Zooplankton Community Composition and Some Limnological Aspects of an Oxbow Lake of the Paraopeba River, São Francisco River Basin, Minas Gerais, Brazil

Edson Vieira Sampaio[1*] and Cristiane Machado López[1]
[1]*Três Marias Hydrobiology and Hatchery Station/CODEVASF, P.O. Box 11, 39205-000, Três Marias - MG, Brazil*

ABSTRACT

Some limnological aspects of Lake Massacará (adjoining the Paraopeba River, São Francisco River Basin) were studied during two periods of the hydrological cycle. Water transparency was equally low during both the periods. During high water, thermal stratification was recorded, with a clinograde oxygen profile; pH was slightly acid, and conductivity was higher near the bottom. Concentrations of inorganic carbon and ammonia, and rates of primary production were higher than during the low water period. During the latter period, complete mixing occurred, with a clinograde oxygen profile; pH was slightly acid, and conductivity unvarying with depth. Higher concentrations of nitrate were found than during high water. With regard to the zooplankton communities, higher density and species richness of organisms occurred during high water. Copepods and rotifers were most numerous during both periods. The taxa identified consisted of 17 rotifers, four copepods, six cladocerans, five protozoans, and two macroinvertebrates. The most abundant species were Thermocyclops minutus, Keratella cochlearis, K. lenzi, and Trichocerca capucina during high water, and Thermocyclops minutus and Conochilus unicornis during low water.

Key words: Oxbow lake, limnology, zooplankton, Paraopeba River, São Francisco River Basin, Brazil.

INTRODUCTION

Oxbow lakes, formed from river meanders, are common in floodplains throughout the world, and are recognized as important locations of biological activity (Joo, 1990). According to Welcome (1985), the interactions between a river and its floodplain are extremely important for fish production. Some studies on "várzea" lakes in the Amazon and Pantanal regions of Brazil have recorded high faunal density. Works carried out in the São Francisco River Basin (Dabés, 1995; Neumann-Leitão & Nogueira-Paranhos, 1989) have found that these lakes have a great variety of protozoans and rotifers. Although the role of the pulse of inundation as a source of organic matter and nutrients for these lakes is still unclear (Junk, 1980, Forsberg *et al*, 1988, Junk *et al*, 1989), floodplain lakes show strong seasonal patterns of change in physical and chemical features, which are attributed to the annual flooding by the rivers (Junk, 1984). According to Camargo & Esteves (1995), the patterns of variation of limnological features in such lakes can be diverse, depending on the environment and the study period; fertilization processes of these lakes depend on various mechanisms such as inflow of enriched river water, turbulence and resuspension of lake sediments, associated with wind action and water inflow, plant decomposition, and entrance of rain water and surface drainage.

The objective of the present study was to characterize limnologically and compare the zooplankton communities of an oxbow lake of the River Paraopeba, during two different periods of the hydrological cycle, in an attempt to detect the influences of the pulse of inundation and low water on the physical, chemical and biological characteristics of the lake.

MATERIALS AND METHODS

Lake Massacará forms part of the floodplain of the River Paraopeba (Upper São Francisco River

* Author for correspondence

Basin) at 19°27'S and 44°34'W. Land use consists of cattle ranching. The lake is bordered by grassland and swampy ground on one side, and by the river on the other. There is abundant growth of submerged (*Utricularia* sp.) and floating (*Eichhornia crassipes*) macrophytes. During high water, surface area can reach 17.25ha.

The study was carried out during two periods of the hydrological cycle in 1996, namely high (April) and low water (September). Sampling was carried out in the central, deep part of the lake, between the times of 11:40 and 13:30 hours.

Water transparency was determined using a Secchi disc. For analysis of phytoplankton primary production, alkalinity, nutrients and chlorophyll, water was collected using a Jorg bottle (Hidrocean), at the surface and at the depths of 10 and 1% light penetration (determined from the Secchi transparency, as recommended by Esteves, 1988). Measurements of temperature, pH, electrical conductivity and dissolved oxygen concentration were made at depth intervals of 0.1m, using an Horiba device (model U-10).

For the analysis of the zooplankton, 40L of water were filtered through a net of mesh size 68μm, fixed in formaldehyde to a final concentration of 4%, and coloured with Bengal Pink. The zooplankton were identified to genus/species level using the following literature: Edmondson (1959), Donner (1966), Smirnov (1974), Koste (1978), Brandorff *et al.* (1982), Matsumura-Tundisi (1983), and Reid (1985). Zooplankton abundance was estimated by counting the organisms, in sub-samples of 1mL, in a Sedgewick-Rafter cell, using a microscope at a magnification of x100.

Alkalinity and nitrite were determined according to Golterman *et al.* (1978), forms of inorganic carbon and nitrate according to Mackereth *et al.* (1978), ammonia according to Koroleff (1976), inorganic phosphate and total dissolved phosphate according to Strickland & Parsons (1960), and total nitrogen and phosphorous according to Valderrama (1981). Chlorophyll *a* concentrations were estimated using the methodology of Nusch (1980), with hot ethanol extraction. For the determination of phytoplankton production, the gas exchange method described by Vollenweider (1974) was used, with dissolved oxygen concentrations being measured by the modified Winkler technique (Golterman *et al.*, 1978); primary production rates were transformed from $mgO_2.m^{-3}.h^{-1}$ to $mgC.m^{-3}.h^{-1}$ according to Strickland (1960). The diversity index of the zooplanktonic community was calculated according to Shannon & Weaver (1949).

RESULTS AND DISCUSSION

According to the classification of Thornthwaite, the climate of the region is humid, with moderate water deficiency in the summer, mesothermal, with a hydric index of 40 to 60mm, and annual evapouration between 855 and 997mm ($B_{2S}B'_{3A}$) (Planvasf, 1989).

Meterological data (Figure 1) indicated that from 1961 to 1990, rainfall was maximum in January and minimum from June to August. Lower percentages of relative humidity occurred between July and October, while highest wind velocities were during September.

Lake Massacará receives water from the River Paraopeba, with highest intensity during the months of December, January and February. During the present study, mean lake depth was 2.9m during high water (April), while during low water (September), this depth decreased to 2.2m. Thus, water level of the lake changed relatively little between the two periods, despite the fact that both periods were well separated from each other, and that the amount of rainfall during autumn and winter was small.

Water transparency was the same during both periods (0.6m), with light penetration reaching 1.8m. Such low values were probably due to the large quantity of material in suspension, originating from the river or resuspended from the sediment. In general, oxbow lakes are turbid, with Secchi values of less than 1m, as found, for example, by Rai & Hill (1980) for some Central Amazonian lakes.

During high water (Figure 2), temperature varied between 29.4°C at the surface, and 24.8°C at the bottom. During low water, the lake was essentially destratified (Figure 3). According to Esteves (1988) and Joo (1990), in shallow tropical lakes, stratification and mixing tend to occur diurnally or several times a month, with few seasonal patterns in evidence. Temperature was lower during low than high water, not just as a result of the usual tendency for lower temperature in the winter, but also due to the greater amount of cloud cover.

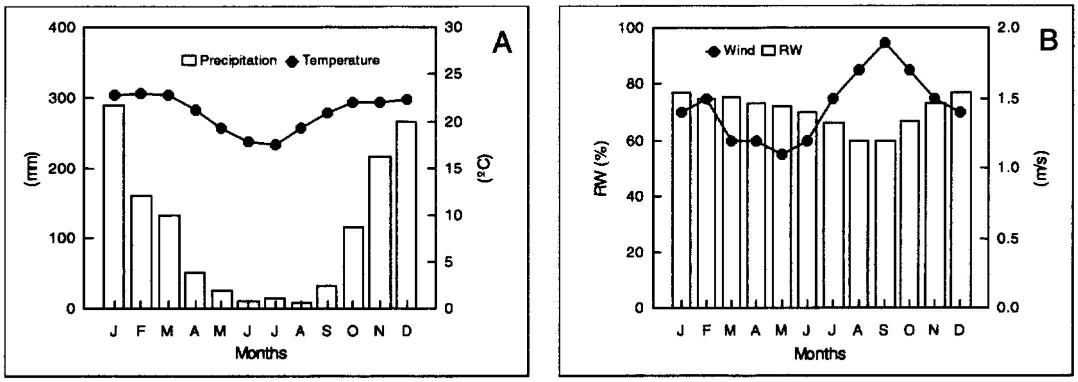

Figure 1- Mean monthly values of meteorological data from 1961 to 1990 at 19º28'W and 44º15'S. A - Precipitation (mm) and air temperature (ºC); B - Relative humidity (%) (RW) and wind speed ($m.s^{-1}$). Source: AGMET-MG.

Values of pH were slightly acid, not reaching neutrality. During high water (Figure 2), the highest value was found at the bottom. Lowest values occurred at a depth of 1.4m (mid-depth of the water column). Not much differences in pH values were observed between high and low water (Figure 3). The slightly acidic pH during both periods might have been due to nitrification, organic matter decomposition with the presence of humic acids, and the nature of the soil of the region. The higher values in the euphotic zone might probably be explained by the higher rate of photosynthesis, as evidenced by the higher rate of primary production in this compartment of the lake.

During high water, dissolved oxygen concentration decreased abruptly during the first 30cm of the water column (Figure 2), giving rise to an oxycline. Below 40cm, the concentration was less then 1.0mg/L, or undetectable at certain depths. During low water (Figure 3), dissolved oxygen concentrations also decreased from surface to bottom, although anoxia did not occur. Joo (1990) observed oxygen depletion in the hypolimnion of oxbow lakes of the Mississipi River after periods of rain, with clinograde profiles. Boneto *et al.* (1984) observed low concentrations of oxygen in an oxbow lake of the Parana River, during the whole year. In Amazonian lakes, such depletions are rare due to the complete mixing of the water column, and the flux of less dense river water into the bottom regions of the lakes (Schmidt, 1972; Hamilton *et al*, 1990).

In contrast to dissolved oxygen, conductivity showed lower values at the surface than at the bottom during high water (Figure 2). The increase in conductivity at the bottom indicated, as the low oxygen concentration, higher reducing activity in this region. The conductivity profile during low water was relatively homogeneous (Figure 3).

Total alkalinity (Table 1) did not change with depth during high water. These values were relatively lower than those found in Tres Marias Reservoir (Esteves *et al.*, 1985) and the outflow of the latter to the São Francisco River (unpublished data), which indicated a lower capacity to buffer acids, with the concentration of free carbon dioxide being higher than the concentration of bicarbonate.

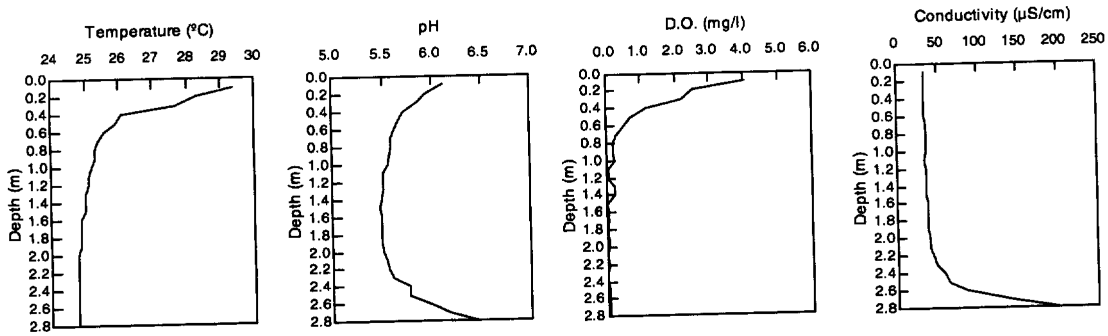

Figure 2 - Vertical profiles of temperature, pH, dissolved oxygen concentration and conductivity obtained at depth intervals of 0.1m in Lake Massacará, during high water (April/1996).

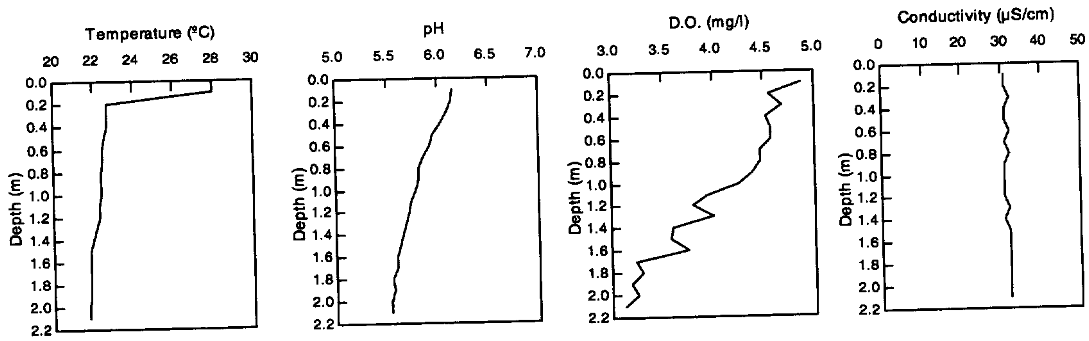

Figure 3 - Vertical profiles of temperature, pH, dissolved oxygen concentration and conductivity obtained at depth intervals of 0.1m in Lake Massacará, during low water (September/1996).

Table 1 - Concentrations of total alkalinity, total CO_2, free CO_2, and HCO_3^-, and rates of primary production and respiration of the plankton, measured at different depths, in Lake Massacará, during the periods of high and low water, 1996.*

Period	Prof. (m)	Alkalinity ($meq.L^{-1}$)	Total CO_2 ($mg.L^{-1}$)	Free CO_2 ($mg.L^{-1}$)	HCO_3^- ($mg.L^{-1}$)	NP ($mgC.m^{-3}.h.^{-1}$)	GP ($mgC.m^{-3}.h.^{-1}$)	R ($mgC.m^{-3}.h.^{-1}$)
High	0.10	0,30	35.81	22.62	13.20	42.82	215.28	172.50
water	0.80	0,30	97.27	84.07	13.20	0,00	10.12	10.12
	1.80	0.30	117.15	103.95	13.20	0.00	0.00	141.22
Low	0.10	0.23	25.70	15.76	9.94	47.43	95.96	48.53
water	0.80	0.18	36.73	28.96	7.78	28.13	39.58	11.46
	1.80	0.21	72.43	63.36	9.07	0.00	36.16	44.20

* GP = gross primary production; NP = net primary production; R = respiration. Concentrations of $CO_3^=$ below or equal to 0.001 mg/L.

During high water, the rates of both gross and net primary production were higher in the surface waters (Table 1). While the gross rate was high, the net rate was markedly lower as a result of the large consumption of dissolved oxygen by the planktonic organisms of this region. Production decreased notably at 10% light penetration and was zero at 1%. During low water, higher primary production was also observed near the surface, with values decreasing with the light. Although primary production was recorded at 1% light penetration, net production was not, probably as a result of reducing activity. The euphotic zone had lower values of gross primary production during low water than during high.

During both periods, there was an increase in both total and free CO_2 from surface to bottom, while the concentration of HCO_3^-remained constant at all depths (Table 1). Concentrations of free CO_2 and HCO_3^- were lower during low water. Higher rates of primary production occurred at the depths where concentrations of free CO_2 were lower, possibily indicating that this form of inorganic carbon was being used amply in photosynthesis.

During high water, all the forms of nitrogen (Table 2) increased from surface to bottom. Ammonium ion and total nitrogen concentrations were higher during high water than during low. The values of NH_4-N found indicated a high degree of decompositional activity. The lower values of NH_4-N observed at the surface could have been partially due to assimilation by the phytoplankton and macrophyte communities (Toetz, 1971). When compared to the high water period, only the concentration of nitrate was higher during low water, while the concentrations of ammonia and especially nitrite decreased. The greater concentration of oxygen during low water and possibly the smaller quantity of organic matter in decomposition probably contributed to the greater concentrations of nitrate in the water column relative to ammonia.

The forms of phosphorous (Table 2) increased in concentration with depth during high water. When the sediment-water interface becomes anoxic, as occurred during this period, the phosphate present in the sediment is released rapidly into the water column, while the decomposition of organic material and excretion by aquatic organisms also contributed to such liberation. During low water, phosphorous concentrations (dissolved and total) were similar to those observed during high water.

Camargo & Esteves (1995) and Magrin & Senna (1997) found increases in electrical conductivity and nutrient concentrations, and decreases in water transparency during flooding, in two different oxbow lakes, of the River Mogi-Guaçu. Boneto *et al.* (1984) observed that fertilisation occurred during the dry season in a lake of the Paraná River in Argentina. In Lake Calado, Melack & Fisher (1990) found that rainwater and superficial drainage were the main sources of nitrogen, while the river water was the main source of phosphorous. According to these authors, the concentration of nutrients was generally higher in the hypolimnion and lower in the euphotic zone during stratification, as was observed during high water of the present study.

During high water, chlorophyll *a* concentrations (Table 3) increased with depth. During low water, chlorophyll *a* concentrations were only somewhat lower than during high water (Table 3).

Highest zooplankton abundance was observed during in April, with the copepods being most numerous (89.0%), followed by the rotifers (6.2%) (Figure 4; Table 4). In September, 64.7% of the zooplankton consisted of copepods, 30.6% of rotifers, and 4% of cladocerans. The Shannon-Weaver index of diversity had low values during both periods, although the April value (2.45 bits . ind^{-1}) was twice as high as that of September (1.26 bits . ind^{-1}). During both periods, a total of 32 taxa were indentified, seventeen of rotifers, six cladoceran, four copepods, four protozoans, and two macroinvertebrates respectively. During high water, the most abundant organisms found were the cyclopoid *Thermocyclops minutus*, including the juvenile forms, and the rotifers of the families Brachionidae, *Keratella cochlearis* and *K. lenzi*, and Trichocercidae, *Trichocerca capucina*. During low water, the most abundant species were *Thermocyclops minutus*, and the rotifer of the family Conochilidae, *Conochilus unicornis*.

Table 2 - Nutrient concentrations at different depths, in Lake Massacará, during the periods of high and low water, 1996. Concentrations are expressed in $\mu g.L^{-1}$.*

Period	Prof. (m)	NO_2-N	NO_3-N	NH_4-N	N Total	IP	TDP	Total P
High water	0.10	6.343	8.44	35.90	253.03	0.50	18.12	19.00
	0.80	6.663	7.63	71.82	358.23	1.24	18.12	23.81
	1.80	6.703	13.12	79.00	301.23	4.20	19.72	24.92
Low water	0.10	1.49	54.04	2.23	153.11	4.30	19.09	20.7
	0.80	n.d.	49.61	125.44	519.2	0.96	11.42	20.7
	1.80	1.65	61.25	3.31	289.2	0.96	15.68	22.42

* n.d. - not detected; IP - inorganic phosphate; TDP - total dissolved phosphate.

Table 3 - Concentrations of chlorophyll *a* at different depths, in Lake Massacará, during the periods of high and low water, 1996. Concentrations are expressed in $\mu g.L^{-1}$.

Prof.	High water			Low water		
(m)	Active Chlorophyll *a*	Phaeophytin	Total Chlorophyll *a*	Active Chlorophyll *a*	Phaeophytin	Total Chlorophyll *a*
0.10	5.86	2.14	8.00	6.97	1.16	8.13
0.80	7.81	3.12	10.93	6.51	1.63	8.14
1.80	9.49	5.97	15.46	4.65	4.14	8.79

Food availability and quality are important factors determining the abundance and composition of zooplankton communities in lakes. In lakes subjected to pulses of inundation, there tends to be a quali-quantitative dominance of rotifers and protozoans; this may be explained principally by the availability of decomposing organic matter arising from the growth and decay cycles of floating and submerged plants, such availability benefitting the groups of microphages (Dabés, 1996). However, in the present study, the zooplankton was dominated by copepods. Likewise, in Lake Janauacá, also characterised as a floodplain lake, the predominant zooplankton were copepods and cladocerans (Fisher & Parsley, 1979). It should be noted that in the present study the contribution of the rotifers and protozoans might have been underestimated due to the relatively large mesh size of 68µm used in sampling.
The highest rate of gross primary production was found at the surface during high water, suggesting a greater supply of algal food for the zooplankton during this period. This may partially explain the greater density and species richness of organisms found during high water.

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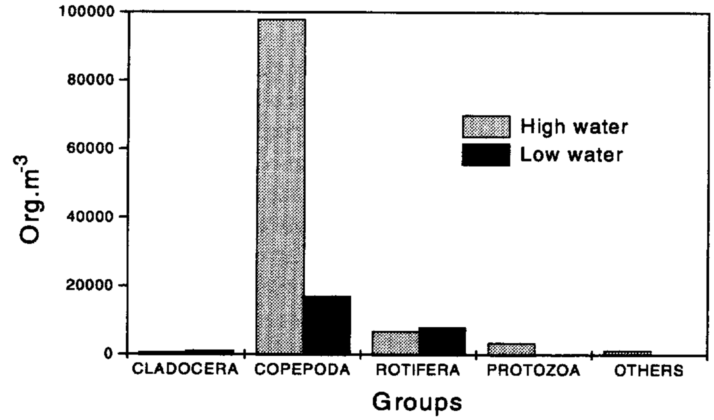

Figure 4 - Total density (organisms.m^{-3}) of the principal groups of zooplankton during the periods of high and low water in 1996.

Table 4 - Relative abundances, expressed as percentages, of the zooplanktonic organisms, in Lake Massacará, during the periods of high and low water (percentages considered abundant are shown in bold), 1996.

Organisms	High water	Low water	Organisms	High water	Low water
CLADOCERA			**ROTIFERA**		
Bosmina hagmanni	0.00	1.44	*Brachionus bidentata*	2.50	0.00
Bosmina tubicen	0.00	1.15	*Brachionus dolabratus*	0.15	0.00
Bosminopsis deitersi	0.15	0.00	*Brachionus falcatus*	2.50	0.00
Alonella sp	0.15	0.00	*Conochilus unicornis*	0.00	**30.36**
Daphnia laevis	0.00	1.34	*Euchlanis dilatata.*	0.44	0.00
Macrothrix sp	0.00	0.10	*Filinia longiseta saltator*	0.88	0.00
COPEPODA			*Hexarthra i brasiliensis*	0.29	0.00
Mesocyclops sp.	0.00	0.77	*Keratella americana*	1.32	0.00
Notodiaptomus sp.	0.00	2.39	*Keratella cochlearis*	**5.29**	0.00
Thermocyclops minutus	**3.52**	**8.24**	*Keratella lenzi*	**12.78**	0.19
Harpacticoida	0.00	0.10	*Keratella tropica*	0.88	0.00
Copepodite (Cyclopoida)	**4.55**	**22.13**	*Lecane lunares*	0.00	0.10
Copepodite (Calanoida)	0.15	**10.25**	*Lecane lunaris*	0.44	0.00
Nauplius (Cyclopoida)	**46.84**	**13.22**	*Polyarthra dolichoptera*	3.67	0.00
Nauplius (Calanoida)	2.35	7.57	*Polyarthra* sp.	0.59	0.10
PROTOZOA			*Trichocerca capucina*	**6.61**	0.00
Arcella sp	0.73	0.00	*Trichocerca* sp.	1.32	0.00
Arcella vulgaris	0.44	0.10	**OSTRACODA**	0.44	0.00
Centropyxis arcelloides	0.73	0.00	**NEMATODA**	0.29	0.00
Difflugia sp.	0.00	0.19			

RESUMO

Lagoa Massacará (marginal ao Rio Paraopeba-MG, Bacia do Rio São Francisco) foi estudada do ponto de vista de alguns aspectos limnológicos durante dois períodos do ciclo hidrológico (cheia e seca). A transparência da água foi baixa e semelhante nos dois períodos. No período de cheia ocorreu estratificação, perfil de oxigênio clinógrado com camadas inferiores anóxicas, pH ligeiramente ácido, alta condutividade elétrica no fundo, com maiores concentrações de CO_2 inorgânico, de íons amônio e taxa de produção primária que na época seca. No período de seca ocorreu desestratificação, perfil de oxigênio clinógrado com camadas inferiores não anóxicas,

pH ligeiramente ácido, condutividade elétrica constantes, com maiores concentrações de nitrato que na época cheia. A composição e abundância da comunidade zooplanctônica não demonstrou grandes flutuações nas duas épocas estudadas. A maior densidade e riquesa de organismos foi detectada na pós-cheia. Copépodas e rotíferos detiveram a maior representatividade numérica em ambos os períodos, não havendo contudo espécies dominantes. Foram identificados um total de 17 taxa de rotiferos, 6 de cladóceros, 4 de copépodas, 4 de protozoários, e 2 de macroinvertebrados. As espécies mais abundantes encontradas na cheia foram: *Thermocyclops minutus, Keratella cochleares, Keratella lenzi,* e *Trichocerca capucina,* e na seca *Thermocyclops minutus,* e *Conochilus unicornis.*

REFERENCES

Boneto, C.A., Zalocar, Y. & Lancelle, H.G. (1984), A limnological study of an oxbow-lake covered by *Eichhornia crassipes* in the Paraná River. *Verh. Internat. Verein. Limnol.*, **22**, 1315-1318

Brandorff. G.O., Koste, W., Smirnov, N. (1982), The composition and strucuture of rotiferan and crustacean comunities of the Lower Rio Nhamundá, Amazonas, Brasil. *Stud. Neotrop. Fauna Environ.*, **17**, 69-121

Camargo, A.F.M. & Esteves, F.A. (1995), Influence of water level variation on fertilization of an oxbow lake of Rio Mogi-Guaçu, state of São Paulo, Brazil. *Hydrobiologia*, **299**, 185-193

Dabés, M.B.G.S. (1995), Composição e descrição do zooplâncton de cinco lagoas marginais do Rio São Francisco, Pirapora/Três Marias, M.G.- Brasil. *Rev. Brasil. Biol.*, **55** (4), 831-854

Dabés, M.B.G.S. (1996), Composição da microfauna (plâncton e pleuston) das lagoas Cajueiro, Curral de Vara e Juazeiro: Inventário das lagoas marginais do Rio São Francisco, na região do Projeto Jaíba - Relatório final. CODEVASF/UFMG

Donner, J. (1966), *Rotifers*. Frederick Warne & Go Ltd., London. Translated and adapted by H.G.S. Wright

Edmondson, W.T. (1959), *Freshwater biology.* John Wiley & Sons, New York

Esteves, F.A. (1988), *Fundamentos de limnologia.* Interciência/FINEP, Rio de Janeiro

Esteves, F.A., Amorim, J.C., Cardoso, E.L., Barbosa, F.A.R. Caracterização limnológica preliminar da Represa de Três Marias (MG) com base em alguns parâmetros ambientais básicos. *Cie. e Cult.*, **37** (4), p. 608-617, 1985.

Fisher, T.R. & Parsley, P.E. Amazon lakes: water storage and nutrient stripping by algae. *Limnol. Oceanogr.*, **24**, 547-553, 1979.

Forsberg, B.R., Devol, A.H., Richey, J.E., Martinelli, L.A. & Dos Santos, H. (1988), Factors conttroling nutrient concentrations in Amazon floodplain lakes. *Limnol. Oceanogr.*, **33**, 41-56

Golterman, H.L., Clymo, R.S., Ohnstad, M.A.M. (1978), *Methods for chemical analysis of freshwater.* (IBP Handbook, n. 8 2nd ed.). Blackwell Scientific Publications, Oxford

Hamilton, S.K., Lewis Jr, W.M., Sauders III, J.F. (1990), Zooplankton abundance and evidence for its reduction by macrophyte mats in two Orinoco floodplain lakes. *J. of Plankton Research*, **12**, 345-363

Joo, G.J. (1990), Limnological studies of oxbow lakes in the southeastern United States: morphometry, physico-chemical characteristics and patterns of primary productivity. PhD Thesis, Department of Biology, Graduate School of University of Alabama, Tuscaloosa, USA

Junk.W.J. (1980), Áreas alagáveis: Um desafio para a limnologia. *Acta Amazonica*, **10**, 775-777

Junk, W.J. (1984), Ecology of the várzea, floodplain of Amazonian white water rivers. In- *The Amazon: limnology and landscape ecolgy of a mighty tropical river and its basin,* ed. H. Sioli. Dr. W. Junk Publishers, Dordrecht, pp. 215-242

Junk, W.J., Bayley, B. & Sparks, R.E. (1989), The flood pulse concept in river-floodplain systems. *Can. Spec. Publ. Fish. aquat. Sci.*, **106**, 110-127

Koroleff, F. (1976), Determination of nutrients. In- *Methods of sea water analysis,* ed. K. Grasshoff, Chemie Weinhein, Verlag, pp. 117-181.

Koste, W. (1978), *Rotatoria*. Gebryder Borntreger, Berlin

Mackereth, F.J.H., Heron, J., Talling, J.F. (1978), *Water analysis: some revised methods for limnologists.* Titus Wilson & Son Ltd, Kendall.

Magrin, A.G.E., Senna, A.C. (1997), Composição e dinâmica de diatomáceas planctônicas em uma lagoa da planície de inundação do médio Mogi-Guaçu, Estado de São Paulo, Brasil. Paper presented at 8th Seminário Regional De Ecologia, São Carlos, São Paulo.

Matsumura-Tundisi, T. (1983), *Tipologia de reservatórios do Estado de São Paulo: cladóceros do Brasil.* Relatório Técnico Científico.Gráfica da UFSCar, São Carlos

Melack, J.M., Fisher, T.R. (1990), Comparative limnology of tropical floodplain lakes with emphasis on the Central Amazon. *Acta Limnol. Brasil.*, **3**, 1-48

Neumann-Leitão, S.E., Nogueira-Paranhos, J.D. (1989), Zooplâncton do Rio São Francisco , região nordeste do Brasil. *Trab. Oceanogr.* **20**, 173-196

Nusch, E.A. (1980), Comparison of different methods for chlorophyll and phaeopigment determination. *Arch. Hydrobiol. Beih. (Ergebn. Limnol.)*, **14**, 14-36

PLANVASF. (1989), Plano diretor para o Vale do São Francisco. Relatório final. PLANVASF, Brasília

Rai, H. & Hill, G. (1980), Classification of central

Amazon lakes on the basis of their microbiological and physico-chemical characteristics. *Hydrobiologia*, **72**, 85-99

Reid, J.W. (1985), Chave de identificação e lista de referências bibliográficas para espécies continentais sulamericanas de vida livre da ordem Cyclopoida (Crustacea, Copepoda). *B. Zool.*, **9**, 17-143

Schmidt, G.W. (1972), Seasonal chances in water chemistry of a tropical lake (Lago do Castanho, Amazonia, South America). *Verh. Internat. Verein. Limnol.*, **18**, 613-621

Shannon, C.E., Weaver, W. (1949), *The matematical theory of communication*. University Ilinois Press, Urbana

Smirnov, N.N. (1974), *Fauna of the USSR: Crustacea*. Keter Publishing House Jerusalem Ltd., Jerusalem

Strickland, J.D.H. (1960), Measuring the production of marine phytoplankton. *Bull. Fish. Res. Board Can.*, **122**, 1-172

Strickland, J.D.H., Parsons, T.R. (1960), A manual of seawater analysis. *Bull. Fish. Res. Board Can.*, **125**, 1-18

Toetz, D.W. (1971), Diurnal uptake of NO_3 and NH_4 by a *Ceratophyllun*-periphyton community. *Limnol. Oceanogr.*, **16**, 819-822

Valderrama, J.C. (1981), The simultaneous analysis of total nitrogen and phosphorus in natural waters. *Marc. Chem.*, **10**, 1109-1122

Vollenweider, R.A. (1974), *A manual on methods for measuring primary production in aquatic environments*. 2nd ed. (IBP Handbook n° 12). Blackwell Scientific Publications, Oxford

Welcome, R.L. (1985), *River fisheries*. *FAO Fish. Tech. Pap.*, **262**, 1-330

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