Influence of Rice Crop on the Benthic Community in Itajaí Valley (Santa Catarina, Brazil).

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ABSTRACT: Influence of Rice Crop on the Benthic Community in Itajaí Valley (Santa Catarina, Brazil). The main aim of this study was to evaluate the influence of the management and the different growing stages of rice crop on the benthic macroinvertebrates community. The study was developed in Itajaí Valley – Santa Catarina and the samples were collected during the growing cycle of the flooded rice, considering two types of management: continuous and intermittent submersions. It was identified 21,831 organisms, being Chironomidae significantly more abundant than other taxa. The results showed a lower abundance and/or absence of organisms sensible to pollution, like Ephemeroptera, Plecoptera and Trichoptera. The type of management developed in Agrolândia, Santa Catarina caused lower impact in the macroinvertebrate fauna, being observed high richness and diversity of organisms in this local. The stages of rice in a growth influenced unsignificantly in the benthic community. The biodiversity loss verified in some sampling sites, demonstrates that environmental disturbance provoked by the techniques of rice crop, caused a reduction of habitats and a ecosystem simplification.
Key-words: Benthic macroinvertebrates, biomonitoring, flooded rice, environmental quality.

RESUMO: Influência da Cultura de Arroz Sobre a Comunidade Bentônica no Vale do Itajaí (Santa Catarina, Brasil). Este trabalho teve por objetivo avaliar a influência do manejo e diferentes estádios de desenvolvimento da cultura do arroz sobre a comunidade de macroinvertebrados bentônicos. O estudo foi desenvolvido no Vale do Itajaí (SC) e as coletas foram realizadas durante o ciclo de desenvolvimento do arroz irrigado, considerando dois tipos de manejo: submersão contínua e intermitente. Foi identificado um total de 21.831 organismos, sendo Chironomidae significativamente mais abundante do que os demais taxa. Os resultados mostraram uma reduzida abundância e/ou ausência de organismos sensíveis à poluição, como Ephemeroptera, Plecoptera e Trichoptera. O tipo de manejo desenvolvido em Agrolândia – SC causou menor impacto a fauna de macroinvertebrados, sendo observado maior riqueza e diversidade de organismos neste local. Os estádios de desenvolvimento do arroz não influenciaram significativamente a comunidade bentônica. Conclui-se que a perda da biodiversidade verificado em alguns pontos de coleta demonstra que distúrbios ambientais provocados pelas técnicas de cultivo do arroz levam a diminuição de habitats levando com isso à simplificação de ecossistemas.
Palavras-chaves: Macroinvertebrados bentônicos, biomonitoramento, arroz irrigado, qualidade ambiental.

Introduction

The aquatic ecosystems have been modified in significant way in function of multiple environmental impacts of the anthropic activities. As the rivers can be considered natural collectors of the landscapes, reflecting the land use of its respective drainage basin (Callisto & Goulart, 2005), an expressive loss of water quality and biodiversity in these ecosystems has been observed (Tundisi, 2003). Thus, the communities in these environments are continuously displayed to the modifications (Callisto & Goulart, 2005). These alterations are detected by the presence or disappearance of the aquatic organisms populations (Gage et al., 2004).

The rice is one of the most important

annual cultures produced in Brazil, meaning about 20% of the grains harvested in the country. The Santa Catarina State, in the 2004/05 harvest, had a production of 997 thousand tons, being the first Brazilian state in average income (6,829.9 Kg/ha) in a planted area of 155,426 ha (Icepa, 2005). This crop is among one of the most demanding in terms of hydric resources, and for the production of 1 kg of rice with rind, it is necessary 2,000 liters of water (Embrapa, 2005). The importance of the water in the rice production is related to its use in the land preparation, to the supplement of water necessity of the plant, to the easiness of weeds control, disease and of some insect-plagues and to the improvement in the nutrients availability (Carbonari et al., 2000; Gomes & Magalhães, 2004; Molozzi et al., 2006).

The rice fields constitute a relatively temporary habitat for aquatic biota (Bambaradeniya et al., 2004), presenting great variations in the physical, chemical and biological aspects (Fernando, 1993). Nevertheless, these sites present a rich diversity of aquatic organisms, composed mainly for arthropods (Bambaradeniya et al., 2004). However, agricultural practices associates to the crop management, as the application of pesticides, fertilizers in the land and irrigation methods, affect the colonization of macroinvertebrates, decreasing the species richness (Suhling et al., 2000; Shepherd et al., 2004: Mesleard et al., 2005). Fernando (1993) comments that the management practice of the crop contribute decisively for the reduction of the diversity in these cultures. In studies approaching the influence of the rice crop and the macroinvertebrates diversity carried out in Spain, it was detected raised indices of organic contamination near of rice fields, resulting in the reduction of the macroinvertebrates diversity (Carballo, 2003). In Australia, Douglas & O'Connor (2005) observed the effect of chemical products used in the rice crop in the benthic macroinvertebrates community, what resulted in a significant decrease of the diversity of these organisms.

The knowledge of the structure in benthic macroinvertebrates community composes a basic step for the agreement of the interspecifics relations and the ecosystem as a whole (Bueno et al., 2003). Fernando (1993) suggests that is necessary more knowledge about the interactions between aquatic organisms and rice crop. The aim of this study was to evaluate the effects of crop management and the different growing stages of rice crop on the benthic macroinvertebrates community in rice fields of Itajaí Valley – Santa Catarina.

Study Area

The study was carried out in Gaspar and Agrolândia, located in the Itajaí Valley, Santa Catarina State, South Brazil. Gaspar is situated in the middle Itajaí Valley (26°55'53" S; 48°57'32" W, with an average altitude of 18 m). The climate is classified as humid mesothermic, with annual average temperature of 20.1°C and an annual precipitation between 1,500 and 1,700 mm. Agrolândia presents an area of 198 km² and, is located in the upper Itajaí Valley (27°24'42" S; 49°49'32" W, with an average altitude of 405 m) (Fig. 1). The climate is classified as humid mesothermic, with an average temperature of 18°C and annual precipitation of 1,300 mm (Molozzi, 2006).

The sampling sites of benthic organisms had been stretches of adjacent streams to the studied rice fields. In Gaspar (sampling sites P1, P2, P3 and P4), the rice fields present as main characteristic of crop management, the use of continuous submersion irrigation method, where a water blade is kept in the field during all the period of the culture. In Agrolândia (sampling sites P5 and P6), the system of crop irrigation is an intermittent type, where the water supplements in the field were made in irregular periods. Molozzi (2006) cited that the management at Gaspar is the most common used in Santa Catarina, although causing great damages to the environment, due the vegetation removal and opening of canals for entrance and exit of the water in the rice fields. The average depth of the sites is 0.32 m; pH is lightly alkaline (7.27) and the average contents of dissolved oxygen are 7.75 mg/L (Molozzi, 2006).

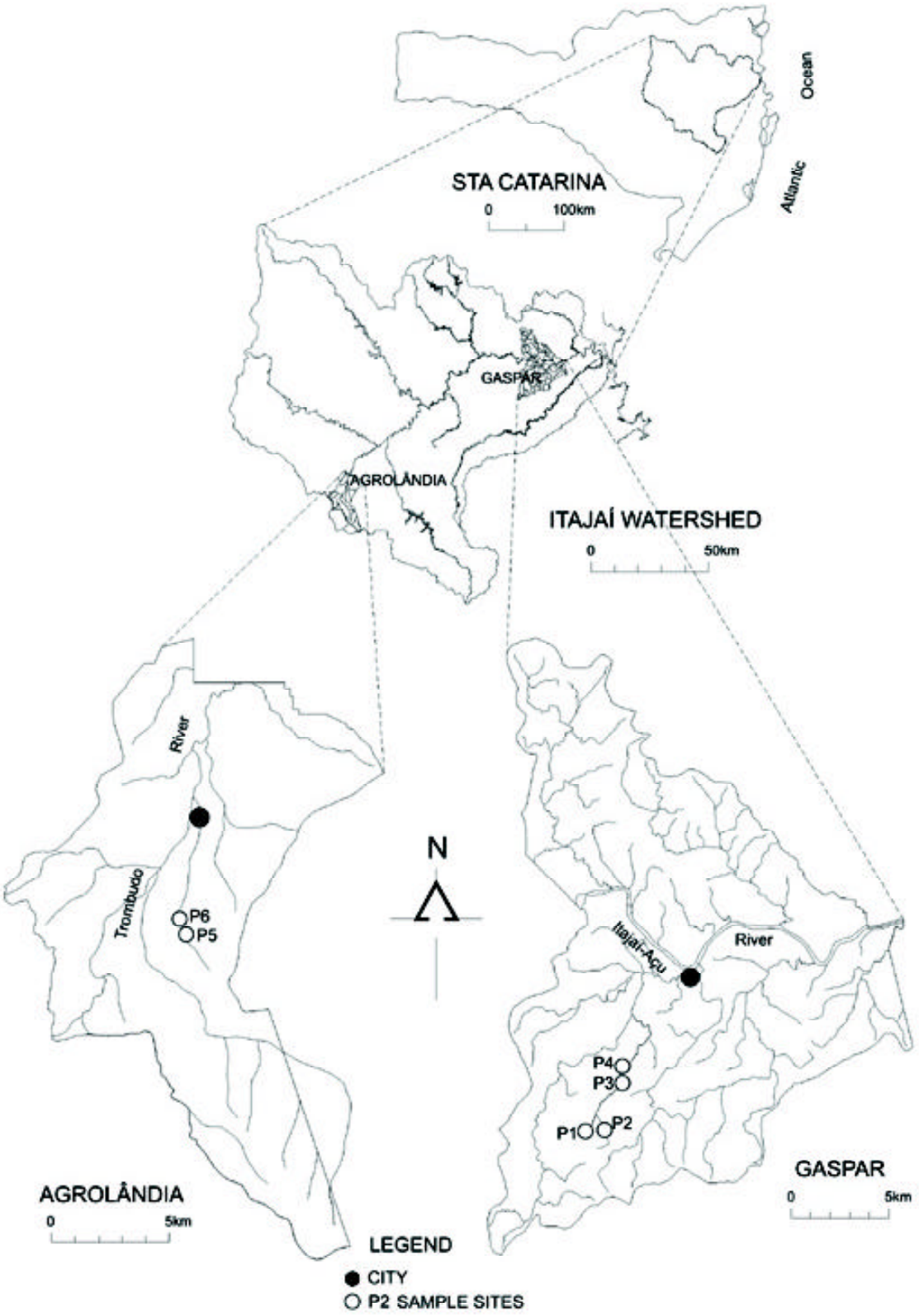

Figure 1: Sampling sites in Gaspar and Agrolândia cities, SC, where the samples were realized in the period of 2004/05.

Material and methods

Macroinvertebrates Benthic

Three samples of benthic macroinvertebrates were carried out in each site, during the developing rice cycle. In Gaspar, the organisms were sampled in August, 2004 and February, 2005 and in Agrolândia, in October, 2004, January and April, 2005. This periodicity was adopted in order to evaluate the different stages of growing on the macroinvertebrate benthic community. The difference between the periods of collection was due to the crop management types adopted in each site. The first sample corresponded to the stages of (i) land preparation and germination; (ii) growth and reproduction and, (iii) maturation and cut.

The benthic organisms were collected with a Surber sampler (0.1 m² area and 0.225 mm of mesh), being realized 10 sub-samplings in each site distributed randomly enclosing the different types of substrate found in the sites, totalizing 1 m² of sampling area. The collected material was fixed in field with formol 10%, stored in plastic bags and taken to the laboratory and washed in sieves with 2, 1 and 0.5 mm of mesh. For the identification, it was used the identification keys of Merritt & Cummins (1996), Bond-Buckup & Buckup (1999) and Fernandes & Domingues (2001).

Data analyses

The values of organisms density (ind/m²), richness (number of identified taxa) and Shannon Diversity and Pileou Evenness indices (Magurran, 2004) were calculated. In order to evaluate the difference of the biologic metric calculated between culture stages and different managements, the ANOVA ($p < 0.05$) was applied (Gotelli & Ellison, 2004). In order to evaluate the similarity between sampling areas, a cluster analysis was carried out (UPGMA) using the Bray-Curtis coefficient similarity with the densities data adjusted (log x + 1) to decrease the variances between the values. The statistics tests were made using the BioEstat Software 3.0 (Ayres et al., 2003) and MVSP (MVSP, 2000).

Results

A total of 21,831 organisms, distributed in 28 taxa was collected (Tab. I). The most abundant site was P4 with 38.37% of the collected organisms, followed by P3 (21.37%), P5 (18.14%), P6 (11.73%), P2 (6.06%) and P1 (4.34%). The most representative taxa were Chironomidae (Diptera) (73.92%), Baetidae (Ephemeroptera) 5.95% and Elmidae (Coleoptera) with 2.50% of the total organisms. Chironomidae was common in all the crop areas and growing stages, being that in P4, these organisms were significantly more abundant (7,346 ind/m²; $F_{5,12} = 4.22$; $p = 0.01$). In sites P5 and P6, high taxa richness ($F_{5,12} = 3.93$; $p = 0.02$) and diversity ($F_{5,12} = 3.37$; $p = 0.03$) were found, while that in P2 and P5 the values were similar ($F_{5,12} = 3.15$; $p = 0.04$) (Fig. 2).

Table I: Total density (ind/m²) of benthic macroinvertebrates collected in different stages of the irrigated rice crop in Itajaí Valley - SC in 2004 and 2005.

Taxa	P1	P2	P3	P4	P5	P6
Annelida						
Hyrudinea	13	13	1	151	115	49
Oligochaeta	13	37	4	46	29	26
Mollusca						
Gastropoda	29	5	5	324	55	47
Bivalve	343	23	7	77	98	38
Crustacea						
Copepoda	-	3	8	10	41	24
Carcinidae	1	-	-	-	-	-
Hidracarina	25	94	42	2	62	33

Table I: Cont.

Taxa	P1	P2	P3	P4	P5	P6
Insecta						
Odonata						
Lestidae	-	-	1	-	-	-
Libellulidae	-	-	1	1	1	1
Calopteygidae	-	-	-	-	2	-
Plecoptera						
Gripopterygydae	-		1	-	6	-
Perlidae	-		4	-	4	2
Ephemeroptera						
Caenidae	-	-	1	-	28	20
Baetidae	15	70	187	26	619	287
Trichorythidae	8	19	21	-	388	112
Leptophlebidae	-	4	8	1	238	109
Trichoptera						
Hydrobiosidae	-	-	1	-	-	-
Hydropsichidae	8	44	119	4	35	90
Hydroptilidae	3	2	49	60	27	11
Leptoceridae	51	58	43	37	28	24
Philopotamidae	-	3	6	21	7	23
Helicopsychidae	2	-	-	-	1	-
Odontoceridae	1	-	-	-	-	1
Diptera						
Chironomidae	403	607	3650	7346	1727	1223
Ceratopogonidae	8	18	16	34	14	5
Empididae	-	5	10	2	5	9
Simuliidae	10	8	205	118	98	67
Stratiomyidae	-	-	-	1	-	-
Tabanidae	-	-	-	-	4	-
Coleoptera						
Elmidae	8	147	73	3	98	41
Psephenidae	-	1	-	-	28	68
Curculionidae	-	83	26	2	125	131
Hydrophilidae	-	-	-	2	-	-
Dryopidae	-	-	-	-	4	-
Scarabaeidade	1	76	34	-	50	97

Table I: Cont.

Taxa	P1	P2	P3	P4	P5	P6
Hemiptera						
Gerridae	-	-	2	-	-	1
Corixidae	-	-	2	-	-	-
Collembola						
Hypogastruridae	-	-	-	7	7	7
Isotomidae	6	2	138	100	16	12
Megaloptera						
Corydalidae	-	-	-	1	-	2

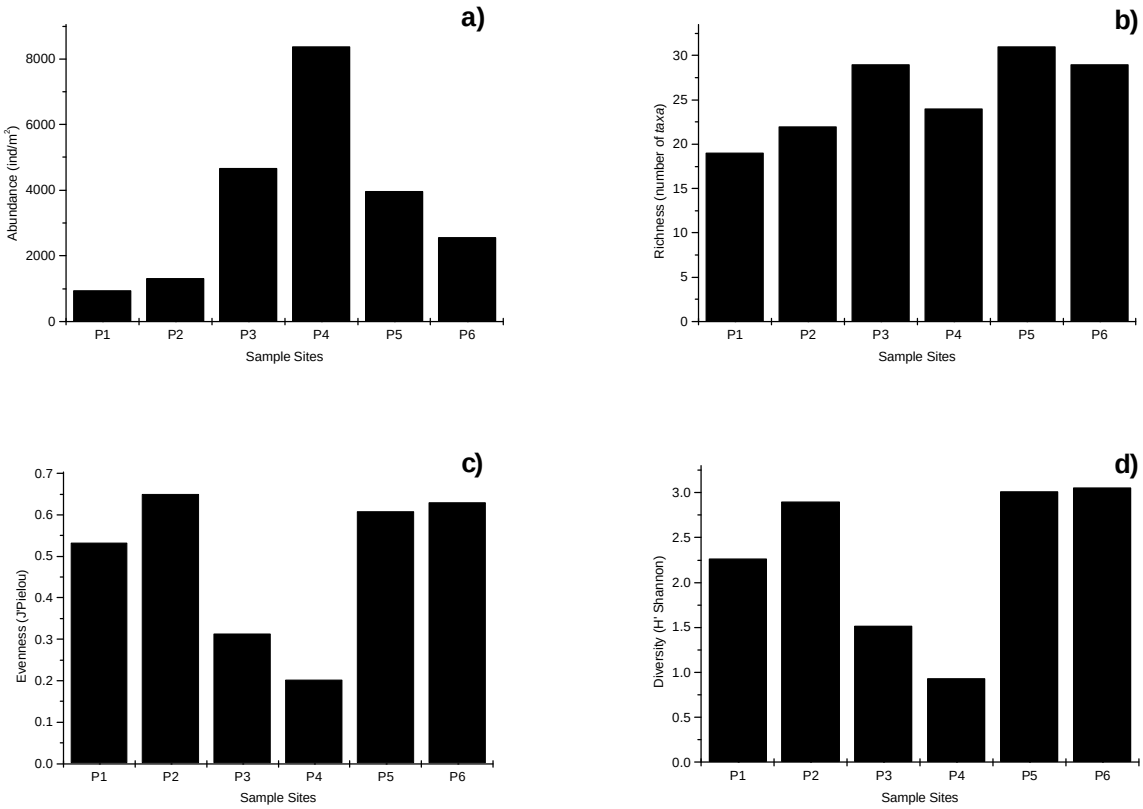

Figure 2: Abundance (ind/m²) (a), richness (b), evenness (Pielou) (c) and diversity (Shannon-Wiener) (d) values of benthic macroinvertebrates collected in rice irrigated crop areas in Itajaí Valley - SC.

In the period of land preparation and germination in Gaspar (P1, P2, P3 and P4 sites) it was found 1,811 ind/m². In the period of growth and reproduction the density was of 1,532 ind/m² and for the period of maturation and cut, the density was 2,041 ind/m². In relation to Agrolândia (P5 and P6 sites), it was registered 2,658 ind/m² density in the period of land preparation and germination. In the period of growth and reproduction, the density was 3183 ind/m2 and in the final period, before the harvest, it presented a density of 2,356 ind/m².

Among the different stages of the rice crop, no significant difference was recorded between the biologic metrics evaluated ($p > 0.05$). However, the stage of growing and reproduction presented highest density and average richness (3,435 ind/m² and 27 taxa, respectively). During the stage of maturation and cut, highest average values were found for the

diversity and evenness (2.146 and 0.533, respectively) (Tab. II). On the other hand, when compared the different managements of the rice fields (Gaspar and Agrolândia), a significant difference was verified among the diversity values ($F_{1,4}$ = 10.98; p = 0.03) and of richness values ($F_{1,4}$ = 66.26; p = 0.002). The similarity analysis showed the formation of three groups, being they formed by the P1 (group 1), P4 (Group 2) and, P2, P3, P5 and P6 sites (Group 3), present great similarity (Fig. 3).

Table II: Abundance (ind/m²), richness (number of taxa), evenness and diversity values of benthic macroinvertebrates in function of the different stages of rice cultivation in Itajaí Valley- SC in 2004 and 2005.

Rice fields/Stages	Abundance	Richness	Evenness	Diversity
All rice fileds (n=6)				
Land preparation/Germination	1769	26	0.501	2.094
Growth/Reprodution	3435	27	0.494	2.083
Maturation/Cut	1884	24	0.533	2.146
Gaspar – SC (n=4)				
P1, P2, P3 and P4				
Land preparation/ Germination	1052	17	0.464	1.811
Growth/Reproduction	1745	15	0.401	1.532
Maturation/Cut	1031	15	0.538	2.041
Agrolândia – SC (n=2)				
P5 and P6				
Land preparation/ Germination	717	25	0.576	2.658
Growth/Reproduction	1691	26	0.681	3.183
Maturation/Cut	853	23	0.523	2.356

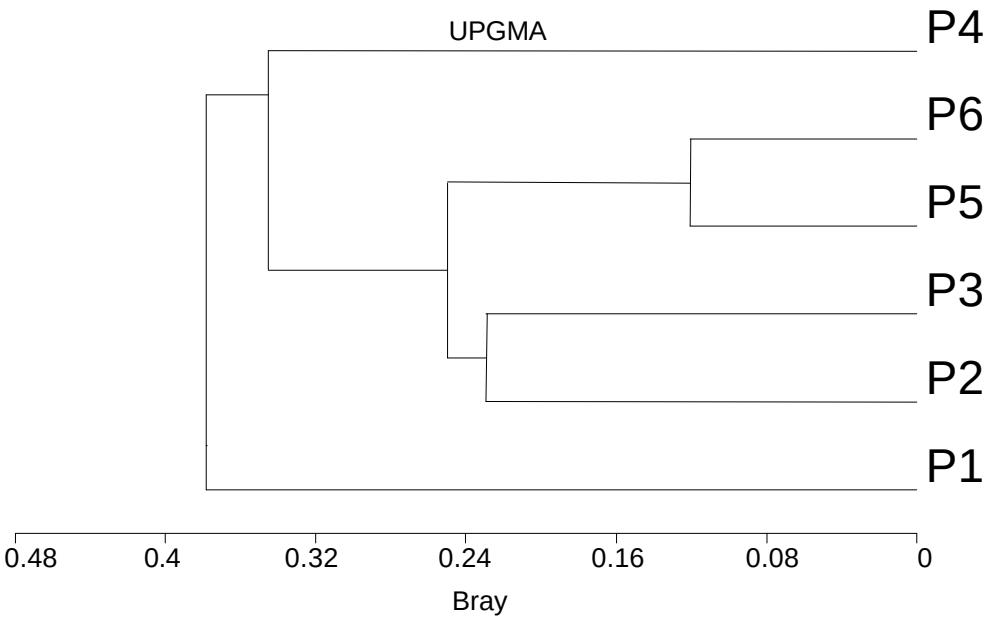

Figure 3: Dendogram of similarity between the rice crop areas in Itajaí Valley - SC.

Discussion

The great abundance of Chironomidae family is due to the fact that some genera are capable to live in condition of total depletion of oxygen for some hours (Kleine & Trivinho-Strixino, 2005). In rice fields, high densities of Chironomidae, Oligochaetas e Mollusca are very common (Fernando, 1993: Suhling et al., 2000). Chironomidae presents great environmental plasticity, living where other more sensible organisms, as the Ephemeroptera, Plecoptera and Trichoptera (EPT) are absent. This explains the low density of EPT in the six sites, during all the cycle of rice crop. Suhling et al. (2000) comment that the low density of organisms of the EPT is due to the insecticides application and the high concentrations of nitrogen and phosphorus. Mesleard et al. (2005) cited that in systems of organic production of rice, Ephemeroptera and Coleoptera were the most abundant organisms, while that Chironomidae predominated in systems of conventional management (application of chemical products).

In growth and reproduction stages of rice, an intense application of chemicals occur in the fields (Molozzi et al., 2006). The pesticide presence in the water surface can result in a reduction of macroinvertebrates diversity due to the elimination of the less tolerant organisms, allowing to the generalist organisms, an expansion and predominance in the environment (Kellog, 1994; Carballo, 2003; Pastor et al., 2004; Douglas & O' Connor, 2005). In the present study, similar condition was recorded, since in Gaspar, the diversity in these periods was low, due to the pesticide application in the rice fields. In Agrolândia, a riparian vegetation separating the rice fields and the hydric body (P5 and P6 sites) favored the diversity and richness organisms (Tab. II). The presence of riparian vegetation has recognized importance, because it favors the existence of diverse ecological niches beyond the input of organic matter (leaves), which is used as food source for the innumerable organisms, including the macroinvertebrates (Bambaradeniya et al., 2004; Straye, 2006; Trevisan & Hepp, 2007).

The number of mollusks bivalves and gastropods found can be associated with the presence of fixed aquatic macrophytes. Therefore, these organisms are frequently associated to the vegetal formations that supplies the necessary oxygen to their survival (Gomes & Magalhães, 2004).

According to cluster analysis, P5 and P6 sites presented highest similarity, probably due to a similarity of the habitats composition, since the management developed in these rice fields maintains the riparian vegetation (Fig. 3). The rocky substrate heterogeneity, as well as riparian vegetation, provides a great richness and abundance of species (Bueno et al., 2003). These sites presented highest richness of taxa, being possible to observe a trend for increase of the diversity of taxa with the increase of the habitats diversity (Santanaría & Klaassen, 2002; Straye, 2006). The presence of more sensible macroinvertebrates to the degradation was observed in these two sites, such as Ephemeroptera and Plecoptera, that were not present in the others sites. In Australia, Douglas & O' Connor (2005) observed similar results with a predominance of taxa more adapted to the environmental alterations provoked by the rice crop, leading to a simplification of ecosystems and the loss of ecological integrity. The dissimilarity found between P1 and P4 sites, must be to the inherent characteristics of degradation of these areas, since both sites present sandy substrate and, constantly the producers make the cleanness of the margin and the removal of the deep sediment. The sandy substrate and the riparian vegetation absence can be considered limiting factors in the faunistic composition, that causes decreasing of refuges and food availability (Allan, 1995).

In conclusion, a relationship exists among the diversity loss and environmental disturbances provoked by the rice crop, mainly related to the management practical developed, in respect to the destruction of landscapes and habitats degradation. This favors the occurrence of tolerant organisms to the worst quality conditions and the proliferation of plagues for the culture. On the other hand, different stages of crop development do not affect the benthic community decisively how it was expected.

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