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Dissertação de Mestrado

EFEITO DE UMA GRAMINEA EXÓTICA SOBRE COMUNIDADES CAMPESTRES E  
ATIVIDADE DE INVERTEBRADOS DE SOLO EM CAMPOS SUL BRASILEIROS

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Porto Alegre, Março de 2014

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## RESUMO

Espécies exóticas são comumente associadas com perdas no número de espécies nativas e mudanças na estrutura de comunidades, acima e abaixo do solo. Acima do solo, tais mudanças normalmente ocorrem em nível de espécies e, abaixo, comunidades de invertebrados do solo também podem ser afetadas, possivelmente levando a impactos em processos ecossistêmicos. *Eragrostis plana* Nees, uma gramínea cespitosa Sul-Africana, é considerada uma das plantas exóticas mais problemáticas nas regiões campestres sul brasileiras pois pode formar amplas aglomerações, possivelmente responsáveis por reduzir a qualidade da forragem e reduzir o espaço disponível para espécies nativas. Suas características biológicas a tornam altamente eficiente em colonizar locais perturbados e manejados. Apesar de pesquisas terem sido conduzidas a seu respeito, pouco se sabe sobre seus efeitos ecológicos, acima e abaixo do solo. Neste estudo, foi avaliada a estrutura vegetal de áreas de campo ao longo de um gradiente de ocupação por *E. plana*, como também avaliado a atividade alimentar de invertebrados de solo. Para ampliar nossa abordagem, utilizamos características da forma de vida das plantas para vislumbrar padrões nas comunidades sobre efeito de *E. plana*. A influência de *E. plana* sobre taxas de consumo foi avaliada com o teste *bait-lamina*, comparando-se o desempenho encontrado em parcelas dominadas pela espécie exótica com parcelas dominadas por espécies nativas, prostradas e cespitosas. No geral, nossos resultados mostraram que *E. plana* esteve claramente correlacionada com a riqueza de espécies e equabilidade da comunidade. Composição de espécies e suas formas de vida também estiveram relacionados com a presença da espécie exótica. A atividade alimentar de invertebrados de solo não foi afetada pela presença de *E. plana* na comunidade.

Palavras-chave: Campos sulinos, *Eragrostis plana*, espécie invasora, teste bait-lamina, atributos funcionais, comunidade vegetal

## ABSTRACT

Non-native species are commonly associated with losses in the number of native species and changes in community structure, above and below ground. Above ground, such changes usually occur at the species level, while below the soil invertebrate communities may also be affected, possibly leading to impacts on ecosystem processes. *Eragrostis plana* Nees, a South African tussock grass, is considered one of the most problematic non-native plants in the Brazilian southern grasslands areas because it can form large stands, possibly responsible for reducing forage quality and reduce the space available to native species. Biological characteristics make it highly efficient colonizer in managed and disturbed sites. Although several studies have been conducted about it, little is known about its ecological effects, above and below ground. In this study, plant community structure was evaluated along a gradient of *E. plana* cover and the effects of the alien species on plant species richness, community evenness and plant composition were analyzed. To broaden our approach, life form traits were used to discern patterns in community's functional traits. Additionally, the influence of *E. plana* on consumption rates was evaluated with the bait-lamina test comparing the performance found in plots dominated by non-native species and on plots dominated by native species, prostrate and tussock. Overall, our results showed that *E. plana* is significantly correlated with effects on species richness and evenness. Species composition and life form relative abundances were also related to the presence of the exotic plant. Moreover, feeding activity of soil invertebrates was not affected by the presence of *E. plana* community.

Key-words: Campos sulinos, *Eragrostis plana*, invasive species, bait-lamina, functional traits, plant community.

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## INTRODUÇÃO

A disseminação de espécies exóticas para além de suas distribuições or devido as atividades humanas pode ter efeitos profundos sobre a comunidade receptora, por vezes irreversíveis. Na maioria das vezes, esses efeitos levam a impactos ecológicos e/ou socioeconômicos não triviais, que podem se somar a outros problemas ambientais causados pelas atividades humanas (Pimentel et al. 2005; Vilà et al. 2011).

Antes de adentrar nos padrões e processos associados à espécies invasoras, é importante definir alguns termos referentes a classificação de tais entidades. Espécies nativas seriam aquelas que não possuem registro prévio de introdução em determinado ambiente, ou seja, foram descritas como a flora e fauna local no passado. Espécies exóticas (não nativas ou não indígenas) ou introduzidas, por sua vez, originar-se-iam de outras regiões ou ambientes independentes da fronteira política relevante, e possuem registro de introdução conhecido ou presumido. Essas espécies passariam serem chamadas de invasoras quando evidencias de colonização não assistida bem sucedida, em ambientes naturais ou não, fossem encontradas.

Alguns importantes conceitos são utilizados para prever quais espécies exóticas, e em que situações, terão maior chance de causar um efeito perceptível sobre uma determinada comunidade receptora. Esses conceitos podem ser agrupados em dois abrangentes termos: invasibilidade de comunidades - características que descrevem quais locais seriam mais suscetíveis à colonização e proliferação de espécies exóticas - e invasibilidade de espécies - traços que distinguem quais espécies teriam mais chances em ambientes diferentes daqueles aonde a espécie evoluiu. Dentro desses conceitos, estão características como plasticidade fenotípica, pressão de propágulos, capacidade de aproveitar janelas de recursos e severidade da competição com espécies residentes entre outros termos. Pode se dizer que os mesmos processos que regrariam a expansão e retração de populações nativas, também regrariam populações exóticas, a diferença ficando a cabo das escalas de tempo. Uma espécie que levaria um tempo geológico para cruzar uma barreira geográfica, com um artefato humano podem transpor tais barreiras em menos de uma geração.

O Bioma Pampa, cuja parte brasileira faz parte dos Campos Sulinos, é caracterizado pela presença de ecossistemas campestres altamente diversos em termos de espécies de plantas e animais que formam uma importante base para a pecuária na região. Ao mesmo tempo, estas áreas campestres estão ameaçadas por mudanças no tipo de uso do solo e apenas uma fração delas encontra-se em unidades de conservação (Overbeck et al. 2007).

*Eragrostis plana* Nees, uma gramínea cespitosa Sul-Africana, é considerada uma das plantas exóticas mais problemáticas às pastagens sul brasileiras e, por consequência às atividades econômicas nelas baseadas (Ferreira and Filippi 2013). Suas características biológicas a tornam altamente eficiente em colonizar áreas perturbadas e sobe manejo pastoril (Medeiros and Focht 2007). A espécie tem-se revelado difícil de controlar com as técnicas agrícolas tradicionais (e. g., pesticidas), devido a sua grande produção de sementes, facilmente dispersas e com alto grau de viabilidade. Além disso, o gado geralmente evita de se alimentar dessa espécie pois seus tecidos contêm alta proporção de fibras e baixa proporção de nutrientes. Herbívoros, em especial o gado bovino, compensam através do sobrepastoreio das plantas restantes e mais palatáveis, criando uma retroalimentação positiva para expansão de *E. plana* (Medeiros and Focht 2007). Embora *E. plana* já tenha colonizado mais de um milhão de hectares nesta região (Medeiros and Focht 2007), sua distribuição potencial é ainda maior, estendendo-se para outras áreas do estado, como campos de altitude e partes centrais do Brasil (Barbosa et al. 2012).

Apesar de toda a problemática envolvendo a espécie, os efeitos da sua presença sobre a diversidade de plantas, bem como seus efeitos sobre processos ecossistêmicos, atividade de organismos do solo e processos de ciclagem de biomassa, ainda não foram estudados em detalhe.

Essa dissertação teve como objetivo avaliar os efeitos da presença de *E. plana* sobre a diversidade e estrutura, tanto em termos florísticos e funcionais, de áreas de vegetação campestre, como também, avaliar os padrões da atividade de invertebrados de solo relacionados a presença da espécie exótica. No capítulo “NEGATIVE EFFECTS OF AN INVASIVE GRASS, BUT NOT OF NATIVE GRASSES, ON PLANT

SPECIES RICHNESS ALONG AN ABUNDANCE GRADIENT”, avaliou-se a composição e estrutura da vegetação campestre ao longo de um gradiente de ocupação por *E. plana*, usando dados de três locais diferentes na região campestre do Sul do Brasil. Nosso objetivo foi quantificar, pela primeira vez, os efeitos da espécie sobre a composição da comunidade e estrutura vegetal, incluindo características florísticas e funcionais. Já no segundo capítulo “EVALUATION OF THE SOIL INVERTEBRATE ACTIVITY IN THE PRESENCE OF A NON-NATIVE EXOTIC GRASS”, propusemo-nos a responder à pergunta, se, e em que medida, a taxa de consumo de invertebrados do solo sobre ocupação de *E. plana* diferia daquela afetada apenas por espécies nativas.



## CAPÍTULO I

### **Negative effects of an invasive grass, but not of native grasses, on plant species richness along an abundance gradient**

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#### **Abstract**

We assessed the impact of invasion by *Eragrostis plana* Nees, the most invasive plant on South Brazilian natural grasslands, on local plant communities. Specifically, we evaluated how total plant richness, evenness and certain functional groups responded along an invasion gradient. In three sites of Rio Grande do Sul state, southern Brazil, we conducted an observational study in which 1×1 m plots were preferentially allocated along a gradient of *E. plana* cover. In data analysis, we also considered coexisting native plants gradient as species identity control, for disentangling the impacts of an invasive species from high abundances native effects. As a result, we showed that *E. plana* invasion reduced total plant richness, with some different effects regarding plant functional groups, and differently from other coexisting natives species. Grasses were the most affected plant group when *E. plana* cover increased.

**Keywords:** Brazil; Capim-annoni; *Eragrostis plana*, exotic; grass; impact; lovegrass; invasive.

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## Introduction

The spread of non-native species across biogeographic ranges can have significant effects on native communities, leading to ecological and/or socio-economic impacts (Pimentel *et al.* 2005; Vilà *et al.* 2011). Non-native species that reproduce consistently and sustain populations at considerable distances from parent plants in the resident communities are considered invasive and have the potential to alter the biodiversity and functioning of ecosystems (Richardson *et al.* 2000; Powell *et al.* 2011). A recent meta-analysis has classified invasive species as one of the most important global threats to biodiversity, next to habitat destruction and fragmentation (Murphy & Romanuk 2014). However, invasion often co-occurs alongside with or even triggered by other changes in the affected ecosystem, such as disturbance, with interactive and inseparable effects (Didham *et al.* 2007).

In general, the presence of an invasive species in a community is associated with lower species richness and diversity than that observed in non-invaded communities (Hejda *et al.* 2009; Pyšek *et al.* 2012). Yet, impacts of invasive species on plant diversity are not universal (Stohlgren & Rejmanek 2014), mainly due to the different spatial scales used in every study (Powell *et al.* 2011). Further, invasive species may have remarkably different effects on different plant life forms in the resident community, again with impacts on local community composition (Alvarez & Cushman 2002; Hejda & Pyšek 2006; Stinson *et al.* 2007; Michelan *et al.* 2010). Despite the scarcity of relevant studies, there are some indications that invasion impact can be particularly strong on species with similar life form to the invader (Mason & French 2008; Gooden & French 2015). This is mainly explained by the principle of limiting similarity, which suggests that species must be functionally different to coexist (MacArthur & Levins 1967). Yet, the opposite has also been observed (Mason & French 2008). One reason for this discrepancy might be that similar life form – which may result in similar strategies of resource use for plants, as e.g. shown for grasses by Cruz *et al.* (2010) – may not necessarily mean similar interactions with other trophic levels, e.g. through grazing, which in turn may determine community composition.

In this study, we assessed the impact of the invasive tussock grass *Eragrostis plana* Nees on vegetation in South Brazilian grasslands. The biodiversity of natural ecosystems in this region is under major threats, such as land use change,

management changes and invasive species spread (Overbeck *et al.* 2007; Guido *et al.* 2016; Koch *et al.* 2016), yet conservation policies are not sufficiently focused on grassland systems (Overbeck *et al.* 2015). The perennial tussock grass *E. plana* Nees (South African lovegrass or capim-annoni, in portuguese) has been introduced to southern Brazil from South Africa in 1957 and it is considered to be one of the – if not the – most frequent and problematic invasive species in the region (Guido *et al.* 2016). Currently, the species occurs in more than one million hectares of native grassland in Rio Grande do Sul, i.e. 1/5 of the native grasslands of the state (Focht & Medeiros 2012). Its high seed production, long seed viability and low palatability make it highly efficient in colonizing disturbed (e.g., roadsides) and managed (e.g., grazed) sites alike (Medeiros & Focht 2007). Cattle usually avoid the species due to its high fiber content that makes it hard to graze and digest. This behavior forces grazers to compensate through overgrazing of remaining, more palatable plants, thus creating a positive feedback for the invader (Medeiros & Focht 2007). These characteristics bear changes in structure and composition of the plant community; however, local effects of *E. plana* invasion on plant species richness or plant diversity have not yet been extensively studied, besides some recent work which has recorded species richness reduction after *E. plana* invasion in an experimental approach involving plant removal (Guido & Pillar 2017).

Here, we worked on a gradient of *E. plana* invasion that spanned from practically non-invaded patches to areas dominated almost entirely by *E. plana*. We evaluated how total plant species richness, evenness and certain functional groups responded along an invasion gradient. We also investigated if a similar gradient of coexisting native grasses would have the same effects as *E. plana*, as a possible control for species identity for a non-experimental study. Our hypothesis was that an increase in *E. plana* cover would reduce plant richness, in contrast to an increase of a coexisting native grass cover. Further, based on the principle of limiting similarity (MacArthur & Levins 1967; Abrams 1983), we assumed that the strongest effect of *E. plana* dominance would be on species of similar life cycle, growth form and space occupancy strategy. Our study will contribute to the general understand of principal effects of invasive species on plant communities, providing information about potential impacts of the most important invasive species in south Brazilian grasslands.

## Methods

The study was conducted at three sites in the Brazilian Pampa biome, in the southern half of Rio Grande do Sul state, southern Brazil. The region is characterized by grassland vegetation, dominated by  $C_4$  grasses and is under grazing (Overbeck *et al.* 2007). Sites were located on three experimental stations: Fundação Estadual de Pesquisa Agropecuária (FEPAGRO; 30°20'12.22"S, 54°15'49.42"W) in São Gabriel, Empresa Brasileira de Pesquisas Agropecuárias (EMBRAPA; 31°21'11.73"S, 54°0'55.82"W) in Bagé, and Estação Experimental Agronômica da Universidade Federal do Rio Grande do Sul (EEA UFRGS; 30°5'35.42"S, 51°40'23.13"W) in Eldorado do Sul. All sites are under Cfa climate (temperate humid with hot summers, without true dry season) in the updated Köppen-Geiger system (Peel *et al.* 2007). All sites were under grazing at varying stocking rates. At each site, we worked in a single paddock with a patchy pattern of *E. plana* invasion.

To study the effect of *E. plana* invasion, 1×1 m plots were preferentially allocated along a gradient of *E. plana* cover. At each site, plots were allocated to areas with the following *E. plana* cover classes established in a previous mapping of the species in the paddocks: (i) 0 – 10 % (non-invaded; n=10), (ii) 10 - 30% (lightly invaded; n=10), (iii) 30 - 40% (intermediately invaded; n=10), and (iv) > 40% (heavily invaded; n=10). We estimated cover of all vascular plant species and total vegetative cover using a decimal scale (Londo 1976). We classified all vascular plants recorded in our plots into categories based on their life cycle (annual or perennial) and life form (forbs, grasses or woody species; Raunkiaer) and on growth habit (erect or prostrate).

We calculated diversity using two standard community diversity descriptors: species richness ( $S'$ ) and Pielou's evenness index ( $J'$ ) (Magurran & McGill 2011). We used linear models to analyze the association between cover of *E. plana* (predictor) and community descriptors. Data from all three sites were pooled together. To compare community responses to increasing cover of *E. plana* versus increasing cover of dominant coexisting native species, we used the same linear models as above, with the following dominant (as detected by vegetation surveys) native grasses cover as predictors: (i) *Paspalum notatum* Alain ex Flüggé, a prostrate grass; (ii) *Andropogon lateralis* Neesgrass and *Axonopus argentinus* Parodi, two tussock grasses pooled

together to be used as one predictor (tussock grasses). Additionally, we modeled the response of functional groups cover to predictor variables (*E. plana*, *P. notatum* and tussock grasses cover). We used the ImPerm library (Wheeler 2010) in the R statistical environment for modeling. Finally, we used a *P* threshold value of 0.01.

## Results

Grasslands plant composition at the three sites consisted of 243 vascular plant species distributed within 37 families. The six families with the most species recorded were: Poaceae (61), Asteraceae (50), Fabaceae (17), Cyperaceae (15), Rubiaceae (13) and Verbenaceae (8). Three plant species were common (average overall cover > 5%) across the three grassland sites: *Paspalum notatum* (17%), *Axonopus affinis* (7%) and *Eryngium horridum* (5%). Other two plant species were only locally abundant: *Andropogon lateralis* (13% at EEA UFRGS) and *Axonopus argentinus* (10% at EMBRAPA). Most of the species sampled (97%) attained low cover values ( $\leq 5\%$ ). A total of 40 species were shared between all three sites (17%).

Cover of all species studied significantly affected species richness (Figures 1a-c). However, *E. plana* cover affected species richness negatively ( $P < 0.01$ ), while *P. notatum* and tussocks cover affected it positively ( $P = 0.01$  and  $P < 0.01$ , respectively). Further, both *E. plana* and tussocks cover affected evenness positively ( $P < 0.01$  for both, Figure 1d and f), while *P. notatum* cover did not affect evenness ( $P = 0.67$ , Figure 1e).

*E. plana* affected negatively every response variable, except woody and prostrate species richness (Table 1). *E. plana* cover affected significantly grasses and annual species richness, while *P. notatum* and tussocks did not. *E. plana* cover significantly reduced forb richness, yet, *P. notatum* and tussocks had the same effect on forbs. Perennial plants richness, was affected by *E. plana* and *P. notatum* cover, while number of erect species was reduced by *E. plana* and tussocks cover.

## Discussion

*E. plana* is widely considered to be one of the most problematic invasive plants in the South Brazilian grassland region (Guido et al. 2016). Here, we conducted an

observational study at three different invaded sites in the state of Rio Grande do Sul to evaluate *E. plana* invasion effects on plant community at local scale. In an innovative way, we consider coexisting native plants as species identity control for disentangling the impacts of an invasive species from possibly similar effects of high abundant native species. Overall, we showed that *E. plana* invasion has significant impact on total plant richness, with some different effects regarding plant functional groups.

Consistent with other studies regarding the impacts of invasive species, our findings suggested that invasion can have significant effects on native vegetation, replacing resident species in natural communities (Andreu *et al.* 2009; Flory & Clay 2009; Hejda *et al.* 2009; Vilà *et al.* 2011). Interestingly, we did not find the same trend when analyzing the effects of coexisting native grasses, suggesting it is the response of resident community to invasion and not to any high abundant species. Our results are also consistent with a recent study of the same invasive plant, in which *E. plana* removal from invaded plots led to increased species richness, demonstrating its impact on species richness (Guido & Pillar 2017). As Guido & Pillar (2017) have suggested, *E. plana* invasion may affect light availability, as it usually grows taller than other native species because of cattle rejection (Medeiros & Focht 2007), which may result in the reduction of the number of species beneath its canopy. We found that *E. plana* invasion has strongest effect on grasses richness, in comparison with other plant groups which, according to the principle of limiting similarity (MacArthur & Levins 1967), suggests greatest inter-specific competition in species with same growth strategy as the invader.

Additionally, species evenness increased with *E. plana* invasion, but it also increased with coexisting native tussock cover. Thus, there may be an effect of tussock abundance on evenness, independently if the species is native or invasive. This could mean that tussocks, including here *E. plana*, have an equalizer effect over the community, possibly due canopy shading of others plants such as *A. lateralis* and *A. argentinus*. Prostrate grasses, represented here by *P. notatum*, can also reach high dominance in grazed grasslands (Fredrigo *et al.* in press), but the competition for light may be less than taller plants, not affecting significantly community evenness. While this causes species losses on paddock scale, on the plot scale no species richness reduction can be observed, as many small species with low competitive ability can be

coexist in the absence of dominant taller species (e.g. Overbeck *et al.* 2005; Fedrigo *et al.* in press; Menezes *et al.* in press).

Local patterns of species losses are commonly scaled up to regional or even ecosystem level to increase the awareness for the possible impacts of non-native species over biodiversity (Vilà *et al.* 2011). *E. plana* is a species able to rapidly spread and increase its cover in invaded areas (see e.g. Guido *et al.* 2016), making it potentially much more abundant than native species. Therefore, *E. plana* invasion is causing local species losses, which may be also affecting the cover of forage species, reducing grassland productivity (Medeiros & Focht 2007) and probably affecting other ecosystem services. At current, the species is reported to cover more than 1/5 of natural grasslands in Rio Grande do Sul state, with high potential of expansion in other regions of South America (Barbosa *et al.* 2013). Nonetheless, no evidence for extinction beyond the local scale exists.

Considering that *E. plana* is the most important invasive species in South Brazilian natural grasslands (Guido *et al.* 2016), surprisingly little research on its impacts and on the drivers of its invasion have been conducted. Our study is one of the few researches that contribute to better understand about its effect on native vegetation to raise public awareness of this problem. We provide observational data about plant community responses to *E. plana* invasion, suggesting a significant reduction of total plant richness, mainly affecting grasses species. We highlight the importance of consider coexisting native plants as species identity control in non-experimental studies, as is useful for disentangling the impacts of an invasive species from other natives with high abundances. Further studies about *E. plana's* mechanisms of invasion are crucial to better understand the invasion process of the species that is threatening Southern Brazilian natural grasslands.

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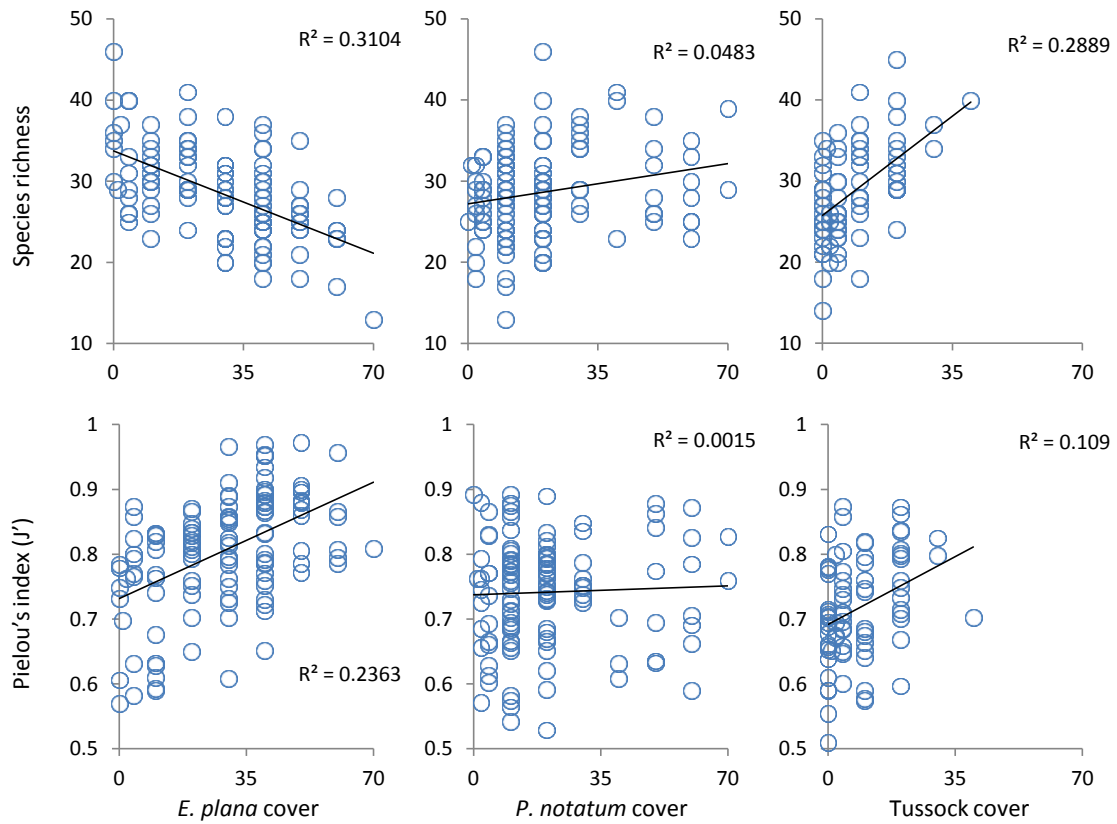
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## Tables and Figures



**Figure 1.** Regression models between different species cover and diversity indexes. Only *P. notatum* models had non-significant P values. N values: 120, 120 and 80, respectively.

**Table 1.** Simple linear regression models for functional groups richness in response to *Eragrostis plana*, *Paspalum notatum* and tussock grasses cover.  $P < 0.01$  are significant and presented in bold. Data are for three different sites in Southern Brazilian natural grasslands.

	<i>E. plana</i>		<i>P. notatum</i>		Tussock grasses	
	$R^2$	$P$	$R^2$	$P$	$R^2$	$P$
Grasses	0.084	<b>&lt; 0.01</b>	0.011	0.26	0.061	0.07
Forbs	0.143	<b>&lt; 0.01</b>	0.189	<b>&lt; 0.01</b>	0.140	<b>&lt; 0.01</b>
Woody	0.000	0.90	0.034	0.04	0.037	<b>&lt; 0.01</b>
Annuals	0.010	<b>&lt; 0.01</b>	0.114	0.02	0.007	0.32
Perennials	0.263	<b>&lt; 0.01</b>	0.042	<b>&lt; 0.01</b>	0.037	0.04
Erect	0.111	<b>&lt; 0.01</b>	0.000	0.91	0.115	<b>&lt; 0.01</b>
Prostrate	0.030	0.06	0.001	0.75	0.051	0.22



## CAPÍTULO II

### EVALUATION OF THE SOIL INVERTEBRATE ACTIVITY IN THE PRESENCE OF A NON-NATIVE EXOTIC GRASS

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#### Abstract

Soil invertebrates are key mediators of soil functions, especially decomposition, and can have a high importance for maintenance of diversity in ecosystems. Invasive species may affect invertebrate communities and thus indirectly plant communities and ecosystem processes. In South Brazilian grasslands, the South African perennial grass *Eragrostis plana* is highly invasive. In this study, we aimed at evaluating the effect of the species on soil invertebrates feeding activity through bait-lamina test. We compared consumption rates in plots dominated by *E. plana* with plots dominated by a native tussock grass and non tussock dominated plots. *E. plana* patches did not differ from control, non tussock dominated plots, concerning average consuming, however, it differed from another tussock species tested, *Sporobolus indicus*. The bait-lamina technique revealed to be an interesting option for investigation of effects of invasive plant species, especially when used together with other approaches.

**Key-words:** alien species, bait-lamina, Campos sulinos, *Eragrostis plana*.

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## Introduction

Soil invertebrates are key mediators of soil processes and play an important role for maintenance of diversity in plant communities (De Deyn et al. 2003). Incorporation of litter into soil, building and maintenance of structural porosity and aggregation, control of microbial communities and activities, plant protection against some pests and diseases and acceleration of plant successions are among the many effects they have on other organisms through their activities (Lavelle et al. 2006). The importance of soil invertebrates for ecosystem processes advocates concern about potential alterations of their communities by exotic plant invasion (Wolfe and Klironomos 2005).

Several mechanisms by which invasive plants affect soil communities have been identified (e.g. Ehrenfeld 2003). As an exotic plant species invades a community, it can alter links between native above and belowground communities, including the timing, quality, quantity, and spatial structure of plant-derived soil inputs (Lavelle et al. 2006). For instance, the invasive plant *Spartina alterniflora* stimulated the growth of nematodes by producing higher quality litter than its native counterpart in salt marsh ecosystems, suggesting that the invasion of exotic plant is likely to alter ecosystem functions indirectly through exerting its effect on soil decomposer (Chen et al. 2007). *Centaurea diffusa*, a Eurasian knapweed species that has invaded many natural ecosystems in western North America, has been demonstrated to have an antimicrobial agent (Vivanco et al. 2004) that affects the soil invertebrate community directly by growth inhibition and with indirect effects on the plant community as well. However, insensitivity to invasive species had been also demonstrated. Gremmen et al. (1998), for example, found no relationship between macro-invertebrates diversity and density of an exotic fast-growing perennial grass of mesic habitats on a sub-Antarctic island. It is important to note that native plants can influence soil communities by the same mechanisms, but the effects of an exotic invader may be more pronounced, as a particular mechanism may be novel to a native community (Wolfe and Klironomos 2005). These differences could explain why allelopathic substances of exotic invaders may have negative influence on plants or animals on invaded sites (Stinson et al.

2006), whereas allelopathic chemicals arising of native species could even promote richness (Ehlers et al. 2014).

*Eragrostis plana* Nees, a South-African perennial tussock grass, is considered an aggressive invader in South Brazilian grasslands, the “Campos sulinos” (Overbeck et al. 2007). A shoot and root system with high mechanical resistance, low palatability for cattle together with high production of persistent and easily dispersed seeds, allowed for its successful spreading (Medeiros and Focht 2007; Scheffer-Basso et al. 2012). The allelopathic potential of the species has been shown in laboratory studies (e. g. Ferreira et al. 2008), however, no study so far has proved any effect of phytotoxic substances of *E. plana* under field conditions, i.e. real effects on organisms in the community.

The bait-lamina test, first introduced by Törne in 1990, is a practical, easily interpretable, quick and cheap way to assess biotic activities in soil. The test system is based on visual assessment of feeding on small portions of thin laminated bait substrate exposed to biotic and abiotic degradation. The method has found its application mainly in soil ecology and soil ecotoxicology (Kratz 1998), and has been applied with success to investigate effects of fire on soil invertebrate activity in southern Brazilian grasslands (Podgaiski et al., in press).

Here, we wished to answer the question if and to what extent the soil invertebrate consumption rate under the exotic species differed from that affected only by native species, using bait lamina test. We hypothesized that bait-laminas under *E. plana* should have decreased consumption when compared to a native cespitose grass and to patches dominated by prostrate grasses and forbs, as a response of soil biota to *E. plana* stoichiometry and physiology.

## **Methods**

The experiment was conducted in summer of 2013 at the Agricultural Experimental Station of the Universidade Federal do Rio Grande do Sul, located in the municipality of Eldorado do Sul, Rio Grande do Sul, Brazil (30°05'22"S, 51°39'08"W), in a grazed grassland area with invasion of *E. plana*. Three groups of plots were compared

regarding soil invertebrates feeding activity; plots with presence of a tussock of *E. plana* (25 plots), plots with a tussock of *Sporobolus indicus* (L.) R. Br. (Subfamily Chloridoideae, tribe Zoysieae) (25 plots); a tussock grass that resemble the exotic species in terms of plant architecture and response to disturbance, and plots covered by prostrate grasses and forbs, without pronounced dominance tussock grasses (25 plots). Every tussock plant was marked in the middle with an iron bar and three bait-laminas were allocated (175 in total) linearly at 0, 5, and 10 cm away to account for the proximity effects. Plots covered only by prostrate grasses were marked with an iron bar and one bait-lamina was allocated near the bar. Bait-lamina consisted of 120 mm long thin printed circuit board blades with 16 holes, spaced 5 mm apart, filled with a mixture composed by cellulose powder (70%), wheat flour (27%) and activated carbon (3%) (Törne 1990).

After 16 days, a period that has been shown to be adequate for bait lamina studies in grasslands in the region (Podgaiski et al. 2011), bait-laminas were removed and analyzed in the lab. Bait removal were classified in two categories: non-consumed (whole bait material remained, "A") and consumed (bait material partially or totally removed, "B"). This evaluation method can be considered a more conservative approach because bait removal is only accounted dicotomically. We used analysis of variance with permutation test to compare responses. We ran the analyses in the software MULTIV (Pillar 2006). We were able to recover only a part of the bait laminas used: 71 in the *Eragrostis* plots, 67 in the *Sporobolus* plots and 18 in the tussock plots.

## Results

Our results show a relevant response of *Sporobolus* group for bait removal. These plots had lower ratio of non-consumed holes ( $2.4\% \pm 4.7$ , on average) than non-tussock ( $7\% \pm 9.3$ ) or *Eragrostis* plots ( $5.4\% \pm 8.4$ ). These differences are relatively meaningful regarding Cohen's *d*, a standardized measure of effect size for means: non-tussock vs. *Sporobolus*,  $p = 0.005$  and  $d = 0.67$ , *Eragrostis* vs. *Sporobolus*,  $p = 0.01$  and  $d = 0.45$ . Should be stressed the much higher standard deviation in non-tussock and *Eragrostis* plots.



## Discussion

Despite the notion that litter dwelling invertebrates being commonly known as generalists (Wardle et al. 2004), our data demonstrates that species identity (*E. plana* or *S. indicus*) has discernible response on invertebrate bait removal in comparison with non-tussock plots, however, not in the sense we had anticipated. *Sporobolus indicus*, our native species comparative, had lower percentage of untouched holes than any other group. This may suggest that *E. plana* biomass, concerning what was measured here, may lead to a lower degree nutrient cycling in the soil, comparable to plots with non-tussock dominance. Such results may not be readily interpreted because plant height, an estimate of the biomass, was not sampled.

The bait-lamina technique is an interesting option for screening experiments, with simplicity in the assembling process and very low costs. However, it only gives an indication of total activity, and does not elucidate any mechanisms in the soil community that could, for example, be caused by changes in the abundance of different groups of soil invertebrates.

Soil-inhabiting invertebrates are extremely diverse in form, differ greatly in size and numbers, and are often aggregated in horizontal and vertical distribution. Methods available for assessing populations include field sampling by help of attractant traps or pitfall traps, and assessing numbers of invertebrates in soil and litter samples. For future studies, these methods seem to be interesting options for a better assessment of effects of *E. plana* on ecosystem processes which basically have not been studied so far. Additionally, it seems important to quantify litter production and decay rates of *E. plana* in comparison to dominant native species, in order to better understand the effects of plants on ecosystem processes.

Research on effects of non-native plants on ecosystem processes, such as C and N cycles, biomass production or decomposition, has been pointed out as an important aspect when evaluating invasion processes (Ehrenfeld 2003), however, the number of studies available remains rather scarce. It now is acknowledged that functional diversity influences ecosystem processes (e.g. Diaz & Cabido 2001). We thus can expect that a non-native species that becomes dominant in a host-community should

have some effects of these processes, just as any native plant does. The question may be to identify the relevant functional differences and the traits related to them.

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## CONCLUSÃO

No geral, nossos resultados mostraram que *E. plana* esteve claramente associado a decréscimo na riqueza de espécies e aumento na equabilidade de comunidades, mas não teve efeitos consistentes sobre a composição da comunidade nem sobre a composição de atributos funcional. Além disso, nossos dados demonstram que a identidade das espécies (exóticas ou nativas) não teve efeito perceptível sobre as taxas de consumo de invertebrados.

Apesar de *E. plana* estar consideravelmente associado a perdas na riqueza de espécies em escala de parcela, esse padrão não deve ser automaticamente assumido como pré-condição de um efeito regional. Por outro lado, *E. plana* é uma espécie capaz de se espalhar rapidamente e constituir altos valores de cobertura na comunidade campestre, tornando-se potencialmente muito mais abundantes do que as espécies nativas. Portanto, a perda de espécies locais é possível e uma cobertura reduzida de espécies forrageiras é esperado (Medeiros & Focht, 2007).

Mais estudos sobre a capacidade competitiva de *E. plana*, em comparação com espécies nativas, como também estudos ao nível populacional do processo de expansão, parecem ser necessários para uma avaliação mais exaustiva dos efeitos da *E. plana*, bem como para a gestão dessa e de outras espécies exóticas.

A técnica de bait-lamina se mostrou uma opção interessante para experimentos de triagem, pela simplicidade do processo de montagem e custos muito baixos. No entanto, a técnica fornece apenas uma indicação da atividade total, e não elucidar quaisquer mecanismos responsáveis pelas diferenças encontradas, como por exemplo, aqueles provocados por variações na abundância dos diferentes grupos de invertebrados do solo. Além disso, parece importante quantificar a produção e as taxas de decomposição da serapilheira de *E. plana*, a fim de compreender melhor os efeitos da planta nos processos ecossistêmicos.

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## Annexes

**Annex 1.** List of species sampled and used in composition and functional traits analyses. Species without designative letters occurred in less than four plots. Acronyms: C = composition analysis, F = functional traits analysis.

Analyses	Family	Species name	Author
	Asteraceae	<i>Acanthostyles buniifolius</i>	(Hook. ex Arn.) R.M. King & H. Rob.
	Asteraceae	<i>Achyrocline satureioides</i>	(Lam.) DC.
	Fabaceae	<i>Aeschynomene falcata</i>	(Poir.) DC.
C	Asteraceae	<i>Ageratum sp.</i>	L.
C, F	Primulaceae	<i>Anagallis arvensis</i>	L.
C, F	Poaceae	<i>Andropogon bicornis</i>	L.
C, F	Poaceae	<i>Andropogon lateralis</i>	Nees
C	Poaceae	<i>Andropogon selloanus</i>	(Hack.) Hack.
C	Poaceae	<i>Andropogon sp.</i>	L.
C	Poaceae	<i>Andropogon ternatus</i>	(Spreng.) Nees
	Apocynaceae	Apocynaceae	Juss.
C	Poaceae	<i>Aristida laevis</i>	(Nees) Kunth
C	Poaceae	<i>Aristida sp.</i>	L.
C	Poaceae	<i>Aristida venustula</i>	Arechav.
	Aristolochiaceae	<i>Aristolochia sessiflora</i>	DC. ex Duch.
	Aristolochiaceae	<i>Aristolochia sp.</i>	L.
C	Asteraceae	<i>Aspilia montevidensis</i>	(Spreng.) Kuntze
	Poaceae	<i>Avena strigosa</i>	Schreb.
C	Poaceae	<i>Axonopus argentinus</i>	Parodi
C	Poaceae	<i>Axonopus fissifolius</i>	(Raddi) Kuhlms.
	Poaceae	<i>Axonopus sp.</i>	P. Beauv.
	Asteraceae	<i>Baccharis coridifolia</i>	DC.
C, F	Asteraceae	<i>Baccharis crispa</i>	(Lam.) Pers.
C, F	Asteraceae	<i>Baccharis dracunculifolia</i>	DC.
	Asteraceae	<i>Baccharis ochracea</i>	Spreng.
	Asteraceae	<i>Baccharis sp.</i>	L.
	Rubiaceae	<i>Borreria capitata</i>	(Ruiz & Pav.) DC.
C	Rubiaceae	<i>Borreria eryngioides</i>	Cham. & Schlttdl.
C, F	Poaceae	<i>Bothriochloa laguroides</i>	(DC.) Herter
	Brassicaceae	Brassicaceae	Burnett
C	Poaceae	<i>Briza minor</i>	L.
	Cyperaceae	<i>Bulbostylis capillaris</i>	(L.) C.B. Clarke
	Cyperaceae	<i>Bulbostylis sp.</i>	Kunth

	Poaceae	<i>Calamagrostis viridiflavescens</i>	(Poir.) Steud.
	Myrtaceae	<i>Campomanesia aurea</i>	O. Berg
	Brassicaceae	<i>Cardamine bonariensis</i>	Pers.
	Asteraceae	<i>Carduus sp.</i>	L.
C	Cyperaceae	<i>Carex phalaroides</i>	Kunth
	Cyperaceae	<i>Carex sororia</i>	Kunth
C	Cyperaceae	<i>Carex sp.</i>	L.
C	Caryophyllaceae	Caryophyllaceae	Juss.
	Apiaceae	<i>Centella asiatica</i>	(L.) Urb.
C	Caryophyllaceae	<i>Cerastium glomeratum</i>	Thuill.
	Fabaceae	<i>Chamaecrista repens</i>	(Vogel) H.S. Irwin & Barneby
C	Asteraceae	<i>Chaptalia nutans</i>	(L.) Pol.
C, F	Asteraceae	<i>Chaptalia runcinata</i>	Kunth
	Asteraceae	<i>Chaptalia sinuata</i>	(DC.) Baker
	Asteraceae	<i>Chaptalia sp.</i>	Vent.
	Poaceae	<i>Chascolytrum lamarckianum</i>	(Nees) Matthei
C	Poaceae	<i>Chascolytrum poomorphum</i>	(J. Presl) L. Essi, Longhi-Wagner & Souza-Chies
	Poaceae	<i>Chascolytrum rufum</i>	J. Presl
	Poaceae	<i>Chascolytrum sp.</i>	Desv.
C	Poaceae	<i>Chascolytrum subaristatum</i>	(Lam.) Desv.
	Poaceae	<i>Chascolytrum uniolae</i>	(Nees) L. Essi, Longhi-Wagner & Souza-Chies
C	Asteraceae	<i>Chevreulia acuminata</i>	Less.
C, F	Asteraceae	<i>Chevreulia sarmentosa</i>	(Pers.) S.F. Blake
C	Rubiaceae	<i>Chomelia sp.</i>	Jacq.
C	Asteraceae	<i>Chromolaena ascendens</i>	(Sch. Bip. ex Baker) R.M. King & H. Rob.
C	Asteraceae	<i>Chrysoleaena flexuosa</i>	(Sims) H. Rob.
	Commelinaceae	Commelinaceae	Mirb.
	Convolvulaceae	<i>Convolvulus sp.</i>	L.
C	Asteraceae	<i>Conyza primulifolia</i>	(Lam.) Cuatrec. & Lourteig
C	Asteraceae	<i>Conyza sp.</i>	Less.
C	Lythraceae	<i>Cuphea campylocentra</i>	Griseb.
	Lythraceae	<i>Cuphea carthagenensis</i>	(Jacq.) J.F. Macbr.
C, F	Lythraceae	<i>Cuphea glutinosa</i>	Cham. & Schltld.
C, F	Apiaceae	<i>Cyclospermum leptophyllum</i>	(Pers.) Sprague ex Britton & P. Wilson
C, F	Poaceae	<i>Cynodon dactylon</i>	(L.) Pers.
	Iridaceae	<i>Cypella herbertii</i>	Hook.
C	Cyperaceae	Cyperaceae	Juss.



C	Cyperaceae	<i>Cyperus aggregatus</i>	(Willd.) Endl.
	Cyperaceae	<i>Cyperus reflexus</i>	Vahl
	Cyperaceae	<i>Cyperus sp.</i>	L.
	Fabaceae	<i>Desmanthus sp.</i>	Willd.
C	Fabaceae	<i>Desmanthus virgatus</i>	(L.) Willd.
C	Fabaceae	<i>Desmodium incanum</i>	(Sw.) DC.
C	Fabaceae	<i>Desmodium sp.</i>	Desv.
C, F	Poaceae	<i>Dichantherium sabulorum</i>	(Lam.) Gould & C.A. Clark
C	Convolvulaceae	<i>Dichondra macrocalyx</i>	Meisn.
C, F	Convolvulaceae	<i>Dichondra sericea</i>	Sw.
	Poaceae	<i>Digitaria violascens</i>	Link
	Moraceae	<i>Dorstenia brasiliensis</i>	Lam.
C	Cyperaceae	<i>Eleocharis viridans</i>	Kük. ex Osten
C, F	Asteraceae	<i>Elephantopus mollis</i>	Kunth
C	Poaceae	<i>Eleusine tristachya</i>	(Lam.) Lam.
	Poaceae	<i>Eragrostis bahiensis</i>	Schrad. ex Schult.
C, F	Poaceae	<i>Eragrostis lugens</i>	Nees
	Poaceae	<i>Eragrostis neesii</i>	Trin.
C	Poaceae	<i>Eragrostis plana</i>	Nees
	Poaceae	<i>Eragrostis polytricha</i>	Nees
C	Poaceae	<i>Eragrostis sp.</i>	Wolf
	Apiaceae	<i>Eryngium ciliatum</i>	Cham. & Schltld.
C, F	Apiaceae	<i>Eryngium horridum</i>	Malme
C	Apiaceae	<i>Eryngium nudicaule</i>	Lam.
	Apiaceae	<i>Eryngium sp.</i>	L.
	Asteraceae	<i>Eupatorium sp.</i>	L.
C	Asteraceae	<i>Eupatorium squarrulosum</i>	Hook. & Arn.
	Euphorbiaceae	<i>Euphorbia selloi</i>	(Klotzsch & Garcke) Boiss.
C, F	Convolvulaceae	<i>Evolvulus sericeus</i>	Sw.
	Fabaceae	Fabaceae	Lindl.
C	Asteraceae	<i>Facelis retusa</i>	(Lam.) Sch. Bip.
C	Fabaceae	<i>Galactia marginalis</i>	Benth.
	Fabaceae	<i>Galactia sp.</i>	P. Browne
C, F	Rubiaceae	<i>Galianthe fastigiata</i>	Griseb.
C, F	Rubiaceae	<i>Galium richardianum</i>	(Gillies ex Hook. & Arn.) Endl. ex Walp.
C	Rubiaceae	<i>Galium sp.</i>	L.
C	Asteraceae	<i>Gamochoaeta americana</i>	(Mill.) Wedd.
C, F	Asteraceae	<i>Gamochoaeta coarctata</i>	(Willd.) Kerguelen
C	Asteraceae	<i>Gamochoaeta sp.</i>	Wedd.
C	Geraniaceae	<i>Geranium sp.</i>	L.

C	Verbenaceae	<i>Glandularia marrubioides</i>	(Cham.) Tronc.
C	Verbenaceae	<i>Glandularia selloi</i>	(Spreng.) Tronc.
	Orchidaceae	<i>Habenaria parviflora</i>	Lindl.
	Lythraceae	<i>Heimia apetala</i>	(Spreng.) S.A. Graham & Gandhi
C	Iridaceae	<i>Herbertia lahue</i>	(Molina) Goldblatt
C	Iridaceae	<i>Herbertia pulchella</i>	Sweet
	Clusiaceae	<i>Hipericum sp.</i>	Neck.
C	Araliaceae	<i>Hydrocotyle exigua</i>	Malme
C	Asteraceae	<i>Hypochaeris albiflora</i>	(Kuntze) Azevêdo-Gonç. & Matzenb.
C	Asteraceae	<i>Hypochaeris chillensis</i>	(Kunth) Britton
C	Asteraceae	<i>Hypochaeris megapotamica</i>	Cabrera
	Asteraceae	<i>Hypochaeris radicata</i>	L.
C	Asteraceae	<i>Hypochaeris sp.</i>	L.
C	Hypoxidaceae	<i>Hypoxis decumbens</i>	L.
C	Fabaceae	<i>Indigofera sp.</i>	L.
C	Juncaceae	<i>Juncus capillaceus</i>	Lam.
C, F	Juncaceae	<i>Juncus microcephalus</i>	Kunth
C	Juncaceae	<i>Juncus sp.</i>	L.
C	Juncaceae	<i>Juncus tenuis</i>	Willd.
C	Acanthaceae	<i>Justicia axillaris</i>	(Nees) Lindau
	Acanthaceae	<i>Justicia sp.</i>	L.
C	Malvaceae	<i>Krapovickasia sp.</i>	Fryxell
C	Cyperaceae	<i>Kyllinga odorata</i>	Vahl
	Cyperaceae	<i>Kyllinga sp.</i>	Rottb.
	Brassicaceae	<i>Lepidium sp.</i>	L.
	Verbenaceae	<i>Lippia sp.</i>	L.
	Poaceae	<i>Lolium multiflorum</i>	Lam.
C	Asteraceae	<i>Lucilia nitens</i>	Less.
C	Plantaginaceae	<i>Mecardonia tenella</i>	(Cham. & Schltld.) Pennell
	Poaceae	<i>Melica sp.</i>	L.
C	Poaceae	<i>Mnesithea seloana</i>	(Hack.) de Koning & Sosef
C	Myrtaceae	Myrtaceae	Juss.
	Poaceae	<i>Nassella megapotamia</i>	(Spreng. ex Trin.) Barkworth
C	Amaryllidaceae	<i>Nothoscordum montevidense</i>	Beauverd
C	Amaryllidaceae	<i>Nothoscordum sp.</i>	Kunth
	Asteraceae	<i>Orthopappus angustifolius</i>	(Sw.) Gleason
C	Oxalidaceae	<i>Oxalis brasiliensis</i>	G. Lodd.
C	Oxalidaceae	<i>Oxalis conorrhiza</i>	Jacq.
C, F	Oxalidaceae	<i>Oxalis eriocarpa</i>	DC.
C	Oxalidaceae	<i>Oxalis lasiopetala</i>	Zucc.

C	Oxalidaceae	<i>Oxalis perdicaria</i>	(Molina) Bertero
	Oxalidaceae	<i>Oxalis sp.</i>	L.
	Apocynaceae	<i>Oxypetalum sp.</i>	R. Br.
C, F	Poaceae	<i>Paspalum dilatatum</i>	Poir.
C, F	Poaceae	<i>Paspalum notatum</i>	Alain ex Flügge
C	Poaceae	<i>Paspalum paucifolium</i>	Swallen
C, F	Poaceae	<i>Paspalum plicatulum</i>	Michx.
C	Poaceae	<i>Paspalum sp.</i>	L.
C	Poaceae	<i>Paspalum umbrosum</i>	Trin.
C	Poaceae	<i>Paspalum urvillei</i>	Steud.
C, F	Amaranthaceae	<i>Pfaffia tuberosa</i>	Hicken
C	Poaceae	<i>Piptochaetium</i>	J. Presl
C, F	Poaceae	<i>Piptochaetium montevidense</i>	(Spreng.) Parodi
C	Poaceae	<i>Piptochaetium stipoides</i>	(Trin. & Rupr.) Hack. ex Arechav.
	Passifloraceae	<i>Piriqueta sp.</i>	Aubl.
C	Plantaginaceae	<i>Plantago myosuroides</i>	Lam.
C	Plantaginaceae	<i>Plantago tomentosa</i>	Lam.
C	Poaceae	Poaceae sp.	Barnhart
C	Polygalaceae	<i>Polygala australis</i>	A.W. Benn.
	Polygalaceae	<i>Polygala sp.</i>	L.
	Myrtaceae	<i>Psidium luridum</i>	(Cambess.) Landrum
C	Asteraceae	<i>Pterocaulon angustifolium</i>	DC.
C	Quillajaceae	<i>Quillaja brasiliensis</i>	(A. St.-Hil. & Tul.) Mart.
	Fabaceae	<i>Rhynchosia diversifolia</i>	Micheli
C, F	Cyperaceae	<i>Rhynchospora barrosiana</i>	Guagl.
C	Cyperaceae	<i>Rhynchospora sp.</i>	Vahl
	Cyperaceae	<i>Rhynchospora tenuis</i>	Willd. ex Link
C, F	Rubiaceae	<i>Richardia brasiliensis</i>	Gomes
C, F	Rubiaceae	<i>Richardia grandiflora</i>	(Cham. & Schltdl.) Steud.
C, F	Rubiaceae	<i>Richardia humistrata</i>	(Cham. & Schltdl.) Steud.
	Rubiaceae	<i>Richardia sp.</i>	L.
	Rubiaceae	<i>Richardia stellaris</i>	(Cham. & Schltdl.) Steud.
C	Rubiaceae	Rubiaceae	Juss.
C	Acanthaceae	<i>Ruellia hypericoides</i>	(Nees) Lindau
C, F	Acanthaceae	<i>Ruellia morongii</i>	Britton
	Polygonaceae	<i>Rumex sp.</i>	L.
	Poaceae	<i>Saccharum angustifolium</i>	(Nees) Trin.
C	Poaceae	<i>Schizachyrium sp.</i>	Nees
	Poaceae	<i>Schizachyrium spicatum</i>	(Spreng.) Herter
	Poaceae	<i>Schizachyrium tenerum</i>	Nees
C, F	Lamiaceae	<i>Scutellaria racemosa</i>	Pers.

	Lamiaceae	<i>Scutellaria sp.</i>	L.
C, F	Asteraceae	<i>Senecio brasiliensis</i>	(Spreng.) Less.
C	Asteraceae	<i>Senecio crassiflorus</i>	(Poir.) DC.
C	Asteraceae	<i>Senecio heterotrichus</i>	DC.
C, F	Asteraceae	<i>Senecio leptolobus</i>	DC.
C	Asteraceae	<i>Senecio madagascariensis</i>	Poir.
C	Asteraceae	<i>Senecio selloi</i>	(Spreng.) DC.
C	Poaceae	<i>Setaria geniculata</i>	P. Beauv.
C, F	Poaceae	<i>Setaria parviflora</i>	(Poir.) Kerguélen
C	Poaceae	<i>Setaria sp.</i>	P. Beauv.
C, F	Malvaceae	<i>Sida rhombifolia</i>	L.
C, F	Iridaceae	<i>Sisyrinchium micranthum</i>	Cav.
C	Iridaceae	<i>Sisyrinchium sellowianum</i>	Klatt
C	Iridaceae	<i>Sisyrinchium sp.</i>	L.
C, F	Asteraceae	<i>Solidago chilensis</i>	Meyen
C	Asteraceae	<i>Solidago sp.</i>	L.
C	Asteraceae	<i>Soliva pterosperma</i>	(Juss.) Less.
C	Poaceae	<i>Sorghastrum sp.</i>	Nash
	Caryophyllaceae	<i>Spergularia grandis</i>	(Pers.) Cambess.
C, F	Rubiaceae	<i>Spermacoce verticillata</i>	L.
C, F	Poaceae	<i>Sporobolus indicus</i>	(L.) R. Br.
C, F	Poaceae	<i>Steinchisma hians</i>	(Elliott) Nash
C	Acanthaceae	<i>Stenandrium diphyllum</i>	Nees
C	Poaceae	<i>Stipa nutans</i>	Hack.
C	Poaceae	<i>Stipa setigera</i>	J. Presl
C, F	Fabaceae	<i>Stylosanthes leiocarpa</i>	Vogel
C	Fabaceae	<i>Stylosanthes montevidensis</i>	Vogel
	Asteraceae	<i>Symphotrichum subulatum</i>	(Michx.) G.L. Nesom
	Asteraceae	<i>Taraxacum sp.</i>	F.H. Wigg.
	Poaceae	<i>Trachypogon sp.</i>	Nees
C	Euphorbiaceae	<i>Tragia bahiensis</i>	Müll. Arg.
C	Fabaceae	<i>Trifolium polymorphum</i>	Poir.
	Fabaceae	<i>Trifolium repens</i>	L.
	Fabaceae	<i>Trifolium sp.</i>	L.
	Passifloraceae	<i>Turnera sidoides</i>	L.
C	Verbenaceae	<i>Verbena bonariensis</i>	L.
	Verbenaceae	<i>Verbena litoralis</i>	Kunth
C	Verbenaceae	<i>Verbena montevidensis</i>	Spreng.
	Verbenaceae	<i>Verbena sp.</i>	L.
C, F	Asteraceae	<i>Vernonanthura nudiflora</i>	(Less.) H. Rob.
	Asteraceae	<i>Vernonanthura sp.</i>	Schreb.

C	Plantaginaceae	<i>Veronica arvensis</i>	L.
C	Plantaginaceae	<i>Veronica sp.</i>	L.
C	Poaceae	<i>Vulpia bromoides</i>	(L.) Gray
	Campanulaceae	<i>Wahlenbergia linarioides</i>	(Lam.) A. DC.
	Fabaceae	<i>Zornia sp.</i>	J.F. Gmel.