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Authors: Guimarães, L. C., Rodrigues, F. H. G., and Scotti, M. R.

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L. C. Guimarães, F. H. G. Rodrigues and M. R. Scotti

L. C. Guimarães, Post-graduate program of Ecology Conservation and Wildlife Management (ICB/UFMG), 31270-901 Belo Horizonte, MG, Brazil. – F. H. G. Rodrigues, Dept of Biology, Inst. of Biological Science, Federal Univ. of Minas Gerais, Av. Antônio Carlos, 6.627 – Campus Pampulha, 31270-901 Belo Horizonte, MG, Brazil. – M. R. Scotti, (mrscottimuzzi@gmail.com), Dept of Botany, Inst. of Biological Science, Federal Univ. of Minas Gerais, Av. Antonio Carlos, 6.627 – Campus Pamphula, 31270-901 Belo Horizonte, MG, Brazil

This study investigated the potential use of diversionary feeding and behavior-contingent sonic deterrents to mitigate the herbivory impacts of capybaras *Hydrochoerus hydrochaeris* on a riparian forest restoration site in the watershed of the Velhas River, the main tributary of the S. Francisco River in southeastern Brazil. *Paspalum notatum*, popularly known as batatais or bahia grass, was chosen as a diversionary food candidate and motion-activated sonic alarms were used as deterrents. A field experiment was conducted to compare the plant cover and the damage incidence in a fenced-off control on open plots with and without sonic deterrents. In these plots, *P. notatum* was cultivated alongside other restoration species of interest. Capybaras distinctly preferred *P. notatum*, which suffered 8.14-fold greater damage than other species and suffered coverage losses of up to 40% outside of the control plots, whereas the remaining species showed no difference from the control. The sonic deterrents did not influence the soil cover by any of the species, but did mitigate the damage to *P. notatum* independently of time. The damage was 93% more prevalent in the plots without deterrents. This success was partial, however, because damage also occurred in the presence of the deterrents. *P. notatum* was efficient at attracting and concentrating the interest of capybaras and therefore showed promise as a cover crop to protect other species of interest. Overall, the results of this study suggest that *P. notatum* is more efficient than electronic deterrents to protect a forest under restoration process against capybara damage.

Riparian forests provide fundamental ecosystem services, such as biodiversity conservation, regularization of hydrological cycles, water and soil conservation, sediment retention, carbon fixation, pollutant filtering and stream bank stabilization (Lawrance et al. 1984, Welsch 1991, Plamondon et al. 1991, Alegrea and Rao 1996, Liu and Sheu 1997, Scott et al. 1999, Tabacchi et al. 2000, Sparovek et al. 2002, Schultz et al. 2004, Neill et al. 2006, Pollen 2007). Consequently, riparian reforestation has been adopted into watershed restoration efforts in various parts of the world, including Brazil (Bullock et al. 2011, Calmón et al. 2011), where, in particular, it has been utilized along the Velhas River. This river is the main tributary of the S. Francisco River whose riparian forest is absent and whose soils are very degraded (Camargos, 2005). Because seedling survival is essential to the success of riparian forest restoration, it is important to protect seedlings from abiotic and biotic pressures, especially from the trampling caused by herbivorous species. Research has shown that herbivore exclusion by fencing increases the success of riparian forest restoration (Sweeney et al. 2002).

Capybaras exist in the tropical Americas from Panama to southern Argentina (Quintana and Bolkovic 2013). Their habitat requirements include forested patches that they use for feeding, shelter and parturition, and water bodies are essential for displacement to new grazing areas for feeding and for predator evasion (Ojasti 1973, Ojasti and Burgos 1985, Herrera and MacDonald 1989). Despite anecdotal reports of crop damage from capybara grazing and the fact that riparian reforestation projects are relatively common, damage assessments remain rare. Nevertheless, damage has been reported on corn, rice and sugarcane crops with herbivory damage incidence reaching as much as 25% on corn fields (Ferraz et al. 2003). Capybara damage is closely associated with proximity to water bodies and forested areas, sharply decreasing with distance (Ferraz et al. 2003). This puts riparian forested areas in the early stages of succession at particular risk in terms of plant survival due to the trampling of young plants of woody species; therefore, damage control management practices are required. Fences efficiently exclude capybaras from reforestation sites, but their installation is not always possible as occurs in slope steepness hampers installation and flooding can damage the fences. Therefore, complementary management tools must be developed for damage mitigation without

lethal suppression of native species (Delibes-Mateos et al. 2011).

Diversionary feeding is a management practice that involves supplying food to problem animals to divert them away from resources or targeted protection areas. It does not rely on population suppression (Sullivan and Sullivan 2008). This strategy has been successfully employed to control damage to crops and young forest stands during early successional stages by rodents such as rabbits, squirrels and voles as well as other mammals, such as boars (Sullivan 1992, Sullivan and Klenner 1993, Sullivan and Sullivan 2008); however, this strategy has also failed to satisfactorily reduce the damage to young forest stands (Sullivan et al. 2001).

Therefore, this study explored the viability of both diversionary feeding and behavior-contingent deterrent devices to mitigate capybara grazing damage. We conducted the experiments in an actual riparian reforestation site during early restoration, enabling the assessment of management practices in a real operational situation, albeit a small-scale one.

An important first step to determine the viability of diversionary feeding is to establish the food preferences of the target species (Miller et al. 2006), especially during the dry season when food scarcity is heightened. The Velhas River presents an open and shallow channel and its flow depends on riparian area flooding during the rainy season. Therefore, restoration of the riparian forest requires intercropping using herbaceous species between rows to protect the soil from erosion during the rainy season after flooding.

Both *Helianthus annuus* (Asteraceae) and *Paspalum notatum* (Poaceae) were selected as diversionary food candidates since they protect riverside against erosion (Lu et al. 2001, Grace 2000) and can be also a food supply during the dry season. Capybaras prefer feeding on species according to the following hierarchy: Poacee > Cyperaceae > Leguminosae > Asteraceae (Forero-Montaña et al. 2003). Despite foraging species are preferred (Quintana 2002), the *H. annuus* establishment is faster and might represent an initial feeding option for capybaras.

Paspalum notatum is a native species (Baki et al. 1992) that can be used as a pioneer forage cultivated between rows in the riparian forest. It is considered to be an important nutritious and palatable forage (Hirata et al. 2003, Arthington and Brown 2005) because it is able to establish a mutualistic association with the nitrogen-fixing bacteria *Azotobacter paspali* (Döbereiner et al. 1972, Day et al. 1975). Therefore, *P. notatum* leaves are rich in protein, serving as an attractive food for capybaras in the establishment of riparian forest.

Another non-lethal pest management strategy to control herbivory that has been demonstrated in the literature due to its simplicity and immediate effects is the use of electronic aversive stimuli, such as loud noises or bright lights; however, animals will eventually habituate to the stimuli, limiting their usefulness (Bomford and O'Brien 1990, Koehler et al. 1990, Nolte 1999). One way to slow this habituation and prolong the deterrence is to employ behavior-contingent devices that depend on the animal's presence or that are activated when the animal enters a specific area (Belant et al. 1996, Shivik and Martin 2000). Various sonic devices have been shown to be effective to different degrees, especially when the short-term deterrence of pests is required during critical periods

(Koehler et al. 1990, Belant et al. 1996, Gilsdorf et al. 2003); however, these have also utterly failed in repelling the target species (Roper and Hill 1985, Bomford and O'Brien1990, Koehler et al. 1990, Belant et al. 1998). In spite of attempts to exclude established rodents from their home territories, sonic devices have had variable effects and have often been ineffective (Schumake 1995, Gilsdorf et al. 2003).

The aim of this work was to ensure forest protection during the first years of establishment when plants may suffer damage by capybaras. Therefore, we hypothesized that: 1) *P. notatum* will be the preferred food by capybaras over other available species, thus shielding the other native species; and 2) trampling and feeding damage by capybaras will be lessened in the presence of deterrent devices.

Material and methods

Study site

The study site is located on the outskirts of Belo Horizonte, in the State of Minas Gerais, in southeast Brazil, at the confluence point of the Velhas River (São Francisco River basin), which is a minor tributary to the left margins of both: 19°50'30.102"S and 43°52'6.6714"W. The area was previously disturbed by removal of its riparian forest, and its vegetative cover was thin and dominated by ruderal species. As part of the restoration efforts undertaken in the Velhas watershed, the site was cleared and reforested with seedlings from an assortment of woody species appropriate to the restoration of its riparian forest. The presence of capybaras was confirmed by visual observation, including footprints and scat in the area, prior to and throughout the experiment.

Cultivated plant species

All of the plots were cultivated with seedlings of woody/shrubby and herbaceous native species intercropped with herbaceous *Paspalum notatum* or *Helianthus annuus* species using a randomized block design with 3 × 3 m spacing, thereby maintaining the biodiversity. Herbaceous species were cultivated between all of the plot rows to ensure surface erosion control. We tested the soil protection efficiency of herbaceous species and their success in preventing damage to woody species by serving as diversionary food during the dry season, which extends from April to September.

The plants were cultivated at an experimental site and the planted species were chosen from selected riparian species using a reforestation model of functional zones (Schultz et al. 2004).

Herbaceous species
Paspalum notatum (Poaceae) seeds were acquired commercially and inoculated with *Azotobacter paspali* (10^8 cells ml^{-1}) at a rate of 500 ml kg^{-1} of seed at the Laboratory of Plant–Microorganism Interaction and Land Reclamation of the Federal Univ. of Minas Gerais, Brazil, (UFMG).

Helianthus annuus (Asteraceae) was also acquired commercially and was planted in plots without *P. notatum* in order to reduce soil erosion. The quick vertical growth of *Helianthus annuus* and high seedling density also facilitated the

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identification of trampling damage when compared to the woody species planted in the area.

Woody species

The woody species were selected from among 50 native species adapted to the riparian conditions of the Velhas River basin.

Experimental design

The experimental design involved 3 completely randomized blocks with six treatments or plots per block. All of the plots were cultivated with native woody or shrubby species plus an herbaceous species. The control area (fenced plots with wire and wood) received two plots (*H. annuus* and *P. notatum*) or 28 m² plot^{-1} which compose each block (56 m²), totaling 168 m². The experimental area (unfenced plots) received four treatments (28 m² per plot) or 112 m² block^{-1}, totaling 336 m². The treatments or plots were as follows: 1) fenced plots with *P. notatum*, 2) fenced plots with *H. annuus*, 3) unfenced plots with *P. notatum* and deterrent devices, 4) unfenced plots with *H. annuus* and deterrent devices, 5) unfenced plots with *P. notatum*, 6) unfenced plots with *H. annuus*. All of the plots were cultivated with woody species at 3×3 m spacing alongside the herbaceous swathes and received complete fertilization as follows: KH_2PO_4: 468 mg pot^{-1}; KCl: 404.2 mg pot^{-1}; $MgSO_4$ $7H_2O$: 53.3 mg pot^{-1}; $ZnSO_4$ $7H_2O$: 49.5 mg pot^{-1}; $(NH_4)_6$ Mo_7O_{24} H_2O: 1.95 mg pot^{-1}; $CO(NH_2)_2$: 219 mg pot^{-1}. This fertilization method was based on that described by Somasegaran and Hoben (1985) and was applied at seedling transplantation. The fenced plots were used as control groups. All of the land surrounding the experimental area was fenced, so that it could only be reached from the river. All of the fences reached 20 cm of depth, so that the capybaras could not dig under them. Transplantation and fencing were carried out four months before the sonic deterrents were installed and sampling began.

Deterrent devices

The deterrent devices employed in this study included motion-activated sonic alarms of 105 dB volume with a sensory range of 8 m long and 4 m wide. Two such sensors were installed in each of the 28-m² plots, positioned to maximize the area covered by the sensors within the plot and to avoid detection outside of it.

Sampling

The soil coverage, which is determined by the capacity of herbaceous and shrub species to cover the soil, was estimated for *P. notatum*, *H. annuus* and all other species, including cultivated seedlings and spontaneously occurring herbs; the latter were grouped under the umbrella tag of native species. The soil coverage was estimated using a 1-m² quadrant that was subdivided into 100 identical cells of 10 cm (Toledo and Schultze-Kraft 1982); the coverage in each cell was recorded at intervals during the study. Three quadrant samples were collected per plot or treatment over 10 sampling events and over four months (three replicates $\times$ six treatments $\times$ three blocks $\times$ 10 samples). The deterrents were installed four months after transplantation. The sampling began three days after deterrent installation and ended eight months after transplantation. Trampling and feeding damage were visually identified in samples obtained from quadrants analysis and the ratio of damaged cover for each species in a given sample was obtained from the area occupied by a species and its impacted subarea. The woody species in each plot were evaluated for damage.

Statistical analysis

The effects of time on the treatments and the association with plant cover were demonstrated using descriptive means and mean comparisons that were performed using regression analysis–likelihood method, wherein the link function and variance were adjusted using the LOWESS method (locally weighted scatterplot smoothing). To consider the interactions between the treatments and time by assessing whether the differences between treatments varied over time, F-test was conducted. The correlations were verified with a Spearman analysis.

The ratio of the damage caused to *Paspalum notatum* by herbivory versus the damage to native species and the trampling damage to *H. annuus* were estimated using the Wilcoxon signed-rank and Mann–Whitney tests. The Kruskal–Wallis test was used to estimate the time effect independently of treatments.

Analyses were conducted using *R* software ver. 2.15.0. The significance level was set to 5% for all analyses.

Results

Plant cover

Paspalum notatum

Figure 1A shows that time influenced all of the treatments ($p < 0.001$) and the cover decreased by 2.2% per day on average. The average occupancy rate decreased along the time 30% and 40% respectively in comparison with the control plots (Table 1A). There was significant difference in the cover rate between the plots with ($p = 0.041$) and without ($p = 0.004$) deterrents in relation to the control plots (Table 1A). However, there was no difference between treatments with and without deterrents ($p = 0.381$, Table 1A). The F-test showed no significant interaction between treatments with time ($p = 0.073$).

Helianthus annuus

Time also influenced the *H. annuus* cover ($p < 0.001$, Fig. 1B), which decreased by 5.4% per day on average until disappearing after the day 54 (Table 1 B). The treatments with and without deterrents did not present significant differences ($p = 0.269$) or between each treatment and the control plots over time ($p = 0.753$ and $p = 0.158$ respectively). Based on F-test no significant differences were found between any of the treatments. The average differences between the treatments did not vary over time ($p = 0.593$).

Native species

Time influenced the native plant cover significantly ($p < 0.001$), producing an average increase of 0.5% per day (Fig. 1C, Table 1C). No differences were found between any
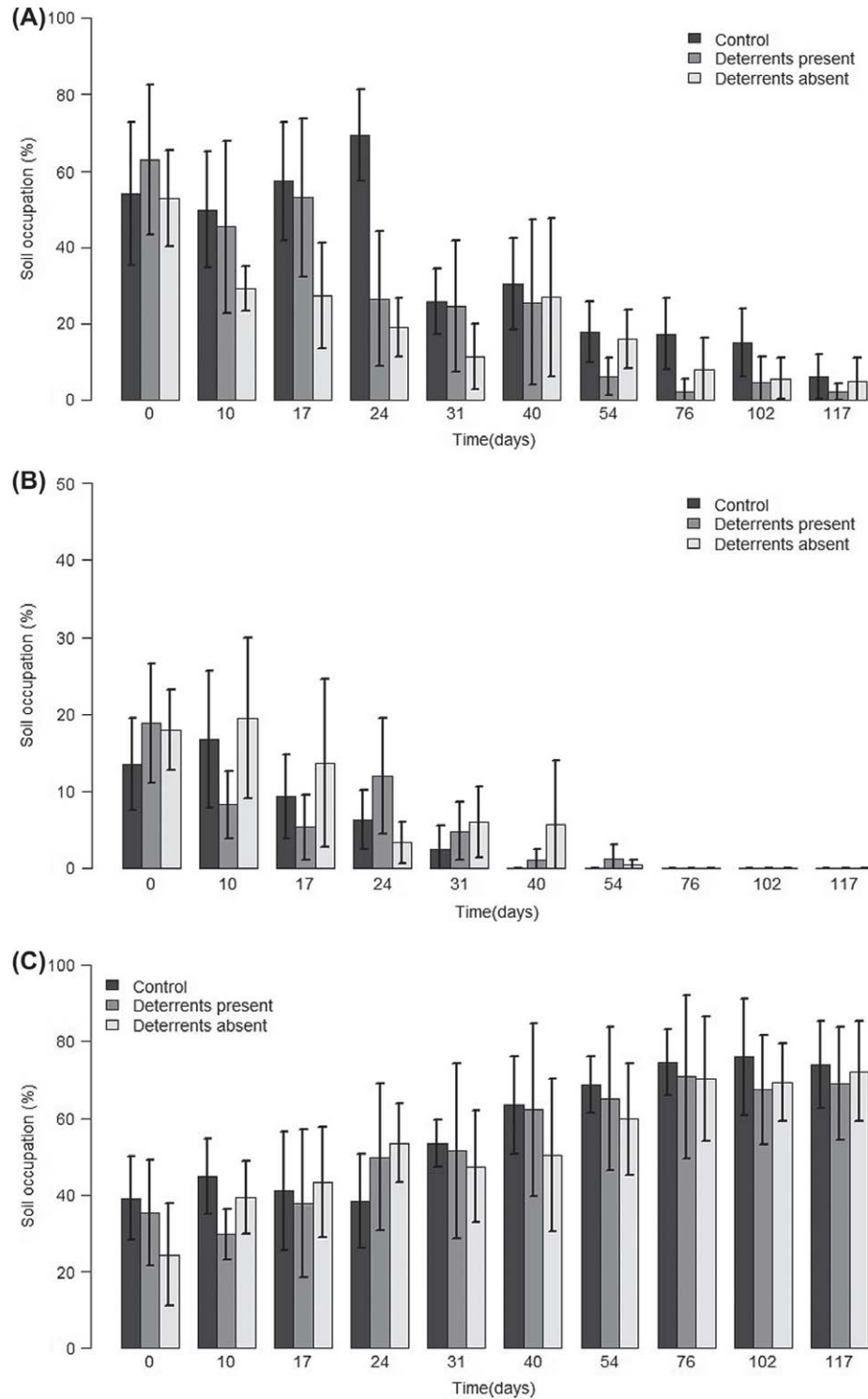
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Figure 1. Descriptive measures of cover averages over time (days) for *P. notatum* (A). *H. annuus* (B) and native species (C) under the following treatments: fenced (control) with and without deterrents.

of the treatments. The average differences (F-test) between the treatments did not vary over time (p = 0.855. Table 1C).

The effects of the association of *P. notatum* and *H. annuus* species with native species cover

Native cover (Table 2) was negatively correlated with both *P. notatum* (r = –0.29) and *H. annuus* (r = –0.33)

covers (p < 0.0001). Native species cover expansion (Table 2) was influenced by its association with either *P. notatum* or *H. annuus* (p = 0.006). The expansion occurred faster alongside *H. annuus* (β = 0.007) than alongside *P. notatum* (β = 0.003). Figure 2 shows that native species cover was initially greater alongside *P. notatum* than alongside *H. annuus* but this behavior reversed after day 68, when a competitive relationship was established, limiting the

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Table 1. Likelihood regression with a logarithmic link function (exp) and a variance proportionate to the average function for variable (β) *P. notatum* cover (A). *H. annuus* cover (B). and native species cover (C) modified by the deterrent treatments over time.

Model	Estimation	SE(β)	p-value	Exp(β)
A				
Intercept	−0.306	0.132	0.021	–
Time	−0.022	0.003	<0.001	0.9784
Treatments with deterrents	−0.346	0.168	0.041	0.7074
Treatments without deterrents	−0.513	0.177	0.004	0.5986
B				
Intercept	−1.716	0.218	<0.001	–
Time	−0.055	0.007	<0.001	0.9464
Treatments with deterrents	0.086	0.273	0.753	10.897
Treatments without deterrents	0.363	0.257	0.158	14.379
C				
Intercept	−0.805	0.06	<0.001	–
Time	0.005	0.001	<0.001	1.005
Treatments with deterrents	−0.065	0.06	0.275	0.937
Treatments without deterrents	−0.08	0.06	0.186	0.924

Table 2. Likelihood regression with a logarithmic link function (exp) and a variance proportionate to the average function for variable (β) native cover modified by *P. notatum* intercropping over time.

Model	Exp estimation β	(β)	p-value
Intercept	−0.995	0.077	<0.001
Time	0.007	0.001	<0.001
Plots	0.275	0.101	0.007
Time × Plots	−0.004	0.001	0.006

Helianthus annuus
The Kruskal–Wallis test showed that the influence of time on damage incidence averages over time (days) was independent of treatment (p = 0.518). The effect of time on *H. annuus* cover declining was not caused by grazing but was influenced by the season (Fig. 3B). No difference was found between the treatments with and without deterrents (Table 4, Fig. 5, p = 0.059) and only the plots without deterrents differed from the control group, which suffered no damage (p = 0.008).

Native species
The Kruskal–Wallis test showed that no influence of time was found on the ratio of herbivory damage to native species cover (p = 0.577). Table 5 shows that, independent of time, there was not significant difference between the treatments with or without deterrent devices (p = 0.837). There was no difference between the control plots and the plots with and without deterrents (p < 0.001 for both).

Comparison of *P. notatum* and native species herbivory incidence

Independent of time, the overall damage to *P. notatum* cover by grazing was 8.14-fold greater than the damage to native species (p = 0.001).

Discussion

Grazing impacts on *Paspalum notatum* cover occurred and, when compared to control plots, plant cover was reduced

growth of each plant in *P. notatum* plots. In contrast, the native species were dominant in *H. annuus* plots after this time period because *H. annuus* was declining.

Herbivory and trampling damage

Paspalum notatum
There is evidence that the average of herbivory rate was higher in plots without deterrents (Fig. 3A). Independently of the time there was a significant difference of rate of herbivory between the treatments with and without deterrents as well as between these treatments and the control plots. (Table 3). The herbivory averages were not influenced over time (days) (p = 0.623). Independently of time (Fig. 4), the damage incidence in *P. notatum* plots was 93% greater in the absence of deterrents than in their presence (p = 0.0005) and was significantly more severe in both of the unfenced treatments compared with the control plots, which suffered no damage at all (p = 0.001).
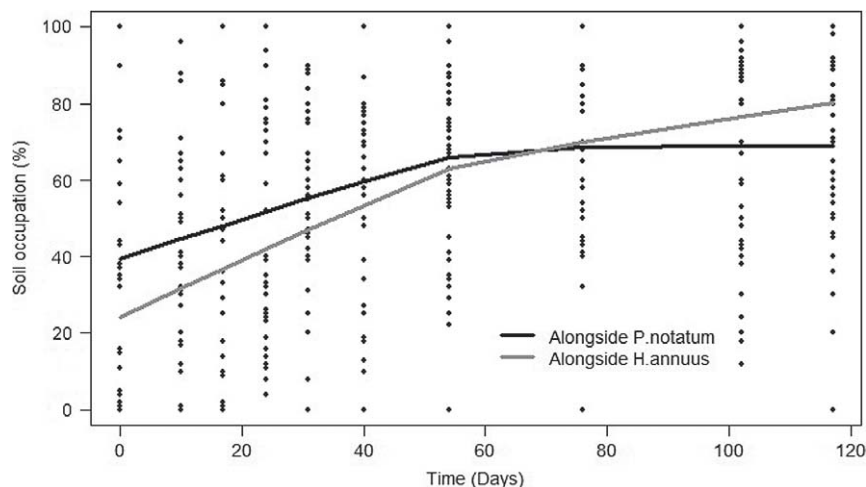

Figure 2. Average dispersal diagram for native species cover alongside *P. notatum* and *H. annuus* over time (days) in which the curves were adjusted via the LOWESS method.
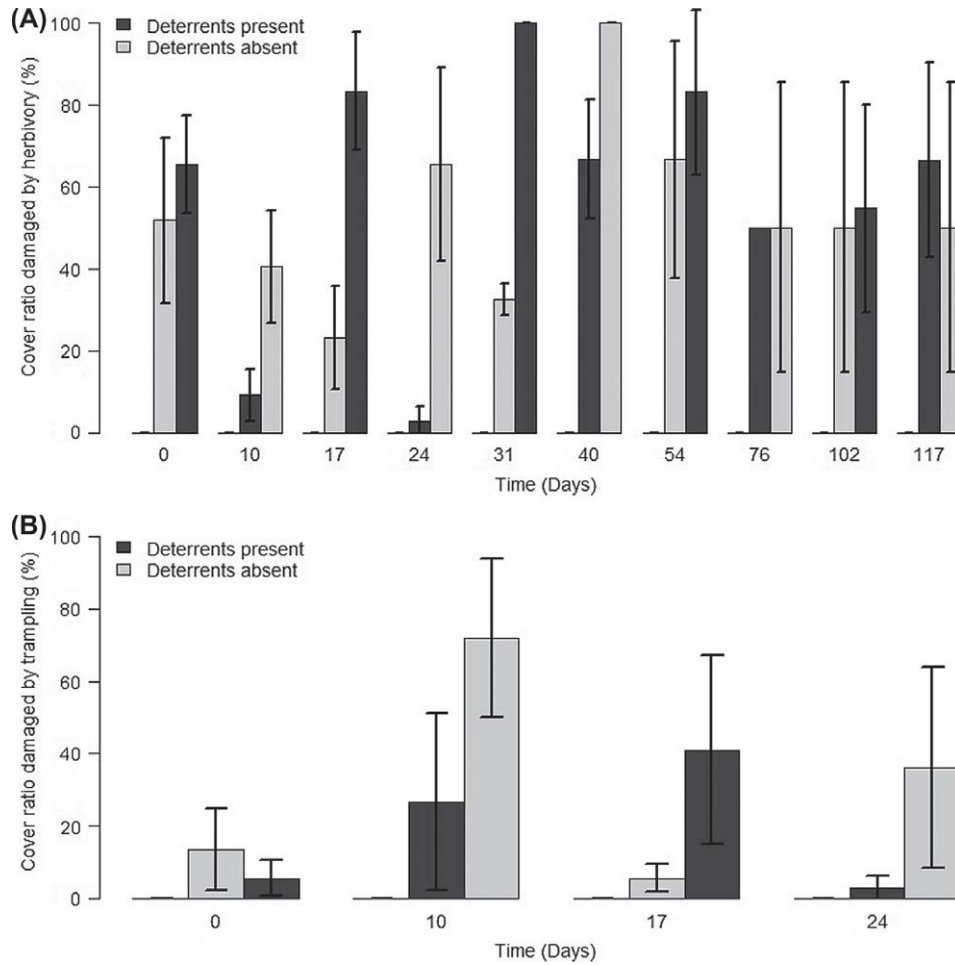
Figure 3. Average ratios of *P. notatum* (A) and *H. annuus* (B) damaged by herbivory over time (days).

independently of the deterrents, especially before the dry season. After this, the influence of time on *P. notatum* cover, which decreased by an average of 2.2% per day, represents the seasonal effects of drought on its above-ground mass. *P. notatum* regression during the dry season is consistent with previous findings in tropical forage (Turner and Begg 1976, Seligman et al. 1992), and the survival of roots enables

posterior regrowth. Additionally, *P. notatum* suffers less desiccation than other Poaceae species, whose dry straw may fuel fires, limiting forest cover and promoting grass

Table 3. p-values for the Wilcoxon signed rank and Mann–Whitney tests for the herbivory ratios of *P. notatum* at different time period, four months after transplantation and independently of the intercropped species.

| | H0: mu = 0 | | |
Time	With deterrents	Without deterrents	H0: mu(with) = mu(without)
0	0.1000	0.0360	0.4641
10	0.3711	0.0579	0.0918
17	0.0975	0.1736	0.0469
24	1.0000	0.1736	0.079
31	0.3711	0.1489	0.1065
40	0.1736	0.1489	0.1876
54	0.3458	0.0369	0.7215
76	1.0000	1.0000	1.0000
102	1.0000	0.3711	1.0000
117	0.3711	1.0000	1.0000
Overall	< 0.001	< 0.001	0.0005

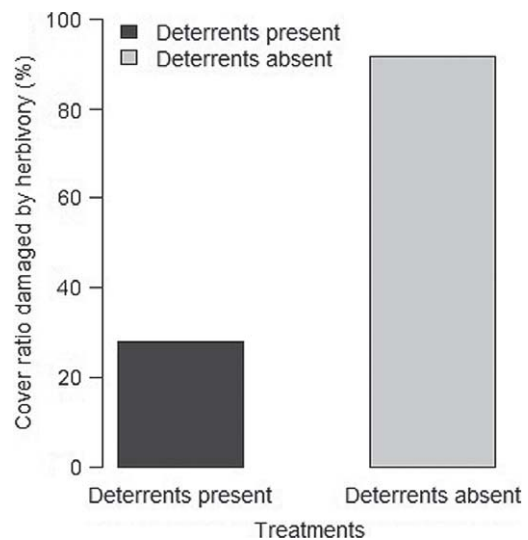Figure 4. Ratio of *Paspalum notatum* cover damaged by herbivory independent of time. $p < 0.001$ (Wilcoxon signed-rank and Mann–Whitney tests).

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Table 4. p-values for the Wilcoxon signed rank and Mann–Whitney tests for the herbivory ratios of *H. annuus* at different time period, four months after transplantation and independently of the intercropped species.

| Time | H0: μranks = 0 | | |
	With deterrents	Without deterrents	H0: μranks(with) = μranks(without)
0	0.3711	1.0000	0.8453
10	0.3711	0.0890	0.2972
17	1.0000	0.3711	0.5536
24	1.0000	0.3711	0.3055
Overall	0.056	0.008	0.0594

Table 5. p-values for the Wilcoxon signed rank and Mann-Whitney tests for the herbivory ratios of native species, at different time period, four months after transplantation and independently of the intercropped species.

| Time | H0: μranks = 0 | | |
	Deterrents present	Deterrents absent	H0: μ ranks (present) μ ranks (absent)
3	0.371	1.000	0.122
10	1.000	0.100	0.045
17	1.000	1.000	0.194
24	0.173	1.000	0.285
31	0.173	1.000	0.331
40	1.000	1.000	0.335
54	0.173	1.000	0.335
76	0.181	0.181	1.000
102	0.371	0.100	0.317
117	0.173	0.059	0.271
Overall	< 0.001	< 0.001	0.837

expansion (Higgins et al. 2000, Brooks et al. 2004, Accatino et al. 2010).

The absence of damage to the fenced plots indicated the efficacy of buried fences for excluding capybaras; indeed, fencing has previously succeeded in lowering rodent density in cropland to almost zero (Barrio et al. 2012).

Helianthus annuus cover also suffered seasonal effects, decreasing by an average of 5.4% per day due to drought. Its insensitivity to fencing and deterrent use may be explained by capybara dietary preferences, because *H. annuus* were not consumed but merely damaged by trampling and not ripped from the ground.

Unlike *P. notatum* and *H. annuus*, native species cover did not suffer a seasonal effect and instead grew by an average of 0.5% a day. Such higher tolerance to drought is characteristic of some native dicotyledonous plants, herbaceous plants, shrubs and woody species whose primary roots can reach the water table (Archer 1994). These species dominated the native species group. Capybara impacts on native species at this site were not significant, because plant cover did not differ between the treatments or the control, despite visible damage that was greater in the unfenced treatment plots. Such low impacts on native and *H. annuus* species can be attributed to the presence of *P. notatum*, whose cover declined 30–40% more in the unfenced areas than in
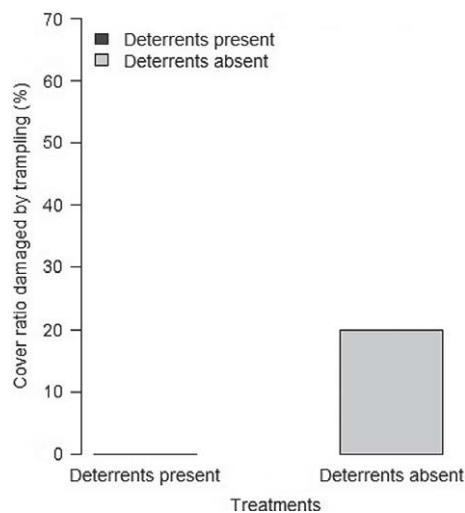
the control plots and whose overall damage incidence was 8.14-fold greater than that of the native species. These results reveal a strong dietary preference by capybaras, which could be attributed to the palatability of this forage. Palatability, or the high acceptance of a forage by an animal, may be affected by texture, smell, taste, hairiness, leaf percentage and chemical composition and is independent of nutritional value (Marten 1978, Quintana 2002). However, nitrogen content can improve the palatability (Ali et al. 2012). Therefore, the preference for *P. notatum* is likely related to its protein content (Hirata et al. 2003, Arthington and Brown 2005), which results from nitrogen fixation promoted by the associative bacterium *Azotobacter paspalli* (Döbereiner et al. 1972), making it more attractive to herbivores. These results suggest a powerful shielding effect, supporting the use of *P. notatum* as a diversionary food (Miller et al. 2006).

Further evidence of the protective effects of *P. notatum* on cultivated plants comes from the analysis of native species cover intercropped with *P. notatum* or *H. annuus*. The cover data refers particularly to native herbaceous species, which increased for the first 68 days following transplantation in both plots of *P. notatum* and *H. annuus*, indicating a high competitive capacity. After this time, the native cover in *P. notatum* plots reached a steady state, suggesting a reduction in the growth index. This effect could be explained by competition with *P. notatum* or by the establishment of a competitive equilibrium among the plants. This hypothesis is reinforced by the fact that coverage or native species growth was not inhibited in the *H. annuus* plots. The dominance of native species in the *H. annum* plots can be associated with a decline in the latter due to their vegetative cycle. In contrast, in *P. notatum* plots, the reduction in cover of herbaceous native species occurred with a concomitant reduction in *P. notatum* herbivory. These data suggest the persistence of *P. notatum*, which are able to regrow and establish an extensive cover on N poor soils due to its nitrogen fixation (Döbereiner et al. 1972) and to protect native cultivated woody species against damage by trampling.

Despite their aggressive colonization capacity, *P. notatum* is a native grass that can decline with drought and shading, allowing native species to eventually dominate the area. *P. notatum* is a candidate forage species that, as a safe

Figure 5. Ratio of *Helianthus annuus* cover damaged by trampling. independent of time. p = 0.008 (Wilcoxon signed-rank and Mann–Whitney tests).

diversionary food, could substitute for invasive grasses used as forage in Brazil.

Time-independent analyses revealed that deterrents mitigated the damage to *P. notatum* when compared to plots without them. Trampling impacts on *H. annuus* seemed, likewise, to be partially alleviated by the presence of deterrents, because the plots without deterrents suffered greater damage than those with deterrents. However, this effect was reduced over time. Such a mild repellent effect could be explained by the fact that animals can habituate to novel stimuli (Koehler et al. 1990, Belant et al. 1996, Gilsdorf et al. 2003); however, the effect was still greater than some previous results for small rodents (Koehler 1990, Schumake, 1995, Gilsdorf et al. 2003). It should be noted that most experiments dealing with rodents have attempted to completely exclude them from their residence areas by means of pain-inducing sonic deterrents (Koehler 1990, Schumake 1995), whereas the present study only attempted to steer capybaras away from woody plants by using alarm deterrents together with an attractive food source nearby. Habituation might be further delayed by using incremental deterrents, such as visual stimuli and signal randomization (Shivik and Martin 2000). Deterrents did not influence the damage to native species, which may be explained by the very low consumption of this plant group.

The results reinforced the recommendation of both *P. notatum* and *H. annuus* for erosion control in riparian forest rehabilitation using the zones functional model (Schultz et al. 2004). *P. notatum* is indicated for cultivation in zone 1 (the first 20 m between the water and soil), and *H. annuus* is indicated for zones 2 and 3, among the rows of woody plants in the riparian forest. Therefore, Capybara presence would be restricted to the zone located in the interface between the aquatic and terrestrial ecosystems, thus, protecting the reforestation sites from damage or trampling.

Conclusions

Paspalum notatum and *H. annuus* may protect the riparian forest not only against soil erosion but *P. notatum* plants also can protect the woody species against capybara damage through diversionary feeding. Sonic deterrents were partially successful in mitigating herbivory and plant damage, warranting further investigation. Therefore, diversionary feeding appeared to be the most efficient strategy to control capybara damage in riparian forest.

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