AMAZONIANA XVII (1/2): 139-151 Kiel, Dezember 2002

Daily fluctuation in rotifer population abundance in two environments of the upper Paraná River floodplain, Brazil.

by

C.C. Bonecker, F.A. Lansac-Tôha, L.M. Bini & L.F.M. Velho

Dr. Claudia C. Bonecker, Nupélia, Posgraduate Course in Ecology of Continental Aquatic Environments, State University of Maringá. Av. Colombo, 5790, Maringá-PR, 87020-900, Brazil; e-mail: bonecker@nupelia.uem.br
Dr. Fábio A. Lansac-Tôha, Nupélia, Posgraduate Course in Ecology of Continental Aquatic Environments, State University of Maringá. Av. Colombo, 5790, Maringá-PR, 87020-900, Brazil; e-mail: fabio@nupelia.uem.br
Dr. Luis M. Bini, Department of General Biology, Federal University of Goiás, Posgraduate Course in Ecology of Continental Aquatic Environments, State University of Maringá, Posgraduate Course in Ecology of Continental Aquatic Environments, State University of Maringá; e-mail: bini@nupelia.uem.br
Dr. Luiz Felipe M. Velho, Nupélia, State University of Maringá; e-mail: felipe@nupelia.uem.br
(Accepted for publication: January, 2002).

Abstract

Daily fluctuation of rotifer population abundance was studied in a lake and in a river of the Upper Paraná River floodplain. Samples were collected in the open water for 14 consecutive days, in the high and low water periods. Densities were higher in the lake, chiefly in the low water period. During the studied period, changes in species dominance were observed. Rotifer abundance showed that higher variability occured during the high water period in both environments. Rotifer abundance showed high variability in the river during the sampling days. In the lake, fluctuation was related to the hydrological periods. Rotifer abundance fluctuations in the lake were influenced by regional factors (fluviometric level); and in the river, by local factors (flow). The sampling design pointed out that seasonal samples are necessary to evaluate rotifer abundance in the lake. However, this is not the case in the river where seasonal differences in abundance were not observed.
Keywords: **Rotifers, daily fluctuation, population abundance, floodplain, Brazil**.

Resumo

As flutuações diárias da abundância das populações de rotíferos foram estudadas em uma lagoa e um rio da planície de inundação do alto rio Paraná, Brasil. As amostras foram coletadas na região pelágica, durante 14 dias consecutivos, nos períodos de águas baixas e altas. O maior número de indivíduos foi registrado na lagoa, principalmente no período de águas baixas. Alterações na dominância de espécies foram observadas durante os dois períodos hidrológicos. A abundância dos rotíferos mostrou uma maior variabilidade durante os dias de coleta no período de águas altas, em ambos os ambientes. No rio a abundância apresentou uma grande variação entre os dias de coleta, e na lagoa entre os períodos hidrológi-

ISSN 0065-6755/2002/139/

cos. A flutuação diária da abundância dos rotíferos na lagoa foi influenciada por fatores regionais (nível fluviométrico), e no rio por fatores locais (fluxo). O desenho amostral utilizado mostrou que as amostras sazonais são necessárias para investigar a abundância dos rotíferos em lagoas, mas não nos rios, onde variações sazonais da abundância não foram observadas.

Introduction

Floodplain systems are made up of numerous lakes, channels, small rivers, streams and the fringing wetlands of larger rivers. At certain times of the year these environments have limnological similarities due to rising and high water levels brought on by the "flood pulse" (JUNK et al. 1989; NEIFF 1990).

Rotifers are a particularly important component of zooplankton, given their capacity to adapt to changes in environmental conditions (ALLAN 1976). In the case of floodplain environments, dynamic environmental variations can explain the success of rotifers. Several authors (HARDY 1980; ROBERTSON & HARDY 1984; VÁSQUEZ 1984; PAGGI & JOSÉ DE PAGGI 1990; BOZELLI 1994; BONECKER & LANSAC-TÔHA 1996; ESPÍNDOLA et al. 1996) have discussed species diversity changes and abundance of rotifers in South American floodplain lakes. Few studies have focused on the population dynamics of rotifers at short intervals (TWOMBLY & LEWIS JR. 1987; VÁSQUEZ & REY 1989; HILLMAN & SHIEL 1991; TAN & SHIEL 1993; ARCIFA et al. 1994; RODRÍGUEZ & MATSUMURA-TUNDISI 2000). Given the high intrinsic growth rates and population renewal times characteristic of rotifers, short time intervals certainly better reflect changes in population size.

This study examines the fluctuation in densities of rotifer populations in two environments of the upper Paraná River floodplain through two temporal scales: daily, for 14 consecutive days and seasonal, considering low and high water periods.

Methods

The Baía River (22°43'S and 53°17'W) has a slow current (0.11 - 0.50m/s) and a slightly inclined bed, characteristic of a floodplain river. Along the stretch of the river, where the sampling took place, high biomass of grasses in particular *Panicum pernambucense* occur on its banks (THOMAZ et al. 1991). Throughout the year, the Paraná River regulates its discharge (THOMAZ et al. 1997) (Fig.1).

Guaraná Lake (22°43'S and 53°18'W) is located in the last stretch of the Baía River and is connected to the river throughout the year by a connection channel. Lake depth ranges between 1.8 and 3.6 meters. In the littoral zone and along the connection channel, aquatic macrophytes are abundant and *Eichhornia azurea* is dominant (Fig. 1).

Samples were collected at the surface in the open water in the Baía River and Guaraná Lake for 14 consecutive days, during the low water period (August 1993) and the high water period (March 1994).

Rotifers were sampled with a motorized pump at the surface and filtered through a 70µm plankton net. One thousand liters were filtered per sample. The samples were preserved in buffered formalin. These organisms were quantified using a Sedgewick-Rafter counting cell. A minimum of 200 individuals was counted in each sample. Identification was based on KOSTE (1978), KOSTE & ROBERTSON (1983), JOSÉ DE PAGGI (1989) and SEGERS (1995).

Spatial and temporal variation of rotifer abundance at the two habitats during the different sampling periods was evaluated by a Detrended Correspondence Analysis - DCA (JONGMAN et al. 1995). A T-test for dependent samples (SOKAL & ROHLF 1981) was used to test the effects of the hydrological period on rotifer abundance. Total density and species densities values were previously log (x+1) transformed. PC-ORD (McCUNE & MEFFORD 1995) and STATISTICA 5.0 (STATSOFT INC. 1996) were used.

Results

The daily change in depth in each of the environments is shown in Figure 2. The highest total density was registered in both lake (2,519,480 ind/m^3) and river (1,439,170 ind/m^3) in the low water period. During the high water period, 1,988,490 ind/m^3 were registered in the lake and 1,033,461 ind/m^3 in the river (Fig. 3).

Conochilus coenobasis was dominant in the lake during the low water period. During the high water period, *B. falcatus* was dominant. *Epiphanes clavatula* became expressive only when densities of *Synchaeta stylata* and *C. coenobasis* decreased (Fig. 4).

In the low water period, *Filinia longiseta* was numerically important when *Ploesoma truncata, Ptygura longicornis* and *Brachionus calyciflorus* were less abundant; and in the other period, *Filinia longiseta* was abundant when *Polyarthra vulgaris* was less abundant (Fig. 4).

Conochilus coenobasis and *B. calyciflorus* were dominant in the river in the low water period. *Ptygura longicornis* and *F. longiseta* dominated when the first two taxa decreased. *P. truncata* dominated only in the presence of *C. coenobasis* and lower densities of *B. calyciflorus*. A greater number of taxa were abundant during the high water period, with similar peaks. *C. coenobasis* was numerically important. *S. stylata, F. longiseta* and *P. vulgaris* were abundant when *Trichocerca insiginis*, *Notommata copeus*, *P. longicornis* and *Filinia saltator* decreased (Fig. 5).

With regards to temporal variation, *C. coenobasis* and *F. longiseta* were abundant during the two hydrological periods. *B. calyciflorus* and *P. truncata* were more abundant during the low water period and *B. falcatus*, and *S. stylata* were more expressive during the high water period.

DCA scores for the environments-sampling days and rotifer abundance during the low water period (λ_1=0.086, λ_2=0.044), and the high water period (λ_1=0.087, λ_2=0.042) are presented in Figure 6.

The DCA showed that the taxa densities were different in the environments during the two sampling periods, which was seen by the separation of environments into two groups along DCA1. The taxa also presented very different densities in the two sampling periods. These differences are determined by the DCA2 axis (Fig. 6).

Rotifer abundance shows greater variability during the high water period in both environments. Considering the environments, density was significantly different between the hydrological periods only in the lake (Fig. 7).

In the low water period, some taxa occurred and were abundant only in the river (*Lecane leontina, Pompholyx* cf. *triloba, Trichocerca inermis, Brachionus quadridentatus* and *Euchlanis incisa*) while others occurred and were abundant only in the lake (*Trichocerca similis, Testudinella patina, Lecane aculeata* and *Dipleuchlanis propatula macrodactyla*).

Proales cf. *decipiens, Lecane inopinata, Asplanchna sieboldi, Filinia pejleri* and *Macrochaetus sericus* occurred and were dominant only in the river during the high water period, while *Mytilinia bisulcata, M. bicarinata, Manfredium eudactylota* and *Ploesoma truncata* occurred and were abundant only in the lake during the same period.

Discussion

Lower rotifer densities during the high water period and higher densities in the other hydrological period are common in floodplain environments, as observed by BRAN-

DORFF & ANDRADE (1978) and GARRIDO & BOZELII (1997) in the Amazon River basin; PAGGI & JOSÉ DE PAGGI (1990) in the Paraná River basin; HECKMAN (1998) and ESPÍNDOLA et al. (1996) in the Pantanal in Mato Grosso and Mato Grosso do Sul States, Paraguay river basin, respectively. In reservoirs of the Paraná basin this pattern is also frequent, as observed by ROLLA et al. (1992) in the Igarapava reservoir, Grande River (Minas Gerais/São Paulo States), LOPES et al. (1997), in the Segredo reservoir, Iguaçú River (Paraná State).

The difference in taxa abundance observed during the two hydrological periods was probably determined by the relationship between the limnological characteristics of each environment and the response of each population to these abiotic fluctuations. Studies developed by CASTELO BRANCO et al. (2000) showed a significant correlation between rotifer densities and limnological variables, such as water transparency, dissolved oxygen, temperature, chlorophyll-*a*, nitrogen compounds and others, in coastal lakes with freshwater condition. ROTHHAUPT (1995) considered the concentration of nutrients (N and P) an important environmental condition for the nutritional quality of phytoplankton, an important resource for rotifers. BONECKER & LANSAC-TÔHA (1996) have shown that high densities of *Brachionus calyciflorus* and *Ploesoma truncata*, two of the most abundant taxa observed in this study, was associated with high concentrations of chlorophyll-*a* and dissolved oxygen and low values of temperature and water level. According to ATTAYDE & BOZELLI (1998), the former species occurs under mesotrophic and eutrophic conditions in a coastal lagoon (Carapebus lagoon, Rio de Janeiro State).

As shown by BONECKER et al. (1998), concerning rotifer richness, the present results suggest that non-planktonic taxa, such as *Notommata copeus* and *Epiphanes clavatula*, are also important to the total abundance of this group, chiefly in the high water period. PAGGI & JOSÉ DE PAGGI (1990) have shown that non-planktonic species contribute to the high densities observed in the pelagic regions of the middle Paraná River floodplain. Another non-planktonic genus (*Lecane*) was found with higher densities in a small reservoir in Paraíba State only after the rainy season (VIEIRA et al. 2000).

The greater variability of rotifer abundance in the high water period occurred due to the dynamic of the floodplain in this period. According to JUNK (1996), the floods played an important role in the strucuture of the aquatic community, influenced habitat changes for colonization, variation of the quality and quantity of the food and physical and chemical characteristics of the environment. CARVALHO (1983), HARDY et al. (1984), BOZELLI & ESTEVES (1991) stated that the fluctuation of rotifer abundance in floodplain lakes was influencied by food availability, for example, promoted by greater interaction with flooded areas during the high water period.

Significant difference in rotifer abundance in the lake between hydrological periods could be due to plankton dilution and stressed conditions in the high water period. BOZELLI (2000) considered the dilution effect an important factor in influencing the structure of the zooplankton community in a floodplain lake, as can be observed in the Amazon basin. In a small lake in northeastern in Brazil, VIEIRA et al. (2000) verified lower densities of rotifers during the rainy season. On the other hand, there was little fluctuation of the environmental conditions; therefore, it is possible that biotic interactions are predominate, as suggested by the daily population variation. Flow is probably the most important factor in the development of rotifer populations in the river.

Density was always lower than in the lake independent of flood stress. According to MARZOLF (1990), in the environment with higher flow, the transport of the organisms is higher than their reproductive rate, which makes the development of higher populations impossible. WARD (1994) stated that reproducing populations of truly planktonic organisms are restricted to the slow-flowing lower reaches of rivers. SHIEL et al. (1982) and KOBAYASHI et al. (1998) registered zooplankton density negatively correlated with flow rate in Australian rivers.

Results of the present study show that the rotifer abundance was influenced by regional factors in the lake (fluviometric levels) and local factors in the river (flow). Thus, in the case of sampling designs to investigate seasonal fluctuations of rotifer abundance in lakes, it is necessary to take monthly samples, which are not very important in the river, because the assemblages are structured by local factors. However, daily and seasonal samples are important for understanding the biotic interactions among rotifer populations.

Acknowledgments

We thank CNPq and DBI/Nupélia for financial and logistical support. Dr. Sidinei Magela Thomaz for suggestions. Dr. Barbara Robertson and Dr. John Jervis Stanley Junior revised the English text. The constructive criticism of the editor and one anonymous referee also is appreciated.

References

ALLAN, J.D. (1976): Life history patterns in zooplankton. - Am. Nat. **110**(971): 165-180.

ARCIFA, M.S., CASTILHO, M.S.M. & J.-P. CARMOUZE (1994): Composition et évolution du zooplankton dans une lagune tropicale (Brésil) au cours d'une période marquée par une mortalité de poissons. - Rev. Hydrobiol. Trop. **27**(3): 251-263.

ATTAYDE, J.L. & R.L. BOZELLI (1998): Assessing the indicator properties of zooplankton assemblages to disturbance gradients by canonical correspondence analysis. - J. Fish. Aquat. Sci. **55**: 1789-1797

BONECKER, C.C., LANSAC-TÔHA, F.A. & D.C. ROSSA (1998): Planktonic and non planktonic rotifers in two environments of the upper Paraná river floodplain-MS, Brazil. - Brazilian Archives of Biology and Technology, Brasil. **41**(4): 447-456.

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

BOZELLI, R.L. (1994): Zooplankton community density in relation to water level fluctuation and inorganic turbidity in an Amazonian lake, "Lago Batata", State of Pará, Brazil. - Amazoniana **13**(1/2): 17-32.

BOZELLI, R.L. (2000): Zooplâncton. - In: BOZELLI, R.L, ESTEVES, F.A. & F. ROLAND (eds.): Lago Batata: Impacto e recuperação de um ecossistema amazônico: 119-138. IB-UFRJ/SBL, Rio de Janeiro.

BOZELLI, R.L. & F.A. ESTEVES (1991): Influência da flutuação do nível d'água sobre a densidade da comunidade zooplanctônica do lago Mussurá e rio Trombetas-Oriximiná (PA). - An. Sem. Reg.Ecol. **6**: 47-66.

BRANDORFF, G.O. & E.R. ANDRADE (1978): The relationship between the water level of the Amazon River and the fate of the zooplanktonpopulationin lake Jacaretinga, a várzea lake in Central Amazon. - Stud. Neotrop. Fauna Environ. **13**: 63-70.

CARVALHO, M.L. (1983): Efeitos da flutuação do nível d'água sobre a densidade e composição do zooplâncton em um lago de várzea da Amazônia, Brasil. - Acta Amazonica **13**: 715-724.

CASTELO BRANCO, C.W., KOZLOWSKY-SUZUKI, B., ESTEVES, F.A. & L. COIMBRA E SOUZA (2000): Rotifers as ecological indicators in three coastal lagoons in the State of Rio de Janeiro. - Anais do V Simpósio de Ecossistemas Brasileiros: Conservação. Espirito Santo: ACIESP **109**(2): 429-456.

ESPINDOLA, E.G., MATSUMURA-TUNDISI, T. & I.H. MORENO (1996): Efeitos da dinâmica hidrobiológica do sistema Pantanal matogrossense sobre a estrutura da comunidade de zooplâncton da lagoa Albuquerque. - Acta Limnol. Brasil. **8**: 37-57.

GARRIDO, A.V. & R.L. BOZELLI (1997): A influência do rejeito de bauxita e da flutuação do nível d'água sobre a comunidade de rotíferos do lago Batata, PA. - An. Sem. Reg.Ecol. **8**: 19-32.

HARDY, E.R. (1980): Composição do zooplâncton em cinco lagos da Amazônia Central. - Acta Amazonica, **10**(3): 577-609.

HARDY, E.R., ROBERTSON, B. & W. KOSTE (1984): About the relationship between the zooplankton and fluctuating water level of lago Camaleão, a Central Amazonian varzea lake. - Amazoniana **9**(1): 43-52.

HECKMAN, C.W. (1998): The seasonal succession of biotic communities in wetlands of the tropical wet-and-dry climatic zone: V. Aquatic invertebrate communities in the Pantanal of Mato Grosso, Brazil. - Internat. Rev. Hydrobiol. **83**(1): 31-63

HILMANN, T.J. & R.J. SHIEL (1991): Macro-and microinvertebrates in Australian billabongs. - Verh. Internat. Verein. Limnol. **24**: 1581-1587.

JONGMAN, R.H.G., TERBRAAK, C.J.F. & G.F.R. VAN TONGEREN (1995): Data Analysis in Community and Landscape Ecology. - University Press, Cambridge.

JOSÉ DE PAGGI, S. (1989): Rotiferos de algunas provincias del noroeste argentino. - Rev. Hydrobiol. Trop. **22**(3): 223-238.

JUNK, W.J. (1996): Ecology of floodplains-a challenge for tropical limnology. - In: SCHIEMER, F. & K.T. BOLAND (eds.): Perspectives in Tropical Limnology: 255-265. The Netherlands: Academic Publishing by Amsterdam.

JUNK, W.J., BALEY, P.B. & R.E. SPARKS (1989): The flood pulse concept in river-floodplain systems. - In: DODGEE, D.P. (ed.): Proccedings of the International large river Symposium. - Can. Spec. Publ. Fish. Aquat. Sci. **106**: 110-127.

KOBAYASHI, T., SHIEL, R.J., GIBBS, P. & P.I. DIXON (1998): Freshwater zooplankton in the Hawkesbury-Nepean River: comparison of community structure with other rivers. - Hydrobiologia **377**: 133-145.

KOSTE, W. (1978): Rotatoria - Die Rodertiere Mitteleuropas begründet von Max Voigt. - Monogononta. Vols. 1 & 2. Gebrüder Borntraeger, Berlin.

KOSTE, W. & B. ROBERTSON (1983): Taxonomic studies of the Rotifera (Phylum Aschelminthes) from a Central Amazonian varzea lake, Lago Camaleão (Ilha de Marchantaria, Rio Solimões, Amazonas, Brazil). - Amazoniana **8**(2): 225-254.

LANSAC-TÔHA, F.A., BONECKER, C.C., VELHO, L.F.M. & A.F. LIMA (1997): Comunidade zooplanctônica. - In: VAZZOLER, A.E.A.M., AGOSTINHO, A.A. & N.S. HAHN (eds.): A planície de inundação do Alto Rio Paraná: Aspectos físicos, químicos, biológicos e socioeconômicos: 117-155. Editora da Universidade Estadual de Maringá, Maringá.

LOPES, R.M., LANSAC-TÔHA, F.A., VALE, R. & M. SERAFIM, JR. (1997): Comunidade zooplanctônica do reservatório de Segredo. - In: AGOSTINHO, A.A. & L.C. GOMES (eds.): Reservatório de Segredo: Bases Ecológicas para o Manejo: 39-60. Editora da Universidade Estadual de Maringá, Maringá.

MARZOLF, G.F. (1990): Reservoirs as environmentals for zooplankton. - In: THORTON, K.W., KIMMEL, B.L. & F.E. PAYNE (eds.): Reservoir limnology: ecological perspectives. - Interscience **7**: 195-208.

McCUNE, B. & M.J.MEFFORD (1995): PC-ORD. Multivariate Analysis of Ecological data. - Version 2.0. Oregon: MJM Software Design gleneden Blach.

NEIFF, J.J. (1990): Ideas para la interpretación ecologica del Paraná. - Interciencia **15**(6): 424-441.

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

ROBERTSON, B.A. & E.R. HARDY (1984): Zooplankton of Amazonian lakes and rivers. - In: SIOLI, H. (ed.): The Amazon: 337-352. W. Junk, Dordrecht.

RODRIGUÉZ, M.P. & T. MATSUMURA-TUNDISI (2000): Variation of density, species composition and dominance of rotifers at a shallow tropical reservoir (Broa reservoir, SP, Brazil) in a short scale time. - Rev. Brasil. Biol. **60**(1): 1-9.

ROLLA, M.E., DABÉS, M.B.G.S., FRANÇA, R.C. & E.M.V.M. FERREIRA (1990): Aspectos limnológicos do reservatório de Volta Grande, Minas Gerais/São Paulo. - Acta Limnol. Brasil. **3**: 219-244.

ROTHHAUPT, O.K. (1995): Algal nutrient limitation affects rotifer growth rate but not ingestion rate. - Limnol. Oceanogr. **40**(7): 1201-1208.

SEGERS, H. (1995): Rotifera. The Lecanidae (Monogononta). - The Hague. The Netherlands: SPB Academics (Guides to the identification of the microinvertebrates of the continental waters of the world), Vol. **2**: 1-226.

SHIEL, R.J., WALKER, K.F. & W.D. WILLIANS (1982): Plankton of the lower River Murray, South Australia. - Aust. J. mar. Freshwat. Res. **33**: 210-227.

SOKAL, R.R. & F.J. ROHLF (1981): Biometry. The principles and practice of statistics in biological research. - W.H. Freeman, New York.

STATSOFT INC. (1996): Tulsa: Statistica. -

TAN, L.W. & R.J. SHIEL (1993): Responses of billabong rotifer communities to inundation. - Hydrobiologia, **225/226**: 361-369.

THOMAZ, S.M., ROBERTO, M.C. & L.M. BINI (1997): Fatores limnológicos abióticos e clorofila-*a*: caracterização dos habitats e influências do pulso de inundação. - In: VAZZOLER, A.E.A.M., AGOSTINHO, A.A. & N.S. HAHN (eds.): A planície de inundação do Alto Rio Paraná: Aspectos físicos, químicos, biológicos e sócio econômicos: 73-102. Editora da Universidade Estadual de Maringá, Maringá.

THOMAZ, S.M., ROBERTO, M.C., LANSAC-TÔHA, F.A., ESTEVES, F.A. & A.F. LIMA (1991): Dinâmica temporal dos principais fatores limnológicos do rio Baía-planície de inundação do alto rio Paraná-MS, Brasil. - Revista UNIMAR, **13**(2): 299-312.

TWOMBLY, S. & W.M. LEWIS, JR. (1987): Zooplankton abundance and species composition in laguna la Orsinera, a Venezuela floodplain lake. - Arch. Hydrobiol. Suppl. **79**(1): 87-107.

VÁSQUEZ, E. (1984): El zooplancton de la sección baja de un rio de aguas negras (rio Caroni) y de un embalse hidroelectrico (Macagua I), Venezuela. - Mem. Soc. Cienc. Nat. La Salle **41**: 109-130.

VÁSQUEZ, E. & J. REY, J. (1989): A longitudional study of zooplankton along the lower Orinoco River and its Delta (Venezuela). - Annls. Limnol. **28**(1): 3-18.

VIEIRA, D.M., CRISPIM, M.C. & T. WATANABE (2000): Impacto da cheia e da seca sobre a comunidade zooplanctônica do açude São José dos Cordeiros no semi-árido paraibano. - Anais do V Simpósio de Ecossistemas Brasileiros: conservação. Espirito Santo: ACIESP **109**(3): 401-407.

WARD, J.V. (1994): The structure and dynamics of lotic ecossystems. - In: MARGALEF, R. (ed.): Limnology Now: 195-218. A paradigm of planetary problems. Elsevier, Amsterdam.

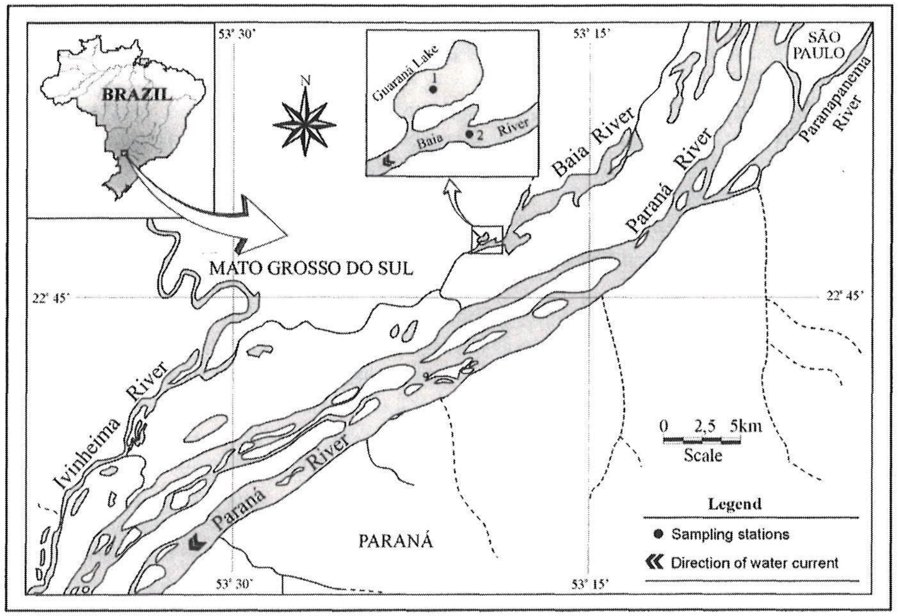

Fig. 1:
Study area and sampling sites.

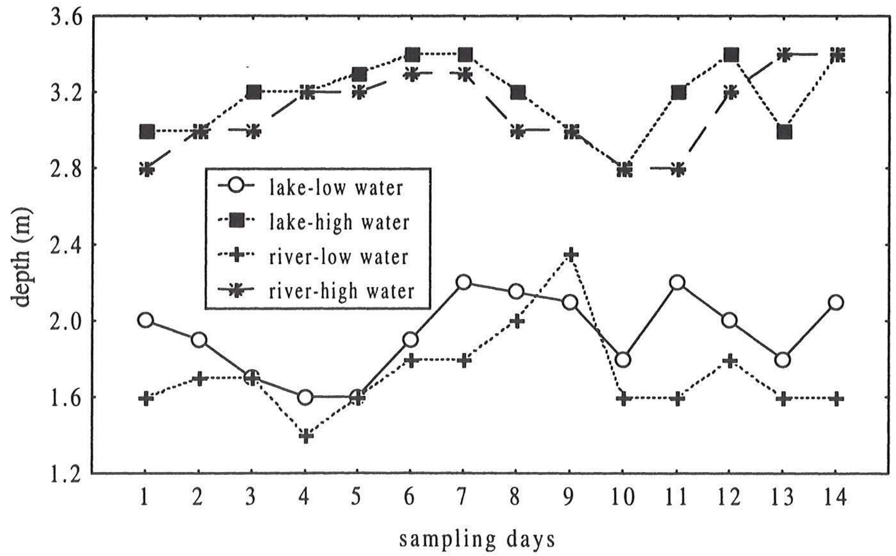

Fig. 2:
Daily variations in depth (m) at each studied environment, in August/93 (low water period) and March//94 (high water period).

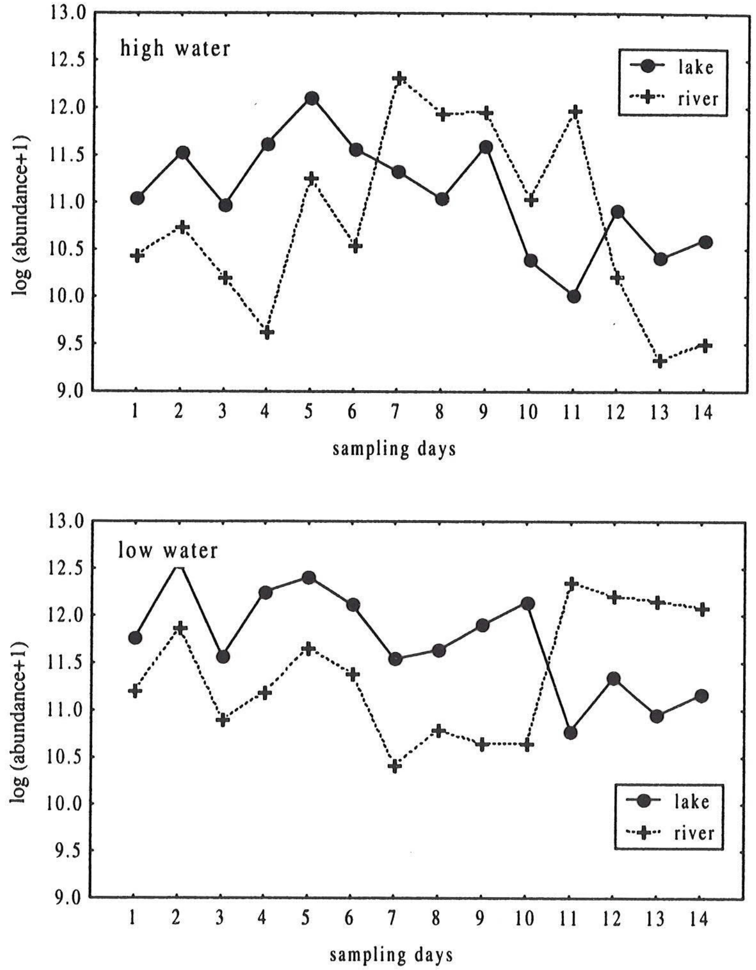

Fig. 3:
Rotifers densities in the lake and in the river during high and low water periods.

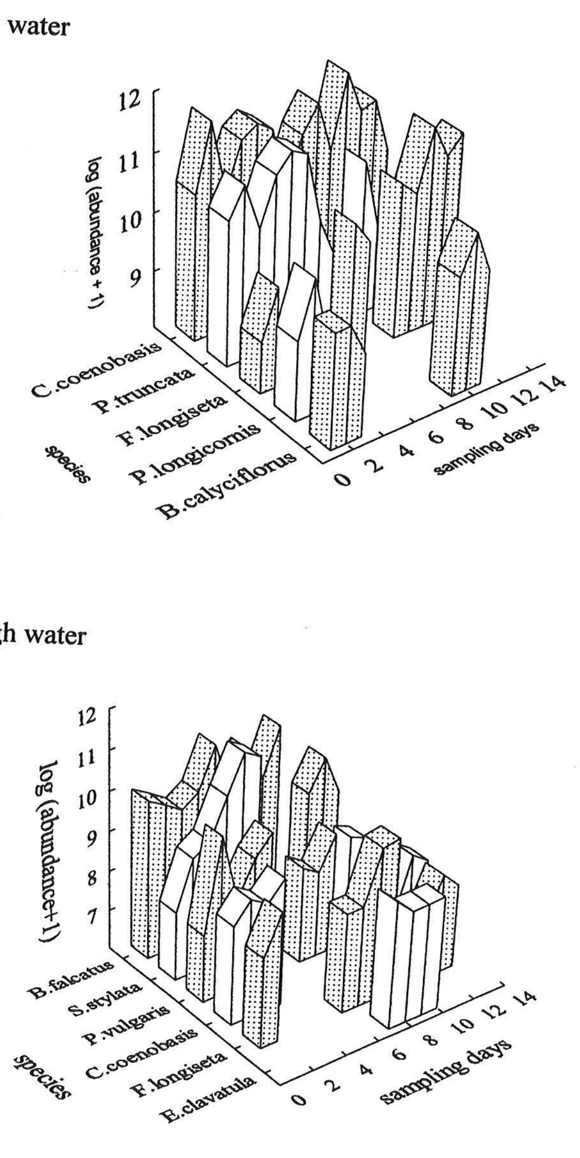

Fig. 4:
Abundant taxa densities in the lake during low and high water periods.

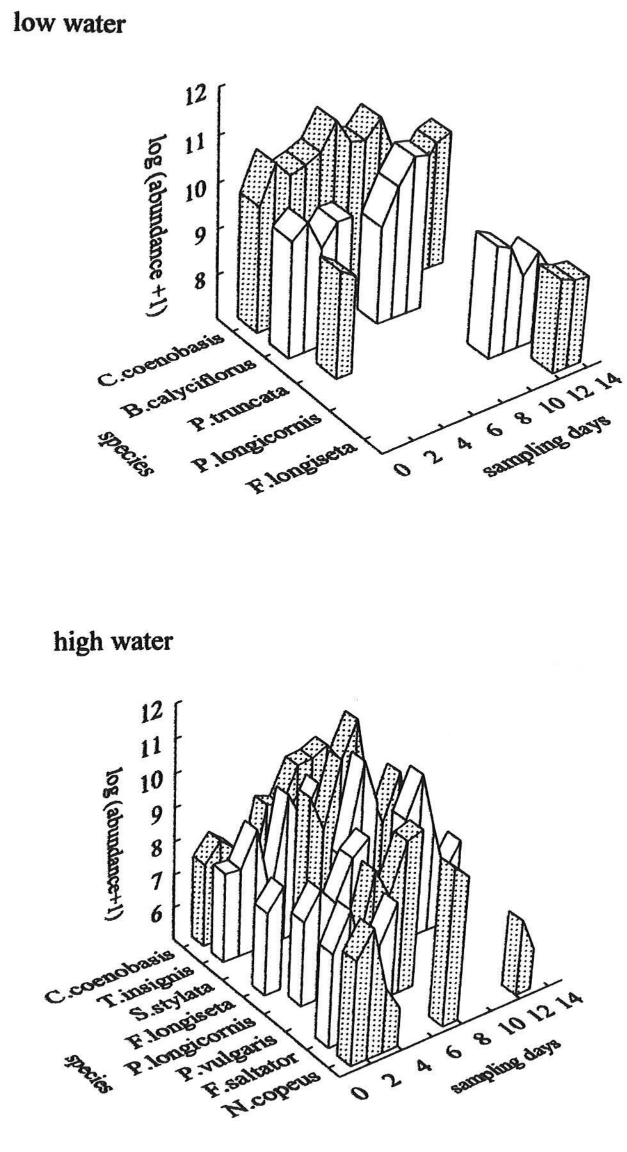

Fig. 5:
Abundant taxa densities in the river during low and high water periods.

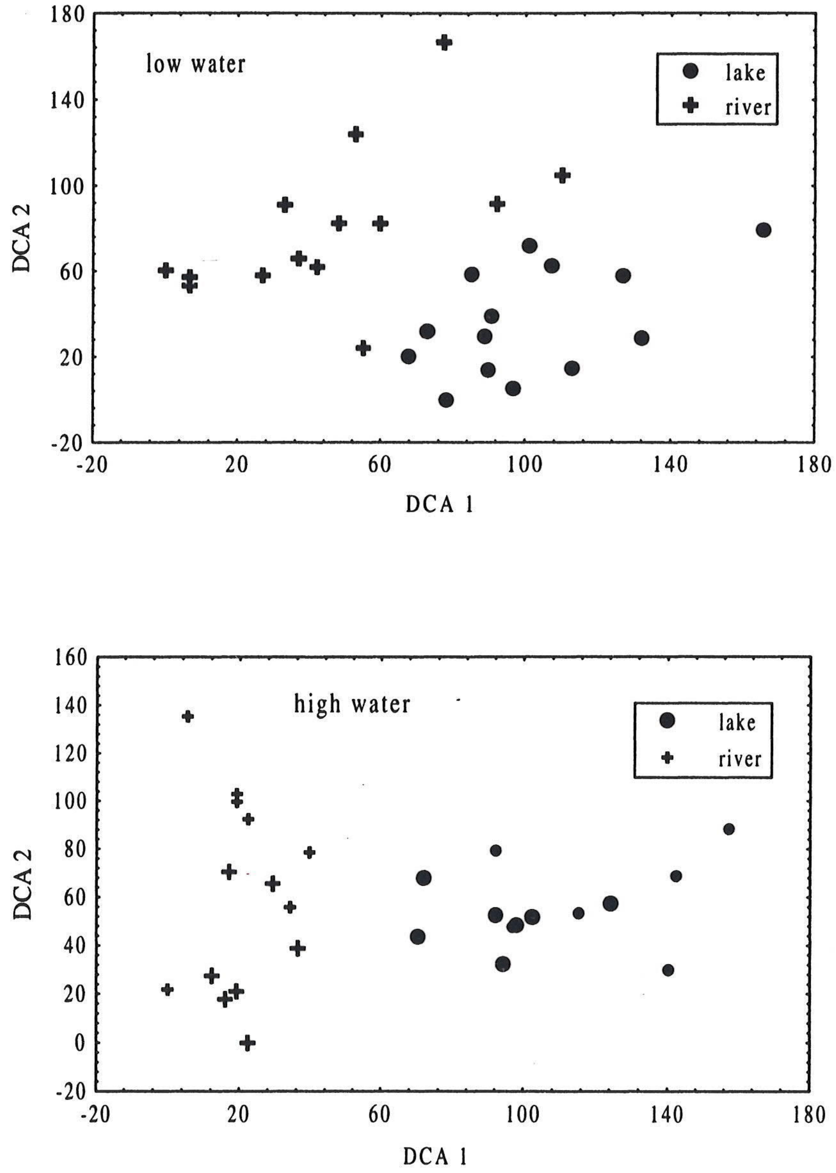

Fig. 6:
Dispersal of environment-sampling days scores along the first two axis of the DCA differentiating the environments during the low and high water periods.

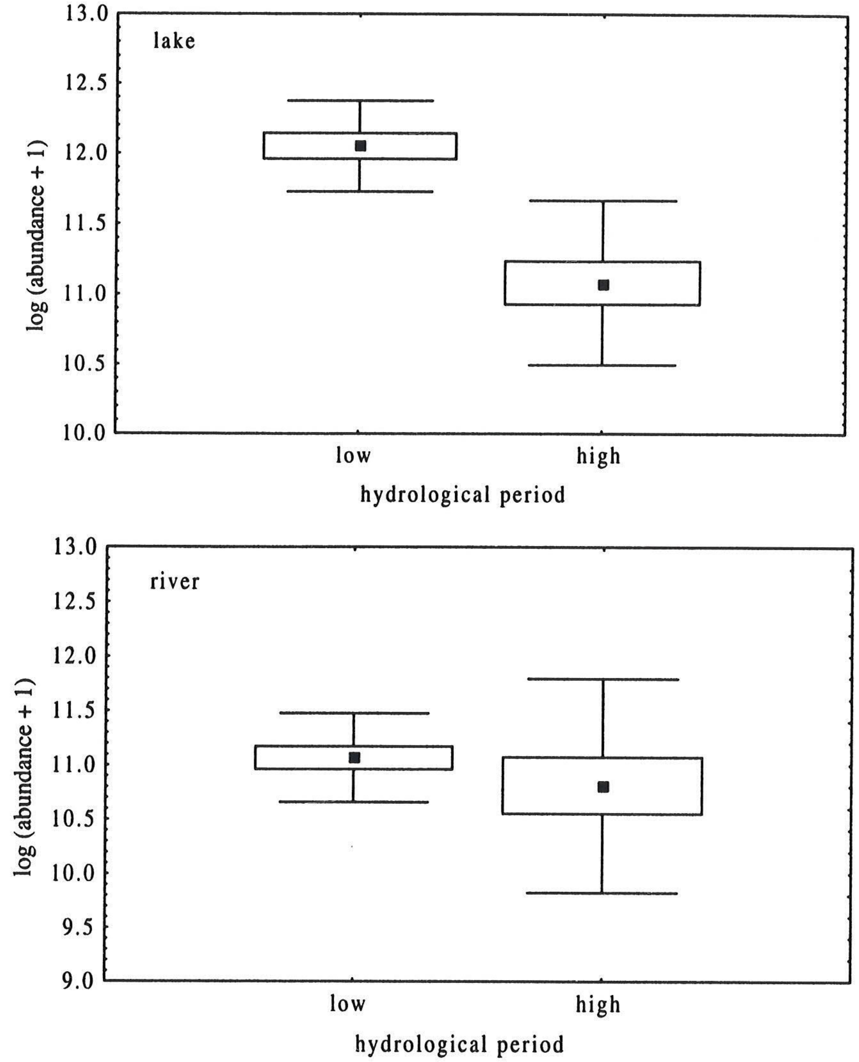

Fig. 7:
The mean and standard deviation of rotifer abundance in the lake and the river during the low and high water periods.