Oecologia Australis
15(3): 522-536, Setembro 2011
doi:10.4257/oeco.2011.1503.07

IMPORTANCE OF LATERAL LAGOONS FOR THE ZOOPLANKTON ASSEMBLAGES (CLADOCERA AND COPEPODA) IN A LARGE TROPICAL RESERVOIR

Mateus Ferrareze[1] & Marcos G. Nogueira[1]*
[1] Universidade Estadual Paulista, Instituto de Biociências, Departamento de Zoologia, Campus de Rubião Júnior, CEP 18618-970, Botucatu, São Paulo, Brasil. Caixa Postal: 510.
E-mails: mferrareze@ibb.unesp.br, nogueira@ibb.unesp.br

ABSTRACT

This study aimed to analyze the composition and the ecological attributes of the zooplankton assemblages (Cladocera and Copepoda), in four marginal lagoons and in the main channel of Rosana Reservoir (SE Brazil). Fieldwork was carried out in September and November/2004 and January, March, May and August/2005. A total of 72 taxa were identified (55 cladocerans and 17 copepods). Seasonally, a significant higher richness was observed during the rainy period. The lateral lagoons, compared to the reservoir, and the rainy period, compared to the dry one, showed higher zooplankton abundance. Copepods exhibited higher abundance than cladocerans. Among the copepods, there was a higher abundance of nauppli forms in the lateral lagoons and in the dry period. Calanoida dominated in relation to Cyclopoida. The most numerous cladoceran family was Bosminidae, followed by Daphniidae. The results showed that the zooplankton assemblages are influenced by the meteorological factors, by some important nutrients (indirectly) and by the phytoplankton abundance. This pattern indicated that in the lateral lagoon system the communities are controlled by bottom-up mechanisms. The results validate the hypotheses that lateral lagoons have a prominent ecological role for the zooplankton of Rosana Reservoir and also evidenced the main driving forces influencing the composition and ecological attributes of the assemblages. The incorporation of the reservoir lateral lagoons in regional environmental programs should be a target strategy for the conservation of the aquatic biota, mitigating the negative impact of the dam.
Keywords: Paranapanema River; floodplain; microcrustaceans; spatial variation; temporal variation.

RESUMO

IMPORTÂNCIA DAS LAGOAS LATERAIS PARA AS ASSEMBLÉIAS ZOOPLANCTÔNICAS (CLADOCERA E COPEPODA) EM UM RESERVATÓRIO TROPICAL DE GRANDE PORTE. O objetivo deste estudo foi analisar a composição e os atributos ecológicos das assembléias zooplanctônicas (Cladocera e Copepoda) de quatro lagoas marginais e do canal principal do reservatório de Rosana (SE, Brasil). Os trabalhos de campo foram realizados em setembro e novembro de 2004 e janeiro, março, maio e agosto de 2005. O número total de táxons identificados foi de 72 (55 cladóceros e 17 copépodes). Sazonalmente, a maior riqueza foi observada durante o período chuvoso. As lagoas laterais, em relação ao reservatório, e o período chuvoso, em relação ao seco, apresentaram maiores abundâncias de organismos. Os copépodes foram mais numerosos que os cladóceros. As lagoas marginais e o período seco apresentaram maior abundância de naúplios. Calanoida foi dominante em relação aos Cyclopoida. Entre os cladóceros, Bosminidae foi a família mais numerosa, seguida por Daphniidae. Os resultados mostraram que as assembléias zooplanctônicas são influenciadas pelos fatores metereológicos, por alguns nutrientes (indiretamente) e pela abundância do fitoplâncton. Esse padrão indicou que no sistema de lagoas laterais, o funcionamento das comunidades é determinado por mecanismos de controle ascendente. Os resultados validaram a hipótese de que as lagoas laterais têm um proeminente papel ecológico para o zooplâncton do reservatório de Rosana e mostraram quais são as principais forças que influenciam na composição e atributos ecológicos das assembléias. A incorporação

das lagoas laterais em programas regionais de conservação ambiental pode ser uma boa estratégia para conservação da biodiversidade aquática, mitigando o impacto negativo da construção da barragem.
Palavras-chave: Rio Paranapanema; lagoas marginais; microcrustáceos; variação espacial; variação temporal.

INTRODUCTION

A large number of reservoirs have been constructed in the last decades in Brazil, mainly in order to supply the increasing energetic demand. Nowadays, the main Brazilian rivers, especially in the Southeast region, were regulated by dams. Besides providing electric power, these reservoirs are also used for water supply, irrigation, aquaculture, recreation, tourism and navigation (Tundisi 2005, Tundisi & Matsumura-Tundisi 2008). As a consequence of the intensive damming, the regional riverine systems have been transformed in large lentic (or semi-lentic) ecosystems (Nogueira *et al.* 1999, Soares *et al.* 2008).

As a consequence of the reservoir filling up, there is an increase of the connectivity between river and floodplain habitats, or even the formation of artificial lagoons (Henry *et al.* 2006). Lateral lagoons form a complex gradient between the river channel and adjacent terrestrial ecosystems, resulting in a variety of secondary and tertiary ecotones (Ward *et al.* 1999). These systems are characterized by remarkable environmental interactions between surface water, groundwater and riparian vegetation, and usually they sustain a significantly high biodiversity (Ward & Tockner 2001). The degree of connectivity of lateral lagoons with the main rivers has also been considered as an important controlling factor of floodplain aquatic communities (Thomaz *et al.* 2007, José de Paggi & Paggi 2008, Bonecker *et al.* 2009, Güntzel *et al.* 2010).

Studies based on zooplankton assemblages contributed for the increasing knowledge of reservoirs structure and functioning (Sendacz & Kubo 1982, Rocha *et al.* 1995, Matsumura-Tundisi 1999, Matsumura-Tundisi & Tundisi 2003, Velho *et al.* 2001, Bezerra-Neto & Pinto-Coelho 2007, Nogueira *et al.* 2008). Nevertheless, studies focusing on the importance of the lateral compartments for the zooplankton biology/ecology are restricted to a few reservoirs (Panarelli *et al.* 2001, Casanova & Henry 2004, Panarelli *et al.* 2008, Casanova *et al.* 2009, Nadai & Henry 2009, Panarelli *et al.* 2010).

There are evidences that changes in the structure and dynamic of zooplankton assemblages can influence all trophic levels of a reservoir ecosystem (Rocha *et al.* 1995). These modifications can determine some undesirable processes, such as algae blooms, which cause a deterioration of the water quality condition (Pinto-Coelho *et al.* 1999). It happens due to the fact that the zooplankton has an important role in the energy transfer between primary producers and consumers of higher trophic levels. Additionally, some zooplankton species, or even information of the assemblage structure, have been used as bio-indicators of spatial and seasonal variability (Matsumura-Tundisi *et al.* 1990, Pinto Coelho *et al.* 1999, Sendacz & Kubo 1999, Nogueira 2001).

In the present study, it was analyzed the composition and ecological attributes of zooplankton assemblages in four lateral lagoons and in the main channel of Rosana Reservoir, Paranapanema River. The specific objectives were to determine the spatial and temporal variation in the composition, richness, abundance and diversity of cladocerans and copepods and to correlate their distribution with the limnological variables (transparency, temperature, pH, electric conductivity, turbidity and concentrations of dissolved oxygen, suspended solids, total nitrogen, total phosphorus and dissolved silicate), precipitation and phytoplankton abundance.

The main hypothesis is that the lateral lagoons have a significant contribution for the zooplankton diversity of Rosana Reservoir. It was also intended to determine the main driving forces influencing on the spatial and temporal variation of the composition and ecological attributes of the zooplankton assemblages in the lateral lagoons system.

MATERIAL AND METHODS

Study area

The study area is in the upstream (tail) zone of Rosana Reservoir, approximately 80 km above dam

(Figure 1), which is located at 22º 36’S and 52º 52’W. The reservoir is the last one of a series of eleven along the Paranapanema River (SP/PR, Brazil), with a surface area of 276km^2 (watershed of 11,000km^2), water retention time of 21 days (annual mean value), relatively shallow (maximum of 26m close to the dam) and in oligo-mesotrophic condition (Nogueira *et al.* 2006).

The climate is subtropical humid (average temperature of 21ºC) with two pronounced seasons: rainy and dry (Duke Energy 2001). During the studied period, the rainy season ranged from September/2004 to January/2005 (mensal average of 157mm), while the dry period ranged from February to August of 2005 (mensal average of 70.7mm). The accumulated rain precipitation in the study period was 1,207.5mm. The rain precipitation data was provided by the meteorological station of the State Park of “Morro do Diabo”, municipality of Teodoro Sampaio (State of São Paulo).

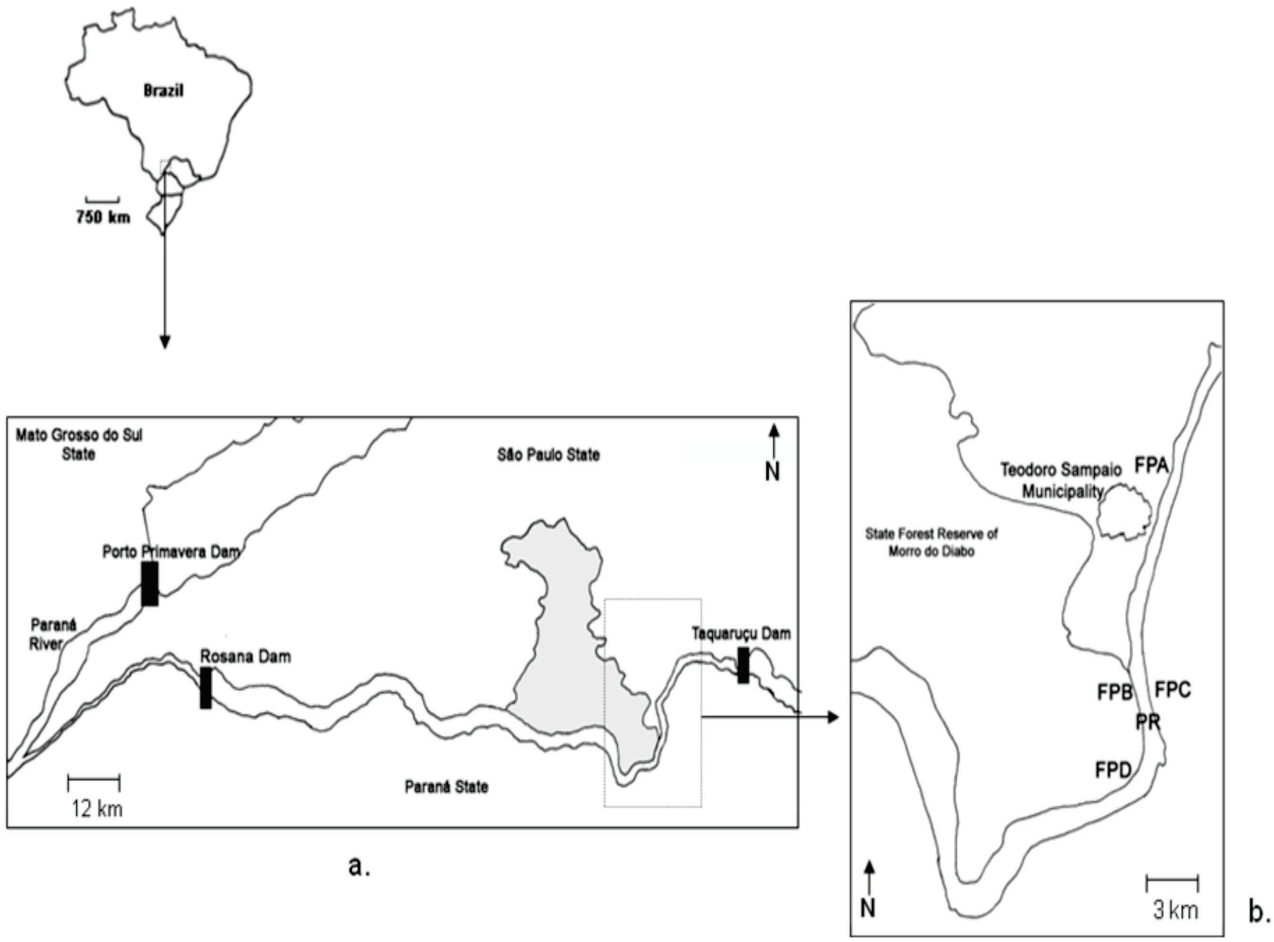

Figure 1. Study area in the region of the confluence of Paraná and Paranapanema Rivers (States of São Paulo - SP, Paraná - PR and Mato Grosso do Sul - MS) showing the positioning of Rosana, Taquaruçu and Porto Primavera dams and the State Park of “Morro do Diabo” (gray area) (a.). On the right (detail) the location of the sampling stations and the municipality of Teodoro Sampaio (b.).

Figura 1. *Área de estudo na região de confluência dos rios Paraná e Paranapanema (estados de São Paulo - SP, Paraná - PR e Mato Grosso do Sul - MS) mostrando o posicionamento das barragens de Rosana, Taquaruçu e Porto primavera e o Parque Estadual do “Morro do Diabo” (em cinza) (a). No lado direito (detalhe) o posicionamento das estações de coleta e a municipalidade de Teodoro Sampaio (b).*

Samplings and laboratory analyses

The study was carried out in 4 lagoons and one sampling station in the Paranapanema River (PR), close to the river bank (Figure 1, Table I). This last station is located in the transitional river/reservoir compartment. Samplings were carried out in September and November of 2004 and January, March, May and August of 2005.

Table I. Denomination of the sampling stations, geographical positioning, lagoons surface area, main aquatic macrophytes and estimated area of connectivity of lagoons with the river/reservoir main channel.
Tabela I. *Denominação das estações de amostragem, posicionamento geográfico, área superficial das lagoas, principais espécies de macrófitas e área estimada de conectividade da lagoa com o rio/reservatório.*

Sampling station	Geographical coordinates	Area (km²)	Dominant macrophytes	Connectivity (m²)
Lateral lagoon A (FPA)	22º 34' 03.3''S / 52º 09' 11.4''W	0.110	*Typha, Eichhornia, Brachiaria, Pontederia* and *Salvinia*	50
Lateral lagoon B (FPB)	22º 36' 56.5''S / 52º 09' 47.3''W	0.024	*Eichhornia, Brachiaria, Pontederia, Salvinia, Pistia, Egeria* and *Nymphaea*	6.5
Lateral lagoon C (FPC)	22º 37' 28,9''S / 52º 09' 21.1''W	0.721	*Eichhornia, Brachiaria, Pontederia, Salvinia* and *Egeria*	525
Paranapanema River Bank (PR)	22º 37' 51.6''S / 52º 09' 30.5''W	-	*Tipha, Eichhornia, Brachiaria, Pontederia, Salvinia* and *Pistia*	-
Lateral lagoon D (FPD)	22º 38' 22.0''S / 52º 09' 29.0''W	0.063	*Eichhornia, Brachiaria, Pontederia, Salvinia, Pistia* and *Nymphaea*	60.2

Two kinds of lagoons were assessed: 3 natural systems (FPB, FPC and FPD) and one originated by the flood of mining digging (FPA). The natural lagoons (FPB and FPD) are located inside the State Park of Morro do Diabo, while the last one (FPC) is located in an area influenced by human activities (agriculture and cattle breeding). The dominant macrophytes of each lagoon, in terms of stand area, were registered (Table I). Identification of these plants was performed at the genus level, with help of taxonomists of Botany Department from Biosciences Institute of UNESP/Botucatu. The main limnological characteristics of each point are showed in Table II. The sampling stations positioning, the area of each lagoon (integration of geometric distances), as well as their connectivity (transversal section of the lagoon mouth) with the river-reservoir main channel (Table 1), were determined using a Garmin E-Trex GPS.

Table II. Mean values (among depths) (except transparency) for the limnological variables measured at the different sampling stations and periods.
Tabela II. *Valores médios (entre profundidades) (exceto transparência) para as variáveis limnológicas medidas nas diferentes estações e períodos de amostragem.*

	pH						Dissolved oxygen (mg L^{-1})						Temperature (°C)					
	set-04	nov-04	jan-05	mar-05	mai-05	ago-05	set-04	nov-04	jan-05	mar-05	mai-05	ago-05	set-04	nov-04	jan-05	mar-05	mai-05	ago-05
FPA	7.2	7.5	6.2	6.6	7.3	6.1	8.7	6.5	6.2	8.4	6.2	8.0	23.0	25.5	27.2	27.6	25.4	22.2
FPB	7.3	6.6	6.3	6.6	7.3	7.6	8.6	7.7	6.3	5.0	9.5	8.3	22.1	25.5	27.1	27.4	25.3	22.4
FPC	7.2	6.3	5.9	6.5	7.2	7.6	9.7	8.0	5.9	5.2	10.0	9.0	20.8	25.7	26.9	27.2	25.2	22.1
PR	7.2	6.2	5.2	6.4	6.9	7.2	9.6	7.8	6.0	6.4	9.2	12.0	20.5	25.2	27.1	26.9	24.6	22.4
FPD	7.4	6.2	5.5	5.9	7.0	7.1	8.8	7.6	5.4	9.2	13.2	12.0	21.0	25.6	27.0	27.3	25.2	22.5

	Conductivity (µ S cm^{-1})						Transparency (m)						Turbidity (NTU)					
	set-04	nov-04	jan-05	mar-05	mai-05	ago-05	set-04	nov-04	jan-05	mar-05	mai-05	ago-05	set-04	nov-04	jan-05	mar-05	mai-05	ago-05
FPA	46	70	70	70	48	64	2.8	1.5	0.4	1	2	3.5*	8.2	36.7	52.4	17.3	15.1	9.0
FPB	70	70	70	70	44	64	2.3	1.6	0.1	0.8	2.2	2.8*	4.5	33.4	40.2	12.3	7.4	4.2
FPC	90	80	90	80	80	65	2.2	1	0.2	1	2.7	3*	5.1	55.1	83.4	14.0	7.8	6.0
PR	60	70	70	70	52	65	2.1	1.3	0.1	0.7	2.2	5.8*	5.1	98.0	135.5	20.3	6.5	5.7
FPD	60	70	90	80	85	65	2.7	1.9	0.2	1	2.5	3.5*	5.0	94.7	140.0	21.0	6.9	5.8

	Suspended Solids (mg L^{-1})						Total Nitrogen (µ g L^{-1})						Total Phosphorus (µ g L^{-1})					
	set-04	nov-04	jan-05	mar-05	mai-05	ago-05	set-04	nov-04	jan-05	mar-05	mai-05	ago-05	set-04	nov-04	jan-05	mar-05	mai-05	ago-05
FPA	4.1	5.8	9.2	4.1	2.2	1.7	193	366	533	321	241	252	14.1	21.7	19.2	33.0	31.6	25.8
FPB	2.2	7.2	18.4	4.3	2.7	2.0	236	361	587	363	301	320	9.5	36.7	53.8	45.6	30.4	26.0
FPC	4.2	13.0	14.8	3.4	2.4	2.0	242	418	662	373	296	466	9.9	28.7	32.4	38.4	39.8	30.2
PR	2.5	5.3	31.9	5.3	3.4	1.8	306	329	659	340	288	306	7.9	32.8	52.8	50.1	34.5	30.6
FPD	2.4	3.2	16.0	3.6	2.0	2.4	224	316	555	364	306	289	5.9	31.6	39.0	38.4	28.7	24.2

*bottom

The zooplankton samples were collected using a conical net (30cm mouth diameter and 50µm mesh size) through vertical hauls from near bottom (ca. 0.5m) to surface. In each point/period it was obtained an additional sample for qualitative analysis. For the quantitative analysis a minimum of 150 individuals was counted per sample and in case of low abundance the entire sample was analyzed. Microcrustaceans were identified by specialized literature for the neotropical fauna (ex. Sendacz & Kubo 1982, Reid 1985, Matsumura-Tundisi 1986, Elmoor-Loureiro 1997, Rocha 1998, Silva 2003). Among cladocerans, the Sididae, Ilyocryptidae and Macrothricidae were grouped as Others (for graphical representation), due to their low representativeness in terms of abundance.

Samples were fixed and preserved in 4% formaldehyde and they are deposited in the Freshwater Microcrustacean Collection of the Department of Zoology, Biosciences Institute of the State University of São Paulo (campus of Botucatu).

Zooplankton diversity was estimated using the Shannon-Weaver Index ($\log_2$). In order to compare the sampling sites, on the basis of the zooplankton assemblages structure, a cluster analysis (r-Pearson similarity) (Pcordwin) was performed, using the abundance per group (family level).

The mean values of the measured assemblages attributes were calculated in order to synthesize the information and facilitate the identification of patterns. Two periods were considered in the analysis: rainy and dry periods. The representativeness of the means was assumed based on the normal data distribution (Shapiro-Wilk's W test) (Underwood 1997, StatisticaTM 6.0).

A one-way ANOVA test was performed to detect differences among sampling sites. When differences were detected, the Tukey test was applied to determine the level of significance (Underwood 1997). Differences between the periods were tested by the test t-student, using the mean of the variables for each season (dry and rainy). Significant different values were considered when $p < 0.05$ (Underwood 1997), which are mentioned in the results. The analyses were performed using StatisticaTM 6.0.

Finally, a canonic correspondence analysis, CCA (Pcordwin) (McCune & Mefford 1995) was used to identify the main limnological factors influencing the zooplankton abundance. The environmental variables (Ferrareze *et al. in press*) and phytoplankton abundance (Ferrareze & Nogueira, *in preparation*) were simultaneously measured.

RESULTS

A total of 72 taxa was found in the zooplankton samples. Cladocera was represented by 55 species (3 Moinidae, 3 Bosminidae, 6 Sididae, 8 Daphiniidae, 2 Ilyocryptidae, 4 Macrothricidae, 9 Chydorinae and 20 Aloninae) and Copepoda by 17 species (6 Diaptomidae and 11 Cyclopidae).

An increasing downstream tendency in the zooplankton richness, considering the lagoons distribution in relations to the river course, was observed. The number of species was significantly higher at the FPD sampling station (p=0.00, F=524.59, Figure 2). Seasonally, significant higher richness was observed during rainy period (mean of 23 taxa) and lower in dry period (mean of 20 taxa) (p=0.035).

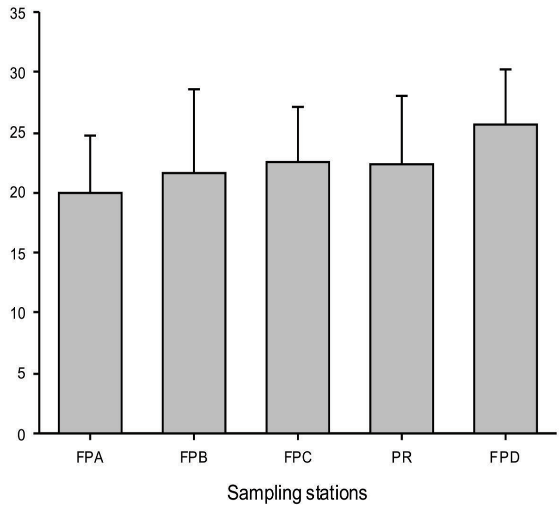

Figure 2. Zooplankton richness (mean values and standard deviation) at the different sampling stations, considering the different study periods.
Figura 2. *Riqueza do zooplâncton (valores médios e desvio padrão) nas diferentes estações de amostragem.*

The lateral lagoons exhibited significant higher zooplankton abundance when compared with the reservoir (p=0.000066, F=22.86, Figure 3). Seasonally, significant higher abundance was observed in the rainy (mean of 12,475individuals m^{-3}) compared to the dry period (mean of 5,228individuals m^{-3}) (p=0.033). The zooplankton abundance was positively correlated with the phytoplankton abundance (r=0.8, p=0.000, Figure 4).

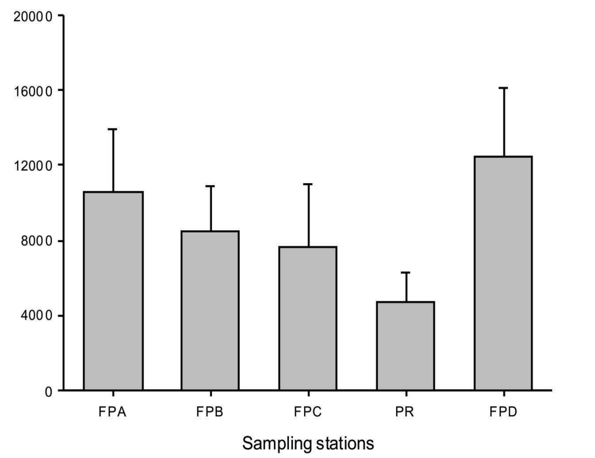

Figure 3. Zooplankton abundance (mean values and standard deviation) at the sampling stations, considering the different study periods.
Figura 3 . *Abundância do zooplâncton (valores médios e desvio padrão) nas diferentes estações de amostragem, considerando os diferentes períodos de estudo.*

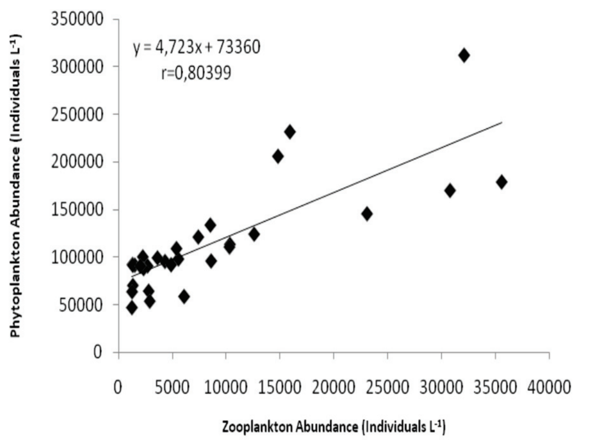

Figure 4. Linear correlation between zooplankton abundance and phytoplankton abundance at the different sampling stations, considering the different study periods.
Figure 4. *Linear correlation between zooplankton abundance and phytoplankton abundance at the sampling stations.*

Copepods showed higher abundance than Cladocerans, 79.5% and 20.5% of the total number of organisms, respectively (p=0.000). An exception was observed at the FPB in January of 2005, where Cladocerans reached 51.6% of the total number of organism. Among the copepods, nauplii of Calanoida (mean of 2,505individuals m^{-3}) were more abundant than nauplii of Cyclopoida (mean of 1,873 individuals m^{-3}) (p=0.026). Higher number of nauplii forms were observed in the lateral lagoons compared to the reservoir (p=0.001). Seasonally, there was higher nauplii abundance in the dry period (66.2% of the population) than in the rainy period (55.5% of the population) (p=0.023).

The Calanoida/Cyclopoida relative abundance (Figure 5) showed a higher proportion of calanoids.

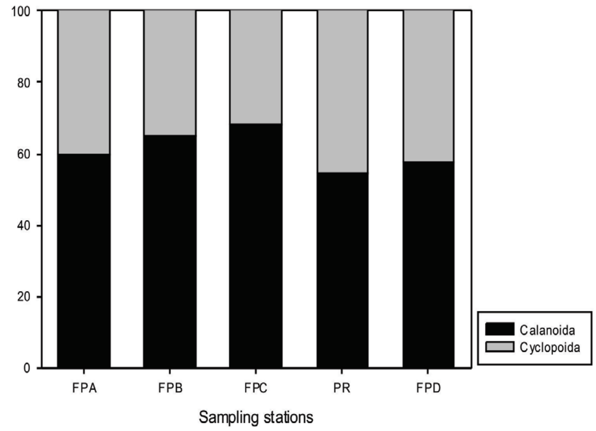

Figure 5. Relative abundance among the Copepoda groups at the different sampling stations, considering the different study periods.
Figure 5. *Abundância relativa entre os grupos de Copepoda nas diferentes estações de amostragem, considerando os diferentes períodos de estudo.*

Among the copepods the main species, in terms of abundance and frequency of occurrence, were the diaptomidae *Notodiaptomus henseni* (Dahl 1894) and *N. iheringi* (Wright 1935) as well as the cyclopidae *Thermocyclops decipiens* (Kiefer 1929), *T. minutus* (Lowndes 1934) and *Mesocyclops ogunnus* (Onabamiro 1957).

The relative abundance among cladocerans (Fig. 6) showed that the Chydoridae, despite having a larger number of species, were not numerically dominant. Bosminidae was the most abundant group (43.6%), followed by Daphniidae (38.2%). Bosminidae exhibited higher dominance in the lagoons FPA, FPB and FPD. Daphniidae were more abundant at the reservoir sampling stations and Chydoridae, typical from littoral habitats, were proportionally more abundant in FPB and FPC lagoons.

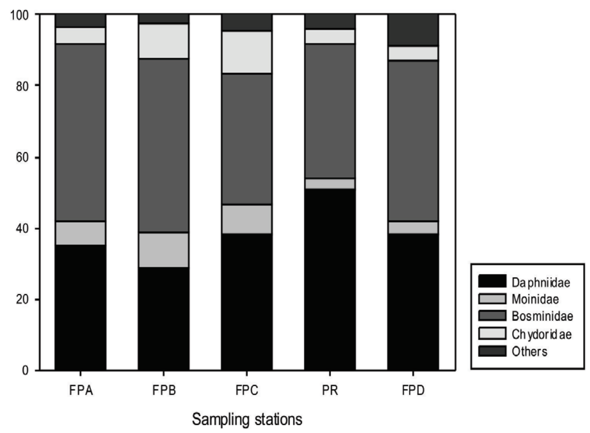

Figure 6. Relative abundance among the Cladocera groups at the different sampling stations, considering the different study periods.
Figure 6. *Abundância relativa entre os grupos de Cladocera nas diferentes estações de amostragem, considerando os diferentes períodos de estudo.*

The main cladoceran species were the Daphiniidae *Daphnia gessneri* Herbst (1967) and *Ceriodaphnia silvestrii* (Daday 1902), the Moinidae *Moina minuta* (Hansen 1899) and the Bosminidae *Bosmina freyi* (De Melo & Hebert 1994) and *Bosminopsis deitersi* (Richard 1895).

Despite a downstream tendency of richness increase, there was no significant difference among the sampling stations diversity (p=0.553, F=1.77, Figure 7). There was also no significant difference between the seasonal periods (p=0.07).

The cluster analysis (Figure 8), on the basis of the zooplankton assemblage structure of each sampling station, showed a higher similarity between the stations FPA and FPD. This analysis also evidenced that the reservoir sampling station (PR) has a distinct zooplankton assemblage compared to the lateral lagoons.

Finally, the results of the CCA (Figure 9 and Table III) explained 73% of the data variability (p=0.01), considering the three first ordination axes (axis 1 = 48.8%, axis 2 = 14.9% and axis 3 = 9.3%). The groups Sididae, Daphniidae and Moinidae were better correlated with the positive side of the axis 1, associated to higher values of total nitrogen, total phosphorus, precipitation, temperature, turbidity, suspended solids and conductivity and also with higher phytoplankton abundance. The groups Bosminidae, Calanoida and Cyclopoida positioned on the negative side of the axis 1, associated to higher values of pH, dissolved silicate and transparency.

Bosminidae and Moinidae were located on the positive side of the axis 2, associated to lower values of conductivity as well as to higher concentrations of dissolved silicate.

Table III. Significant (r>0.4) correlations of the biotic and abiotic variables with the main components 1 e 2 (CCA analysis).
Tabela III. *Correlações significativas (r>0.4) entre as variáveis bióticas e abióticas com os componentes principais 1 e 2 (análise de CCA).*

	Abbreviation	r (Axis 1)	r (Axis 2)
Biotic			
Sididae	Sididae	0.7	-0.01
Daphniidae	Daphn	0.9	0.2
Moinidae	Moinidae	0.6	0.5
Bosminidae	Bosmi	-0.5	0.5
Calanoida	Calano	-0.6	-0.1
Cyclopoida	Cyclo	-0.2	0.4
Abiotic			
Total Nitrogenous	Nt	0.8	-0.2
Total Phosphorus	Pt	0.5	-0.2
Dissolved Silicate	Silica	-0.1	0.4
Rain precipitation	Pluvio	0.9	0.1
pH	pH	-0.8	0.3
Temperature	T	0.6	-0.2
Conductivity	K	0.4	-0.5
Transparency	Transp	-0.7	0.2
Turbidity	Turb	0.8	-0.2
Phytoplankton abundance	Phyto	0.5	0.3
Total Suspended Solids	SSt	0.9	-0.1

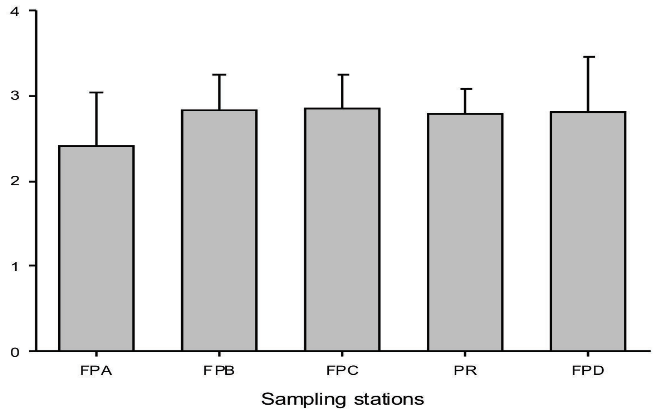

Figure 7. Diversity of zooplankton assemblages (mean values and standard deviation) at the sampling stations, the different sampling stations, considering the different study periods study periods.

Figure 7. *Diversidade das assembléias zooplanctônicas (valores médios e desvio padrão) nas diferentes estações de amostragem, considerando os diferentes períodos de estudo.*

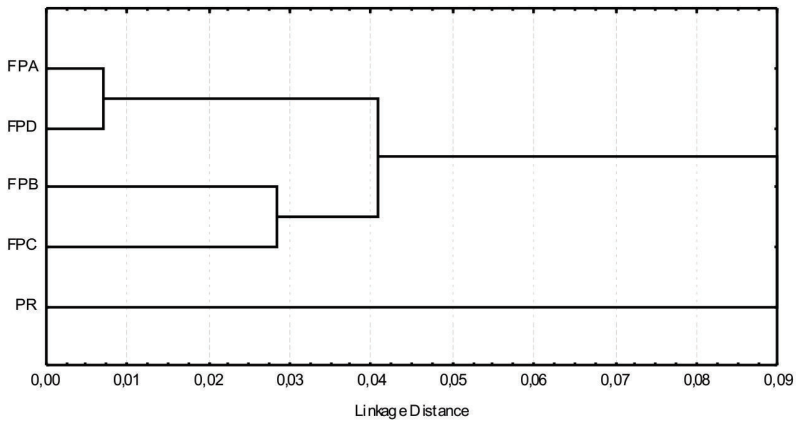

Figure 8. Similarity analysis among the sampling stations based on the abundance of the zooplankton groups.

Figure 8. *Análise de similaridade entre as estações de amostragem baseada na abundância dos grupos zooplanctônicos.*

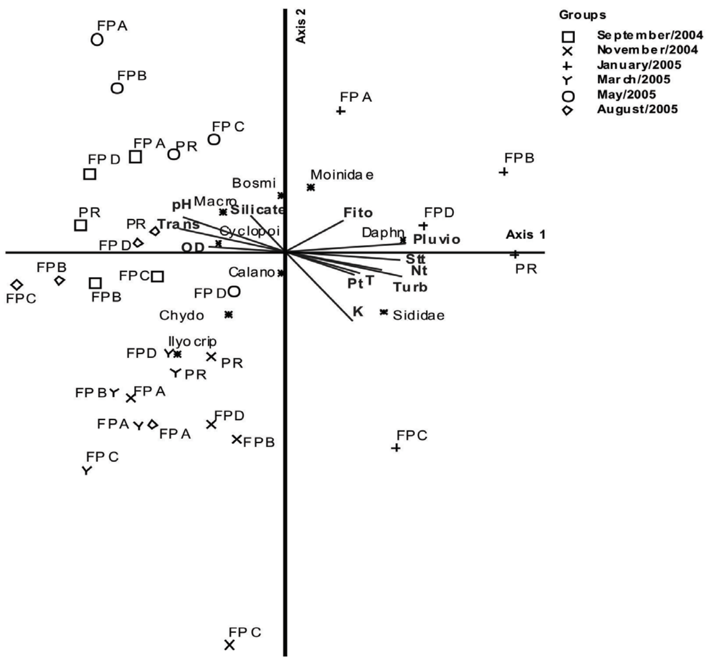

Figure 9. Canonical correspondence analysis (CCA) showing the distribution of the zooplankton species in relation to the limnological variables. See Table III for abbreviations.

Figure 9. *Análise de correspondência canônica (CCA) mostrando a distribuição das espécies zooplanctônicas em relação às variáveis limnológicas. Ver Tabela III para as abreviações.*

Some associations among the periods and the phytoplankton assemblages could be observed through the CCA analysis. Sididae, Daphniidae and Moinidae reached higher representativeness during the rainy period (January of 2005). Calanoida, Chydoridae and Ilyocryptidae were better represented during November/2004 and March/2005, while, Bosminidae, Cyclopoidae and Macrothricidae exhibited higher representativeness during the dry period.

DISCUSSION

Studies carried out in the upper Paranapanema basin, in Jurumirim Reservoir, evidenced that the lateral lagoons have a major importance for the zooplankton diversity (Panarelli *et al.* 2001, Casanova & Henry 2004, Panarelli *et al.* 2008, Casanova *et al.* 2009, Nadai & Henry 2009, Panarelli *et al.* 2010). In the present investigation, the microcrustacean richness found in the lateral lagoons of Rosana Reservoir (lower Paranapanema basin), 72 taxa, is much higher when compared to previous analyses of the zooplankton assemblages sampled along this reservoir main channel (46 taxa) (Sartori 2008). The amount of species is also higher than the ones found in other reservoirs and lagoons of the Paranapanema River basin (Nogueira 2001, Sampaio *et al.* 2002, Panarelli *et al.* 2003, Martins & Henry 2004, Nadai & Henry 2009, Panarelli *et al.* 2010) and comparable to the microcrustacean richness determined for the whole basin (limnetic habitats of reservoirs), 75 species (Nogueira *et al.* 2008).

The zooplankton of the lateral lagoons/reservoir system exhibited remarkable seasonal changes, with dominance of different groups under particular limnological conditions. It was possible to recognize, through the statistical analyses (CCA and regression analyses), a clear separation of the sampling stations along the study periods. These analyses also indicated the main driving forces influencing on the composition and the ecological attributes of the assemblages. Variations in composition and abundance were influenced by meteorological factors, such as precipitation and temperature, indirectly by some important nutrients (nitrogen and phosphorus) and also by the phytoplankton abundance. Similar correlations have been reported for other environments of the upper Paraná basin (Bonecker & Lansac-Tôha 1996, Aoyagui & Bonecker 2004, Lansac-Tôha *et al.* 2005, Nogueira *et al.* 2008).

The Cladocera and Copepoda species found during this study have already been reported in other zooplankton studies carried out in the Paranapanema River (Henry & Nogueira 1999, Nogueira 2001, Sampaio, *et al.* 2002, Panarelli *et al.* 2003, Gralhóz 2005, Nogueira *et al.* 2006, Sartori 2008, Nogueira *et al.* 2008, Nadai & Henry 2009, Perbiche-Neves & Nogueira 2010).

In terms of zooplankton composition, the higher proportion of Cladocera (55 species) in relation to Copepoda (17 species) follows the tendency observed in other regional studies on planktonic microcrustaceans (Rocha *et al.* 2002, Nogueira *et al.* 2008). However, it is important to note that this is not an exclusive pattern for the neotropics and studies in the Amazonian region (Robertson & Hardy 1984) and middle Paraná (Paggi & José de Paggi 1990) have demonstrated that Copepoda can also be of a major importance in terms of richness, reaching 40 to 50 species of the local fauna.

Higher richness during the rainy period, probably due to the transport and homogenization of different water masses, was also observed in other studies in the upper Paraná basin (Bonecker & Lansaca-Tôha 1996, Aoyagui & Bonecker 2004).

Another possible recurrent tendency is the longitudinal (towards the dam) increase in the zooplankton richness. In our research the highest number of species occurred in the most downstream located lagoon (FDP). This pattern was observed in Rosana (Sartori 2008) and in other reservoirs of the Paranapanema basin (Mitsuka & Henry 2002, Nogueira *et al.* 2006, Nogueira *et al.* 2008), as well as in other river basins (Velho *et al.* 2001). Another contributing factor for zooplankton richness in FDP is the high transparency and low values of suspended matter. Oligotrophic environments tend to exhibit high number of zooplankton species (Maitland 1990).

The high abundance verified in the lagoons demonstrated that these lateral environments contributed for the exportation of organisms (Aoyagui & Bonecker 2004). The zooplankton development in the lagoons (composition, abundance and diversity) is succeeded due to the habitat complexity (presence of macrophytes stands) (Maia-Barbosa *et al.* 2008), high water retention time and low flow conditions. In an study carried out in floodplain habitats (bays and lagoons) of the Paranapanema Basin a very high number of cladoceran species was registered, 70, most belonging to Chydoridae (Gralhóz 2005). Rare species have also been registered in these habitats (Debastiani Junior et al 2009). In the Danube River, the main channel with high flow velocity showed lower density of zooplankton, while in the lateral environments, a higher density was found. These lateral habitats were considered centers for the zooplankton development in the river (Reckendorfer *et al.* 1999).

The increase of zooplankton abundance verified during the rainy period was directly related with the phytoplankton abundance. The phytoplankton growth is a response to the higher nutrient availability during the late spring and summer (Ferrareze & Nogueira, *in preparatio*n). When the phytoplankton abundance declined the zooplankton also reduced. This pattern indicated that in the lateral lagoon system, the communities are controlled by bottom-up mechanisms (*sensu* Townsend *et al.* 2006).

The composition and dominance among Diaptomidae in the present study, when compared with previous investigations, indicates the occurrence of important long-term structural changes in the zooplankton assemblages of the Paranapanema basin. In this study, *Notodiaptomus iheringi* and *N. henseni* were the main species and *N. conifer* was found in low abundance in the FDP lagoon. This last species used to be abundant in the Paranapanema reservoirs during the late 1970s (Sampaio *et al.* 2002), and was also observed in relative high numbers in the end of 1990s and beginning of 2000s (Nogueira 2001, Mitsuka & Henry 2002). Another important Diatomidade species in the past, *Argyrodiaptomus furcatus*, has presently a minor contribution. Changes in the composition of Calanoida fauna along the last three decades in the reservoirs of the State of São Paulo are discussed by Matsumura-Tundisi & Tundisi (2003). The authors consider that the substitution of species may be related to the progressive increase of the electric conductivity and alterations in the ionic composition of the water, reflecting the advance of eutrophication.

In this study, adults of Copepoda and copepodits were more abundant in summer, when Calanoida was dominant. In the other hand, during winter, when Cyclopoida increased their proportion in the zooplankton assemblages, the nauplii and the copepodits were found in high number. This discrepancy of abundance among the distinct phases of Calanoida and Cyclopoids development could be related to their different reproductive strategies (Casanova & Henry 2004, Sartori *et al.* 2009, Nogueira *et al.* 2008). The Cyclopoids can be considered r-strategists (colonist) with high reproductive rate, but with low rate of survival during larval phases. The Calanoida (k-strategists) eggs are generally bigger than the ones of Cyclopoids, generating larvae in a better nutritional condition and with higher possibility to succeeded (Nogueira *et al.* 2008).

Higher abundance of nauplii observed in the lateral lagoons indicates that these lateral environments can have an important role for the recruitment of copepod populations. This hypothesis was also considered for the lagoons of Jurumirim Reservoir by Casanova & Henry (2004).

In relation to the adults of Copepoda, *N. henseni* was the most abundant species. This species has already been found in high abundance in the Paranapanema River (Nogueira *et al.* 2008) and also in other reservoirs of the upper Paraná region (Lopes *et al.* 1997, Nogueira 2001, Bonecker *et al.* 2001, Serafim Júnior *et al.* 2005, Nogueira *et al.* 2006, Santos Wisniewski & Rocha 2007). Among the Cyclopoida, the genera *Thermocyclops* and *Mesocyclops* showed high abundance. These genera are also commonly found in Brazilian reservoirs (Sendacz & Kubo 1982, Lopes *et al.* 1997, Pinto-Coelho 2002).

The Calanoids and Cyclopoids co-existed in the whole study. Temporally, there was a decrease of Calanoids in relation to the Cyclopoids during the dry period. A higher abundance of Cyclopoids during the dry period, mainly due to the contribution of *Thermocyclops*, has already been documented by Panarelli *et al.* (2001) and Mitsuka & Henry (2002) for the Jurumirim Reservoir. The changes in the proportion between the zooplankton Orders could indicate the occurrence of a high mortality rate during the larval phases of Cyclopoids, as previously mentioned.

Among the Cladocera, Bosminidae was the dominant family, mainly in the lagoons, represented by *Bosmina*. The presence in high abundance of this genus can be an indicative of the trophic condition, as the individuals feed on bacterium and detritus (Sendacz *et al.* 1985). Daphniidae was also abundant, mainly in the reservoir sampling station. The rains in the watershed promote the introduction of allochthonous material into the lagoons, increasing the eutrophication and stimulate the development of some species and decrease of others (Sartori 2008).

High abundance of *Bosmina* and *Daphnia* was already verified in other studies in the Paranapanema River by Nogueira (2001), Panarelli *et al.* (2003), Nogueira *et al.* (2008) and Sartori (2008). Some genera considered rare in limnetic samples, and observed in our study, are frequent when the hauls are carried out close the vegetation, as the case of *Chydorus*, *Ephemeroporus*, *Ilyocriptus*, *Leydigia* (Elmoor-Loureiro 1997, Gralhóz 2005, Maia-Barbosa *et al.* 2008).

The diversity did not show a clear difference among the different sampling stations and periods. This is due to the fact that some taxa of *Bosmina*, *Daphnia*, *Thermocyclops* and *Notodiaptomus* were abundant in the whole study. In general the diversity values were similar to the ones found in other studies in the Paranapanema basin (Henry & Nogueira 1999, Nogueira 2001, Sampaio *et al. 20*02, Panarelli *et al.* 2003, Gralhóz 2005, Nogueira *et al.* 2006, Sartori 2008, Nogueira *et al.* 2008).

The similarity based on the zooplankton structure showed that the connectivity with the river/reservoir influences on the composition and abundance of the lagoons assemblages. The analysis also indicated the importance of the interaction of the surrounding landscape with the aquatic environments. The lateral lagoons located inside the environmental protection area and with the narrowest connectivity exhibited more distinctive assemblages than the other lagoons. The cluster analysis also evidenced the influence of the river assemblages on the assemblages of the lateral lagoon FPC. The same pattern is observed in other communities, ichthyofauna (Ferrareze & Nogueira *in press*) and phytoplankton (Ferrareze & Nogueira *in preparation*) and even in the nutrients dynamics (Ferrareze & Nogueira *in press*). Other studies which investigated the influence of connectivity on the zooplankton assemblages showed that higher connectivity among the river and the lagoon determine higher similarity among local communities (Forbes & Chase 2002).

Our results validated the hypotheses that lateral lagoons have a prominent ecological role on the zooplankton assemblages, in terms of richness and abundance. It was also evidenced the main driving forces influencing the composition and the ecological attributes of zooplankton assemblages in the lateral lagoons system.

The incorporation of lateral lagoons in environmental programs should be a strategy for the conservation of the regional aquatic biota, in order to mitigate the negative impact of the dam.

ACKNOWLEDGMENTS: The authors are grateful to the CNPq for the scholarship conceived to the first author, and to Duke Energy International Geração Paranapanema and Fundação do Instituto de Biociências for financial and administrative support, respectively.

REFERENCES

AOYAGUI, A.S.M. & BONECKER, C.C. 2004. Rotifers in different environments of the Upper Paraná River floodplain (Brazil): richness, abundance and the relationship with connectivity. *Hydrobiologia*, 522: 281-290.

BEZERRA-NETO, J.F. & PINTO-COELHO, R.M. 2007. Diel vertical migration of the copepod *Thermocyclops inversus* (Kiefer 1936) in a tropical reservoir: the role of oxygen and the spatial overlap with Chaoborus. *Aquatic Ecology*, 41: 535-545.

BONECKER, C.C. & LANSAC-TÔHA, F.A. 1996. Community structure of rotifers in two environments of the Upper River Paraná floodplain (MS)-Brazil. *Hydrobiologia*, 325: 137-150.

BONECKER, C.C.; LANSAC-TÔHA, F.A.; VELHO, L.F.M. & ROSSA, D.C. 2001. The temporal distribution pattern of copepods in Corumbá reservoir, State of Goiás, Brazil. *Hydrobiologia*, 453: 375-384.

BONECKER, C.C.; AOYAGUI, A.S.M. & SANTOS, R.M. 2009. The impact of impoundment on the rotifer communities in two tropical floodplain environments: interannual pulse variations. *Brazilian Journal of Biology*, 69: 529-537.

CASANOVA, S.M.C. & HENRY, R. 2004. Longitudinal distribution of Copepoda Populations in the transition zone of Paranapanema river and Jurumirim Reservoir (São Paulo, Brazil) interchange with two lateral lakes. *Brazilian Journal of Biology*, 64: 11-26.

CASANOVA, S.M.C.; PANARELLI, E.A. & HENRY, R. 2009. Rotifer abundance, biomass, and secondary production after the recovery of hydrologic connectivity between a river and two marginal lakes (São Paulo, Brazil). *Limnologica*, 39: 292-301.

DEBASTIANI JUNIOR, J.R.; NOGUEIRA, M.G.; ELMOOR-LOUREIRO, L. & PERBICHE-NEVES, G. 2009. Occurrence of *Pseudosida ramosa* Daday 1904 (Crustacea: Cladocera: Ctenopoda) in marginal lakes of the Paranapanema River, with comments on its distribution. *Acta Limnologica Brasiliensia*, 21: 415-418.

DUKE ENERGY 2001. *Relatório para licenciamento ambiental-UHE Rosana. Vol. I e II*. 447p.

ELMOOR-LOUREIRO, L.M.A. 1997. *Manual de identificação de cladóceros límnicos do Brasil*. Universa, Brasília. 156 p.

FERRAREZE, M.F. & NOGUEIRA, M.G. Importance of lateral lagoons for the ichthyofauna in a large tropical reservoir. *Brazilian Journal of Biology*, 71. (*in press*).

FERRAREZE, M.F.; NOGUEIRA, M.G. & SARTOTI, L.P. Limnology of lateral lagoons in a tropical reservoir (SE Brazil) – spatial and temporal variability. *Limnetica*. (*in press*).

FORBES, A.E. & CHASE, J.M. 2002. The role of habitat connectivity and landscape geometry in experimental zooplankton metacommunities. *Oikos*, 96: 433-440.

GRALHÓZ, G. 2005. Associações de Cladocera (Crustacea Branchiopoda) e fatores limnológicos em áreas de várzea do rio Paranapanema (SP-PR). *Dissertação de Mestrado*. Universidade Estadual Paulista. Botucatu, SP, Brasil. 273p.

GÜNTZEL, A.M.; PANARELLI, E.A.; SILVA, W.M. & ROCHE, K.F. 2010. Influence of connectivity on Cladocera diversity in oxbow lakes in the Taquari River floodplain (MS, Brazil). *Acta Limnologica Brasiliensia*, 22: 93-101.

HENRY, R. & NOGUEIRA, M.G. 1999. A Represa de Jurumirim (São Paulo): primeira síntese sobre o conhecimento limnológico. Pp. 651-686. *In*: R. Henry (ed.). Ecologia de Reservatórios: Estrutura, Função e Aspectos Sociais. Tipomic, Botucatu, SP. 799p.

HENRY, R.; PANARELLI, E.A.; CASANOVA, S.M.C.; SUIBERTO, M. & AFONSO, A.A.O. 2006. Interações hidrológicas entre lagoas marginais e o Rio Paranapanema na zona de sua desembocadura na Represa de Jurumirim. Pp. 57-82. *In*: M.G. Nogueira, R. Henry & A. Jorcin (eds.). Ecologia de Reservatórios. Impactos potenciais, ações de manejo e sistemas em cascata. Rima Editora, São Carlos, SP. 459p.

JOSÉ DE PAGGI, S.B. & PAGGI, J.C. 2008. Hydrological Connectivity as a Shaping Force in the Zooplankton Community of Two Lakes in the Paraná River Floodplain. *International Review of Hydrobiologia*, 93: 659-678.

LANSAC-TÔHA, F.A.; BONECKER, C.C. & VELHO, L.F.M. 2005. Estrutura da Comunidade Zooplanctônica em Reservatórios. Pp. 115-127. *In*: L. Rodrigues, S.M. Thomaz, A.A. Agostinho & L.C. Gomes (eds.). Biocenoses em Reservatórios: Padrões Espaciais e Temporais. Rima Editora, São Carlos, SP. 333p.

LOPES, R.M.; LANSAC-TÔHA, F.A.; VALE, R. & SERAFIM-JÚNIOR, M. 1997. Comunidade zooplanctônica do Reservatório de Segredo. Pp. 39-60. *In*: A.A. Agostinho & L.C. Gomes (eds.). Reservatório de Segredo: bases ecológicas para o manejo. Eduem, Maringá, PR. 387p.

MAIA-BARBOSA, P.M.; PEIXOTO, R.S. & GUIMARÃES, A.S. 2008. Zooplankton in littoral waters of a tropical lake: a revisited biodiversity. *Brazilian Journal of Biology*, 68: 1069-1078.

MAITLAND, P.S. 1990. *Biology of fresh waters*. Second Edition. Blackic, London, UK. 572p.

MARTINS, G. & HENRY, T. 2004. Composição e abundância do zooplâncton em três lagoas laterais ao rio Paranapanema na zona de sua desembocadura na represa de Jurumirim (São Paulo). Pp. 53-72. *In*: S. Chelappa & J.Z.O. Passavante (eds.). Ecologia Aquática Tropical. ServGraf, Natal, RN. 165p.

MATSUMURA-TUNDISI, T. 1986. Latitudinal distribution of Calanoida copepods in freshwater aquatic systems of Brazil. *Brazilian Journal of Biology*, 46: 527-553.

MATSUMURA-TUNDISI, T. 1999. Diversidade de zooplâncton em represas do Brasil. Pp. 39-54. *In*: R. Henry (ed.). Ecologia de Reservatórios: Estrutura, Função e Aspectos Sociais. Fapesp/Fundibio, Botucatu, SP. 799p.

MATSUMURA-TUNDISI, T. & TUNDISI, J.G. 2003. Calanoida (Copepoda) species composition changes in the reservoirs of São Paulo State (Brazil) in the last twenty years. *Hydrobiologia*, 504: 215-222.

MATSUMURA-TUNDISI, T.; LEITÃO, S.N.; AGUENA, L.S. & MIYAHARA, J. 1990. Eutrofização da Represa de Barra Bonita: estrutura e organização da comunidade de Rotifera. *Brazilian Journal of Biology,* 50: 923-935.

McCUNE, B. & MEFFORD, M.J. 1995. *PC-ORD Multivariate analysis of ecological data*. MJM Software Design, Gleneden Blach, OR. 126p.

MITSUKA, P.M. & HENRY, R. 2002. The fate of copepod populations in the Paranapanema River (São Paulo, Brazil), downstream from the Jurumirim dam. *Brazilian Archives of Biology and Technology*, 45: 479-490.

NADAI, R. & HENRY, R. 2009. Temporary fragmentation of a marginal lake and its effects on zooplankton community structure and organization. *Brazilian Journal of Biology*, 69: 819-836.

NOGUEIRA, M.G. 2001. Zooplankton composition, dominance and abundance as indicators of environmental compartimentalization in Jurumirim Reservoir (Paranapanema River), São Paulo, Brazil. *Hydrobiologia*, 455: 1-18.

NOGUEIRA, M.G.; HENRY, R. & MARICATTO, F.E. 1999. Spatial and temporal heterogeneity in the Jurumirim Reservoir, São Paulo, Brazil. *Lakes and Reservoirs: Research and Management*, 4: 107-120.

NOGUEIRA M.G.; JORCIN A.; VIANNA N.C. & BRITTO Y.C. 2006. Reservatórios em cascata e os efeitos na limnologia e organização das comunidades bióticas (fitoplâncton, zooplâncton e zoobentos): um estudo de caso no rio Paranapanema (SP/PR), pp. 435-459. *In*: M.G. Nogueira, R. Henry A. & Jorcin. (eds.). Ecologia de reservatórios: impactos potenciais, ações de manejo e sistemas em cascata. Rima, São Carlos, SP. 459p.

NOGUEIRA, M.G.; REIS OLIVEIRA, P.C. & BRITTO, Y.T. 2008. Zooplankton assemblages (Copepoda and Cladocera) in a cascade of reservoirs of a large tropical river (SE Brazil). *Limnetica*, 27: 151-170.

PAGGI, J.C. & JOSÉ DE PAGGI, S. 1990. Zooplâncton de ambientes lóticos e lênticos do rio Paraná médio. *Acta Limnologica Brasiliensia*, 3: 685-719.

PANARELLI, E.A.; NOGUEIRA, M.G. & HENRY, R. 2001. Short-term variability of copepod abundance in Jurumirim Reservoir, São Paulo, Brazil. *Brazilian Journal of Biology,* 61: 577-598.

PANARELLI, E.A.; CASANOVA, S.M.C.; NOGUEIRA, M.G.; MITSUKA, P.M. & HENRY, R. 2003. A comunidade zooplanctônica ao longo de gradientes longitudinais no Rio Paranapanema/ Represa de Jurumirim (São Paulo, Brasil). Pp. 129-160. *In*: R. Henry (ed.). Ecótonos nas interfaces dos ecossistemas aquáticos. Rima, São Carlos, SP. 349p.

PANARELLI, E.A.; CASANOVA, S.M.C. & HENRY, R. 2008. The role of resting eggs in the recovery of zooplankton community in a marginal lake of the Paranapanema River (São Paulo, Brazil), after a long drought period. *Acta Limnologica Brasiliensia,* 20: 73-88.

PANARELLI, E.A.; CASANOVA, S.M.C. & HENRY, R. 2010. Secondary production and biomass of Cladocera in marginal lakes after the recovery of their hydrologic connectivity in a river–reservoir transition zone. *Lakes and Reservoirs: Research and Management*, 15: 319-334.

PERBICHE-NEVES, G. & NOGUEIRA, M.G. 2010. Multidimensional effects on Cladoceran (Crustacea Anomopoda) assemblages in two cascade reservoirs. *Lakes and Reservoirs: Research and Management*, 15: 139-152.

PINTO-COELHO, R.M. 2002. *Fundamentos em Ecologia*. Primeira Edição. Artmed, Porto Alegre, RS. 252p.

PINTO-COELHO, R.M.; COELHO, M.M.; ESPÍRITO-SANTO, M.M. & CORNELISSEN, T.G. 1999. Efeitos da eutrofização na estrutura da comunidade planctônica no lago da Pampulha, Belo Horizonte-MG. Pp. 553-572. *In*: R. Henry (ed.). Ecologia de Reservatórios: Estrutura, Função e Aspectos Sociais. Fapesp/ Fundibio, Botucatu, SP. 799p.

RECKENDORFER, W.; KECKEIS, H.; WINKLER, G. & SCHIEMER, F. 1999. Zooplankton abundance in the River Danube, Austria: the significance of inshore retention. *Freshwater Biology*, 41: 583-591.

REID, J.W. 1985. *Chave de identificação para as espécies continentais sulamericanas de vida livre da ordem Cyclopoida (Crustacea, Copepoda).* Boletim de Zoologia, Universidade de São Paulo, 9: 17-143.

ROBERTSON, B.A. & HARDY, E.R. 1984. Zooplankton of Amazonian lakes and rivers. Pp. 337-352. *In*: H. Sioli (ed.). The Amazon: limnology and landscape ecology of a mighty tropical river and its basin. Dr. W. Junk Publishers, Dordretch, The Netherlands and Hingham, MA. 763p.

ROCHA, O.; MATSUMURA-TUNDISI, T. & TUNDISI, J.G. 2002. Hot spots for zooplankton diversity in São Paulo state: origin and maintenance. *Verhandlungen des Internationalen Verein Limnologie,* 28: 872-876.

ROCHA, O.; SENDACZ, S. & MATSUMURA-TUNDISI, T. 1995. Composition, biomass and productivity of zooplankton in natural lakes and reservoirs of Brazil. Pp. 151-165. *In*: J.G.

Tundisi, C.E.M. Bicudo & T. Matsumura-Tundisi (eds.). Limnology in Brazil. ABC/SBL, Rio de Janeiro, RJ. 376p.

ROCHA, C.E.F. 1998. New morphological characters useful for the taxonomy of genus *Microcyclops* (Copepoda, Cyclopoida). *Journal of Marine Systematics*, 15: 425-431.

SAMPAIO, E.V.; ROCHA, O.; MATSUMURA-TUNDISI, T. & TUNDISI, J.G. 2002. Composition and abundance of zooplankton in the limnetic zone of seven reservoirs of the Paranapanema River. *Brazilian Journal of Biology*, 62: 525-545.

SANTOS-WISNIEWSKI, M.J. & ROCHA, O. 2007. Spatial distribution and secondary production of Copepoda in a tropical reservoir: Barra Bonita, SP, Brazil. *Brazilian Journal of Biology,* 67: 223-233.

SARTORI, L.P. 2008. Compartimentalização longitudinal do reservatório de Rosana (Rio Paranapanema, SP/PR) - variáveis limnológicas e assembléias zooplanctônicas. *Tese de Doutorado*. Universidade Estadual Paulista, Botucatu, SP, Brasil. 273p.

SARTORI, L.P; NOGUEIRA, M.G.; HENRY, R. & MORETTO, E.M. 2009. Zooplankton seasonal patterns in the Jurumirim Reservoir (São Paulo, Brazil): a three-year study. *Brazilian Journal of Biology*, 69: 1-18.

SENDACZ, S. & KUBO, E. 1982. Copepoda (Calanoida e Cyclopoida) de reservatórios do Estado de São Paulo. *Boletim do Instituto de Pesca*, 9: 51-189.

SENDACZ, S. & KUBO, E. 1999. Zooplâncton de reservatórios do alto Tietê, Estado de São Paulo. Pp. 511-529. *In*: R. Henry (ed.). Ecologia de Reservatórios: Estrutura, Função e Aspectos Sociais. Fapesp/Fundibio, Botucatu, SP. 799p.

SENDACZ, S.; KUBO, E. & CESTAROLLI, M.A. 1985. Limnologia de reservatórios do sudeste do Estado de São Paulo, Brasil. VIII. Zooplâncton. *Boletim do Instituto de Pesca,* 12: 187-207.

SERAFIM-JÚNIOR, M.; GHIDINI, A.R.; NEVES, G.P. & BRITO, L. 2005. Comunidade Zooplanctônica. Pp. 406-434. *In*: C.V. Andreoli, & C. Carneiro (eds.). Gestão Integrada de Mananciais de Abastecimento Eutrofizados*.* Ed. Gráf. Capital Ltda, Curitiba, PR. 499p.

SILVA, W.M. 2003. Diversidade dos Cyclopoida (Copepoda, Crustacea) de água doce do Estado de São Paulo: taxonomia, ecologia e genética*. Tese de Doutorado*. Universidade Federal de São Carlos, São Carlos. São Carlos, SP, Brasil. 170p.

SOARES, M.C.S.; MARINHO, M.M.; HUSZAR, V.L.M.; BRANCO C.W.C. & AZEVEDO, S.M.F.O. 2008. The effects of water retention time and watershed features on the limnology of two tropical reservoirs in Brazil. Lakes and Reservoirs: *Research and Management*, 13: 257-269.

THOMAZ, S.M.; BINI, L.M. & BOZELLI, R.L. 2007. Floods increase similarity among aquatic habitats in river-floodplain systems. *Hydrobiologia*, 579: 1-13.

TOWNSEND C.R.; BEGON M. & HARPER J.L. 2006. *Fundamentos de Ecologia*. Segunda Edição. Artmed, Porto Alegre, RS. 592p.

TUNDISI, J.G. & MATSUMURA-TUNDISI, T. 2008. *Limnologia*. Primeira Edição. Oficina de Texto, São Paulo, SP. 745p.

TUNDISI, J.G. 2005. Gerenciamento Integrado de Bacias Hidrográficas e Reservatórios – Estudos e Perspectivas. Pp. 1-21. *In*: M.G. Nogueira, R. Henry, & A. Jorcin (orgs.). Ecologia de Reservatórios – Impactos Potenciais, Ações de Manejo e Sistemas em Cascata. Rima Editora, São Carlos, SP. 459p.

UNDERWOOD, A.J. 1997. *Experiments in Ecology: Their Logical Design and Interpretation Using Analysis of Variance.* First Edition. Cambridge University Press, London, UK. 432p.

VELHO, F.F.M.; LANSAC-TÔHA, F.A; BONECKER, C.C.; BINI, L.M. & ROSSA, D.C. 2001. The longitudinal distribution of Copepods in Corumbá Reservoir, State of Goiás, Brazil. *Hydrobiologia*, 453/454: 385-391.

WARD, J.V. & TOCKNER, K. 2001. Biodiversity: toward a unifying theme for river ecology. *Freshwater Biology*, 46: 807-819.

WARD, J.V.; TOCKNER, K. & SCHIEMER, F. 1999. Biodiversity of floodplain river ecosystems: ecotones and connectivity. *Regulated Rivers: Research and Management*, 15: 125-139.

Submetido em 09/05/2011
Aceito em 03/08/2011