Spatial variation of the benthic community in the Corumbá reservoir, Goiás, Brazil

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ABSTRACT. The benthic community composition and abundance were analyzed in three stations of the Corumbá reservoir. Collections were undertaken at the margin and the center of the stations, aiming to analyze the abiotic parameters affecting this community. Variables such as depth, dissolved oxygen and sediment type were the main factors that determined the benthic community structure. Fauna was abundant in the marginal region, probably because of the lower depth and higher dissolved oxygen concentrations. The opposite occurred at the central region, with the exception of the reservoir's riverine station. This fact may be due to the shallowness of the place and the water current high speed. Oligochaeta and Chironomidae were the most frequent and abundant taxa in the Corumbá Reservoir. These results show that the benthic community in the reservoir is spatially related to depth and to dissolved oxygen.

Key words: benthic community, reservoir, abundance, spatial variation.

RESUMO. Variação espacial da comunidade bêntica no reservatório de Corumbá, Estado de Goiás, Brasil. A composição e a abundância da comunidade bêntica foi analisada em três estações do reservatório de Corumbá. Foram feitas coletas na margem e no centro das estações, visando a analisar os parâmetros abióticos que influenciaram essa comunidade. Variáveis, tais como profundidade, oxigênio dissolvido e o tipo de sedimento, foram os principais fatores que determinaram a estrutura da comunidade bêntica. A fauna apresentou uma maior abundância na região marginal, provavelmente devido às menores profundidades e maiores concentrações de oxigênio dissolvido. O inverso foi verificado na região central, exceto na estação fluvial do reservatório, pois trata-se de um local raso e com maior velocidade de correnteza. Oligochaeta e Chironomidae foram os principais táxons em freqüência e abundância no reservatório de Corumbá. A partir desses resultados, pode-se sugerir que a comunidade bêntica no reservatório estudado está relacionada, espacialmente, com a profundidade e com o oxigênio dissolvido.

Palavras-chave: comunidade bêntica, reservatório, abundância, variação espacial.

Introduction

Reservoir formation is a key factor in the transformation of fast water systems into slow ones. In fact, there is a significant reduction in the water flow (Bianchini, 1999), which modifies the limnological characteristics of the dammed environment (Lansac-Tôha *et al*., 1999).

Most organisms have physiological tolerance limit to physical and chemical changes in water (Wetzel and Likens, 1991) that occur along the time in the reservoir. Benthic community is no exception and its structure is also controlled by the abiotic factors (Bechara, 1996).

Difficulties in sampling and identification of benthic organisms limit our understanding of this community in inland water environments. Nevertheless, some researches in reservoirs have been performed in Brazil, by Strixino and Strixino (1980); Fukuhara *et al.* (1997); Henry and Simão (1986); Valenti and Froehlich (1986); Strixino and Trivinho-Strixino (1991); Brandimarte and Shimizu (1996 a, b); Brandimarte *et al*. (1999); Higuti *et al.* (2000) and Santos and Henry (2001).

Focalizing on the fact that the environment spatial heterogeneity is highly influential on the benthic community biological traits, the current research verifies the main abiotic factors that affect its distribution and abundance in the Corumbá reservoir.

Material and methods

Study area

The reservoir of the Corumbá Hydroelectric Plant, in the state of Goiás, Brazil, was built on the impounding of the Corumbá river, whose hydrographic basin affected the Paranaíba river basin on the Goiás - Minas Gerais border. The reservoir area is 65 km^2, with a total volume of 1500 x 10^6 m^3, 23 m average depth and 30-day average residence time (De Filippo and Soares, 1996). The two last factors may vary significantly due to discharge oscillation of the Corumbá river. Pirapetinga and Santo Antonio rivers, its main tributaries, flow into the lacustrine station.

Three sampling stations were established for current research, riverine station (lotic environment feature), intermediate station (environment feature between lotic and lentic) and lacustrine station (lentic environment feature) (Figure 1).

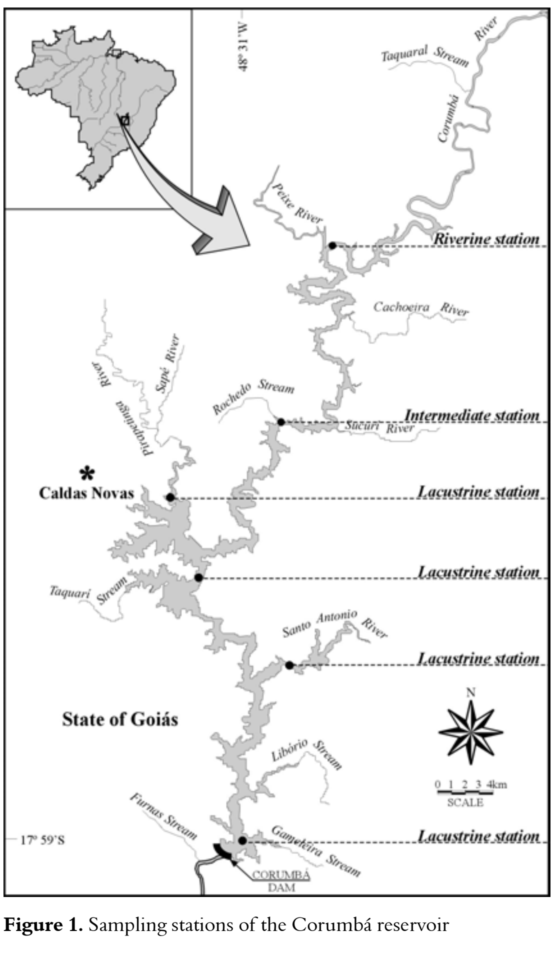

Figure 1. Sampling stations of the Corumbá reservoir

Sampling and laboratory analysis

Research was undertaken every two months, from January 1999 to January 2000. Samples for quantitative and qualitative analyses of benthic organisms were collected with modified Petersen grab (0.0345 m^2), from one margin of the reservoir to the other (transversal section).

Four samples were collected at each site, three samples for biological analyses and one sample for granulometric texture and organic matter contents. Depth and water temperature were measured by a thermistor and water transparency by Secchi disc. Water samples, close to the bottom, were collected with a Van Dorn bottle to measure the pH and electrical conductivity. Dissolved oxygen was determined by modified Winkler method (Golterman *et al*., 1978).

Sediment samples were fixed in formaldehyde 4%, buffered with calcium carbonate. A 200 µm sieve was used to separate benthic fauna from sediments.

Granulometric composition was determined according to the method of Suguio (1973) with the Wentworth scale (1922). This scale considers the particles diameter as follows: pebble and granule (bigger than 2 mm), very coarse sand (1 mm), coarse sand (0.5 mm), medium sand (0.25 mm), fine sand (0.125 mm), very fine sand (0.062 mm) and mud (less than 0.062 mm). Estimates of sediment organic matter were obtained by burning 10 g of sample in a muffle furnace at 560ºC for four hours.

Data analysis

Principal Components Analysis (PCA) and Detrended Correspondence Analysis (DCA) were applied to reduce the dimensionality of the limnological and biological data, respectively. These multivariate techniques also facilitate the understanding of data variation by ordinating stations/months sampled (Pla, 1986). Abiotic data matrix (except pH) were standardized ($x = x-\bar{x}/sd$) and biotic data (benthic community) was squared root transformed, to minimize the discrepant values effect. Analyses were done with the Statistica 5.5 program (Statsoft Inc., 2000) and PC-ORD version 3.15 (McCune and Mefford, 1997), to PCA and DCA, respectively.

Analysis of variance (ANOVA) was employed to test spatial and temporal differences in density and richness. Density was a dependent factor, whereas regions (margin and center), stations and sampling months were independent ones.

Pearson correlation between the PCA and DCA scores (first two axes) were used to verify the influence of limnological variables on the benthic community.

Results

Abiotic parameters

High concentrations of dissolved oxygen were registered at the margins of the lacustrine, intermediate and riverine stations. As a general rule, pH values oscillated from acid (4.2) to basic (9.5) at different sampling stations. Depth values ranged between 0.2 m and 76.0 m, while dissolved oxygen ranged between 0.0 and 9.2 mg/L. Electrical conductivity oscillated from 16.6 µS/cm to 117.0 µS/cm (Table 1).

The results show that the highest values in depth, electrical conductivity and hypoxia and/or anoxia in the hypolimnium occurred in the central region of the reservoir's lacustrine station. Contrastingly, the lowest mean depth values and dissolved oxygen concentrations were recorded in the central region of the intermediate and riverine stations.

PCA explained 34.5% (axis 1) and 27.73% (axis 2) of the variability physical and chemical.

As a general rule, the Corumbá reservoir differentiated the margins from the center by means of depth abiotic variables, dissolved oxygen and sediment texture. Principal Component 1 showed that the stations central region differentiated itself from the margins due to the fact that centers were deep, with high electrical conductivity, low concentrations of dissolved oxygen and fine sediment. Principal Component 2 separated the station merely by sediment texture. A mixture of fine and coarse particles in some stations, probably due to sedimentation process since the impounding, could be noticed (Figure 2).

Zoobenthic community

Twenty-three invertebrates taxa were recorded in the Corumbá reservoir. Rotifera, Nematoda, Oligochaeta (*Narapa bonettoi* included), Cladocera, Ostracoda, Cyclopoida, Harpacticoida, Ceratopogonidae and Chironomidae accounted for the highest densities.

Taxa with a density lower than 100 specimens/m² were classified as "others" and comprised Gastropoda, Bivalvia, Hirudinea, Prostigmata, Calanoida, Collembola, Ephemeroptera, Odonata, Trichoptera, Diptera (including Chaoboridae), Coleoptera and Lepidoptera (Figure 3).

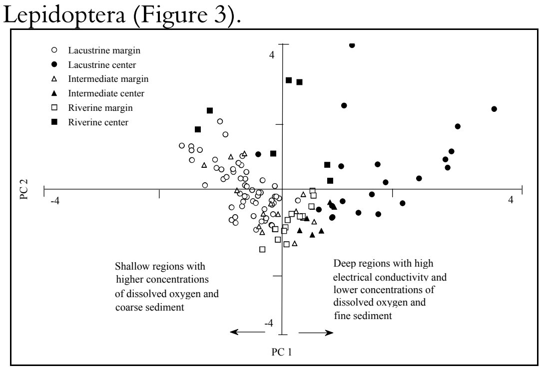

Figure 2. Sampling stations/months ordination for the first two axes of Principal Components Analysis

Table 1. Mean values, standard deviation (in parenthesis), variation amplitude and observation number (n) of the physical and chemical variables

Environment variables	Depth (m)	Water temperature (°C)	pH	Electrical conductivity (µS/cm)	Dissolved oxygen (mg/L)	Organic matter (%)	Sediment (> %)
Riverine							
Margin	0.8 (0.8)	24.9 (2.3)	7.4 (0.7)	39.9 (9.7)	7.1 (1.4)	8.0 (4.8)	Fine sand
	0.3-3.0	21.0-28.8	6.6-8.6	22.6-56.0	4.4-9.0	1.3-13.5	
	n=14	n=14	n=14	n=14	n=14	n=14	
Center	4.0 (2.3)	24.8 (2.3)	7.4 (0.7)	39.6 (10.3)	7.3 (1.4)	1.3 (0.9)	Medium sand
	1.0-7.7	21.0-27.8	6.5-8.7	22.4-55.7	4.6-9.0	0.1-2.5	
	n=7	n=7	n=7	n=7	n=7	n=7	
Intermediate							
Margin	0.7 (0.2)	26.2 (2.5)	6.9 (0.4)	39.5 (8.5)	6.8 (1.2)	14.9 (24.7)	Very fine and fine sand
	0.5-1.0	22.8-30.4	6.3-7.9	24.0-52.8	4.6-7.9	3.7-10.0	
	n=14	n=14	n=14	n=14	n=14	n=14	
Center	20.4 (5.7)	24.9 (2.3)	6.9 (0.38)	39.9 (9.3)	6.6 (1.1)	12.1 (1.9)	Very fine sand
	13.0-28.0	21.6-27.4	6.4-7.71	23.1-53.9	4.4-7.5	8.9-13.8	
	n=7	n=7	n=7	n=7	n=7	n=7	
Lacustrine							
Margin	0.7 (0.3)	27.2 (2.4)	7.2 (0.8)	38.9 (7.4)	7.2 (1.2)	5.7 (2.2)	Very fine and fine sand
	0.2-1.3	22.3-33.4	6.1-9.5	27.3-55.0	4.2-9.2	2.4-15.7	
	n=56	n=56	n=56	n=56	n=56	n=56	
Center	46.3 (19.6)	22.1 (1.5)	6.5 (0.6)	53.9 (29.8)	1.8 (2.3)	12.2 (5.5)	Very fine sand
	17.0-76.0	20.8-25.4	4.2-7.3	16.6-117.0	0.0-6.1	1.5-18.7	
	n=21	n=21	n=21	n=21	n=21	n=21	

Figure 3 also shows organisms mean density in the central and marginal regions of the stations. The highest densities occurred at the margin of all stations, with special reference to Oligochaeta and Chironomidae. Such results may be due to the low depth and the high concentration of dissolved oxygen. However, this density pattern has not merely been registered in the riverine station of the reservoir, with the central region having the highest abundance. In this case, the medium and coarse sand was probably the main factor that produced the highest number of invertebrates represented by Rotifera, *N. bonettoi* and Harpacticoida.

On the other hand, low density in the central region of the reservoir lacustrine station may be caused by the higher depth and the lower dissolved oxygen.

ANOVA showed significant differences (GL=1; F=31.61; p=0.00000) in the organisms density between the margins and the center of the reservoir stations (Figure 4).

The first and second DCA axes present eigenvalues of 0.36 and 0.11, respectively. The distribution of stations/months in the ordenation separated the fauna of the riverine station from the lacustrine station. Then, two main groups were distinguished. One group was constituted by organisms adapted to lotic habitats, as Rotifera, Nematoda, *N. bonettoi* and Harpacticoida; on the other hand, the microcrustaceans (Calanoida, Cyclopida, Cladocera and Ostracoda) were the main organisms from the lentic habitats (Figure 5).

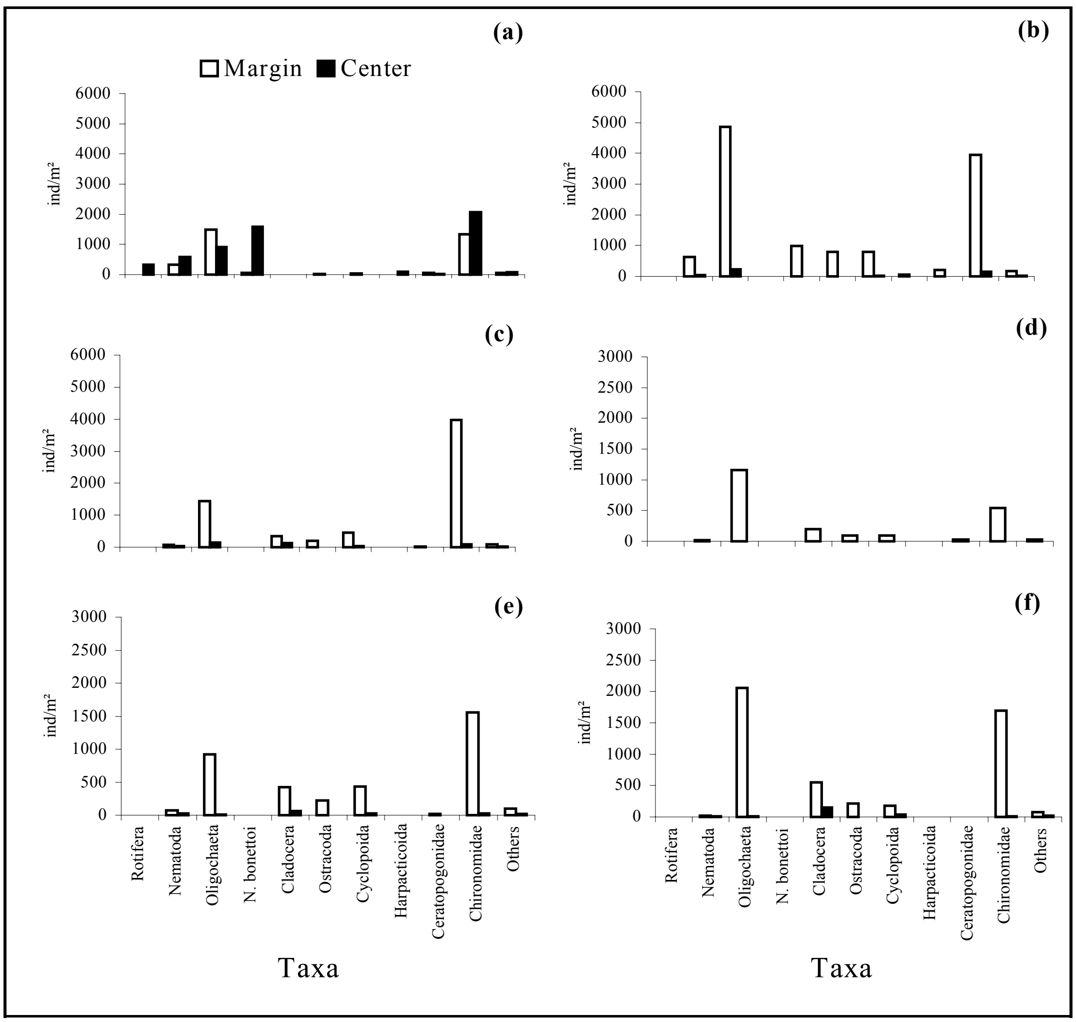

Figure 3. Mean density (ind/m²) of benthic invertebrates at the margin and center of the Corumbá reservoir. (a) riverine station, (b) intermediate station and (c, d, e, f) lacustrine station

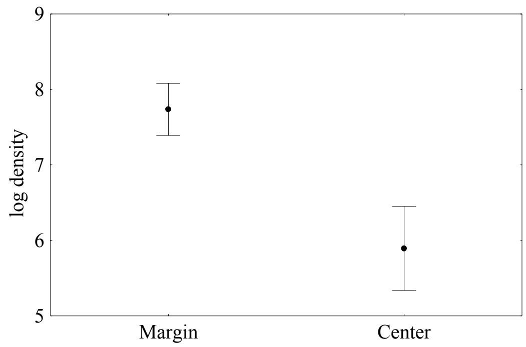

Figure 4. Density of benthic invertebrates in different regions

Pearson correlation between the first axes of the PCA and DCA was significant (p=0.003) evidencing the influence of the limnological variables on the structure (composition and density) of the benthic community. It is also clear the 'envelope effect' (Scheiner and Gurevitch, 1993), meaning that the structure of the benthic community in some stations/months (those positioned on the left in figure 6) were less influence by the limnological variables.

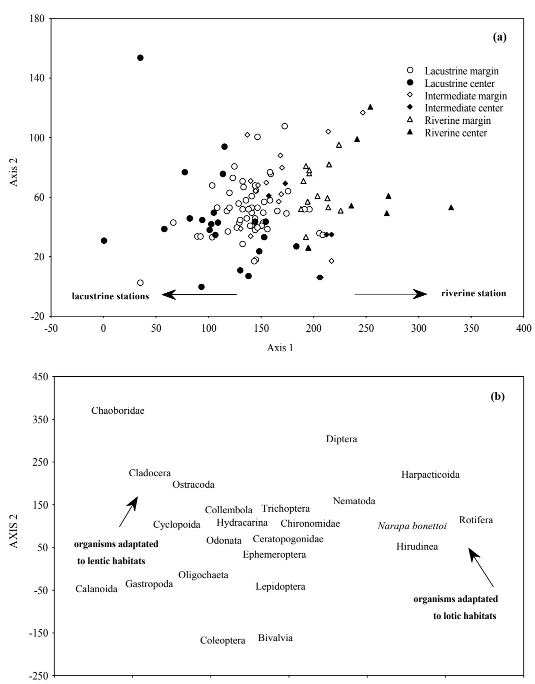

Figure 5. Detrended Correspondence Analysis (DCA) ordination diagram. (a) ordination of the stations/months scores, (b) benthic community ordination

Discussion

Different environmental characteristics of the sampled stations seem to be the main factors that determined the invertebrates colonization and abundance in the Corumbá reservoir.

The reservoir margins were the most favorable regions for benthic organism development, as show the significant differences in invertebrates density and diversity compared to those of the central region. According to Marchese and Ezcurra de Drago (1992) and Esteves (1998), the shore region of freshwater environments has higher food diversity and a more oxygenated water column. Depth and dissolved oxygen concentration influence on the above mentioned biological factors was also significant. Such characteristics, together with lower rates of organic matter in the sediment, have been probably responsible for the establishment of benthic fauna at the reservoir shores.

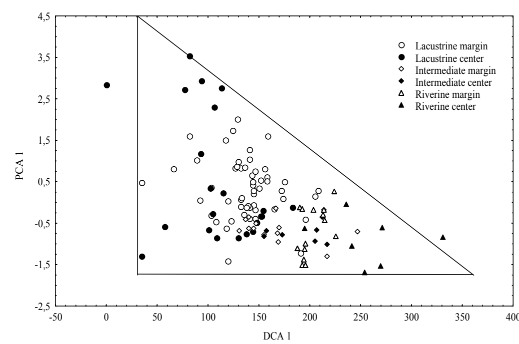

Figure 6. Ordination of the PCA (abiotic data) and DCA (biotic data) scores

This close relationship between benthic organisms and abiotic variables, significantly correlated with the community, may also explain the lower abundance and diversity in the central region of the lacustrine and intermediate stations. Since several studies have shown the relationship between dissolved oxygen and depth on invertebrates, this seems to be a key factor in the determination of the benthic communities complexity (Prat *et al.*, 1991; Int Panis, 1996).

On the other hand, high concentrations of dissolved oxygen and water speed, coupled to sediment formed by coarse particles, were the main factors affecting high density and diversity of the riverine station central region. Although water current makes fixation and establishment of benthic invertebrates difficult, Rotifera (non-planktonic), Oligochaeta (mainly *N. bonettoi*) and Harpacticoida, may have already adapted to these conditions. As a rule, non-planktonic rotifers, associated with the sediment, feed on particles found in the sediment (Margalef, 1983). The high density of *N. bonettoi* may also be associated with the sediment (medium and coarse sand) and the low rate of organic matter, since the species, also characterized as rheophile and psammophile (Marchese, 1987), is highly adaptable to such sediments (Montanholi-Martins and Takeda, 1999). The occurrence and abundance of Harpacticoida was due to the fact that the microcrustacean inhabits sandy places (Reid, 1993). Besides, Nematoda may be abundant in reservoirs (Mesfin *et al*. 1988), as the central region of the reservoir riverine station evidences. Since the latter is an opportunist organism (Thomas and Munteanu, 1997) and resistant to adverse conditions (Brandimarte and Shimizu, 1996), its high densities at this station may probably be accounted for.

Oligochaeta and Chironomidae were the two most frequent and abundant groups in all stations. According to Van Den Brink (1994), Oligochaeta live in organic and sandy environments. However, they may also inhabit many other different aquatic environments (Brinkhurst and Jamieson, 1971). Chironomidae may also inhabit a great variety of places but are characteristic of dammed environments (Growns and Growns, 2001). Larvae are r-strategists (Fuller and Cowell, 1985) and adapt themselves to several different environments. Such adaptability favors the presence and abundance of these invertebrates in the reservoir. These groups predominate in other reservoirs, too (Prat, 1978; Kaster and Jacobi, 1978; Hale and Bayne, 1980; Di Giovanni *et al.*, 1996; Thomas and Munteanu, 1997 and Al-Lami *et al.*, 1998).

High densities of Ceratopogonidae larvae were found at the margins of the intermediate and riverine stations. Since, according to Dessaix *et al.* (1995), these Diptera prefer fast water environments, their abundance is probably related to the water current at these stations. The contribution of Chaoboridae within this group with regard to benthic fauna density has been reported. This fact may be related to food availability for their larvae (Stenson, 1990). In fact, the reservoir formation caused the development of planktonic (Lansac-Tôha *et al*., 1999) and benthic microcrustaceans, which may have favored the development of these potential zooplankton predator larvae.

Our research suggests that depth, dissolved oxygen and hydrodynamic characteristics of the different stations were the main determining factors of the benthic community spatial variation. In fact, this community showed a heterogeneous spatial variation throughout the reservoir.

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References

AL-LAMI, A.A. *et al*. Benthic invertebrates community of the river Euphrates upstream and downstream sectors of Al-Qadisia dam, Iraq. *Regul. Rivers Res. Manag*, Chichester, v. 14, n. 4, p. 383-390, 1998.

BECHARA, J.A. The relative importance of water quality, sediment composition and floating vegetation in explaining the macrobenthic community structure of floodplain lakes (Paraná River, Argentina). *Hydrobiologia*, Dordrecht, v.333, p.95-109, 1996.

BIANCHINI JR., I.A decomposição da vegetação e o consumo de oxigênio nos reservatórios: implicações ecológicas. *In*: HENRY, R. (Ed.). *Ecologia de reservatórios*: estrutura, função e aspectos sociais. Botucatu: Fundibio/Fapesp, 1999. cap. 21, p. 627-650.

BRANDIMARTE, A.L.; SHIMIZU, G.Y. Temporal and spatial variations in littoral benthic communities of Paraibuna reservoir (São Paulo, Brazil). *Trop. Ecol.*, Jodhpur, v. 37, n. 2, p. 215-222, 1996a.

BRANDIMARTE, A.L.; SHIMIZU, G.Y. Littoral benthic communities of Paraibuna reservoir (São Paulo, Brazil): indicators of seral stages of terrestrial vegetation. *Trop. Ecol.*, Jodhpur, v. 37, n. 2, p. 277-280, 1996b.

BRANDIMARTE, A.L. *et al*. Comunidade de invertebrados bentônicos nas fases pré- e- pós enchimento em reservatórios: um estudo de caso no reservatório de aproveitamento múltiplo do Rio Mogi-Guaçu (SP). *In*: HENRY, R. (Ed.). *Ecologia de reservatório*: estrutura, função e aspectos sociais. Botucatu: Fundibio/Fapesp, 1999. cap. 13, p.375-408.

BRINKHURST, R.O.; JAMIESON, B.M.G. *Aquatic Oligochaeta of the world*. Edinburg: Oliva & Boyd, 1971.

DE FILIPPO, R.; SOARES, C.B.P. Caracterização limnológica e da qualidade da água do rio Corumbá e de seus principais afluentes na área de influência da UHE Corumbá. Rio de Janeiro: FURNAS – Centrais Elétricas S.A., Departamento de Meio Ambiente, 1996. 21p. (Relatório).

DESSAIX, J. *et al*., Changes of the macroinvertebrates communities in the dammed and by-passed sections of the

French upper Rhone after regulation. *Regul. Rivers Res. Manag.*, Chichester, v. 10, nº. 2-4, p. 265-279, 1995.

DI GIOVANNI, M.V. *et al.* Macrobenthos in Montedoglio reservoir, central Italy. *Hydrobiologia*, Dordrecht, v. 321, p. 17-28, 1996.

ESTEVES, F.A. *Fundamentos de Limnologia.* Rio de Janeiro: Interciência/Finep, 1998.

FUKUHARA, H. *et al.* Standing crop of zoobenthos in Lakes Dom Helvecio and Jacaré. *In*: SAIJO, Y.; TUNDISI, J.G. (Ed.). *Limnological studies on the Rio Doce Valley Lakes, Brazil*. Rio de Janeiro: Brazilian Academy of Sciences; São Carlos: University of S. Paulo School of Engineering at S. Carlos. Center for Water Resources and Applied Ecology, 1997. cap. 6, p. 335-344.

FULLER, A.; COWELL, B.C. Seasonal variation in benthic invertebrate recolonization of small-scale disturbances in a subtropical Florida lake. *Hydrobiologia*, Dordrecht, v. 124, p. 211-221, 1985.

GOLTERMAN, H.L. *et al. Methods for physical and chemical analysis of freshwaters.* Oxford: Blackwell Scientific. 1978.

GROWNS, I.O.; GROWNS, J.E.. Ecological effects of flow regulation on macroinvertebrate and periphytic diatom assemblages in the Hawkesbury- Nepean River, Australia. R*egul. Rivers Res. Manag.*, Chichester, v. 17, nº. 3, p.275-293, 2001.

HALE, M.M; BAYNE, D.R. Effects of water level fluctuations on the littoral macroinvertebrates of West Point reservoir. *Proc Annu Conf Southeast Assoc Fish Wildl Agencies*, Frankfurt, v. 34, p. 175-180, 1980.

HENRY, R; SIMÃO, C.A. Abundância, diversidade e biomassa de Mollusca na represa de Piraju (Rio Paranapanema, SP). *Rev. Bras. Biol.*, Rio de Janeiro, v. 46, nº. 3, p. 507-516, 1986.

HIGUTI, J. *et al.* Variação Longitudinal da Comunidade Zoobêntica no Reservatório de Corumbá, Goiás. *In*: SIMPÓSIO DE ECOSSISTEMAS BRASILEIROS: CONSERVAÇÃO, 5., 2000, Vitória. *Anais...* Vitória: ACIESP/UFES, 2000. n. 3, p. 383-392.

INT PANIS, L. *et al.* On the spatial distribution and respiratory environment of benthic macroinvertebrates in ponds. *Hydrobiologia*, Dordrecht, v. 319, p.131-136, 1996.

LANSAC-TÔHA, F.A. *et al.* Estrutura da comunidade zooplanctônica antes e após a formação do reservatório de Corumbá-GO. In: HENRY, R. (Ed.). *Ecologia de reservatórios*: estrutura, função e aspectos Sociais. Botucatu: FUNDIBIO/FAPESP, 1999. cap. 12, p.347-374.

KASTER, J.L.; JACOBI, G.Z. Benthic macroinvertebrates of a fluctuating reservoir. *Fresh. Biol*, Oxford, v. 8, n. 3, p. 283-290, 1978.

MARCHESE, M.R. The ecology of some benthic Oligochaeta from the Paraná River, Argentina. *Hydrobiologia*, Dordrecht, v. 155, p. 209-214, 1987.

MARCHESE, M.; EZCURRA DE DRAGO, I. Benthos of the lotic environments in the middle Paraná River system: transverse zonation. *Hydrobiologia,* Dordrecht, v. 237, p. 1-13, 1992.

MARGALEF, R. *Limnologia*. Barcelona: Omega.1983.

McCUNE, B.; MEFFORD, M.J. *PC-ORD. Multivariate Analysis of Ecological Data, Version 3.15.* Gleneden Beach, Oregon: MJM Software, 1997.

MESFIN, M. *et al*. Some limnological observations on two Ethiopian hydroelectric reservoirs: Koka (Shewa administrative district) and Finchaa (Welega administrative district). *Hydrobiologia*, Dordrecht, v. 157, p. 47-55, 1988.

MONTANHOLI-MARTINS, M.C; TAKEDA, A.M. Communities of benthic Oligochaetes in relation to sediment structure in the upper Paraná River, Brazil. *Stud Neotrop Fauna Environ*, Lisse, v. 34, n. 1, p.52-58, 1999.

PLA, L.E. *Analisis multivariado: metodo de componentes principales*. Washington, DC: Organización de los Estads Americanos. 1986.

PRAT, N. Benthos typology of Spanish reservoirs. *Verh Internat Verein Limnol*, Stuttgart, v. 20, nº. 3, p. 1647-1651, 1978.

PRAT, N. e*t al*. El bentos profundo y litoral de una cadena de Tres Embalses Españoles del Río Guadiana (SW España). *Limnetica*, Madrid, v. 7, p. 133-152, 1991.

REID, J.W. The harpacticoid and cyclopoid copepod fauna in the Cerrado region of central Brazil, 1: species composition, habitat, and zoogeography. *Acta Limnológica Brasileira*, São Paulo, v.6, p.56-58, 1993.

SANTOS, C.M.; HENRY, R. Composição, distribuição e abundância de Chironomidae (Diptera, Insecta) na represa de Jurumirin (Rio Paranapanema – SP). *Acta Limnológica Brasileira*, Botucatu, v.13, n. 2, p. 99-115, 2001.

SCHEINER, S.M.; GUREVITCH, J. Design and analysis of ecological experiments. Nova York: Chapman and Hall, 1993. p. 87-88.

STATSOFT INC. *Tulsa: Statistica.* v. 3, 2000.

STENSON, J.A.E. Creating conditions for changes in prey community structure by *Choborus* ssp. in lake in Sweden. In: DUMONT, H.J. *et al.* (Ed.) *Intrazooplankton predation*. Kluwer Academic Publisher: Dordrecht. 1990. p. 205-214.

STRIXINO, G.; STRIXINO, S.T. Macroinvertebrados do fundo da represa do Lobo (Estado de São Paulo - Brazil). I. Distribuição e abundância de Chironomidae e Chaoboridae (Diptera). *Trop. Ecol.*, Jodhpur, v. 21, nº. 1, p. 16-23, 1980.

STRIXINO, G.; TRIVINHO-STRIXINO, S. Chironomidae (Diptera) associados a sedimentos de reservatórios: significado dos diferentes povoamentos. In: SEMINÁRIO REGIONAL DE ECOLOGIA, 6., 1991, São Carlos, SP. *Anais*... São Carlos: UFSCar, 1991. p. 151-168.

SUGUIO, K. *Introdução à sedimentologia.* São Paulo : Edgard Blücher, 1973.

THOMAS, G.P.; MUNTEANU, N. Benthic community populations near two adjacent northern pulpmill discharges. *Water Sci Technol*, London, v. 35, n. 2-3, p. 381-388, 1997.

VALENTI, W.C.; FROEHLICH, O. Estudo da diversidade da taxocenose de Chironomidae de dez reservatórios do Estado de São Paulo. *Ciênc. Cult.*, São Paulo, v. 38, n. 4, p. 703-707, 1986.

VAN DEN BRINK, F.W.B. *et al.* Macrozoobenthos abundance and community composition in three Lower Rhine floodplain lakes with varying inundation regimes. *Regul. Rivers Res. Manag*. Chichester, v.9, p. 279-293, 1994.

WETZEL, R.G.; LIKENS, G.E. *Limnological analyses*. 2. ed ed. New York: Springer-Verlag, 1991.

WENTWORTH, C.K. A scale of grade and class terms for clastic sediments. *J. Geol.*, Chicago, v.30, p.377-392, 1922.

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