Post-drainage changes in the structure of the benthic macroinvertebrate community in a floodplain palustrine wetland in the South of Brazil.

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ABSTRACT: Post-drainage changes in the structure of the benthic macroinvertebrate community in a floodplain palustrine wetland in the South of Brazil. The drainage of wetlands for agricultural irrigation was the principal responsible for the destruction of wetlands in the South of Brazil. The objective of this study was to analyze the effects of a drainage event on the richness, density and composition of the benthic macroinvertebrate community in a floodplain palustrine wetland in the South of Brazil. Twelve monthly macroinvertebrate collections were carried out from April 2003 to March 2004. In each collection five macroinvertebrate samples were collected at random along the whole area of the studied palustrine wetland. The studied period was characterized by two hydrological phases: before and after the drainage event. A total of 48 taxons and 1,930 macroinvertebrates were sampled. Ephydridae was the single taxon observed in all collections. Tubificidae and Glossiphoniidae were present in 91% of collections. The mean number of taxons and the mean density of benthic macroinvertebrates were lower after the drainage event than before it and the macroinvertebrate composition varied between the two hydrological phases. The structure of the macroinvertebrate community changed with the decrease in the water level over the drainage succession in the studied palustrine wetland, where typically aquatic taxons were replaced by taxons either adjusted or resistant to the land condition. In this sense, programs aimed at the conservation of wetland biodiversity in the South of Brazil should be a priority, mainly when 90% of the wetlands in this area have disappeared along the last century.

Key-words: drainage, floodplain, wetland, macroinvertebrate, conservation.

RESUMO: Mudanças na estrutura da comunidade de macroinvertebrados bentônicos após a drenagem de uma área úmida palustre associada a uma planície de inundação no Sul do Brasil. A drenagem de áreas úmidas para irrigação da agricultura foi a principal causa da destruição desses ecossistemas no Sul do Brasil. O objetivo desse estudo foi analisar os efeitos da drenagem na riqueza, densidade e composição de macroinvertebrados bentônicos em uma área úmida palustre associada a uma planície de inundação no Sul do Brasil. Foram realizadas 12 coletas de abril de 2003 a março de 2004. Em cada coleta, cinco amostras de macroinvertebrados foram coletadas aleatoriamente ao longo de toda a extensão da área úmida palustre. O período estudado foi caracterizado por duas fases hidrológicas: antes e após o evento de drenagem. Um total de 48 táxons e 1.930 macroinvertebrados foi amostrado. Ephydridae foi o único táxon observado em todas as coletas. Tubificidae e Glossiphoniidae estiveram presentes em 91% das coletas. O número de táxons e a densidade de macroinvertebrados foram, em média, menores após o evento de drenagem do que na fase anterior à drenagem, e a composição de macroinvertebrados variou entre as duas fases hidrológicas. Na área úmida estudada, a estrutura da comunidade de macroinvertebrados variou com a diminuição do nível de água causada pela drenagem, onde táxons tipicamente aquáticos foram substituídos por táxons adaptados ou resistentes à condição terrestre. Nesse sentido, programas voltados à conservação da biodiversidade das áreas úmidas no Sul do Brasil deveriam ser prioritários, principalmente pelo fato de que 90% das áreas úmidas dessa região já foram destruídas ao longo do último século.

Palavras-chave: drenagem, planície de inundação, área úmida, macroinvertebrado, conservação.

Introduction

Many of the world's wetlands have been recognized for the wildlife conservation benefits they provide (Getzner, 2002). However, most wetlands, and especially rural wetlands were degraded as a result of various land use activities (agricultural, horticultural and urban) within their catchments. Almost 50% of the world's wetlands have disappeared in the last century due to agriculture and urban development (Shine & Klemm, 1999). In Europe, the situation is critical with the loss of almost 2/3 of wetlands by the beginning of the 20th century (Santamaría & Klaassen, 2002).

One of the main hydrological characteristics of South America is the existence of large wetlands (Neiff, 2001). In the South of Brazil, approximately 72% of the wetlands are smaller than 1 km² due to strong habitat fragmentation (Maltchik et al., 2003; Gomes & Magalhães Jr., 2004). The drainage of wetlands for agricultural irrigation, especially related to rice plantations, was responsible for the destruction of wetlands in this region (Gomes & Magalhães Jr., 2004). Understanding the impacts of the drainage on the structure of aquatic communities in natural wetlands is a priority for biodiversity conservation strategies in Southern Brazil.

The community of macroinvertebrates plays an important role in the trophic dynamics of the wetlands associated to floodplain systems (Van den Brink et al., 1994). Studies that analyzed the effects of the drainage continuum on the soil invertebrate fauna of wetlands were concentrated in the North Hemisphere (Silvan et al., 2000; Laiho et al., 2001; Wasilewska, in press). In the South of Brazil, these studies are unknown. The objective of this study was to analyze the effects of a drainage event on the richness, density and composition of the benthic macroinvertebrate community in a floodplain palustrine wetland in the South of Brazil.

Materials and methods

Study area

The study was carried out in a floodplain palustrine wetland located in the South of Brazil (Novo Hamburgo, Rio Grande do Sul) (29°43'19.7"S, 51°01'26.0"W) (Fig. 1). The floodplain system is associated with the Guari stream, a third order permanent tributary of the lower course of the Sinos River. It is 11 km long and 3 m wide, from its origin 100 m above sea level, to its confluence with the Lomba Grande wetland, 3 m above sea level. Annual precipitation in the Sinos River basin (~4,000 km²) ranges from 1,200 to 2,000 mm/y and it is distributed throughout the year. Increases in discharge due to high precipitation generate a series of floods of brief duration (1-3 days) that temporarily inundate the studied floodplain.

The area of the studied palustrine wetland has approximately 2 ha and it is a representative wetland class of the Sinos River Basin. It is located between the lower course of the Guari stream and a shallow lake (4 ha) (Fig. 1), 500 m far from the Guari stream. The palustrine wetland and the shallow lake had surface water permanently, both fed by surface water from the Guari stream during the flood events. The hydric soil of the palustrine wetland was constituted basically by silt. Eichhornia crassipes, Eichhornia azurea and Luziola peruviana were the dominant plant species found in the floodplain system. By the end of July 2003 the lake was drained for agricultural activities, and part of the upriver water was diverted to avoid new flood events.

Macroinvertebrates sampling

Twelve monthly macroinvertebrate collections were carried out from April 2003 to March 2004. In each collection five macroinvertebrate samples were collected at random along the whole area of the studied palustrine wetland. The samples were collected using a corer (7.5 cm diameter) inserted 5 cm into the substratum, preserved in 10% formaldehyde and taken to the laboratory, where they were elutriated through 0.42 mm mesh to remove mud and plant remains. The used mesh size was small enough to retain most macroinvertebrates (Batzer et al., 2001). For the sorting and classification of the macroinvertebrates specimens in the laboratory it was used a 40X magnification through a stereomicroscope, and then the organisms were kept in small tubes with 80% alcohol in the reference collection of the Laboratório de Ecologia e Conservação de Ecossistemas Aquáticos (UNISINOS). The macroinvertebrate classification was made based on Borror & Delong (1969), Lopretto & Tell (1995), Merritt & Cummins (1996) and Fernández & Domínguez (2001).

Data analyses

The flood duration was measured in days and classified as brief (between two and seven days) and very brief (between 4 and 48 hours) (Tiner, 1999). The macroinvertebrate richness and density were the total number of taxons and individuals per collection (n=5), respectively. The macroinvertebrate taxons considered more abundant were represented by 10 or more individuals found over the studied period. The macroinvertebrate density was log transformed to remove heteroscedasticity.

Variations of the number of taxons and density of macroinvertebrates over the studied period and between the two hydrological phases (before and after of drainage event) were evaluated through analysis of variance (One-Way ANOVA) and t-test, respectively.

The composition of macroinvertebrates along the studied period was analyzed through Detrended Correspondence Analysis (DCA) (Hill & Gauch, 1980). DCA is geared to ecological data sets and the terminology is based on samples and species. Collection scores were categorized according to the hydrological phase, and the biological variables were the macroinvertebrate taxons seen as more abundant over the studied period. The variation of macroinvertebrate composition between the two hydrological phases (before and after of drainage event) was analyzed by Multi-Response Permutation Procedures (MRPP), considering the same macroinvertebrate taxons utilized in DCA. Moreover, the density of the more abundant taxons was compared between the hydrological phases through t-test.

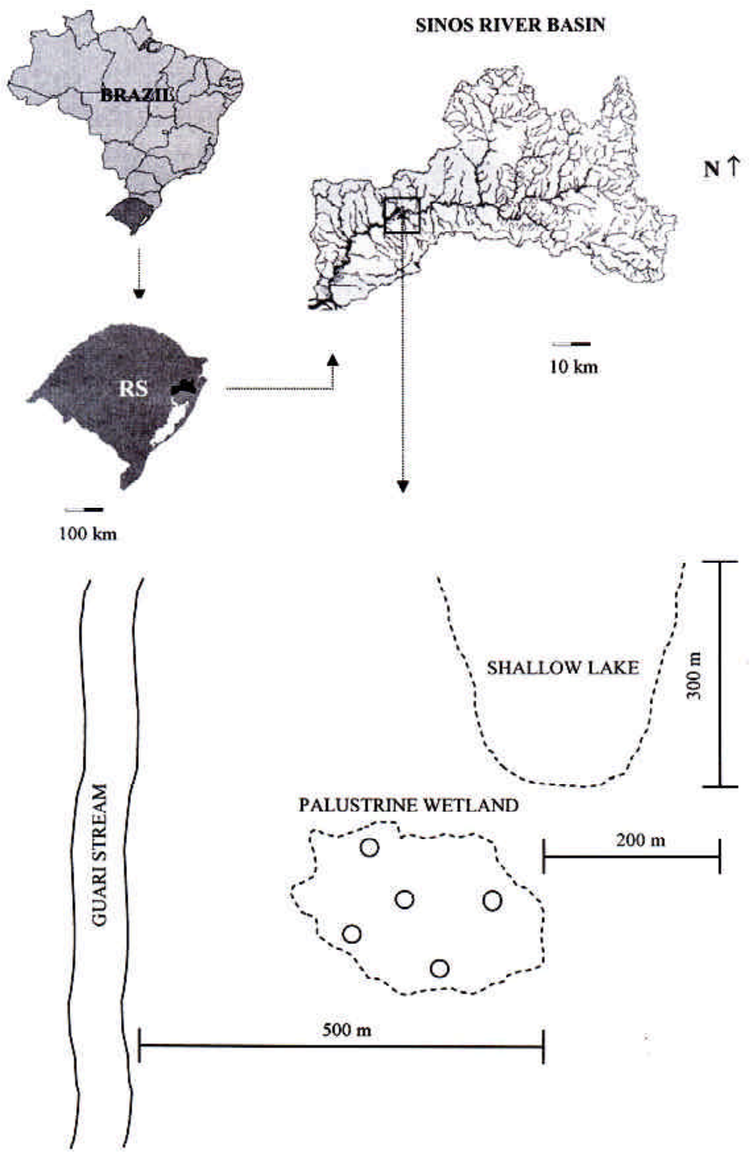

Figure 1: Position of studied floodplain palustrine wetland in the Sinos River basin (Rio Grande do Sul, Brazil) showing the sampling procedure.

Results

The studied period was characterized by two hydrological phases: before and after the drainage event. Before the drainage event (from April 16 to July 9), the palustrine wetland was characterized by presence of surface water (water depth between 24 and 40 cm) and the occurrence of three flood events (Tab. I). Two floods were considered of very brief duration (one day), and one flood was considered of brief duration (three days). After the drainage event (from August 6 to March 12), the surface water decreased to zero, and flood occurrence was not observed; however, the hydric soil still remained saturated (Tab. I).

Table I: Physical characteristics and macroinvertebrate richness and density (n=5) in the floodplain palustrine wetland over the studied period (2003-2004).

	16 apr	**25 apr**	**30 apr**	**28 may**	**16 jun**	**18 jun**	**07 jul**	**09 jul**	**06 aug**	**03 sep**	**01 oct**	**29 oct**	**10 feb**	**20 feb**	**12 mar**
Hydrological phases	**Phase with floods and surface water**								**Drained phase**						
Flood duration (Days)	-	1	-	-	1	-	3	-	-	-	-	-	-	-	-
Days after floods (Days)	-	0	5	33	0	2	0	2	30	58	86	114	156	228	249
Water Depth (cm)	36	40	24	24	40	39	40	30	-	-	-	-	-	-	-
Total Richness	18	-	16	7	-	16	-	12	19	11	19	13	12	22	12
Total Density	462	-	382	145	-	268	-	142	169	164	84	26	28	18	42

*flood occurrence

A total of 48 taxons and 1,930 macroinvertebrates were sampled. The majority of macroinvertebrate taxons corresponded to aquatic insects (70.8%). Ephydridae was the single taxon observed in all collections. Tubificidae and Glossiphoniidae were present in 91% of collections. A total of 21 taxons were present in one only collection. Ephydridae, Tubificidae and Glossiphoniidae represented 75% of the total number of sampled individuals over the studied period (Fig. 2).

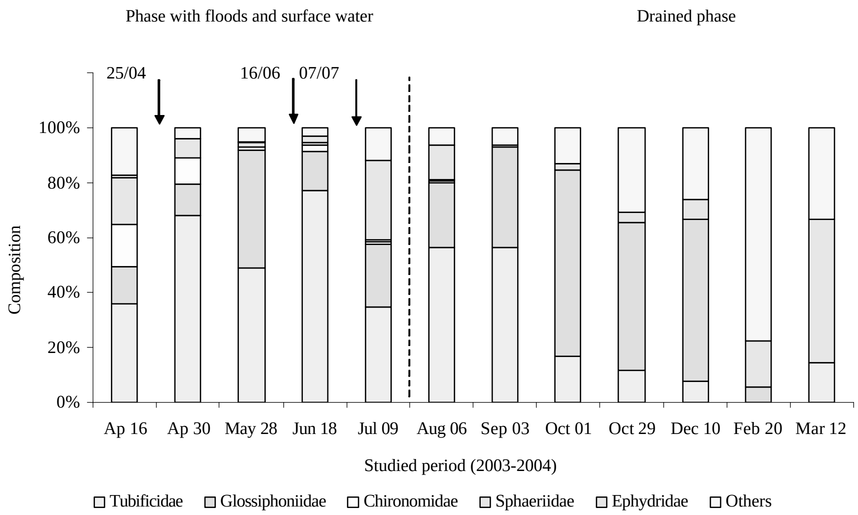

Figure 2: Macroinvertebrate composition in the floodplain palustrine wetland over the studied period (2003-2004). Arrow = flood occurrence.

While 39 macroinvertebrate taxons and 1,399 individuals were observed before the drainage event, 30 taxons and 531 individuals were observed after it. A total of 18 macroinvertebrate taxons were observed only before the drainage event, nine taxons were present only after the event, and 21 macroinvertebrate taxons were common to both phases. Tubificidae, Glossiphoniidae, Chironomidae, Ephydridae, and Sphaeriidae represented 87.2% of the total number of individuals collected before the drainage event, and 83.6% after drainage event.

The mean number of taxons and density of macroinvertebrates varied during the studied period ($F_{11,48}$ = 7.182; P<0.001 and $F_{11,48}$ = 6.813, P<0.001, respectively) and tended to decrease in the drained phase (Figs. 3 and 4). The total number of taxons and density of macroinvertebrates was lower after the drainage event than before it (t= 2.779, df= 10, P= 0.019 and t= 3.372, df= 10, P= 0.007, respectively) (Tab. I).

Based on the DCA ordination, the first and the second axes of DCA explained 46.8% of the variance in the macroinvertebrate composition (39.1% and 7.7%, respectively) (Fig. 5). The axis 1 of DCA evidenced a gradient of variation on the macroinvertebrate composition before and after drainage (Fig. 5), and the MRPP analysis confirms this change of the macroinvertebrate composition between the two hydrological phases (A=0.1955, P=0.013). While Chironomidae, Sphaeriidae, Cladocera, Tabanidae, Cyclopidae, Ceratopogonidae, Dugesiidae, Isotomidae, and Tubificidae taxons were more associated to the phase with floods and surface water, Curculionidae, Dytiscidae, Leptoceridae, and Ephydridae families were more associated to the drained phase (Fig. 5). However, the density of some macroinvertebrate taxons was similar between both hydrological phases, e.g., Glossiphoniidae and Planorbidae families (t test, P>0.05).

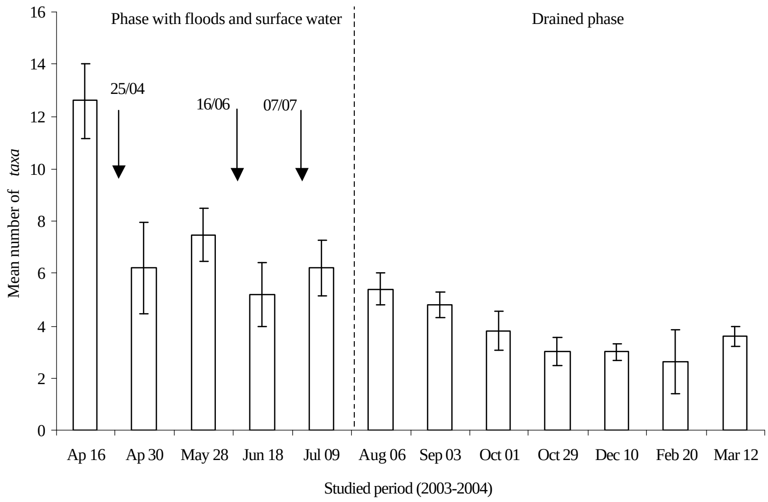

Figure 3: Mean number of taxons of macroinvertebrates in the floodplain palustrine wetland over the studied period (2003-2004). Arrow = flood occurrence.

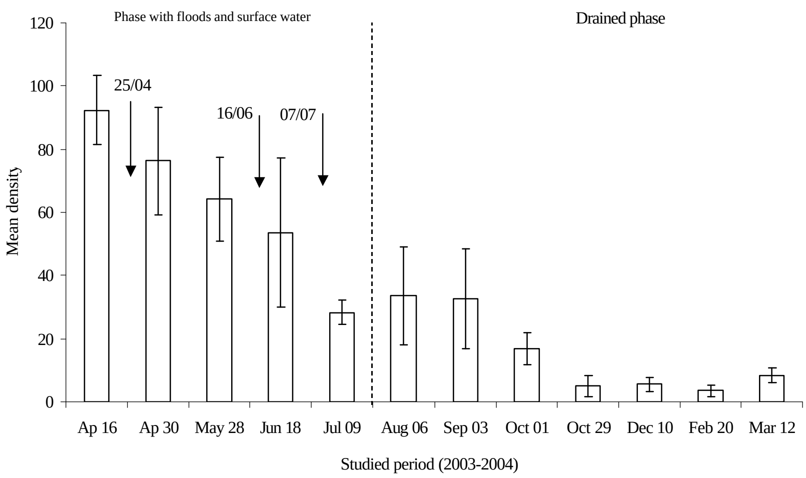

Figure 4: Mean density of macroinvertebrates in the floodplain palustrine wetland over the studied period (2003-2004). Arrow = flood occurrence.

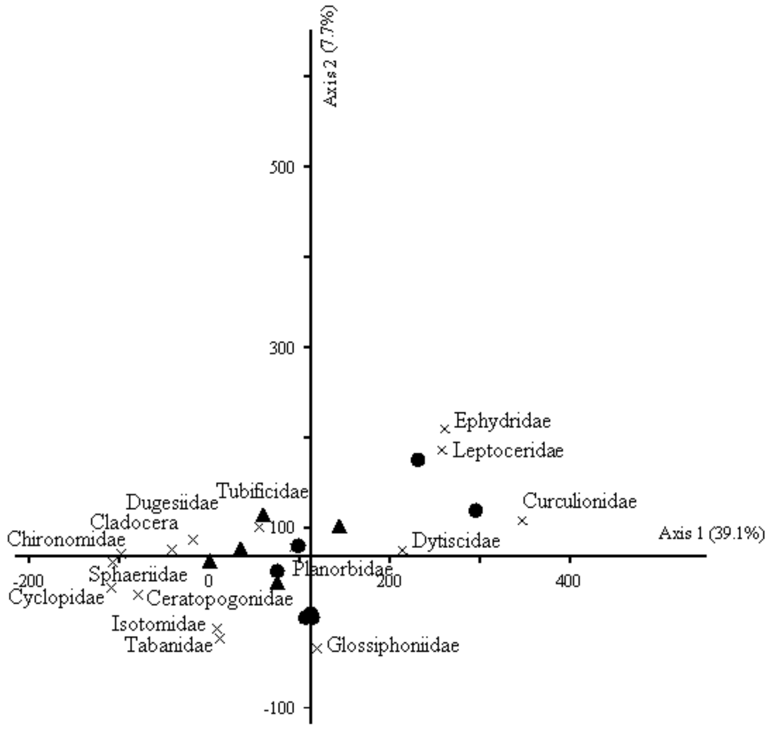

Figure 5: Diagram of Detrended Correspondence Analysis (DCA) ordination: Relationship among collections of each hydrological phase (▲= phase with floods and surface water; • = drained phase) and macroinvertebrate taxons (x).

Discussion

The loss of aquatic diversity due to wetland drainage for intensive agriculture was largely undocumented, and the changes in soil fauna over the drainage succession have not been systematically studied. In our study the effects of the drainage event on the number of taxa and density of aquatic macroinvertebrates were clearly negative. Coulson et al. (1990) also evidenced that drainage can eliminate or degrade wetlands and their associated invertebrate communities. The loss of water imposes a potential catastrophe on aquatic fauna. Many changes in the abiotic characteristics of the wetland are linked to the disappearance of the water, e.g., decrease in habitat size (area and depth) (Williams & Hogg, 1996), increased insolation, changes in dissolved oxygen and temperature of water until the wetland total dryness (Williams, 1996). In natural temporary pools, the drought is often a major mortality factor for insects (Jeffries, 1994). Aquatic insects have countered the modification of their habitat (aquatic to terrestrial conditions) by means of physiological tolerance, migration, and life history modification (Williams, 1996).

Typical wetland species decreased after drainage while habitat generalists and species preferring drier environments took their place (Markkula, 1986). Silvan et al. (2000) and Laiho et al. (2001) found that the number of the studied soil invertebrates clearly increased after drainage in peatlands drained for forestry in Southern Finland. Kozlovskaja (1974) and Vilkamaa (1981) also noticed that densities and activity of soil invertebrates were higher on drained than undrained peatland wetlands. The disappearance of surface water in the studied wetland resulted in change of the composition of macroinvertebrate taxons. The macroinvertebrates associated to the phase with surface water were represented by typically aquatic taxons. After the drainage event, the macroinvertebrate composition varied, and the taxons associated to this phase were represented by Curculionidae, a coleopteran family typically terrestrial, and by brachyceran Ephydridae, a dipteran family most prevalent in temporary than in permanent wetlands (Williams, 1996). Dytiscidae is a typically aquatic family, although its presence and density have been related to the drained phase. The resistance of desiccation in adult aquatic insects was best documented for beetles that survive drying by burying themselves in the mud (Wiggins et al., 1980; Lake et al., 1989; Jeffries, 1994). The fact that the hydric soil kept itself saturated up to the end of the study could have favored the resistance of the Dytiscidae family in the drained phase when compared with other families of aquatic insects.

Our results have identified a negative effect of draining on the richness, density and composition of aquatic macroinvertebrates. The structure of macro-invertebrate community changed with the decrease in the water level over the drainage succession in the studied palustrine wetland, where typically aquatic taxons were replaced by taxons either adjusted or resistant to the land condition. In this sense, programs aimed at the conservation of wetland biodiversity in the South of Brazil should be a priority, mainly when 90% of the wetlands in this area have disappeared along the last century.

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