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ARTICLE

Dry artificial perches and the seed rain in a subtropical riparian forest

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ABSTRACT: (Dry artificial perches and the seed rain in a subtropical riparian forest). The recovering of forest areas is important for the conservation and maintenance of environments deforested by the agriculture expansion. A low cost alternative of forest restoration is the use of dry artificial perches to increase and qualify the seed rain. The present work aimed at evaluating the effect of the dry artificial perches on the seed rain in an abandoned pasture next to a Seasonal Subtropical Forest remnant in the Ijuí river sub-basin (28°35'25"S, 54°08'09"W), Jóia, Rio Grande do Sul State, Brazil. The seed rain under the dry perches was compared to the seed rain under the forest remnant. The identification of the potentially disperser birds was also carried out. The seed traps were disposed under the forest remnant, under the dry perches and at random in the open area as a control, and the seeds were collected monthly between November 2007 and May 2008. It has been collected 9,926 seeds, distributed in 18 families. Asteraceae and Poaceae summed 6,671 seeds. The tree species reached the amount of 2,177 (21.9%) pertaining to 15 species. Such value represents 0.76 seeds·m^{-2}·day^{-1} to the tree species. Under the forest remnant, the seed rain intensity of all tree species and of the zoochoric tree species were 2.59 and 0.41 seeds·m^{-2}·day^{-1}, respectively. In the seed traps under the perches the seed rain intensity was 0.29 seeds·m^{-2}·day^{-1}, and more than 99% of them were of zoochoric tree species. The only one anemochoric species observed in the seed traps of the pasture was *Helietta apiculata* Bentham, which presented only two seeds in the traps of pasture, indicating a low efficiency of dispersion. The birds observed in the perches pertaining to Thraupinae and Turdinae.
Key words: ecological restoration, seed dispersal, zoochory, anemochory, riparian forest.

RESUMO: (Poleiros secos artificiais e a chuva de sementes em uma mata ciliar subtropical). A recuperação de áreas florestais é importante para conservação e manutenção de ambientes desflorestados pela expansão agrícola. Uma alternativa de baixo custo para a restauração florestal é a utilização de poleiros secos artificiais para o recrutamento de sementes. O objetivo deste trabalho foi avaliar o efeito dos poleiros secos artificiais sobre a chuva de sementes de espécies arbóreas em uma pastagem abandonada junto a um fragmento de Floresta Estacional na sub-bacia do rio Ijuí (28°35'25"S, 54°08'09"W), em Jóia, Rio Grande do Sul, Brasil. A chuva de sementes sob os poleiros secos foi comparada com a observada sob a floresta remanescente. As aves potencialmente dispersoras foram identificadas. Foram utilizados coletores dispostos sob o remanescente florestal, sob os poleiros secos, e aleatoriamente na área de estudo como controle. As sementes foram coletadas mensalmente entre novembro de 2007 e maio de 2008. Foram coletadas 9.926 sementes distribuídas em 18 famílias. Asteraceae e Poaceae somaram 6.671 sementes. As espécies arbóreas representaram 2.177 sementes (21,9%), pertencentes a 15 espécies. Este valor representa 0,76 sementes·m-2·dia^{-1} para as espécies arbóreas. No interior da floresta, a intensidade da chuva de sementes de todas as espécies arbóreas e apenas das espécies arbóreas zoocóricas foi de 2,59 e 0,41 sementes·m^{-2}·dia^{-1}, respectivamente. Sob poleiros a intensidade da chuva de sementes foi de 0,29 sementes·m^{-2}·dia^{-1}, e mais de 99% destas foram de espécies arbóreas zoocóricas. A única espécie anemocórica observada nos coletores da pastagem, *Helietta apiculata* Bentham, apresentou apenas duas sementes neste ambiente, indicando uma eficiência relativamente baixa de dispersão. As aves mais freqüentes nos poleiros pertencem à família Thraupinae e à subfamília Turdinae.
Palavras-chave: restauração ecológica, dispersão de sementes, zoocoria, anemocoria, matas ciliares.

INTRODUCTION

In Brazil, as well as in other countries, the riparian forest degradation is a result of agriculture expansion in the absence of environmental planning to delimitate the areas to be conserved (Rodrigues & Gandolfi 2000). The riparian forest contributes to reduce the loss of soil from the erosive processes and undermining of river margins, assuring the preservation of headwaters and protecting the streams from the impacts of agricultural chemical products (Rozza 2003). The riparian forest presents a variable structure, composition and spatial distribution of species, configuring a mosaic of ecological conditions in terms of physiognomy and floristics (Rodrigues 2000, Budke *et al.* 2008).

It is possible to recover the pristine vegetation through diverse methods. Nevertheless, the different methods are based on divergent ideas and goals (Rodrigues & Gandolfi 2000). The environmental recovery and restoration are defined in the Brazilian laws (BRASIL 2000) as follows: "Recuperation is the restitution of a degraded ecosystem or wild population to a non-degraded condition, which could be different in relation to the original condition, and restoration is the restitution of a degraded ecosystem or wild population for a similar situation to its original condition as much as possible".

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The ecological restoration of riparian forest is also a tool to establish corridors, connecting the remnants of wild biomes and conservation units, turning possible the genic flux and the viability of species and populations (Bennet 1990, Gascon & Lovejoy 1998). However, in order to represent an effective strategy of conservation, restoration needs to respect the local ecological characteristics and diversity (Reis *et al.* 2003). The restoration process needs to take into account the secondary ecological succession as a source of information about the behaviour and evolution of one plant community (Glufke 1999).

The seed dispersion is important in the natural regeneration and the configuration of populations and ecosystems. The lack of dispersers is a strong barrier that prevents the colonization of degraded areas (Uhl *et al.* 1991). Birds are among the frugivorous vertebrates with a major contribution to restore forest areas. Birds tend to deposit more seeds near open areas, where the availability of perches is higher. In such way, seeds of diverse pioneer species could reach the disturbed site beginning the secondary succession. The effects of the frugivorous animals go beyond the dispersion of the seeds, because they have other non-immediate effects over the seeds and seedlings (Wunderle Jr. 1997, Jordano *et al.* 2006).

Dry artificial perches as a focus of increment of propagules are an alternative to accelerate the plant succession (Reis *et al.* 2003). The seed rain promotes the arrival of diaspores, which have the function of colonizing areas starting the succession process (McClanahan & Wolfe, 1993), besides the maintenance of genetic diversity of populations, because the diaspores are originated in the near forest remnants (Reis *et al.* 1999). The perches promote a floristic composition similar to the vicinity. Moreover, they reduce the costs of restoration (Zucca & Castro 2005). The disadvantages are the slow rate of plant recovery, the need of a near source of seeds and the presence of effective dispersers. In addition, the perches do not contribute to the dispersion of the anemochoric and autochoric species. The past background of the area could also interfere in the succession and restoration processes, since pastures or sites deforested a longer time ago impose difficulties to germination and plant recruitment (Uhl *et al.* 1988, Camargo *et al.* 2002). Although increasing seed inputs from forest species is a critical step in accelerating revegetation, Shiels & Walker (2003) suggest that supplemental restoration techniques are needed in addition to bird perches to promote forest recovery.

Dry perches can be effective to promote the arrival of plant diaspores, enhancing the seed rain (Holl 1998, Melo *et al.* 2000) and the recruitment of tree species (Zanini & Ganade 2005), although in some situations live perches (isolated trees of diverse age and size) can be more effective than dry perches (Santos & Pillar 2007).

The aim of this work was to analyze the seed rain of tree species under dry artificial perches, comparing with the seed rain in the near forest remnant. In addition, the birds that occur in the area were identified, in order to detect potential dispersers.

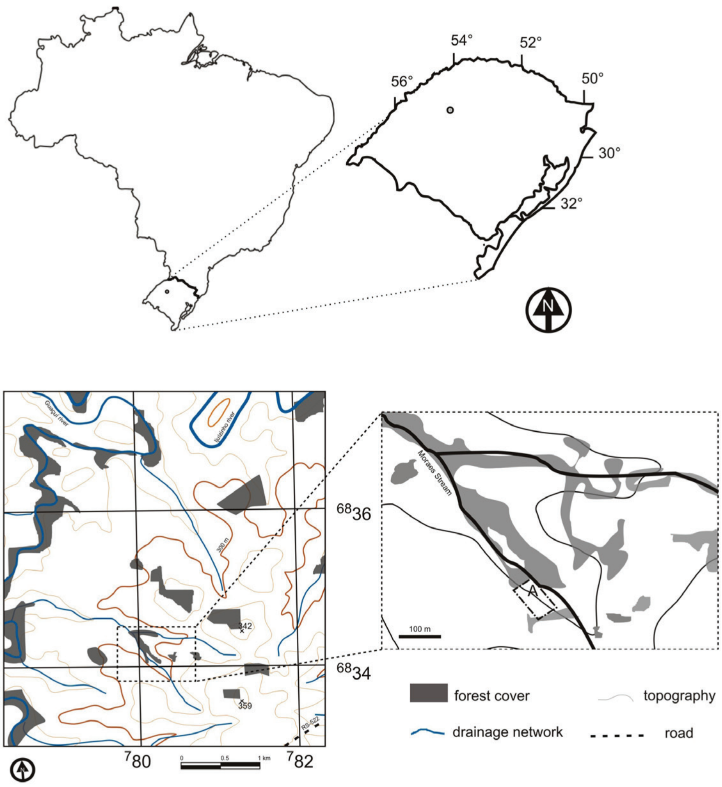

Figure 1. Site location. Above the map of Brazil and Rio Grande do Sul State, and below the region where the studied site is located, with forest cover.

MATERIAL AND METHODS

Site description

The studied site is a private land in Jóia municipality, Northwest of the Rio Grande do Sul State, Brazil (28°35'25"S, 54°08'09"W). The predominant forest cover is the Seasonal Forest (Teixeira & Coura-Neto 1986) mixed with typical species of open areas, especially *Acacia caven* (Molina) Molina (Fabaceae). The climate is subtropical Cfa in the Köppen system (Moreno 1961), with homogeneous rainfall during the year and an annual average temperature of 18ºC.

The seed traps were installed in an abandoned pasture isolated by fencing in the margins of Moraes stream, a first order watercourse tributary of Guaçuí river, pertaining to the Ijuí river sub-basin. The experimental area without forest cover is 300 m^2 (Fig. 1). The pasture was abandoned and isolated one year before the beginning of the experiment, and was characterized by an assemblage of native species, mainly Poaceae (*Aristida*, *Schizachirium*, and *Panicum*, among others) and Asteraceae (*Baccharis*, *Pterocaulon*, *Soliva* and *Solidago*) and some adventitious species such as *Apium leptophyllum* (Pers.) F. Muell. (Apiaceae) and *Lolium multiflorum* Lam. (Poaceae). Seedlings of *A. caven* were observed sparsely in the area.

Perches and seed traps installation

The seed traps (N=16) were made with a 1 x 1 m wood square, with a nylon net bottom and a cover net of a thin fabric above the bottom to avoid the loss of small seeds. The traps were 50 cm above the soil. Net and fabric were disposed in a funnel shaped manner and with approximately 30 cm deep.

The traps were distributed at random in the pasture area (Fig. 2), six under a dry artificial perching structure (P) and six without a perch, as a control (C). Four additional perches were installed inside the remnant forest near the open area (Fig. 2) and named F. The perches were made of bamboo, with a height of 2 m, with a horizontal branch of 70 cm as an arriving structure, similar to the indications of Reis *et al.* (2003). Excrements, seeds and fruits were collected from November 2007 to April 2008, totalizing 180 days. Seeds or fruits of tree species were not observed between May 2008 and September 2008 in the open area traps, therefore this period was excluded of the analysis. The species were identified through comparison with the collection of the seed Laboratory in the Viveiro Florestal CCR/UFSM (Santa Maria, Brazil) or with direct comparison with the nearby plants, and with the aid from the literature (Lorenzi 1992 and 2006, Kissmann 1997, Backes & Irgang 2002). *Zanthoxylum fagara* (L.) Sarg. and *Z. rhoifolium* Lamarck (Rutaceae) were not distinguished through the seeds and they were joined in the analysis. Seeds without identification were named as morphotypes.

Statistical procedures

The treatments (P, C and F) were compared in terms of the total number of tree species seeds per m^2 during the 180 days of collection.

The experimental design was completely randomized considering the collectors as repetitions and the obtained values were transformed according to the square root of (X + 0.5) (Zar 1995). The data were analyzed with a one-way ANOVA and the Tukey test was used to pair wise comparisons.

The data of seed mass was obtained through 15 seeds per species to *Cupania vernalis* Cambess., *Ocotea pulchella* (Nees) Mez, *Prunus myrtifolia* (L.) Urb., *Erythroxylum deciduum* A. St.-Hil., *Styrax leprosus* Hook. & Arn., *Lithraea molleoides* (Vell.) Engl., *Myrsine laetevirens* (Mez.) Arechav. and *Zanthoxylum spp.*

Birds identification

The birds were identified through visual recognition with a 7 x 35 mm binoculars and auditive identification. The classification was based on the literature (Sick 1997, Belton 2004, Naroski & Yzurieta 2006). The birds were observed during 6 hours each month, summing 36 hours of observation between November 2007 and April 2008.

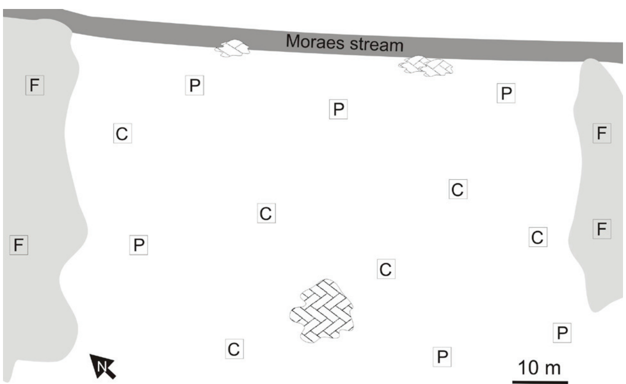

Figure 2. Traps distribution in the abandoned pasture under the perches (P), controls (C) and inside the remnant forest (F); spots with diagonal lines are isolated specimens of *Acacia caven*.

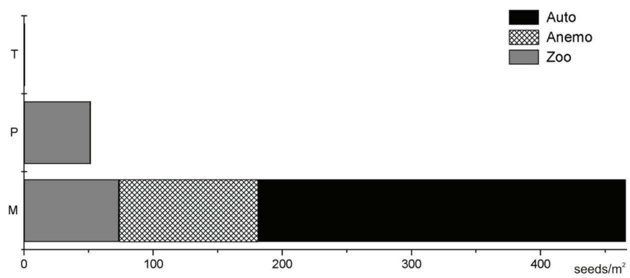

Figure 3. Seeds per m^2 during 180 days of collection to the different treatments and dispersion mechanisms, in the traps inside the remnant forest (F), in the abandoned pasture under the perches (P) and controls (C), Jóia, Rio Grande do Sul State, Brazil.

Table 1. Accumulated number of seeds of tree species per m^2 during 180 days between November 2007 and April 2008, in the traps inside the remnant forest (F), in the abandoned pasture under perches (P) and controls (C), Jóia, Rio Grande do Sul State, Brazil. The dispersion mechanism (SD) is indicated in the right column (Zoo = Zoochoric, Anemo = anemochoric, Aut = Autochoric).

	F	P	C	SD
Anacardiaceae				
Lithraea molleoides (Vell.) Engler	6.0	4.67	0	Zoo
Erythroxylaceae				
Erythroxylum deciduum A. St.-Hil.	36.3	28.8	0	Zoo
Euphorbiaceae				
Sebastiana commersioniana (Baill.) Smith	271.3	0.17	0.17	Aut
Lauraceae				
Nectandra lanceolata Ness	0.3	0	0	Zoo
Ocotea puberula Ness	0.8	0	0	Zoo
Ocotea pulchella Nees	5.3	0.67	0	Zoo
Leguminosae – Mimosoidae				
Acacia recurva Bentham	13.5	0	0	Aut
Myrsinaceae				
Myrsine coriacea (Sw.) R. Br.	0.5	0.83	0	Zoo
Myrtaceae				
Eugenia uniflora L.	0	0.67	0	Zoo
Rosaceae				
Prunus myrtifolia (L.) Urban	0.5	0.5	0	Zoo
Rutaceae				
Helietta apiculata Bentham	107.8	0.17	0.17	Anemo
Zanthoxylum spp.	2.0	9.17	0.17	Zoo
Sapindaceae				
Cupania vernalis Camb.	0.5	2.5	0	Zoo
Styracaceae				
Styrax leprosus Hook. & Arn.	21.5	3.5	0	Zoo
Total tree seeds·m^{-2} (during 180 days)	466.00	51.67	0.50	
Tree seeds· m^{-2} · day^{-1}	2.59	0.29	0.003	

RESULTS

A total of 9,926 seeds were collected in the 16 traps, during the 180 days (November 2007 to April 2008). The species identified belonged to 31 species and 18 families. Among them, Poaceae and Asteraceae were dominant, with 3,693 and 2,978 seeds, respectively. Both families reached 67% of total seeds.

The tree species encompassed 2,177 seeds (21.9%) in the sum of the three treatments, and they belonged to 14 species and 11 families (Table 1). This amount correspond to 0.76 seeds of tree species·m^{-2}·day^{-1}. The seeds of zoochoric tree species were only 603 (6.1%). The two autochoric tree species presented 1,087 and 54 seeds, respectively. The single anemochoric species *Helietta apiculata* Bentham presented 433 seeds.

The three treatments differed in relation to the total seed number during the period (One-way ANOVA, F=17.96, P = 0.0002). The seed rain was greater inside the forest remnant (Fig. 3). However, 84 % of the tree seeds inside the forest were from autochoric or anemochoric species. On the other hand, in the perch traps those species reached less than 1% of total seeds of tree species.

Considering only the zoochoric species, the treatments

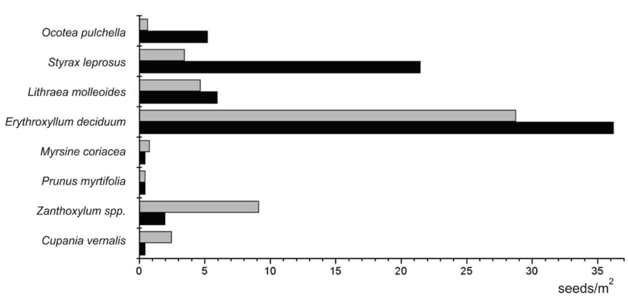

Figure 4. Seed of zoochoric species per m^2 during 180 days to the perch traps (gray bars) and to the forest traps (black bars) between November 2007 and April 2008, Moraes stream, Jóia, Rio Grande do Sul State, Brazil.

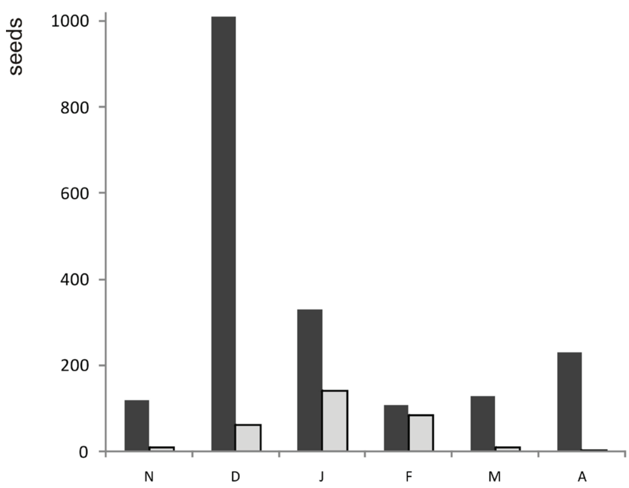

Figura 5. Seed rain in absolute numbers in the perch traps (gray columns) and to the forest traps (black columns) between November 2007 and April 2008, Moraes stream, Jóia, Rio Grande do Sul State, Brazil.

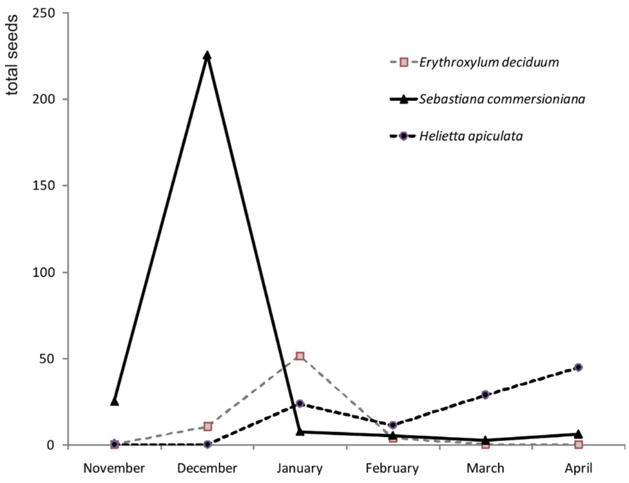

Figure 6. Phenology of seed rain of the more abundant tree species, for all treatments, between November 2007 and April 2008. Moraes stream, Jóia, Rio Grande do Sul State, Brazil.

also presented differences (One-way ANOVA, F=7.148, P = 0.0081), meanwhile the forest traps and the perches traps did not differed (Tukey test, P > 0.05). The forest traps presented an average of 73.7 (± 33.7) seeds·m^{-2} of zoochoric species during 180 days, and the perches traps presented 51.3 (± 52.4).

The forest traps (F) presented 1,864 seeds of tree species, which corresponds to 85.6 % of the total amount of seeds of tree species in all treatments. The seed rain of tree species in the forest was 2.59 seeds·m^{-2}·day^{-1}, belonging to 14 species. *Sebastiania commersioniana* (Baill.) L. B. Sm. & Downs accomplished 58.2% of these total, followed by *H. apiculata* with 23.1%. The twelve zoochoric species reached 16 % of the seeds in the forest, which corresponds to a seed rain intensity of 0.41 seeds·m^{-2}·day^{-1}.

Eleven tree species were identified in the perch traps. Of them, nine species were zoochoric, which reaches 99.4% of total seeds in these traps. The more abundant species was *Erythroxylum deciduum* with 55.8%, *Zanthoxylum* spp. with 17.7 % and *Lithraea molleoides* with 9.0%. The tree species seed rain intensity under the perches was 0.29 seeds·m^{-2}·day^{-1}.

The zoochoric species presented different proportions of seeds between the traps of the forest (F) and the traps under the perches (P). *C. vernalis* and *Zanthoxylum* spp. presented the greater P/F ratio, 7.5 and 6.9 respectively. In the other extreme, *O. pulchella* and *S. leprosus* have the lower P/F ratio (Fig. 4). The species presented different seed mass (One-way ANOVA, P < 0.0001). However, the P/F ratio linear correlation with seed mass was not significant (r^2= 0.155, P= 0.334, n = 8 species).

Erythroxylum deciduum was the tree zoochoric species with the greater number of seeds as much in the perch traps as in the forest traps (Fig. 4). The dispersion of the autochoric species and of the anemochoric *H. apiculata* did not effectively reach the open area of the pasture since it was limited to only one seed in the perch traps and one seed in the control traps (Table 1).

The greater seed intensity of seed rain inside the forest corresponded to December, with a small peak between March and April (Fig. 5). The first maximum is related to the higher abundance of seeds of *S. commersoniana*, with a second contribution of *E. deciduum*. In turn, the peak between March and April corresponded to a higher abundance of seeds of *H. apiculata* (Fig. 6).

Potentially disperser birds

A total of 87 bird species were identified (Appendix). They belong to 14 orders and 33 families. The birds effectively observed in the artificial perches were only the Turdinae *Turdus rufiventris, T. leucomelas* and *T. amaurochalinus*. The Thraupinae such as *Thraupis sayaca* and *T. bonariensis* were observed on the border of the forest near the artificial perches but not in the perches themselves.

DISCUSSION

The forest exhibited a higher intensity of seed rain than the pasture with or without perches. The difference is caused by the higher abundance of seeds from anemochoric and autochoric species, virtually absent in the pasture.

The artificial perches allowed a seed rain of zoochoric species equivalent to 70% of the seed rain observed in the forest. Only two of the zoochoric species that occurred in the forest traps were absent in the traps beneath the artificial perches. Both of the two were Lauraceae, which, on the other hand, also exhibited a low seed rain in the forest.

Artificial perches as an isolated strategy are usually unable to increase the seedlings establishment (Holl 1998, Shiels & Walker 2003), but associated with other techniques can enhance significantly the recruitment (Oliveira, 2006). Our data of seed rain under the artificial perches corroborate this potentiality.

The diversity of birds observed in the perches was very low, which could be a limitation of perches when used to increment the seed rain. However, the homogeneity and the relatively low height of the perches used here could have contributed to the reduced diversity of birds (Wunderle Jr. 1997).

The perches were more effective to increment the seed rain of certain species such as *E. deciduum, L. molleoides, Zanthoxylum spp.* and *C. vernalis*. The ratio between the seed rain in the forest and in the artificial perches indicates that the birds have a preference to certain species such as *Zanthoxylum spp.* and *C. vernalis* since these species had a higher seed rain beneath the perches. Since the dispersion efficiency of the zoochoric species in the pasture was not correlated with the seed mass, possibly the preference of the birds was oriented by other factor, such as the quality of the nutritional rewards. In Neotropical tree species from Panama, the seed size explains less than 20% of the seed dispersion distances (Muller-Landau *et al.* 2008). Moreover, among animal-dispersed species the quantity and quality of pulp, the sizes of seeds, the chemical composition of pulp and seeds and the time of fruiting may explain attractiveness to different disperser groups (Howe 1989, Tewksbury & Nabhan 2001, Van Schaik *et al.* 1993).

The diversity of potentially disperser birds tends to be lower in disturbed landscapes, especially in relation to great size avian species (Wright 2007, Pizo 2007). In fact, certain important seed dispersers such as toucans (Ramphastidae), manakins (Pipridae), cotingas (Cotingidae) and guans (Cracidae) were not observed in the site. The absence of such avian dispersers could be an important limitation to the restoration, especially to the large-seeded species, and could implicate additional management efforts beyond the use of perches (Wunderle Jr. 1997, Holl 1998, Shiels & Walker 2003).

Erythroxylum deciduum exhibited the greater abundance of seeds among the tree zoochoric species. These species occur in pristine forests and in secondary ones. It is suggested to the enrichment of degraded ecosystems and recovery of sandy coasts (Backes & Irgang 2002). *Zanthoxylum spp.* also exhibited high seed rain intensity under the perches. *Z. rhoifolium* is considered a pioneer tree species that is indicated to forest restoration by some authors (Backes & Irgang 2002) while others pointed out that species is frequent in forest borders along transitions between grasslands and forests (Müller 2006).

The dispersion of *H. apiculata* in the pasture area was very low. In addition, no other wind-dispersed species were observed on any type of trap. As a rule, wind-dispersed species tend to present wide seed shadows. In certain circumstances, the dispersion effectiveness of the anemochoric species can be similar or even greater than the one of the zoochoric species (White *et al.* 2004). Wright (2007) reported that the dispersion of these species tends to be facilitated in landscapes without wind barriers such as tree plantations or forest remnants. However, the dispersion effectiveness of the anemochoric species is highly variable among species of the same forest formation (Armesto *et al.* 2001).

An additional hypothesis to considerer here is the partial missing of wind-dispersed seeds in the pasture traps, due to exposition to the winds in the open area. Further studies could be addressed to clarify this point. On the other hand, it should be stressed that no other wind-dispersed species was observed even in the forest interior, in spite of the presence of such species in the vicinities, for instance *Parapiptadenia rigida* (Bentham) Brenan, *Gochnatia polymorpha* (Less.) Cabrera, *Cordia americana* (L.) Gottschling & J. E. Mill. and *Luehea divaricata* Mart. (data not showed, authors' personal observation).

The anemochoric species constitute a dominant fraction in the dossel and among the emergent trees of the Seasonal Forest (Giehl *et al.* 2007), and the limited dispersion of these species could be a restriction to the regeneration of that forest.

CONCLUSIONS

The dry artificial perches provided a seed rain of zoochory tree species in a magnitude near the seed rain observed inside the forest remnant (70%).

The dispersion of anemochoric tree species, particularly *Helietta apiculata*, was very limited in the abandoned pasture.

The birds effectively observed in the artificial perches were the Turdinae *Turdus rufiventris, T. leucomelas* and *T. amaurochalinus*.

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