The influence of the hydrologic pulse on the water physical and chemical variables of lateral lakes with different connection levels to Paranapanema River in the mouth zone at Jurumirim Reservoir (São Paulo, Brazil)

Flutuação sazonal de variáveis físicas e químicas da água em lagoas marginais com diferentes níveis de associação com o Rio Paranapanema na zona de desembocadura no Reservatório de Jurumirim (São Paulo, Brasil)

Granado, DC.[1] and Henry, R.[2]

[1]Programa de Pós-Graduação em Ciências da Engenharia Ambiental,
Centro de Recursos Hídricos e Ecologia Aplicada, Escola de Engenharia de São Carlos, Universidade de São Paulo – USP,
Av. Trabalhador São-carlense, 400, Pq Arnold Schimidt, CEP 13566-590, São Carlos, SP, Brazil
e-mail: daniellicg@yahoo.com.br

[2]Departamento de Zoologia, Instituto de Biociências, Universidade Estadual Paulista – UNESP,
CP 510, CEP 18618-000, Botucatu, SP, Brazil
e-mail: rhenry@ibb.unesp.br

Abstract: This study examined the influence of hydrologic pulse on the water physical and chemical variables in Paranapanema River and in three marginal lakes at the Paranapanema River mouth zone at Jurumirim Reservoir. Surface and bottom (0.5 m above sediment) water samples were collected from July/04 to July/05 and on the surface of the Paranapanema river for determination of water electrical conductivity, suspended matter, alkalinity, pH, dissolved oxygen, nutrients. Data on water temperature, transparency, and water velocity of the Paranapanema River, rainfall and water level were also obtained. The different degrees of connection of the lakes to the river affect lake water physical and chemical factors. In two marginal lakes, Camargo and Coqueiral, it was observed a pattern of the water quality fluctuation similar to that of the river, but with low abiotic factor variation, because the lakes receive river water continuously. A distinct pattern was evidenced in an isolated lake, Lake Cavalos, with a higher variation of water quality factors. The large water volume stored downstream in Jurumirim Reservoir acts as a weakening system of the flood pulses of the main tributary (Paranapanema River). Nevertheless, the seasonal hydrometric variations affect the physical and chemical factors of water quality of the marginal lakes, which may be compared with the water quality of the wetlands.

Keywords: hydrologic pulse, floodplain lakes, connectivity, seasonal fluctuation, hydrometric level.

Resumo: O presente estudo examinou a influência do pulso hidrológico na variação dos variáveis físicas e químicas da água no Rio Paranapanema e em três lagoas marginais na zona de desembocadura no Reservatório de Jurumirim. Durante um ano (julho/04 a julho/05), amostragens mensais foram realizadas na sub-superfície e no fundo (0,5m acima do sedimento) nas lagoas e na sub-superfície do Rio. As variáveis analisadas foram: condutividade elétrica da água, alcalinidade, oxigênio dissolvido, pH, material em suspensão, nutrientes, temperatura, velocidade da correnteza no Rio, precipitação e nível hidrométrico. Os diferentes graus de conexão que as lagoas mantêm com o Rio, influenciam as variáveis físicas e químicas das lagoas. Nas lagoas associadas (Camargo e Coqueiral) foi verificado um padrão de variação similar a do curso do Rio, com menores amplitudes de variação, por estarem constantemente recebendo alimentação de água. Na lagoa isolada (Cavalos) foi observado um padrão distinto, com maior amplitude de variação dos dados. Apesar do grande volume de água acumulada no Reservatório de Jurumirim, que atua como um "sistema tampão" amortecendo os pulsos de inundação de seu principal tributário, as variações hidrométricas sazonais implicaram em mudanças na estrutura física e química das lagoas marginais que permitem que sejam comparadas àquelas encontradas nas áreas alagáveis.

Palavras-chave: pulso hidrológico, lagoas marginais, conectividade, flutuação sazonal, nível hidrométrico.

1. Introduction

Wetland region is shaped by the main and secondary channels of river, islands and marginal lakes on floodplain, which constitute a single ecological unit functionally dependent on the river horizontal flow (Junk, 1997; Neiff, 2003). Variations in river water level determine a level variation pattern in marginal lakes between two phases, the limnophase, when the lakes are isolated from the river, and the potamophase, when they are connected to the main water course channel after lateral flood (Neiff, 1990a; Neiff, 1990b). A common characteristic of wetlands is the occurrence of uni-modal frequency flood pulses, such as in Pantanal (Hamilton et al., 1998), or multiple short-term floods as in the floodplains of Mid Mogi Guaçu river (Krusche and Mozetto, 1999) and Paraná river wetlands, upstream its confluence with Paraguay river (Domitrovic, 2003). The water level variation acts as decisive factor in the ecological processes of the floodplain environments, since it affects water velocity, depth, and surface area and modifies the limnological characteristics and nutrient recycling patterns of the lateral aquatic systems (Thomaz et al., 1997).

The Paranapanema river, one of the important tributaries of the river Paraná presents in the mouth zone at Jurumirim Reservoir (first of series of Reservoirs in cascade) a wetland with some marginal lakes. However, this region does not present a characteristic floodplain behavior, because two important marginal lakes, Camargo and Coqueiral, are connected with the river channel. This association is due to the large water volume stored in Jurumirim Reservoir, which weakens and changes the frequency and duration of the hydrologic pulses of the tributaries (Henry, 2005). The transition zone between the Paranapanema river and Jurumirim Reservoir is characterized by a significant reduction of water velocity (Casanova and Henry, 2004) and large sedimentation rates of allochthonous material transported by the river (Henry and Maricato, 1996). The limnological characteristics and hydrological interactions of three of the many marginal lakes of the region landscape, Lakes Camargo, Coqueiral, and Cavalos, have been studied (Moschini-Carlos et al., 1998; Henry 2003, 2005; Fulan and Henry, 2006; Henry et al., 2006; Carmo, 2007).

Since hydrologic variation is a major controlling factor of wetland metabolism (Junk et al., 1989), the goal of this research was to examine the influence of hydrologic pulse on the water quality of three marginal lakes with different degrees of association with the Paranapanema River in its mouth zone at Jurumirim Reservoir.

2. Material and Methods

Lakes Camargo, Coqueiral, and Cavalos, located in the mouth zone of the Paranapanema river at Jurumirim Reservoir (between 23° 08' S and 23° 35' S; 48° 30' W and 49° 13' W) in Southeast São Paulo State (Figure 1), were selected as study sites. The three lakes present distinct morphometric characteristics and degrees of association with the river. Lake Camargo (surface area: 641,263 m^2) has low association with the river, while Lake Coqueiral (surface area: 224,465 m^2) is widely connected, and Lake Cavalos (surface area: 8,592.5 m^2) is isolated from the Paranapanema river.

Surface and bottom (0.5 m above sediment) water samples were collected from July 2004 to July 2005 on Lakes Cavalos (one station), Camargo and Coqueiral (two stations each, Figure 1) and on the surface of the Paranapanema river (two stations, Figure 1) for determination of water electrical conductivity (Hatch conductivimeter, with values corrected for 25 °C, according to Golterman et al., 1978), suspended matter (Teixeira and Kutner, 1962), alkalinity (Mackeret et al., 1978), pH (Micronal B380 pHmeter), dissolved oxygen (Winkler method described in Golterman et al., 1978), total nitrogen, nitrate, and nitrite (MacKereth et al., 1978), ammonia (Koroleff, 1976), total phosphorus, total dissolved and inorganic phosphate (Strickland and Parsons, 1968), and "reactive" silicate (Golterman et al., 1978). Water temperature (Toho Dentam thermistor), measured each 0,1 m and transparency (Secchi disk) were also examined in all the environments. The water velocity was measured through an ELE current meter at the two stations on the Paranapanema River.

Rainfall data from pluviometric station E—5-017, located at Angatuba Town, around 30 km from the study area, were supplied by the "Departamento de Águas e Energia Elétrica" (D.A.E.E.). Hydrometric level values of Jurumirim Reservoir were supplied by the operation sector of Duke Energy Company. According to Pompeo et al. (1999), there is a correspondence between the water level variation patterns of the Reservoir and of the mouth zone of the Paranapanema River at Jurumirim Reservoir.

Abiotic data were submitted to ANOVA in GLM procedure of SAS system (version 9.12) and completed with Tukey test. Principal component analysis (PCA) was conducted from co-variance matrixes with data transformed by ranging variation amplitude ($[x - x_{min})/(x_{max} - x_{min})]$) in order to assess the temporal and spatial distribution of sample units as a function of the analyzed limnological variables. Data were transformed with software FITOPAC (Shepherd, 1996) and submitted to multivariate analysis in PCORD version 3.1 for Windows (Mc Cune and Meford, 1997).

3. Results

No rainfall was recorded in August 2004 and rainfall values >100 mm were observed only in October (114 mm), December 2004 (120 mm), and January 2005 (244 mm) (Figure 2a). Water levels in Jurumirim Reservoir were always higher than 563.6 m (the frontier between connection and disconnection of Lakes Camargo and Coqueiral

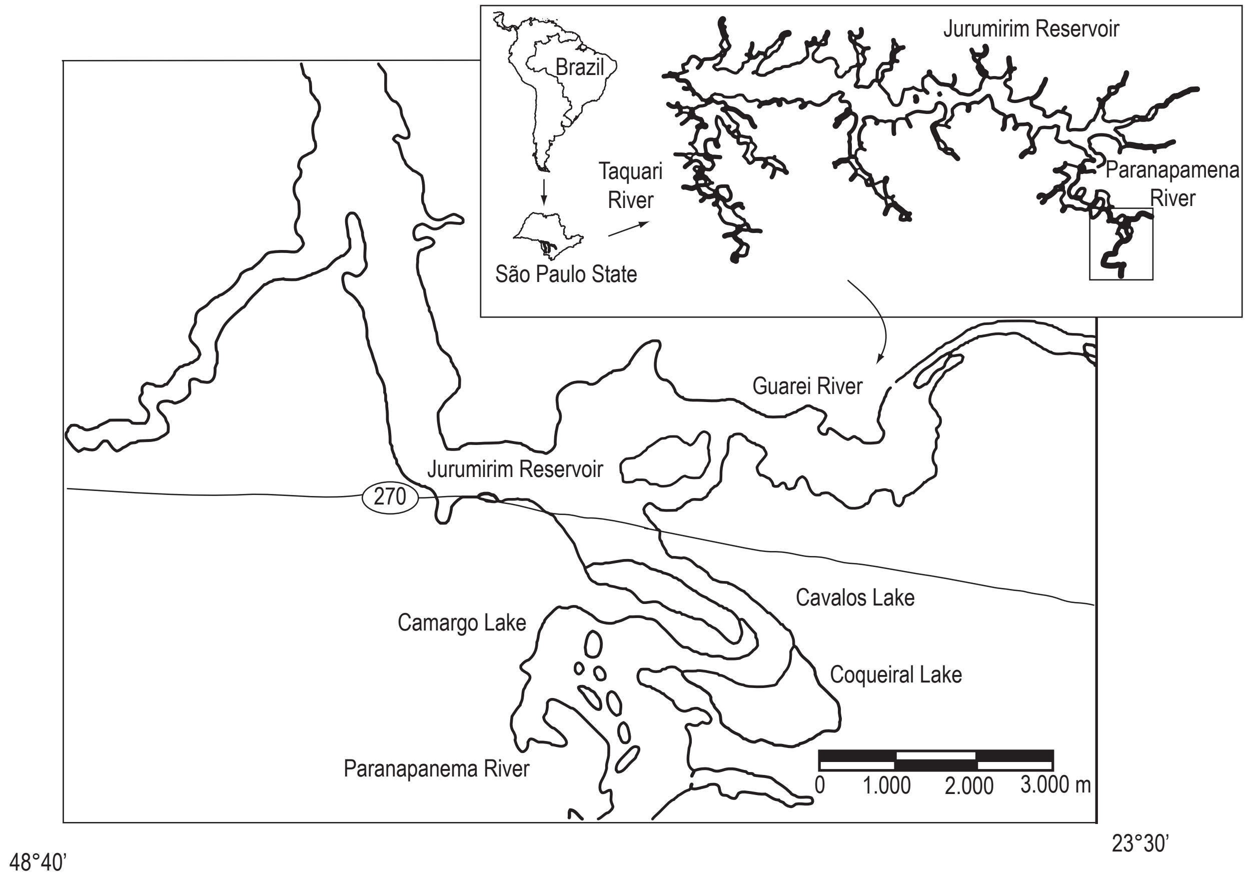

Figure 1. Study area: the mouth zone of the Paranapanema River at Jurumirim Reservoir (São Paulo).

with the Paranapanema river, according to Henry, 2005). The highest levels were found in June and July 2004 (566.82 m) (Figure 2b). A reduction to 564.49 m was recorded in November 2004 followed by an increase in the subsequent months, reaching 566.43 m in February 2005, later decreasing again to 565.63 m in July 2005. Five different periods were identified as a function of this variation pattern: emptying (July, August, and September 2004), drought (October, November, and December 2004), filling (January, and February 2005), high water (March and April 2005), and emptying (May, June, and July 2005) (Figure 2b). The water velocity of the Paranapanema River increased from 0.15 m/s (September 2004) to 0.85 m/s (February 2005) (Figure 2c), apparently related with the increase in rainfall.

The lowest water temperatures were recorded in July 2005 in all the environments (Figures 3 and 4), while the highest ones were found on the surface of the lakes (around 28 °C) and of the river (26 °C) in March 2005. An evident seasonal cycle with isothermy (from July to September 2004 and from May to July 2005) and a thermal stratification period (from October 2004 to April 2005) were observed in the two lakes. A circulation episode was detected in February 2005. During the thermal stratification period, a surface-to-bottom temperature decreasing range of around 3 °C was found in the end of emptying period in 2004 and in the filling and high water periods. Mean water transparency values were similar in all environments, around 0.8 m in the Paranapanema River and Lake Camargo and 0.9 m in the other two lakes. However, Lakes Camargo and Coqueiral had the highest variation along the study (±0.4 m SD; CV≈ 50%) in relation to the river and Lake Cavalos (±0.3 m SD; CV ≈ 35%) (Figure 5).

The highest mean water electrical conductivity values (x ≈ 85 ± 20 μS.cm^{-1} SD; CV ≈ 23%) and alkalinity (x ≈ 0.600 ± 0.150 meq.L^{-1} SD; CV ≈ 25%) were observed in Lake Cavalos. In the other systems, the mean values were similar, conductivity around 60 to 64 ± 10 μS.cm^{-1} SD and 0.400 ± 0.050 meq.L^{-1} SD alkalinity (Figure 6).

The pH values were similar in all the environments, with an annual mean of 6.6 ± 0.15 SD (CV = 2%) in Lake Cavalos and 6.7 ± 0.2 SD (CV = 3%) at the other sampling stations. Mean concentrations of dissolved oxygen were the highest in the Paranapanema River (x ≈ 9.2 ± 1.3 mg.L^{-1} SD). In Lake Camargo and at Lake Coqueiral station 1, the mean dissolved oxygen values varied from 7.0 to 8.3 ± 1.5 mg.L^{-1} SD and decreased from the surface to the bottom. Lake Coqueiral station 2 had a

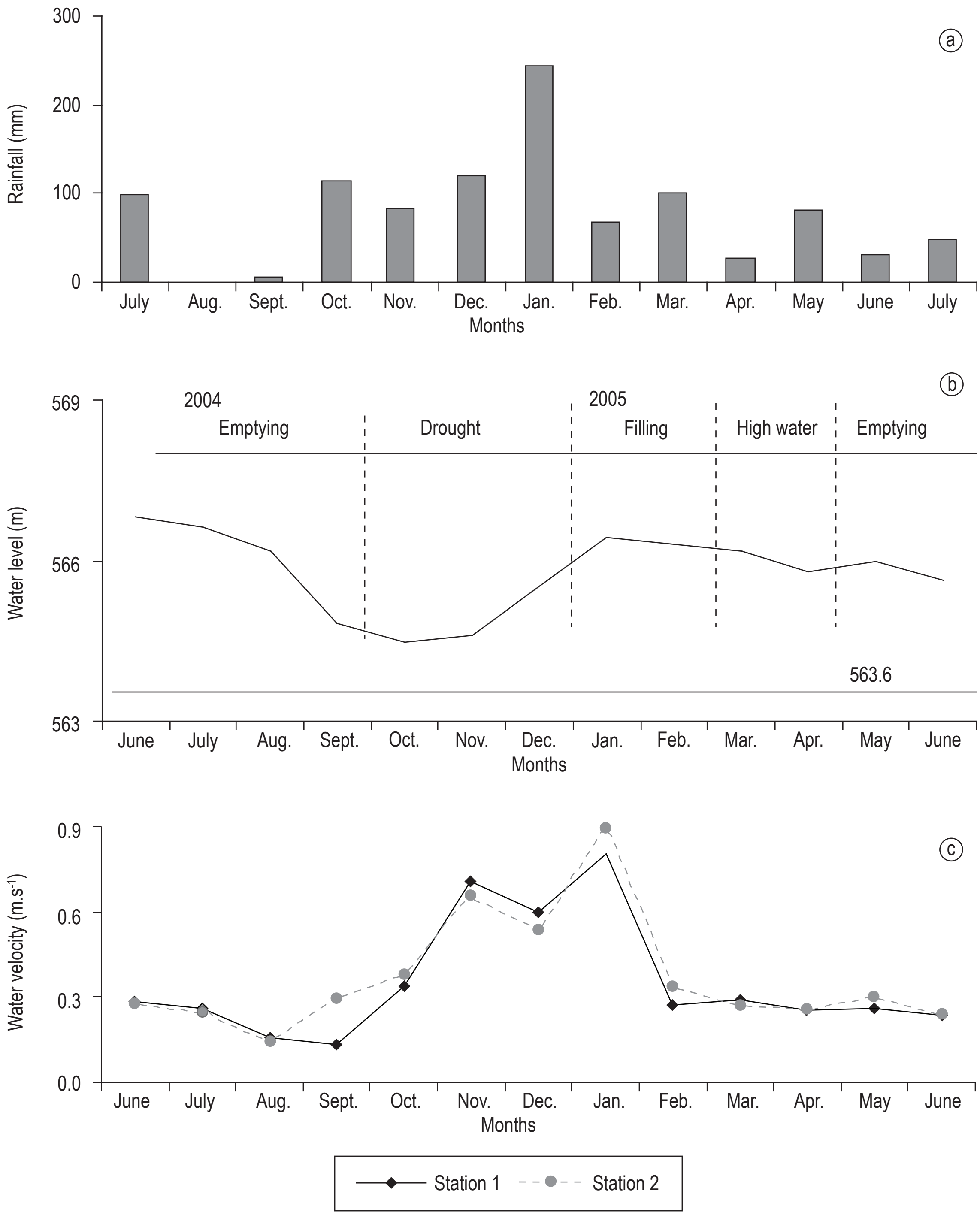

Figure 2. a) Monthly rainfall, b) variation of hydrometric level of Jurumirim Reservoir, and c) current velocity of the Paranapanema River from July 2004 to July 2005.

mean of around 6 ± 1.5 mg.L^{-1} SD, 4.2 ± 1.1 mg.L^{-1} SD on the surface, and Lake Cavalos, 2.9 ± 1.6 mg.L^{-1} SD at the bottom (Figure 6).

The highest mean concentrations of total nitrogen (x ≈ 550 ± 300 µg.L^{-1} SD; CV ≈ 55%) and phosphorus (x ≈ 50 ± 40 µg.L^{-1} SD; CV ≈ 70%) were observed in Lake Cavalos. The mean total nitrogen and phosphorus of Lakes Camargo and Coqueiral were 300 ± 150 µg.L^{-1} SD and 20 ± 15 µg.L^{-1} SD, respectively. In relation to dissolved nutrients, the highest means were recorded also in Lake Cavalos, except for nitrate, whose highest mean concentrations were observed in the Paranapanema River (Table 1).

ANOVA pointed out differences in alkalinity, conductivity, dissolved oxygen, total nitrogen, and phosphorus between the environments and in dissolved oxygen and

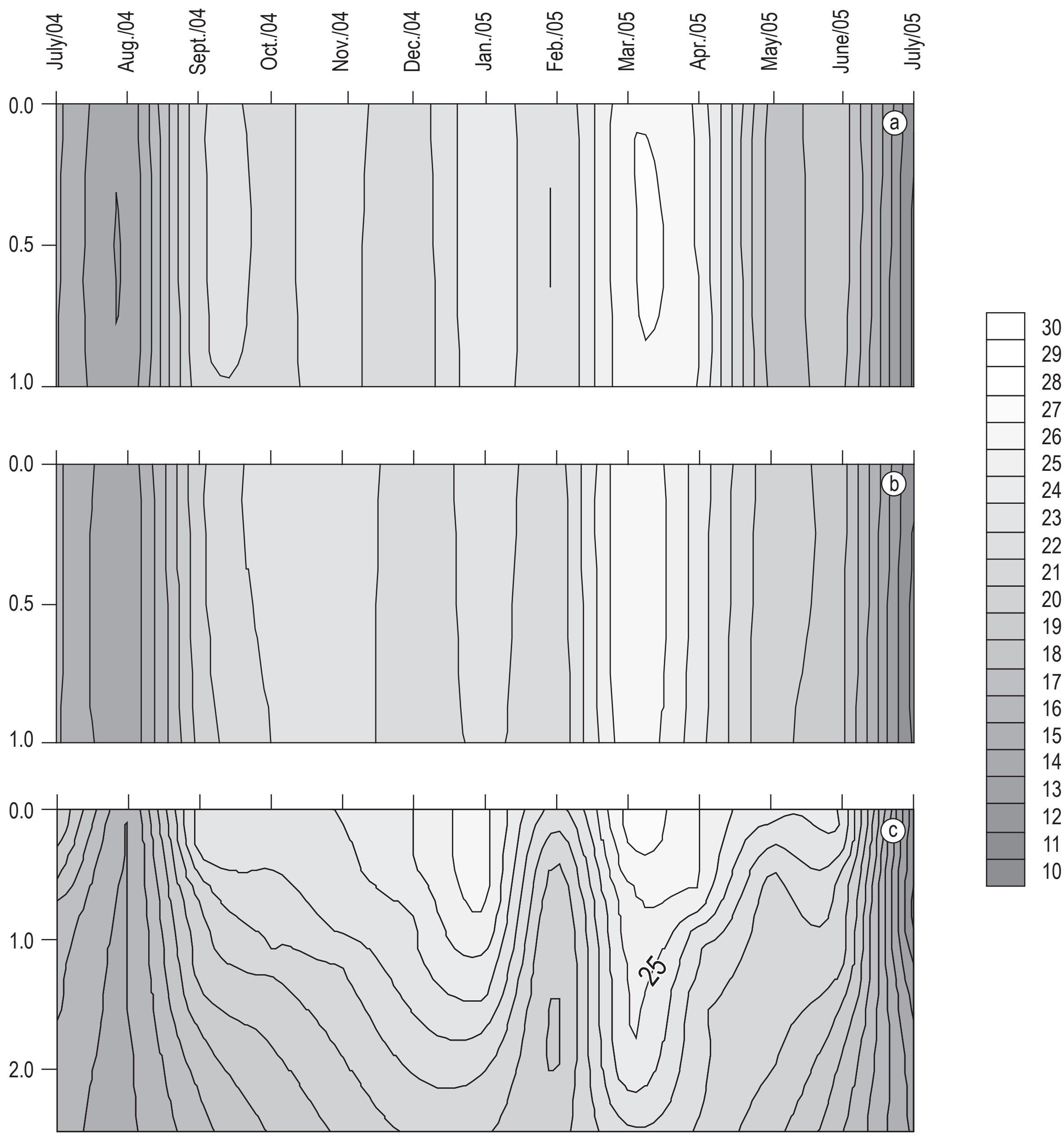

Figure 3. Water temperature (°C) variation at stations: a) 1, b) 2, of the Paranapanema River and c) Lake Cavalos from July 2004 to July 2005.

Table 1. Means and standard deviations of nutrient concentrations in the Paranapanema River and the studied marginal lakes from July 2004 to July 2005.

Nutrient	Unity	River	L. Camargo	L. Coqueiral	L. Cavalos
Nitrogen	$\mu g.L^{-1}$	324 ± 154	262 ± 128	306 ± 193	550 ± 286
Phosphate	$\mu g.L^{-1}$	22 ± 21	23 ± 14	22 ± 17	53 ± 39
Ammonium	$\mu g.L^{-1}$	29 ± 19	20 ± 16	36 ± 32	36 ± 47
Nitrate	$\mu g.L^{-1}$	129 ± 55	60 ± 51	59 ± 61	31 ± 43
Nitrito	$\mu g.L^{-1}$	16 ± 8	11 ± 4	13 ± 6	17 ± 12
Dissolved phosphate	$\mu g.L^{-1}$	14 ± 12	16 ± 11	13 ± 11	30 ± 25
Inorganic phosphate	$\mu g.L^{-1}$	9 ± 9	10 ± 8	8 ± 6	17 ± 17
Silicate	$mg.L^{-1}$	5 ± 2	5 ± 2	4 ± 2	6 ± 2

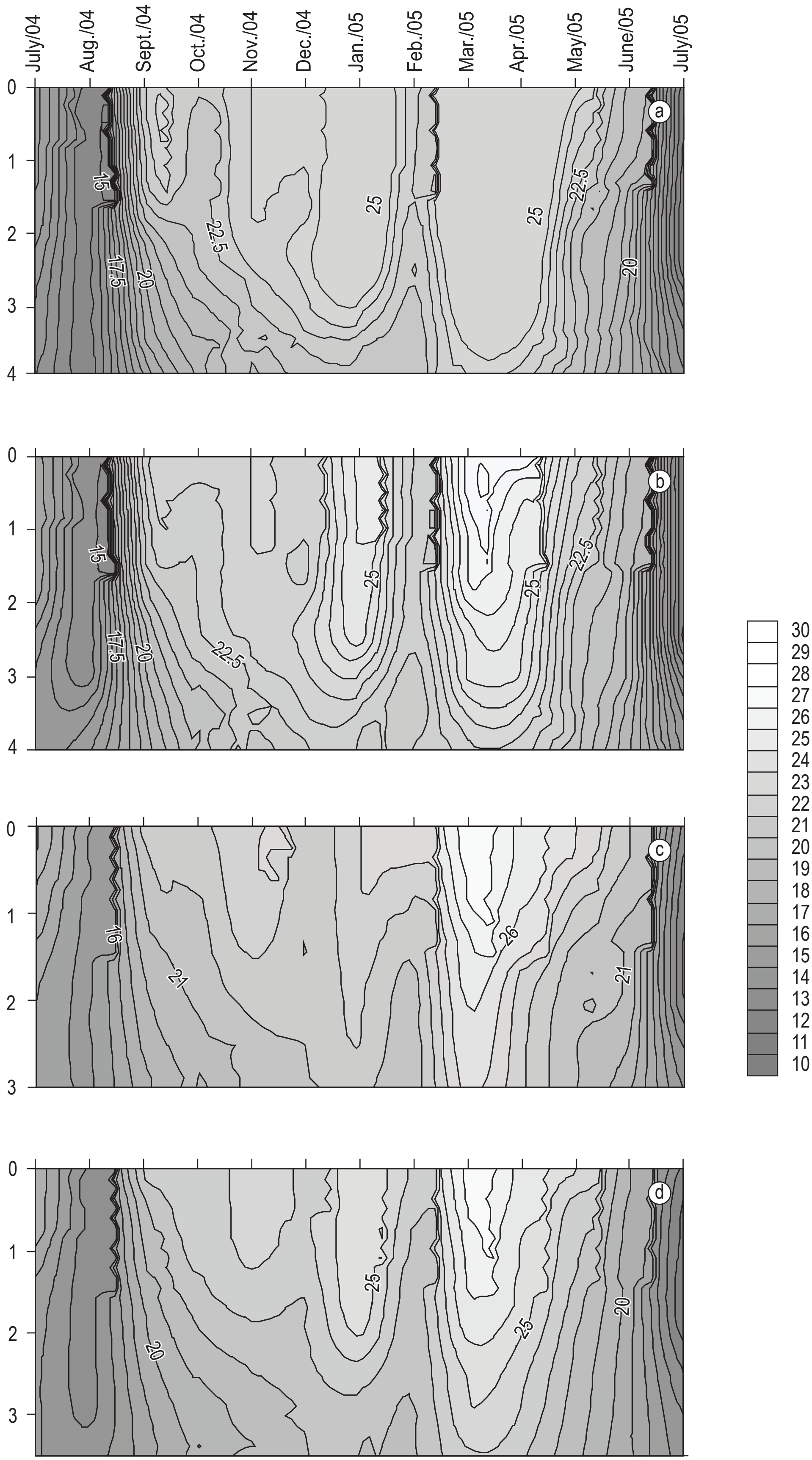

Figure 4. Water temperature (°C) at stations a) 1, b) 2 of Lake Camargo; c) 1 and d) 2 of Lake Coqueiral from July 2004 to July 2005.

suspended matter between the sampling stations (Table 2). Tukey test of these data showed that Lake Cavalos differed significantly from the other studied environments (Table 3). As to dissolved oxygen, a statistical difference was observed between all the water bodies and even the two Lake Coqueiral stations (Table 3).

The principal component analysis (PCA) allowed distinguishing some period groupings for the sample units of the Paranapanema River and Lakes Camargo and Coqueiral. The 2004's emptying period was correlated with the large transparency and depth and the low suspended matter values. The end of 2005's emptying period was characterized by high dissolved oxygen concentrations. The end of filling was associated with high water level, and the beginning of 2005's emptying periods correlated with the distribution of sample units near the axis intersection, evidencing low correlation of all limnological variables included in the analysis due to dilution effect (Figure 7).

PCA also evidenced a distinct behavior for Lake Cavalos in relation to the other environments, especially for sample units at the end of the filling and high water periods and half of 2005's emptying period, being characterized by high alkalinity and conductivity values and low dissolved oxygen concentrations. In the dry period, the isolated lake samples grouped with sample units of the other environments, indicating similarity in this phase characterized by high suspended matter and nutrient concentrations and low water transparency and depth values (Figure 7).

Table 2. ANOVA results of data of the different environments, sampling stations from July 2004 to July 2005.

Parameter	R	CV	Pr > F	
			Environment	Station
Alkalinity	0.655	15.03	<0.0001	0.8937
Conductivity	0.511	14.64	<0.0001	0.4978
pH	0.655	1.70	0.1018	0.8933
Dissolved oxygen	0.896	11.17	<0.0001	<0.0001
Supended matter	0.279	85.39	0.2828	0.0386
Nitrogen	0.764	32.34	<0.0001	0.6869
Phosphate	0.601	59.00	<0.0001	0.3007

4. Discussion

Water level variations are determining factors of floodplain ecological processes, since they may affect depth and the surface area of lateral aquatic environments, thus modifying limnological characteristics and nutrient cycling patterns (Thomaz et al., 1997).

Lakes Camargo, Coqueiral, and Cavalos are normally perennial environments. The two first are connected to the main channel of the Paranapanema River, except for two drought episodes, when the lakes remained disconnected (Henry et al., 2006). These lakes are not typical floodplain environments, whose main characteristic is being subject

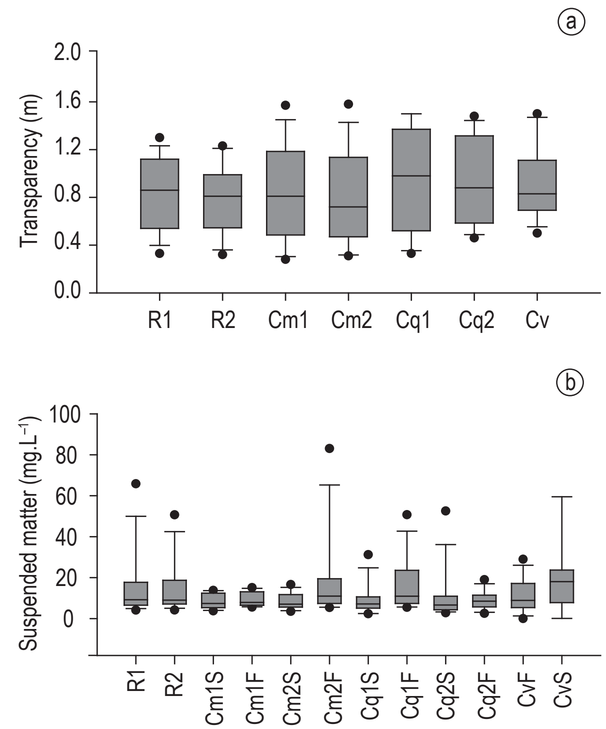

Figure 5. Means and standard-deviations of a) water transparency and b) suspended matter in the Paranapanema River (R1 and R2) and Lakes Camargo (Cm1 and Cm2), Coqueiral (Cq1 and Cq2), and Cavalos (Cv) from July 2004 to July 2005. (S = surface and B = bottom).

Table 3. Tukey test conducted with data of the different environments from July 2004 to July 2005 (R1 and R2: Stations 1 and 2 of Paranapanema River; Cm1 and Cm2: Station 1 and 2 of Camargo Lake; Cq1 and Cq2: Station 1 and 2 of Coqueiral Lake; Cv: Cavalos Lake).

Station	Alkalinity		Conductivity		Oxygen		Nitrogen		Phosphate	
	Average	Tukey	Average	Tukey	Average	Tukey	Average	Tukey	Average	Tukey
R1	0.41	B	64.07	B	9.16	A	321.83	B	21.99	B
R2	0.41	B	63.63	B	9.17	A	326.37	B	22.25	B
Cm1	0.38	B	60.44	B	7.99	B	273.59	B	20.84	B
Cm2	0.38	B	60.22	B	7.87	B	250.83	B	23.46	B
Cq1	0.41	B	62.78	B	7.02	C	334.28	B	24.58	B
Cq2	0.39	B	61.92	B	6.11	D	296.62	B	21.67	B
Cv	0.58	A	82.78	A	3.67	E	540.92	A	51.85	A

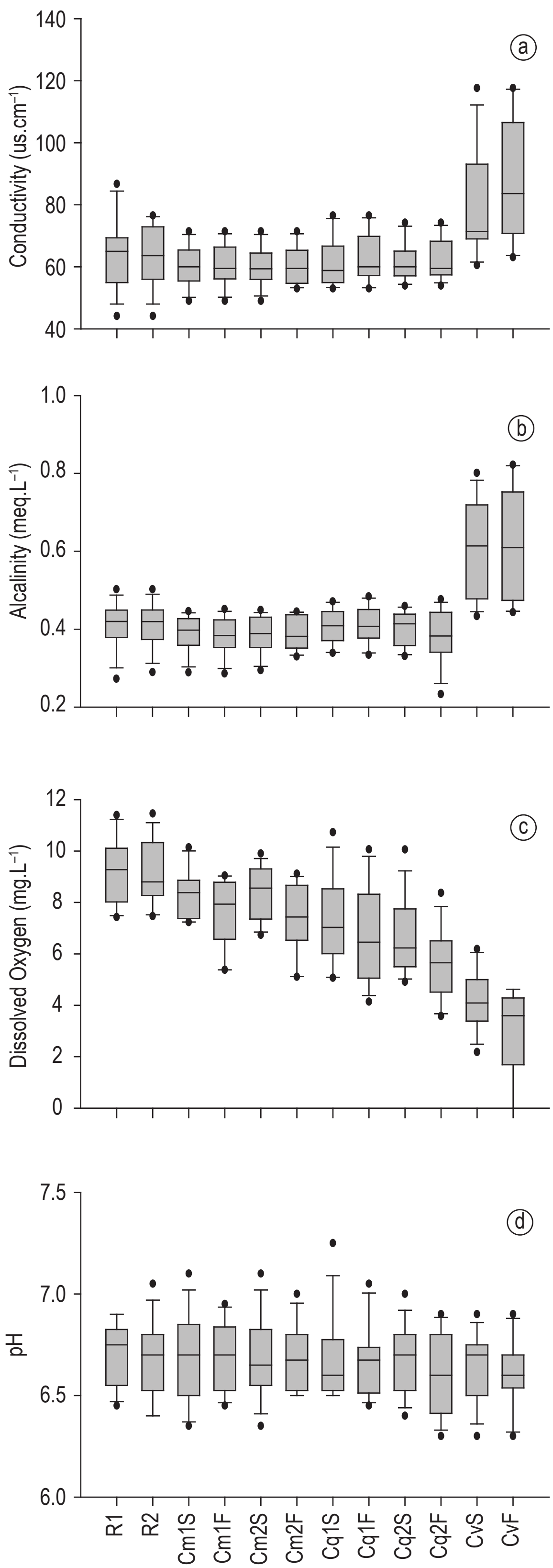

Figure 6. Means and standard-deviations of a) water electrical conductivity, b) alkalinity, c) dissolved oxygen and d) pH in the Paranapanema River (R1 and R2) and Lakes Camargo (Cm1 and Cm2), Coqueiral (Cq1 and Cq2) and Cavalos (Cv) from July 2004 to July 2005. (S = surface and B = bottom).

to seasonal hydrologic pulses (Junk, 1997) and presenting a limnophase and a potamophase (Neiff, 1990a).

Episodes of isolation of the lakes from the Paranapanema River in the transition zone with Jurumirim Reservoir were observed from October 1999 to December 2000 and from October 27 to November 30, 2002 (Henry et al., 2006). Such prolonged disconnection events are rare in this region, as shown by CESP's (Companhia Energética de São Paulo) data on the Jurumirim Reservoir formation in 1962. Only in three occasions (1969, 1976, and 1986) were recorded water levels lower than 563.6 m.

The variation of the stages in the dam is similar to hydrometric variation in the mouth zone of the Jurumirim Reservoir, as observed by Pômpeo et al. (1999). Values below 563,6 m correspond to isolation of the Camargo and Coqueiral Lakes in relation to Paranapanema river. Such information evidences distinct behavior from that area in comparison to the Amazonian, Pantanal and Paraná river floodplains (Domitrovic, 2003; Hamilton, et al.; 1998, Junk, 1980).

According to Henry (2003), the great volume of accumulated water in the Reservoir of Jurumirim acts as a "buffer" system softening the flood pulses of the main tributary. The annual hydrometric variation is conditioned the needs of water for generation of electric power by the CESP, because that is the first of a series in "cascade" and one of their functions is of storage of water for the others Reservoirs.

Thus, the seasonal rainfall variation apparently has little influence on water level variation in the mouth zone of the Paranapanema river at Jurumirim Reservoir, as confirmed by comparison of the accumulated annual rainfall during the study (1,022.1 mm), with values for 1998 (1,544.3 mm), 1999 (1,273.8 mm), and 2000 (1,080.2 mm). In 2000, Lakes Camargo and Coqueiral remained disconnected from the river and rainfall was from 20 to 30% lower than in the previous and the following years (Henry, 2005). Although the annual rainfall in this study was lower than that of 2000, the lakes remain linked to the river, as the Reservoir water level was always over 563.6 m.

Regarding water temperature, the lowest values (range of 12-15 °C) were observed in all environments in July 2005. In March 2005, the highest water temperatures were obtained on the surface of the lakes (≈28 °C) and the river (26 °C). As the Paranapanema river profiles were limited to 1 m deep the thermal homogeneity was evidenced on the surface layer. Lakes Camargo and Coqueiral presented thermal stratification in September, in the end of the filling and high water periods.

Comparatively, Junk (1980) concluded that Amazonian floodplain lakes are oligomictic during the high water period and polymictic in the drought season. In drought season, the environments become shallow and water circulation occurs due to the action of the wind rather than to the

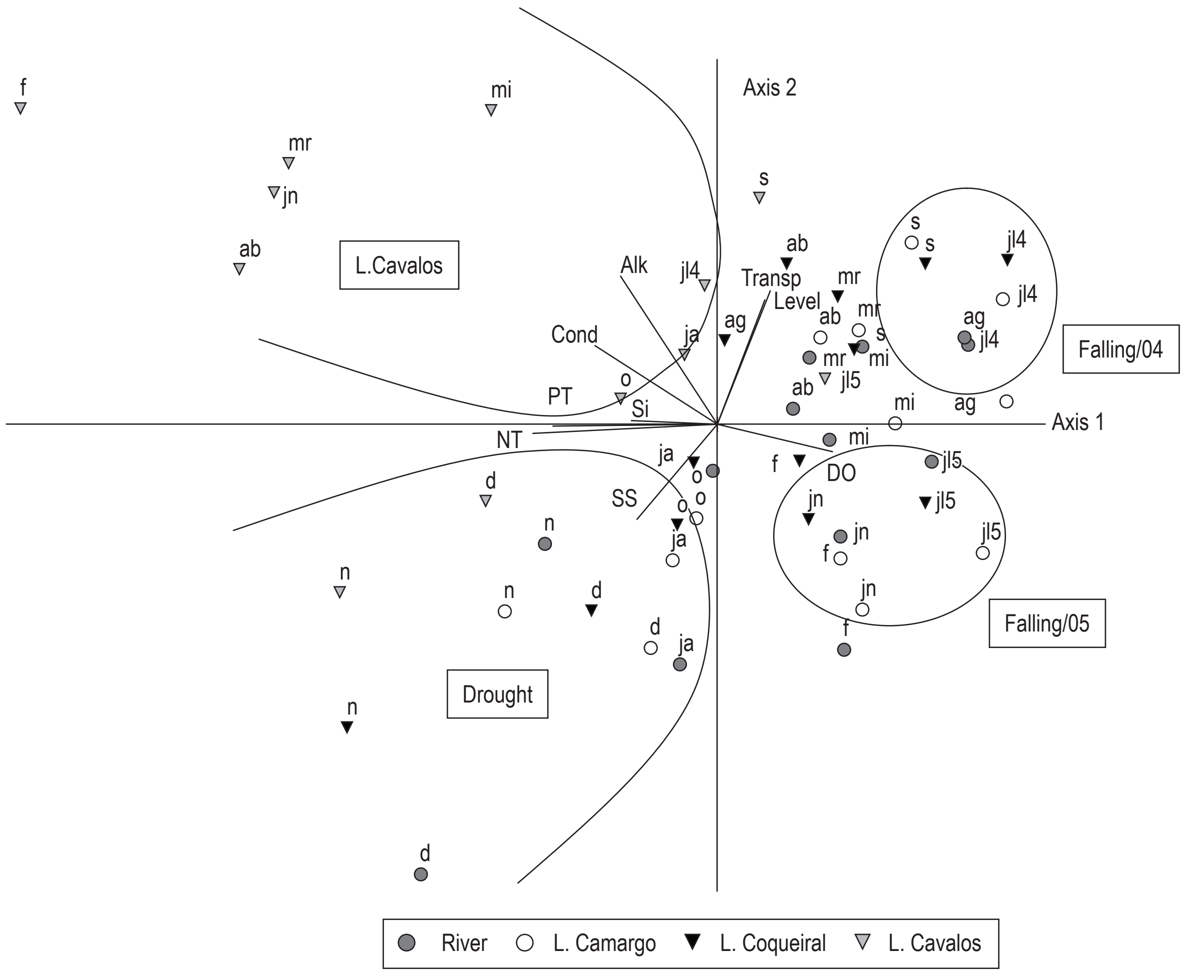

Figure 7. Monthly ordination by PCA (axes 1 and 2) of samples from the Paranapanema River and Lakes Camargo, Coqueiral and Cavalos from July 2004 to July 2005. Letters together with sample units indicate the beginning of the sampling months (Jul/4: July 2004, Aug: August, Sep: September, Oct: October, Nov: November, Dec: December, Jan: January, Feb: February, Mar: March, Apr: April, May: May, Jun: June, Jul/5: July 2005). The abiotic factor abbreviations are presented in Table 4.

cooling of the surface layer, which may lead to increased turbidity due to bottom sediment re-suspension. In the high water period, thermal gradient may reach 4 °C and stable thermal stratification may develop in protected lake areas due to a large difference in water density. The thermal gradient of Lake Cavalos ranged from 2 to 4 °C, except in August, when moderate winds occurred, in December, when the lake was extremely shallow, and in July 2005.

This lake is small and shallow when compared with the other lakes. Thus, isothermy should occur most of the year, but Lake Cavalos, an isolated lake, probably develops temporary thermal stratification during nicthemeral cycle. According to Esteves (1998), daily differences in temperature in tropical lakes are larger than the seasonal ones. Melo and Huszar (2000) in the Lake Batata (Amazonian floodplain) observed a reduction in water layer mixing during the more intense solar radiation hours and mix-

Table 4. Pearson and Kendall correlation coefficients between abiotic variables and the two first ordination axes from July 2004 to July 2005.

Variable	Abbreviations	Principal component	
		Axis 1	Axis 2
Alkalinity	Alk	–0.613	–0.691
Conductivity	Cond	–0.679	–0.514
Dissolved oxygen	DO	0.668	0.299
Suspended matter	SS	–0.566	0.543
Temperature	Temp	–0.467	–0.092
Transparency of water	Transp	0.464	–0.639
Nitrogen	NT	–0.855	0.165
Phosphate	PT	–0.803	0.070
Silicate	Si	–0.588	–0.091
Hidrometric level	Level	0.449	–0.622
Explicability		36.0%	18.5%

ing expansion during the night. During the dry season, it was recorded isothermy, while persistent stratification was observed during the flood season.

Lakes Camargo and Coqueiral, the two connected lakes, presented a similar variation seasonal pattern for most physical and chemical water factors when compared with the Paranapanema River, evidencing their large level of association. Except for dissolved oxygen, no other abiotic variables presented significant differences between the river and the connected lakes. All variables measured in Lake Cavalos, except for pH, suspended matter, and water transparency, were significantly different from those recorded in the other studied environments.

The high electrical conductivity, alkalinity, and nutrient values and the low dissolved oxygen concentrations recorded in Lake Cavalos are indicative of decomposition of aquatic macrophytes and surrounding vegetation submersed during flood. PCA showed the clear separation of the sample units of Lake Cavalos in relation to those of the other lakes and Paranapanema River during most of the studied period. During the drought period, samples from Lake Cavalos grouped with those of the other lakes, indicating a similar behavior in this period with high suspended matter and nutrient concentrations and low water transparency due to concentration effect as a result of the reduced lake water volume.

In comparison, a study carried out by Casanova (2005) during a severe drought period, showed that the variation of the limnological water parameters of Lake Cavalos was distinct from those of Lakes Coqueiral and Camargo. Two periods of variation of environmental characteristics were identified. The first one, corresponding to the end of filling and high water periods, and the beginning of the drought period in this study, presented high suspended matter and total phosphorus and low transparency values. In contrast, the second one, corresponding the to drought period in this study, presented high total nitrogen and organic matter concentrations and low depth, dissolved oxygen, suspended matter, and nitrate values. In a study on the underground water flow direction between the Paranapanema river and lateral Lakes Camargo, Coqueiral, and Cavalos, Carmo (2007) reported a distinct variation pattern for nitrogen, phosphorus, and aluminum concentrations in Lake Cavalos with values higher than those of the river and the connected lakes.

As also observed in other studies (Taniguchi et al., 2004, Lake Diogo in the Mogi-Guaçu River floodplain; Rodrigues et al., 2002, Lake Patos in the High Paraná River basin; Benassi, 2006, Jacupiranguinha lowlands in Ribeira Valley, São Paulo; Henry, 2005; Henry et al., 2006, lateral lakes in the Paranapanema River), hydrometric variation is the main controlling factor of limnological characteristics of marginal lakes of the Paranapanema River.

The different degrees of connection among the lakes and the river channel also affect the water physical and chemical variables of the Lakes Camargo and Coqueiral. Similar variation pattern and low variation amplitudes were evidenced in the river and in the connected lakes.

In Lake Cavalos, the isolated one, a different pattern was observed, with high amplitude of variation of the water physical and chemical factors in relation to the other two lentic systems. In Cavalos Lake, the water level variation is exclusively due to rainfall variation and water hyporheic inflow from the river. Nevertheless, the limnologic behavior of the Paranapanema River – Jurumirim Reservoir transition region is distinct from that of most floodplains. Hydrometric variations implied changes in the water physical and chemical factors of the marginal lakes and allowed comparison with the changes recorded for the floodplains.

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