae are species with a predominantly littoral habitat (Paggi and José de Paggi, 1990). Open-water species of genra *Bosmina, Moina* and *Daphnia* were only slightly recorded in fauna associated with *E. azurea*.

Although a seasonal pattern is not clear in these three systems, results suggest a trend towards a higher number of species in the low water months, which could be due to a smaller drift of individuals belonging to associated fauna towards open water during this period. Souza-Franco and Takeda (2000) registered an increase of fauna diversity associated with *Paspalum repens* Berg. (Poaceae) during a heavy decline in the Paraná River's water level. Poi de Neiff and Bruquetas de Zozaya (1989) also found a higher richness of cladoceran species associated with aquatic macrophytes during the low water period when lakes remained isolated from Paraná River. The scarcity of these organisms in the flooding period has been attributed to the entrance of the water into Paraná River in these environments.

However, Lima *et al.* (1996) registered an increase in the number of plankton species taken in plankton samples of the littoral region of different environments of this floodplain. This fact can be explained by an increase in littoral species carried from the flooded area to open water during the high water period. During this period there is a greater connection between the cultivated plain area (várzea) and the pelagic region of various floodplain environments.

The low densities of cladocerans associated to *E. azurea* in Paraná system are probably due to hydrodynamic factors, such as current. Similar patterns related to lentic and lotic environments have been observed for the planktonic segment (Bonecker and Lansac-Tôha, 1996; Lansac-Tôha *et al.*, 1997; Lima *et al.*, 1998; Velho *et al.*, 1999). The Ilyocryptidae family, represented by *Ilyocryptus spinifer*, was the most abundant species in fauna associated with *E. azurea* in the Paraná River. It is worth mentioning that *I. spinifer* was the most abundant in the three systems, with extensive ecological amplitude. Among the cladocerans of planktonic samples of the littoral region from different environments of the upper Paraná River floodplain, the above species had the highest frequency and abundance in the context of typically littoral cladocerans (Lansac-Tôha *et al.*, 1997). In studies made by Paporello de Amsler (1987a, b), *I. spinifer* was also the most frequent species in lakes, channels and tributaries of Paraná River among the cladocerans associated with aquatic macrophytes. Paterson (1994) also registered a great abundance in *Ilyocryptus* sp. in submersed macrophytes of Lake Jake, Canada.

Although researches on floodplain have shown the occurrence of seasonal patterns in the cladocerans abundance distribution, mainly related to the water level (Poi de Neiff and Bruquetas de Zozaya, 1989; Lansac-Tôha *et al.,* 1997; Lima *et al.,* 1998), in the present study these patterns were not evident. Similar results have been given for Cyclopoida (Copepoda) associated with *E. azurea* in the same lakes studied in our research (Lansac-Tôha *et al.*, forthcoming).

In the floodplain-affected Baía and Ivinheima systems, with high connectivity between the rivers and lakes by means of channels, assemblages of typical littoral species were formed.

Euryalona occidentalis, *Macrothrix triserialis*, *Chydorus eurynotus*, *Chydorus pubescens* and *Pleuroxus* sp. were frequent and abundant in lakes of the middle Paraná River, together with *Kurzia latissima*, *Diaphanosoma brevireme* and *Oxyurella longicauda* (Paporello de Amsler, 1987b). Studies achieved by Valdivia and Zambrano (1989) in the littoral zone of Paca Lake, Peru, showed that *Simocephalus vetulus* and *Camptocercus similis*, were the most abundant species, followed by *Alona cambouei*, *Ephemeroporus acanthodes*, *Pleuroxus aduncus* and *Pleuroxus inermis*.

On the other hand, it is important to emphasize the presence of open water species, such as *Daphnia gessneri, Moina minuta* and *Bosmina hagmanni* in Paraná River system. Results show, once again, the relevant role of hydrodynamic factors in the structuring of cladoceran assemblages associated with margin vegetation. According to Paterson (1994), planktonic species are not significantly correlated with the surface area of aquatic macrophytes. The presence of these species in such environments may be explained by the fact that banks of aquatic macrophytes act as refuges from high currents and predators. Stanfield *et al.* (1997) found that *Daphnia* spp. in three British lakes were expelled from open waters by predators and survived in aquatic macrophyte banks.

Our results suggest that the hydrodynamic differences observed among the environments studied, as well as the greater or lesser degree of connectivity between lentic and lotic environments, that distinguish the varzea systems, such as Baía and Ivinheima systems, from the Paraná River system, are important in the structuring and the dynamics of cladocerans assemblages associated to littoral vegetation.

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