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# Effects of cutting disturbance in *Schoenoplectus californicus* (C.A. Mey.) Soják on the benthic macroinvertebrates

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**ABSTRACT.** Lagoons are considered protected areas because these systems play a key ecological role. However, the extraction of macrophyte *Schoenoplectus californicus* is held for manufacture of handcrafts, being an alternative income for riverbank communities. This study evaluated the impact of *S. californicus* experimental cutting on benthic macroinvertebrates trough a field experiment. Macroinvertebrates were sampled at 1, 12, 26 and 60 days after the macrophyte cutting in demarked plots (1 $m^2$), as well at control plots. The families number was not statistically different (ANOVA, $p > 0.05$), but the total density of invertebrates, and the density of Ceratopogonidae were significant (ANOVA, $p < 0.05$) for interaction between sampling date and treatment. A Principal Components Analysis identified that the level of the water column was the variable that most influenced the variation between the samples gathered in the experiment. We concluded that the cutting of *S. californicus*, in this area, as the intensity of the cut held, did not affect considerably the aquatic macroinvertebrates. The results suggest that the small-scale extractivism in these regions carries little effect because the fauna of adjacent areas probably can quickly colonize the disturbed areas.

**Key words:** disturbance, bioindication, vegetal management, *Schoenoplectus californicus*, aquatic macrophyte, non-wood products.

**RESUMO. Efeito do distúrbio de corte em *Schoenoplectus californicus* (C.A. Mey.) Soják sobre a fauna de macroinvertebrados bentônicos.** No Brasil, as margens de lagoas são consideradas áreas protegidas por desempenharem importante papel ecológico. No entanto, a extração da macrófita *Schoenoplectus californicus* é realizada para a fabricação de artesanato, sendo alternativa de renda para as comunidades ribeirrinhas. Este estudo teve como objetivo avaliar o impacto do corte de *S. californicus* sobre os macroinvertebrados bentônicos por meio de um experimento de campo. Os macroinvertebrados foram amostrados um dia, 12, 26 e 60 dias após o corte em macrófitas em parcelas demarcadas (1 $m^2$), bem como nas parcelas-controle. As famílias de macroinvertebrados mais abundantes não apresentaram diferenças significativas (ANOVA, $p < 0,05$), mas a densidade total de invertebrados e a densidade de Ceratopogonidae foram significativas (ANOVA, $p < 0,05$) para a interação entre a data de amostragem e tratamento. A Análise de Componentes Principais identificou que a profundidade no local do experimento foi a variável que influenciou a variabilidade entre as amostras coletadas no experimento. Concluiu-se que o corte de *S. californicus*, nessa área, como a intensidade do corte realizado, não afeta drasticamente a composição de macroinvertebrados aquáticos. Os resultados sugerem que o extrativismo em pequenas escalas nessas regiões exerce pouca influência, pois a fauna em áreas adjacentes pode rapidamente colonizar as áreas perturbadas.

**Palavras-chave:** distúrbio, bioindicação, manejo vegetal, macrófita aquática, produtos não-madeiráveis.

## Introduction

Lagoons areas colonized by aquatic macrophytes may shelter several species (ESTEVES, 1998), and the benthic macroinvertebrates in these environments are most abundant in the presence of aquatic vegetation than in areas without vegetation (KRULL, 1970; MCABENDROTH et al., 2005). Aquatic macrophytes play a key role in ecosystem, by the biomass produced to organic matter decomposition pathway (SANTOS; ESTEVES, 2006). Communities of aquatic macrophytes are important because these plants provide habitat complexity (DOWING, 1991) essential for the diversity and biomass of invertebrates

(MCABENDROTH et al., 2005). Furthermore, environments colonized by aquatic macrophytes provide protection to macroinvertebrates against predators and a food source for scrapers, detritivores and predators (OERTLI; LACHAVANNE, 1995; SHAFFER, 1998).

The presence of emerging macrophytes enables the presence of another aquatic plants with other habits (e.g. rooted-floating and free-floating), which provide different habitat structures, associated to abundance and diversity of aquatic macroinvertebrates (DEJOUX, 1983; KURASHOV et al., 1996; MCABENDROTH et al., 2005; OLSON et al., 1999). *Scirpus cubensis* plays important role in aquatic ecosystems, according to the study from Correia and Trivinho-Strixino (1998). The evaluated stands allowed the colonization of different associated taxa, besides that the macrophyte has an important role in the organic matter decomposition pathway in the evaluated ecosystem.

The aquatic invertebrates have been widely used in biomonitoring studies of environmental impacts in different aquatic ecosystems, and with different sources of disturbances (BRADT et al., 1999; BURTON et al., 2002; GLEASON et al., 2003; KOSTECKE et al., 2005; REHAGE; TREXLER, 2006). The biomonitoring using the fauna of macroinvertebrates is an important tool for environmental supervisory boards (RODRIGUES et al., 2006), because these organisms may respond in different ways to different environmental disturbances and, due to the large number of species, provide a broad spectrum of responses to environmental stress (ROSENBERG; RESH, 1992).

The macrophyte *Schoenoplectus californicus* (C.A., Meyer) Soják, synonymy *Scirpus californicus* (C.A., Meyer) Steudel, is commonly known as *junco*. This aquatic emergent macrophyte belongs to the family Cyperaceae, has linear aerial ramets, and occurs in aquatic environments in the American continent, occurring both in the Pacific coast and the Atlantic coast, also occurring in Hawaii, Southern Islands and the Western Islands (MACÍA; BALSLEV, 2000). Aiming the sustainable use, some people cultivate of *S. californicus* (BANACK et al., 2004), to use as a source of income in the manufacture of tools and pieces of handcrafts (MACÍA; BALSLEV, 2000).

The edges of the lakes are considered areas of permanent protection by brazilian environmental laws, with restricted use. However, traditional farmers in the coastal plain of the Rio Grande do Sul State, Southern

Brazil, reap ramets of *S. californicus* to use as raw material for manufacture of handicrafts. This activity is an important alternative source of income for these communities. In the Latin America, this aquatic macrophyte is widely used as key material by local people living near the lakes (MACÍA; BALSLEV, 2000).

The management of this species is done via traditional practices worldwide, and its stems are harvested for fabrication of handicrafts by small farmers and riverbank people, thus serving as an important source of economic livelihood (KUBO et al., 2008). Therefore, considering the importance of maintenance and conservation of aquatic ecosystems and their biota, and the growing environmental threats that they have suffered through recent years, the present study assessed the disturbance effect caused by cutting of macrophyte *S. californicus* on the aquatic macroinvertebrates in a coastal lagoon, Southern Brazil.

## Material and methods

### Study area

The study was carried out at North Coastal Plain of the Rio Grande do Sul State, Southern Brazil (Figure 1). The basin of the Maquiné river has a surface area of approximately 546 $km^2$, linked to Quadros Lagoon, part of Tramandaí river Basin, with a transition area between the coastal plain and the slopes of Serra Geral, whose maximum reach altitudes up to 900 meter (BECKER et al., 2004). The experiment was conducted on a point of the west margin of the Quadros Lagoon (29° 41' 30"S - 50° 08' 29.8"O). This location was chosen due to the abundant presence of *S. californicus*, easy access and logistical support.

### Evaluation of disturbance on the fauna of aquatic macroinvertebrates

To measure the impact of cutting ramets of *S. californicus* on aquatic invertebrates, we established four plots of 2.5 x 5 m in a transect parallel to the margin. The distance between each plot was about 2 m. In each plot, we bounded eight sub-plots of each 1 $m^2$. In four plots the macrophyte ramets were harvested, at a height of about 30 cm from the rhizome, and in the other four plots, they were kept intact as controls; the ramets at each sub-plot were counted at each sampling date. The cuts were held in June 21, 2005 and the experiment extended by 60 days.

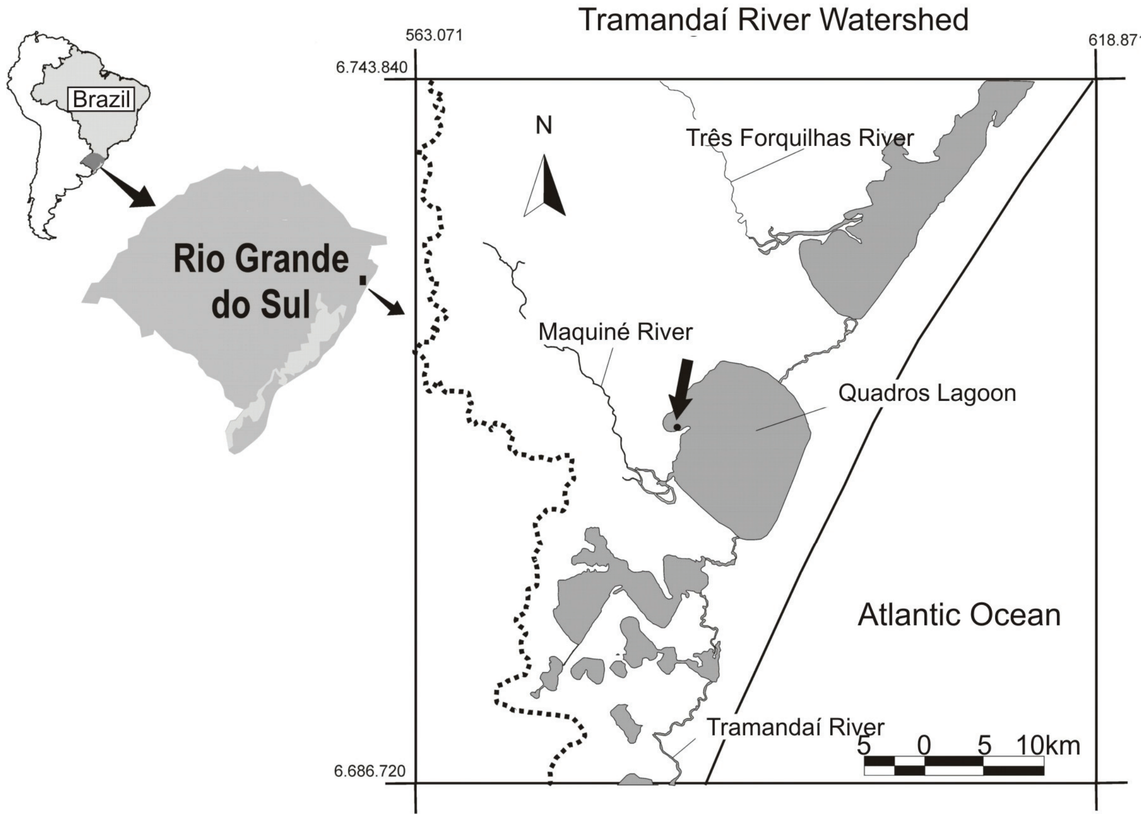


**Figure 1.** Study region, the arrow indicates the site where the field experiment was carried out.

#### Sampling of aquatic macroinvertebrates

After the cut, the plots were drawn for collection of aquatic macroinvertebrates in each time lag: 24 hours, 12, 26 and 60 days. In each sub-plot (1 $m^2$) one sample of sediment was gathered with a corer (BRADIMARTE et al., 2004) of 1 m in length with 10 cm in diameter, introducing 20 cm in the sediment. After, the samples were placed in plastic bags, identified and preserved with alcohol 95%. In laboratory, samples were washed in sieve (250 $\mu$m) and stained by adding 2-5 $mL^{-1}$ of Rose-Bengal solution (500 mg $L^{-1}$) in each sample. The macroinvertebrates were sorted on a stereomicroscope and preserved in alcohol 70%. The invertebrates were identified at family level (BRINKHURST; MARCHESE, 1989; MCCAFERTY, 1981; MERRITT; CUMMINS, 1996; PENNAK, 1989; TRIVINHO-STRIXINO; STRIXINO, 1995), except Odonata (being damaged), and Turbellaria, Collembola, being used in this taxonomic level to carry out the analysis.

#### Environmental variables

In field, we measured at each sampling date the following environmental variables: water temperature and pH (DIGIMED, model DM-2), dissolved oxygen (oximeter ALFAKIT, model AT 140), conductivity (WTW, model LF 320) in adjacent areas of plots set. The depth of the water column was obtained through the four measures of depth equidistant along each plot. At sampling dates 1, 26 and 60, one sediment sample of each treatment was used to determine the organic matter, according to Allem (1974).

#### Statistical analysis

To test the disturbance effect of cutting *S. californicus* on the aquatic macroinvertebrates, during different sampling periods, and between treatments, we applied an analysis of variance (ANOVA, $p \leq 0.05$) with two factors for the following variables-response: 'the total number of families', 'total density of invertebrates', and all taxa abundance, sampled with over 4% of individuals. This criterion for the matrix reduction, considering only those taxa with abundance above 4%, was used because the species with low density do not present patterns analyzable (FIELD et al., 1982; SZALAY; RESH, 1997). For the implementation of all analyses we used the densities (ind. $m^{-2}$) transformed into log (x + 1), to reduce data variability.

A Principal Components Analysis (PCA) was conducted to check the influence of 'treatment', 'period of collection' and 'level of the water column' on the sample units collected. For this analysis, we used the densities of all taxa sampled. The ANOVA was performed in R software (R DEVELOPMENT CORE TEAM, 2009) and PCA were done in the PC-ORD (MCCUNE; MEFFORD, 1997).

## Results

The environmental variables presented a relative variation during the experiment, pH (6.5 - 7.3), conductivity (76 - 126 $\mu$S $cm^{-1}$), dissolved oxygen (4.8 - 8 mg $L^{-1}$) and water temperature (16 - 24.7°C). The mean depth was recorded (n = 4) in the plots sampled from each date of collection after the disturbance of cutting, displaying a wide variation (24 hours = 27.5 cm, 12 days = 0.0 cm, 30 days = 7.5 cm and 60 days = 40 cm). Notice the depth with zero value in the collection of 12 days after the disturbance of cutting, on this occasion the sediment was saturated with water, but without water column. The mean values of organic matter (%) were 7.1% in controls, and 3.1% in cut treatment. The mean density of *S. californicus* ramets in the control plots was 38.0 + 12.5 (n = 4), in the period from June to August 2005. In this period, we sampled a total of 321 macroinvertebrates, belonging to 20 taxonomic groups (Table 1).

**Table 1.** Macroinvertebrate taxa sampled in both treatments during this study.

| Taxa | 1 day | | 12 days | | 26 days | | 60 days | |
|---|---|---|---|---|---|---|---|---|
| | control | cut | control | cut | control | cut | control | cut |
| Oligochaeta | | | | | | | | |
| Naididae | 3 | 6 | 3 | 1 | 0 | 0 | 4 | 5 |
| Enchytraeidae | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 1 |
| Tubificidae | 15 | 24 | 1 | 0 | 1 | 0 | 8 | 13 |
| Diptera | | | | | | | | |
| Ceratopogonidae | 15 | 25 | 4 | 0 | 8 | 14 | 3 | 0 |
| Chironomidae Ceratopogonidae | 13 | 5 | 19 | 2 | 6 | 3 | 4 | 15 |
| Tabanidae | 3 | 0 | 1 | 0 | 1 | 1 | 0 | 0 |
| Tipulidae | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| Molusca | | | | | | | | |
| Hydrobiidae | 9 | 3 | 0 | 2 | 17 | 9 | 1 | 1 |
| Spharidae | | | | | | | | |
| *Gundlachia* sp. | 0 | 1 | 1 | 0 | 2 | 1 | 0 | 2 |
| Ephemeroptera | | | | | | | | |
| Campsurinae | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 |
| Crustacea | | | | | | | | |
| Hyallelidae | | | | | | | | |
| *Hyallela* sp. | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 17 |
| Odonata | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Collembola | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| Hirudinea | | | | | | | | |
| Hirudinidae | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Glossiphonidae | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 2 |
| Lepdoptera | | | | | | | | |
| Pyralidae | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| Turbelaria | | | | 0 | | 0 | 0 | 1 |
| Coleoptera | | | | | | | | |
| Disticydae | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Hydrophilidae | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 |

After the disturbance, we verified variations in the average taxa richness and in the total average density of invertebrates (Figure 2). In the control treatment, the average of taxa richness did not change markedly during the experiment, on the other hand, the cut treatment presented a sharp decrease at 12 days after the disturbance, near to the controls values, in the following samplings (30 and 60 days). The ANOVA evidenced significant differences for the 'period of collection' regarding variable number of taxa (Table 2).

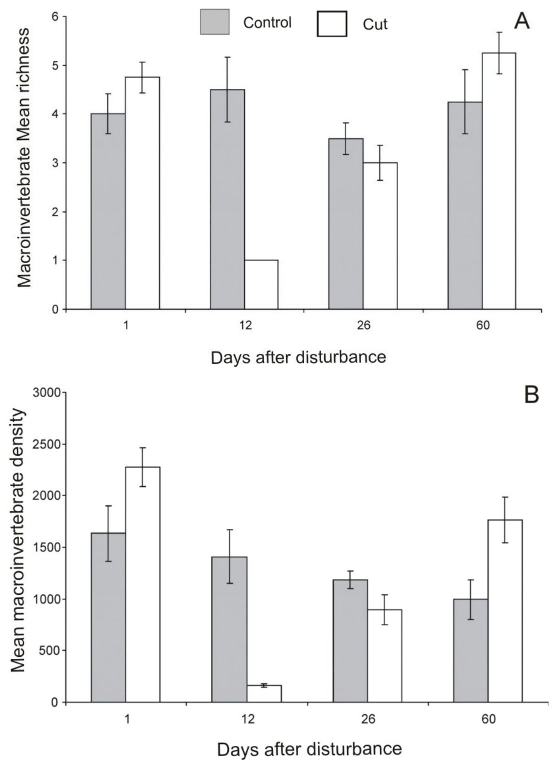


**Figure 2.** A, Mean values of macroinvertebrates richness in control and cut treatments; B, Mean density of macroinvertebrate in control and cut treatments (S.E.; n = 4).

The mean density of macroinvertebrates presented a variation, after the disturbances in the control treatment, with a reduction during the experiment. Regarding the cut disturbance, a sharp decrease in density was registered at 12 days after the disturbance (Figure 2B), and in the following collections, an increase was recorded. The ANOVA detected significant differences for the period of collection and for interaction between 'sampling date' and 'treatment' for the variable total density of invertebrates (Table 2)

Among sampled groups, in both treatments, the following families were considered dominant:

Ceratopogonidae (23.9%), Tubificidae (19.3%), Hidrobiidae (17.1%), Chironomidae (14.6%), Naididae (6.8%), and Hyallelidae (6.2%), totaling 87.9% of those sampled, throughout the experiment (Figure 3). Hidrobiidae and Chironomidae were present in both treatments, in all sampling periods.

**Table 2.** ANOVA performed with macroinvertebrate richness, total density and dominant families. D, sampling date; T, treatment; P*T, interaction between sampling date and treatment.

| | | Richness | Density | Naididae | Tubifficidae | Ceratopogonidae | Chironomidae | Hyallelidae | Hidrobiidade. |
|---|---|---|---|---|---|---|---|---|---|
| Effect | d.f. | F | F | F | F | F | F | F | F |
| D | 3 | 2.27 | 3.52 | 2.39 | 7.27 | 16.67 | 0.66 | 1.67 | 0.91 |
| T | 1 | 0.81 | 0.01 | 0.16 | 0.03 | 7.51 | 0.06 | 0.57 | 3.59 |
| D*T | 3 | 2.75 | 3.04* | 0.56 | 1.17 | 4.07* | 0.45 | 2.77 | 0.53 |

*= $p \leq 0.05$.

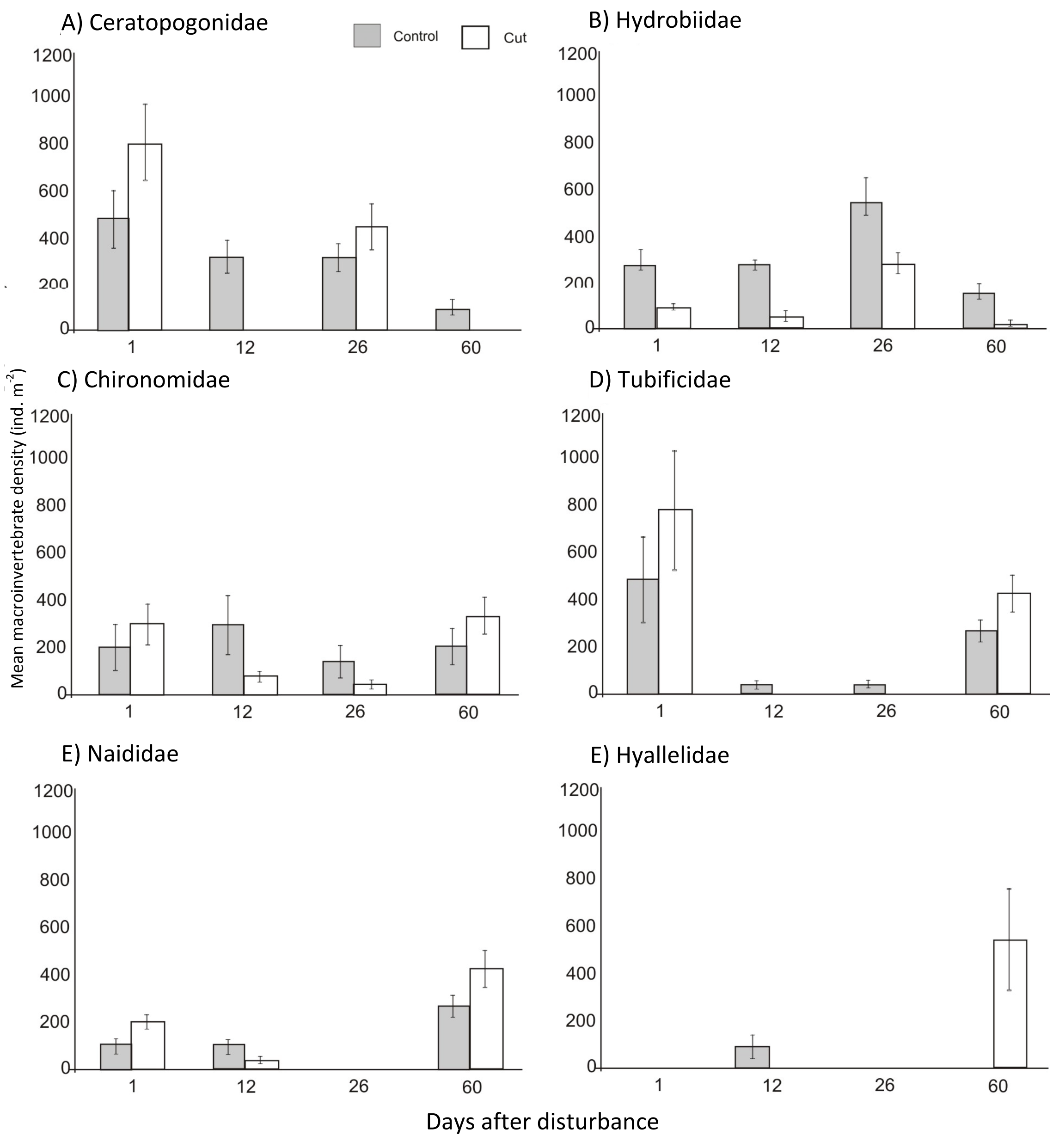


**Figure 3.** Mean density of dominant macroinvertebrate (log. A, Ceratopogonidae; B, Hidrobiidae; C, Chironomidae; D, Tubificidae; E, Naididae; F, Hyallelidae.

The ANOVA performed with each dominant taxon did not indicate significant differences for the interaction between time and treatment, for most taxa (ANOVA, $p > 0.05$). However, for the 'treatment', significant differences were found for Ceratopogonidae (ANOVA, $p < 0.05$) (Table 2), which also showed significant differences for the interaction between the effects 'period of collection' and 'treatment' (ANOVA, $p < 0.05$).

The evaluation of 'sampling date', 'treatment' and 'changes in the level water column' effects in the variability of the data was performed by a PCA (Figure 4). The first two PCA axes explained 96.7% of total data variability. The axis 1 explained 95.9% of the variation found, and was inversely affected by the depth of the water column ($r = -0.99$), demonstrating that changes in water column level was the variable that best explained the data variation. The PCA presented two groups: (i) samples at 1 and 60 days after the disturbance, and (ii) samples at 12 and 26 days after the disturbance.

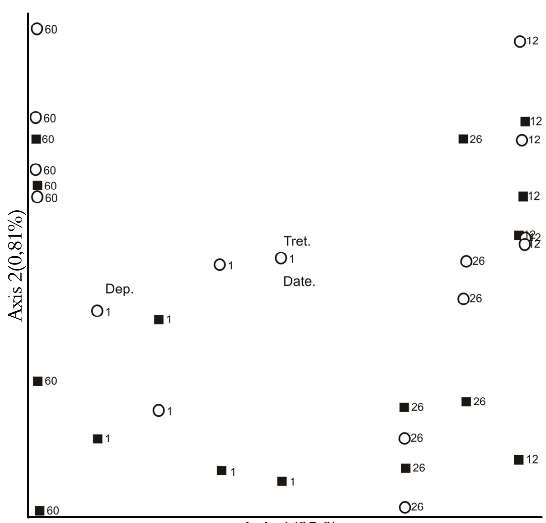


**Figure 4.** Principal Component Analysis with the density of sampled taxa. ■, control treatment, the number beside symbol indicates the sampling date; ○, cut treatment, the number beside symbol indicates the sampling date; Tret., treatment; Date, sampling date; Dep., depth.

## Discussion

The present study assessed the community of macroinvertebrates associated to *S. californicus,* in marginal area of a coastal lagoon. Several studies have been conducted involving *S. californicus*, but few studies have an experimental character, involving the management of native emergent macrophytes of the Coastal Plain of Rio Grande do Sul State, Brazil. This macrophyte is a dominant species in many aquatic ecosystems from Neotropics, therefore its importance for the maintenance of these systems is crucial, since there is a tendency to use it in a sustainable manner (BANACK et al., 2004; MACÍA; BASLEV, 2000). *S. californicus* serves as a structuring of these coastal areas, both to alleviate the effects of 'fetch', as the basis of many aquatic macroivertebrates. The macroinvertebrates in the coastal lagoons of Southern Brazil occur as the major biotic components in the processing of nutrients in organic material, through decomposition as the basis of the food chain in freshwater ecosystems (RODRIGUES; HARTZ, 2000).

It is common the occurrence of these detritivores organisms, as Chironomidae, Tanaidacea (*Synelobus stanfordi*), Isopodes (*Cassidinidea tuberculata*) and many Oligochaeta, but others with different dietary habits, also occur. Because only the fauna associated with sediment have been assessed in this study, some taxa more active or rare, were not sampled in larger quantities, among them Odonata, Ephemeroptera and Hyallelidae (Table 1). The sampler used (corer) is more effective in collecting taxa with little mobility, i.e. most of detritivores. This dominance may be explained by sediment traits, rich in organic matter (3.1 - 7.1%), mainly derived from the decomposition of plant material, being food source for detritivores (SZALAY; RESH, 1996). In studies using different strategies for sampling (KOSTECKE et al., 2005; OLSON et al., 1999) is recorded greater wealth of taxa. Wiedenbrug et al. (1997) found 95 taxa in a coastal freshwater lake, in Southern Brazil, Rodrigues and Hartz (2000) found 47 taxa; Cenzano and Würdig (2006) found 54 taxa.

The variable response 'total density of invertebrates' and 'Ceratopogonidae' was statistically significant for interaction between 'period of collection' and 'treatment'. The importance is given to the interaction between the effects (in this study, treatment and period of collection) because the interactions cause many ecological changes, and usually the synergism between the effects is more important than separate effects (GOTELLI; ELLISON, 2004). This evidences that the cut affect adversely these variables-response, which are susceptible to the cut disturbance. These two variables are closely related, because Ceratopogonidae was the most representative among the dominant taxa. It is possible that Ceratopogonidae has been affected by having a greater mobility (swimmer), not entirely dependent on the substrate, also depending on water column

(SPINELLI, 1998), and possibly, these organisms are dispersed in areas suitable for their ecological requirements.

The level of the water column next to zero, in the sampling after 12 days, influenced the density decrease of macroinvertebrates. The influence of disturbance, as a pulse, caused by the change in the water column, may have pressured the organisms present in the plots to migrate to more favorable or deeper areas, is considered a rapid response of biota against mortality, searching for shelters, according to the study from Tronstad et al. (2005). Meanwhile, despite the change in the water column have reached both treatments, the treatment control showed greater richness and density of macroinvertebrates, compared with the treatment of cut.

Some studies carried out to evaluate the response from aquatic invertebrates against physical disturbances presented a low response from the macroinvertebrates fauna. Kostecke et al. (2005), examined the response from the macroinvertebrates community in front of different managements of *Typha* spp. (cutting, burning and cattle grazing), and observed that the macroinvertebrates showed little variation in comparison to the controls. The community of macroinvertebrates also presented a weak response from the mechanical control of *Spartina anglica* in the study by Frid et al. (1999). However, in some cases the macroinvertebrates community responded to physical disturbances, as observed in the study by Szalay and Cassidy (2001) that assessed the response from the community of aquatic invertebrates in relation to the disturbance caused by an aquatic rodent (*Ondatra zibenthicus*). The same authors verified that the activity of the rodent changed the composition of the community of aquatic invertebrates, through physical disorder in the area of emerging vegetation along with the changes of water quality. Rehage and Trexler (2006) also registered differences about the response of aquatic communities (fish and macroinvertebrates) in front of the influence of the channels construction in flooded areas.

In this study, we observed that the macroinvertebrates were not strongly influenced by the disturbance caused by the cut of *S. californicus*, and that the fluctuations in the water level exerted strong influence on richness, density and presence of Ceratopogonidae. The increase in the water depth may have enabled the connection of source areas close to experimental site, facilitating the recolonization. In this way, the response from the community of macroinvertebrates in front of the cutting disturbance was mainly influenced by abiotic variables.

Regarding the spatial scale, the size of the plots may have been responsible for the little difference between treatments. According to Frid et al. (1999), small areas can be easily recolonized by an adult and/or with reasonable dispersion capacity in disturbed areas < 2000 $cm^2$. Szalay and Resh, (1997) and Martin and Neely (2001) used the isolation of disturbed areas with mesh barriers, avoiding the dispersion of invertebrates to other treatments and/or the colonization by immigrants macroinvertebrates stemming from intact areas. This strategy was not used in this study, so it may be due to colonization of disturbed areas by invertebrates from intact areas, masking the disturbance held.

## Conclusion

The macroinvertebrates response to the disturbance cut in *S. californicus* was more influenced by the oscillation in the water level, than the cut itself.

The 'total density' and 'Ceratopogonidae' were the variables-response that had significant differences for the interaction between 'period of collection' and 'treatment', responding to the disturbance of cutting.

The cutting of *S. californicus* did not affect deeply the associated aquatic macroinvertebrates, as evidenced by PCA. Our results indicate that the extrativism in small scales in these regions (plots with 1 $m^2$) has little influence, since the fauna at adjacent areas can probably colonize the disturbed areas.

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