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Poleiros artificiais aumentam a diversidade e abundância de mudas em uma área degradada na região Centro-Oeste do Brasil

Artificial perches increase seedling diversity and abundance in a degraded area in the Brazilian Midwest region

Las perchas artificiales aumentan la diversidad y abundancia de plántulas en un área degradada en la región del Medio Oeste de Brasil

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Resumo

Na região Centro-Oeste do Brasil, os fragmentos florestais do bioma Mata Atlântica estão desconectados na paisagem e com baixa resiliência. Buscando técnicas potenciais para restauração, este estudo teve como objetivo avaliar as interações de poleiros artificiais com algumas técnicas de nucleação, com o objetivo de confirmar a hipótese de que a combinação dessas técnicas aumenta a diversidade de sementes e regenerantes na área. O delineamento experimental foi em blocos casualizados, com cinco tratamentos e três repetições. Os tratamentos de restauração incluíram (1) somente poleiros de controle; (2) poleiros com coletores de propágulos; (3) poleiros com transposição de galharia; (4) poleiros com suprimento de alimentos; e (5) poleiros com transposição de galharia e suprimento de alimentos. O experimento foi realizado em uma área degradada, anteriormente colonizada por pastagem, nos arredores de um remanescente florestal (ecossistema de referência). Após 365 dias, os regenerantes foram identificados (número de espécies e indivíduos). Na diversidade de regenerantes houve um aumento significativo com a interação de mais de uma técnica de nucleação, destacando a eficiência da combinação de poleiros artificiais com coletores (T2) e transposição de galharias com suprimento de alimentos (T5). Com base nos resultados, pode-se afirmar que o uso de poleiros artificiais combinados com outras técnicas de nucleação favorece o recrutamento de mudas de espécies zoocóricas e aumenta o banco de sementes através do forrageamento de pássaros. Acredita-se que essa técnica é economicamente viável e tem potencial para ser usada em projetos de restauração.

Palavras-chave: Nucleação; Transposição de galharia; Bioma Mata Atlântica.

Abstract

In the Midwest region of Brazil, forest fragments from the Atlantic Forest biome are disconnected from the landscape and with low resilience. Searching for potential restoration techniques, this study aimed to evaluate the interactions of artificial perches with some nucleation techniques, in order to confirm the hypothesis that the combination of these techniques increases the diversity of seeds and regenerants in the area. The experimental design was randomized in blocks, with five treatments and three replications. The restoration treatments included (1) control perches only; (2) perches with propagule collectors; (3) perches with brushwood transposition; (4) perches with food supply; and (5) perches with brushwood transposition and food supply. The experiment was conducted in a degraded area, which was previously colonized by pasture, in the surroundings of a forest remnant (reference ecosystem). After 365 days, the regenerants were identified (number of species and individuals). In the diversity of regenerants there was a significant increase with the interaction of more than one nucleation technique, highlighting the efficiency of the combination of artificial perches with collectors (T2) and brushwood transposition with food supply (T5). Based on the results it can be stated that the use of artificial perches combined with other nucleation techniques favors the recruitment of seedlings of zoochoric species and increases the seed bank through bird foraging. We believe that this technique is economically viable and has the potential for being used in restoration projects.

Keywords: Nucleation; Brushwood transposition; Atlantic Forest biome.

Resumen

En la región del Medio Oeste de Brasil, los fragmentos de bosque del bioma del bosque atlántico están desconectados del paisaje y tienen poca resistencia. En busca de posibles técnicas de restauración, este estudio tuvo como objetivo evaluar las interacciones de las perchas artificiales con algunas técnicas de nucleación, con el fin de confirmar la hipótesis de que la combinación de estas técnicas aumenta la diversidad de semillas y regenerantes en el área. El diseño experimental fue en bloques al azar, con cinco tratamientos y repeticiones. Los tratamientos de restauración incluyeron (1) solo perchas de control; (2) perchas con recolectores de propágulos; (3) perchas con transposición de ramas; (4) perchas con apoyo alimentario; y (5) perchas con transposición de ramas y apoyo alimentario. El experimento se llevó a cabo en un área degradada, previamente colonizada por pastizales, cerca de un remanente de bosque (ecossistema de referencia). Después de 365 días, se identificaron los regenerantes (numero de especies e individuos). En la diversidad de regenerantes hubo un aumento significativo con la interacción de más de una técnica de nucleación, destacando la eficiencia de combinar perchas artificiales con colectores (T2) y transposición de ramas con apoyo alimentario (T5). Con base en los resultados, se puede decir que el uso de perchas artificiales combinadas con otras técnicas de nucleación favorece el reclutamiento de plántulas de especies zoochóricas y aumenta el banco de semillas a través del forrajeo de las aves. Se cree que esta técnica es económicamente viable y tiene el potencial de ser utilizada en proyectos de restauración.

Palabras clave: Nucleación; Transposición de ramas; Bioma del bosque atlántico.

1.Introduction

One of the greatest threats to global biodiversity Is the anthropogenic impact due to the expansion of agricultural frontiers (Hansen et al., 2013). In the last decade, with the increase of agriculture practice, terrestrial ecosystems have changed drastically due to the reduction in the vegetation cover of tropical forests (Reis et al., 2010), causing a decrease in biodiversity, and provision of several ecosystems services (Hansen et al., 2013).

Brazilian semideciduous seasonal forests are forest formations that belong to the Atlantic Forest biome (Martins & Cavararo, 2012) and are protected by the Law 12.651 (Brazil, 2012) due to their various environmental functions, such as the preservation of water resources, landscapes, geological stability, and biodiversity. These forests facilitate gene flow of fauna and flora, protect the soil, and ensure human well-being. However, although

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protected by law, many forest formations of the Atlantic Forest biome have been extremely degraded (Ribeiro et al., 2009).

To mitigate the environmental impact of these degraded ecosystems, restoration programs have focused on planting tree seedlings and seeking other techniques to attract propagules to the degraded area.

Proper restoration programs prioritize functionality, which indicates encouraging biotic and abiotic diversity via nuclei that are attracted to the dispersing fauna, thereby attracting propagules to the area and increasing the plant density (Guidetti et al., 2016).

The adoption of restoration strategies based on natural processes, such as seed dispersal by animals, can be economically feasible as these low-cost techniques do not depend on planting seedlings, but on surrounding forests as seed sources, thus increasing natural succession (Almeida et al., 2016). The formations of these nuclei are known as nucleation techniques which speed up forest succession by maintaining the ecosystem functionality (Reis et al., 2003).

One of the restoration methods for forest ecosystems has been the construction of artificial perches outside the forest edge (Graham & Page, 2012), which act as safe spots for rest, foraging, and latrines attracting highly diverse propagules (Reis et al., 2010). It is worth mentioning that, at the landscape scale, the use of artificial perches can contribute to cost reduction and also in the planning of forest restoration actions (Dias et al., 2014).

Another nucleation technique is brushwood transposition, which consists of the addition of dry stalks, leaves, branches, and roots from native species obtained through tree pruning in the degraded area, which acts as a refuge seed dispersers besides protecting the soil from radiation (Reis et al., 2003; Fragoso et al., 2017).

The adoption of different restoration techniques enhances the knowledge on this matter and can provide subsidies for the initial steps of restoration of degraded biomes, such as the Atlantic forest.

In this context, we aimed to investigate the interactions of some nucleation techniques in a degraded area next to a forest remnant. The hypothesis fostered in this study was that the use of artificial perches together with other nucleation techniques increase the seed diversity and wealth and regenerants in the area, a relevant factor to be considered in ecological restoration, since, they can enhance the process of natural succession in degraded environments.

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2.Material and Methods

This study used both field and laboratory researches (Pereira et al., 2018). The nature of the work was quantitative.

2.1 Study sites

The study was conducted at the "Fazenda Experimental de Ciências Agrárias" (FAECA) of the Universidade Federal da Grande Dourados, Dourados, Mato Grosso do Sul. The farm has approximately 294 hectares. The restoration experiment was conducted in a degraded ecosystem located next to a forest remnant of the submontane semideciduous seasonal forest (Martins & Cavararo, 2012), typical phytophysiognomy of the Atlantic Forest biome (22º15′03″ S and 54º59′02″ W). The soil was classified as dystroferric red latosol with high levels of iron, a characteristic that results in low fertility (Embrapa, 2006). According to the Köppen system, the climate was Cfa (humid subtropical climate with hot summer), presenting an average temperature of 18°C in cold months and over 22°C in warm months (Alvares et al., 2013). The average annual rainfall is 1,410 mm (Arai et al., 2010).

Before the experimental farm was acquired in 2008 by the university, it was a private land on which grain crops (soybean and corn) were mainly cultivated for many years; however, due to the agricultural expansion, several areas were degraded [withdrawal of fine woods of forest remnants, such as *Aspidosperma polyneuron* Müll. Arg.; Drainage of wetlands with the introduction of exotic grasses, such as *Urochloa decumbens* (Stapf) R.D.Webster, which has completely covered the soil in these areas].

2.2 Experimental design

The experiment was carried out in October 2012 in an area of 25 x 40 m withing the forest fragment. In this area, spontaneous vegetation under the soil was cleared out with a tractor. The experimental design used was randomized in blocks, with three blocks, five treatments and 5 replicas: T1 (perches only), T2 (perches with propagule collectors), T3 (perches with brushwood), T4 (perches with food supply), and T5 (perches with brushwood transposition and food supply). The blocks were at least 2m away from each other. In each block, plots of 2 x 2 m in size corresponded to the treatment replica. In total, 25 perches per block totalizing 75 perches were implanted throughout the experimental area.

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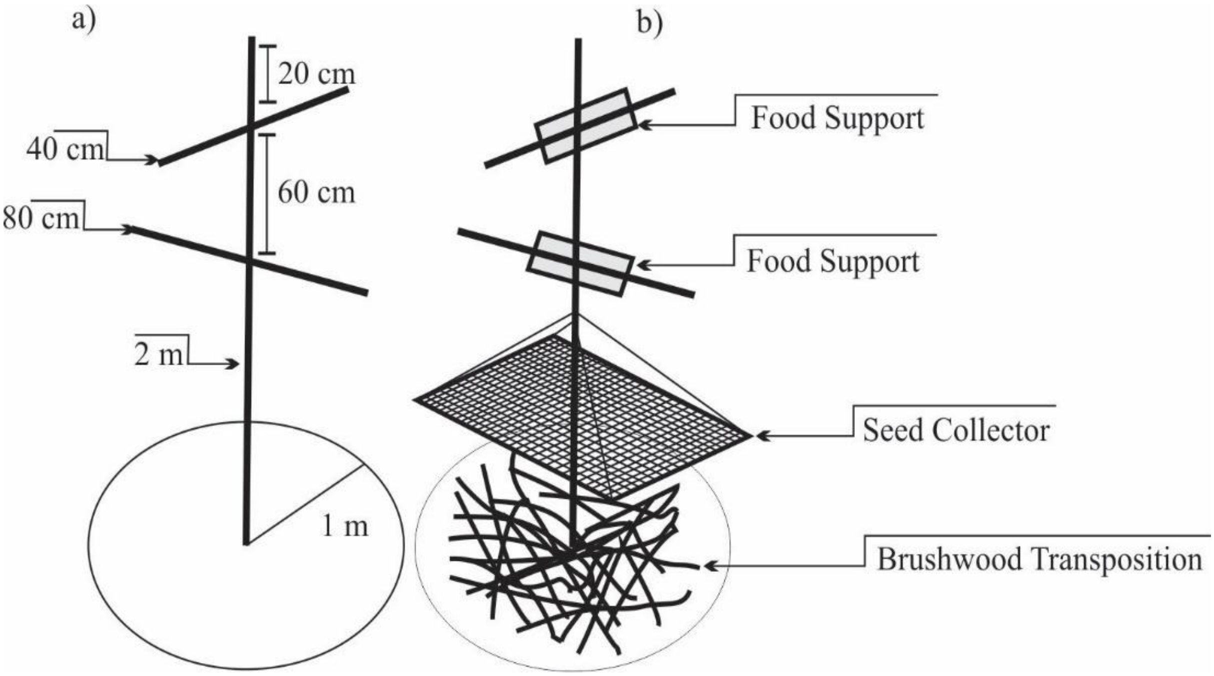
The artificial perches were made out of bamboo (*Bambusa vulgaris* Schrad. ex J.C. Wendl.). The bamboo was 2m height (80 cm buried in the soil), and had two perpendicular structures of 80 and 40 cm arranged in a circular area of 1 m (Figure 1).

Figure 1. Structure of the artificial perches (a) and description of the different treatments applied (b) (Dourados, 2017).



Source: Research authors (2017).

In Figure 2, the images show how artificial perches were allocated to the experimental field in their respective treatments (T1 to T5), using easily accessible materials such as bamboo, pet bottle, smooth wire, and brushwood transposition. It is also possible to observe that among the limits between treatments, exotic grasses were controlled by manual weeding.

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Figure 2. Implantation of artificial perches in the field (Dourados, 2017). (a) artificial perch model of the control treatment, T1; (b) artificial perch model with seed collectors from treatment 2; (c) artificial perch model with brushwood transposition occurring in treatments 3 and 5; (d) artificial perch model occurring in treatment 4 and 5.

Source: Research authors (2017).

The monofilament screen (Sombrite ®) with the mesh density (70% shading) was added in the T2 with the height above the soil surface of 40 cm, in order to collect seeds dispersed by birds. In treatments T4 and T5, food supports were attached with wires to the perpendicular bamboo rods of 80 and 40 cm; these supports were made out of polyethylene terephthalate bottles (cut in the middle) for bird food (a mixture of corn starch, canary seeds, millets, sunflowers, turnips, and oats). In treatments T3 and T5, at the base of the perch, brushwood transposition (from local tree pruning) was piled in 1-m^2 area (Figure 2).

The emergence of plantules surrounding the perches installed in October 2013 was evaluated at the end of the 365 days to identify the species and number of individuals. Plantules were classified according to the life forms (herb, liana, subshrub, shrub, and tree) and dispersion syndrome (anemochory, autochory, and zoochory) by specialized literature (Van der Pijl, 1982; Angiosperm Phylogeny Group III, 2009; Flora do Brasil, 2017).

The exotic vegetation on the seed bank surrounding the perches was manually removed to ensure the emergence of propagules from bird dispersal. In T2, the seeds found on the collectors were brought by the wind and bird feces. The seeds were collected biweekly from November 2012 to November 2013, identified in the laboratory using a magnifying glass, and then stored in plastic containers. Diaspores were classified according to the dispersion syndrome (Van der Pijl, 1982).

The results were analyzed using the analysis of variance (ANOVA). The variables analyzed included the numbers of species and individuals. The mean values were compared using the Tukey test at 5% significance. The R software was used to perform the analysis (R Development Core Team, 2017).

3. Results

After 365 days of the experiment implementation, the regenerators diversity was significant among the blocks ($F = 12.19$, $p < 0.01$; Figure 3) and treatments ($F = 13.14$, $p < 0.01$; Figure 3). The number of plant individuals was also significant among the blocks ($F = 9.30$, $p < 0.01$; Figure 3) and treatments ($F = 5.92$, $p < 0.05$; Figure 3).

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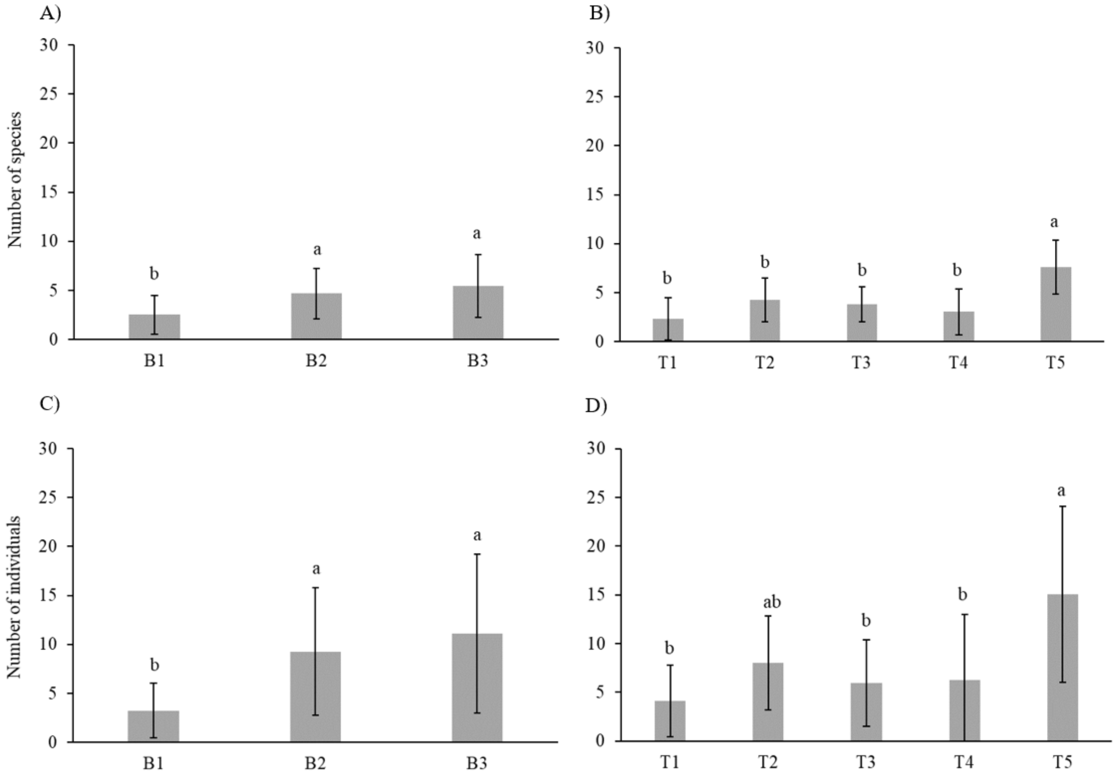
Figure 3. Species richness and number of plant regenerants in the various restoration treatments of a degraded semideciduous seasonal forest area at day 365 after the implementation of the treatments. (A) species richness in the three lines spaced from the forest fragments; (B) species richness in the different treatments; (C) number of individuals in the thee lines spaced from the forest fragments; (D) number of individuals in the different treatments. The error bars represent ±SD; the columns with a common letter are not significantly different (Tukey test; p > 0.05) (B1, block 1; B2, block 2; B3, block 3; T1, control, perch only; T2, perches with seed collectors; T3, perches with brushwood transposition; T4, perches with food supply; T5, perches with brushwood transposition and food supply).



Source: Research authors (2017).

Among the blocks, differences were observed both for species richness (Fig.3, A) and number of individuals (Fig.3, C). Regarding treatments, it was observed that treatment 5 was different from the other treatments regarding species richness (Fig.3, B). Analyzing the number of individuals, treatments 2 and 5, were different from the others (Fig.3, D).

A total of 590 plantules from 15 families distributed across 29 genera and 35 species were observed, of which six were identified at the genus level and three at the family level only. The family Asteraceae had the greatest number of plantules (12 species; 34.3%), followed by Euphorbiaceae with four species (11.4%) and Malvaceae with three (8.6%). The other families had one or two species each (Table 1).

Table 1. Regenerants observed in the analyzed treatments and seeds found on the collectors of T2 in Dourados (MS-BR) in 2017. Dispersion syndrome, DS; Anemo, anemochory; Auto, autochory; Zoo, zoochory.

Family	Species	Species regeneration	Seeds in the T2	Habit	DS
Anacardiaceae	*Lithraea molleoides* (Vell.) Engl.	x		Tree	Zoo
Anacardiaceae	*Myracrodruon urundeuva* Allemão	x		Tree	Anemo
Asteraceae	*Ageratum conyzoides* L.	x		Herbs	Anemo
Asteraceae	*Asteraceae* sp.	x		Herbs	Anemo
Asteraceae	*Baccharis dracunculifolia* DC.	x		Shrub	Anemo
Asteraceae	*Chromolaena* sp.	x	7	Herbs	Anemo
Asteraceae	*Conyza bonariensis* (L.) Cronquist	x		Herbs	Anemo
Asteraceae	*Emilia sonchifolia* (L.) DC. ex Wight	x		Herbs	Anemo
Asteraceae	*Gamochaeta pensylvanica* (Willd.) Cabrera	x		Herbs	Anemo
Asteraceae	*Lessingianthus* sp.	x		Herbs	Anemo
Asteraceae	*Mikania cordifolia* (L.f.) Willd.	x		Liana	Anemo
Asteraceae	*Porophyllum ruderale* (Jacq.) Cass.	x		Herbs	Anemo
Asteraceae	*Sonchus oleraceus* L.	x		Herbs	Anemo
Asteraceae	*Vernonanthura polyanthes* (Sprengel) Vega & Dematteis	x		Herbs	Anemo
Bignoniaceae	*Handroanthus heptaphyllus* (Vell.) Mattos	x		Tree	Anemo
Cannabaceae	*Celtis iguanaea* (Jacq.) Sarg.		2	Tree	Zoo
Cannabaceae	*Trema micrantha* (L.) Blume	x	127	Tree	Zoo
Convolvulaceae	*Ipomoea* sp.	x		Liana	Auto
Euphorbiaceae	*Actinostemon concolor* (Spreng.) Müll. Arg.		3	Tree	Auto
Euphorbiaceae	*Euphorbia heterophylla* L.	x		Herbs	Auto
Euphorbiaceae	*Euphorbia hyssopifolia* L.	x		Herbs	Auto
Euphorbiaceae	*Euphorbiaceae* sp.	x		Herbs	Auto
Euphorbiaceae	*Sebastiania brasiliensis* Spreng.	x		Tree	Auto
Fabaceae	*Fabaceae* sp.	x		Herbs	Auto
Fabaceae	*Leptolobium elegans* Vogel.	x		Tree	Anemo
Fabaceae	*Machaerium acutifolium* Vogel		142	Tree	Anemo
Fabaceae	*Peltophorum dubium* (Spreng.) Taub.		1	Tree	Anemo
Lamiaceae	*Aegiphila verticillata* Vell		2	Tree	Zoo
Lauraceae	*Lauraceae* sp.		1	Tree	Zoo
Malpighiaceae	*Amorimia rigida* (A.Juss.) W.R.Anderson		2	Liana	Anemo
Malvaceae	*Sida cordifolia* L.	x		Herbs	Anemo
Malvaceae	*Sida rhombifolia* L.	x		Herbs	Anemo
Malvaceae	*Sida* sp.	x		Herbs	Anemo
Moraceae	*Maclura tinctoria* (L.) D.Don ex Steud.	x	178	Tree	Zoo
Onagraceae	*Ludwigia* sp.	x		Herbs	Anemo
Phyllanthaceae	*Phyllanthus tenellus* Roxb.	x		Herbs	Anemo
Plantaginaceae	*Scoparia dulcis* L.	x		Herbs	Anemo
Poaceae	*Urochloa decumbens* (Stapf) R.D.Webster		44	Herbs	Anemo
Poaceae	*Melinis repens* (Willd.) Zizka		9	Herbs	Anemo
Rubiaceae	*Chomelia obtusa* Cham. & Schltdl.		4	Tree	Zoo
Rubiaceae	*Guettarda viburnoides* Cham. & Schltdl.		5	Tree	Zoo
Rubiaceae	*Psychotria carthagenensis* Jacq.		11	Shrub	Zoo
Sapindaceae	*Paullinia elegans* Cambess.	x		Liana	Zoo
Sapindaceae	*Serjania* sp.	x		Liana	Anemo
Sapindaceae	*Cardiospermum halicacabum* L.		113	Liana	Zoo
Smilacaceae	*Smilax* sp.		1	Liana	Zoo
Solanaceae	*Solanum americanum* Mill.	x		Herbs	Zoo
Solanaceae	*Solanum sisymbriifolium* Lam.	x	446	Herbs	Zoo
Urticaceae	*Cecropia pachystachya* Trécul	x	2719	Tree	Zoo
	Morphospecies 1		6		
	Morphospecies 2		1		

Source: Research authors (2017).

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The predominant life form in the whole experimental area was herbaceous (22 sp., 62.9%), followed by arboreal (8 sp., 22.9%), liana (4 sp., 11.4%), and shrub (1 sp., 2.8%) (Table 1); the predominant dispersion syndrome was anemochoric (22 sp., 62.9%), followed by autochoric (6 sp., 17.1%) and zoochoric (7 sp., 20%) (Table 1). In the different treatments, these observations were similar, with a predominance of anemochoric species of herbaceous habit (Table 2).

Table 2. Percentage (%) of the dispersion syndrome and life form of the species identified in the studied treatments.

	Block 1						
	Anemochory	**Autochory**	**Zoochory**	**Herb**	**Tree**	**Liana**	**Shrub**
T1	50	50	0	100	0	0	0
T2	50	33	17	90	0	0	10
T3	60	30	10	70	10	10	10
T4	60	40	0	90	0	0	10
T5	60	27	13	66	20	7	7
	Block 2						
	Anemochory	**Autochory**	**Zoochory**	**Herb**	**Tree**	**Liana**	**Shrub**
T1	38	38	24	61	23	8	8
T2	31	54	15	77	8	15	0
T3	40	47	13	80	13	0	7
T4	44	44	12	89	11	0	0
T5	68	13	19	74	13	13	0
	Block 3						
	Anemochory	**Autochory**	**Zoochory**	**Herb**	**Tree**	**Liana**	**Shrub**
T1	75	25	0	88	12	0	0
T2	72	11	17	60	28	6	6
T3	84	8	8	84	8	0	8
T4	67	13	20	53	20	20	7
T5	76	5	19	71	14	10	5

Source: Research authors (2017).

The T2 was the only treatment setting with a seed collector, and during the 365 days, 3,824 seeds were collected, belonging to 14 families across 18 genera and 21 species; two species were identified at the genus level, one at the family level, and two at the morphospecies level (Table 1).

The classification based on seed habit showed that most were tree species (11 species, 52.4%), followed by herbs (4, 19%), lianas (3, 14.3 %), and shrubs (1, 4.8%); two species could not be characterized (9.5%). In the classification according to the dispersion syndrome, most seeds were of zoochoric species (12, 57.1%), followed by anemochoric (6, 28.6%) and autochoric (1, 4.8%).

The species with the highest number of propagules were *C. pachystachya* (2,719 seeds), *S. sisymbriifolium* (446 seeds), *M. tinctoria* (178 seeds), *M. acutifolium* (142 seeds), and *T. micrantha* (127 seeds).

During the experiment, the presence of seed-dispersing birds on artificial perches was recorded: smooth-billed ani (*Crotophaga ani*; Linnaeus, 1758), great kiskadee (*Pitangus sulphuratus*; Linnaeus, 1766), fork-tailed flycatcher (*Tyrannus savanna*; Daudin, 1802), chalk-browed mockingbird (*Mimus saturninus*; Lichtenstein, 1823), and peach-fronted parakeet (*Eupsittula aurea*; Gmelin, 1788).

4. Discussion

Graham & Page (2012) mention that a way to assess whether the method used in the restoration was effective, is to verify whether the use of artificial perches has led to a significant increase in seed dispersal and seedling recruitment. Based on this principle, it is believed that the use of artificial perches alone was effective in the range of regenerating, however, when combined with other nucleation techniques such as brushwood transposition, food supply, and collectors, it can be seen an increase in the species diversity.

The greater number of species and individuals in T5 may be due to the food placement that maintained higher bird flow on these perches; and when combined with the transposition of galls at the base of the artificial perch, it is possible that germination was facilitated by the birds, defecating or regurgitating the seeds and also because of the microhabitat created by the brushwood transposition, which blocked excessive radiation, creating a germination-friendly microclimate.

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Some researchers believe that seed dispersal on perches is associated with bird diversity, because some birds forage in forest environments, while others forage in open areas, such as pasture (Holl, 1998; Shiels & Walker, 2003; Reid & Holl, 2013).

The birds observed in the experiment (*Crotophaga ani*, *Pitangus sulphuratus*, *Tyrannus savana*, *Mimus saturninus*, and *Eupsittula aurea*) enjoy fruits of native trees and are commonly found in open areas. The smooth-billed ani had already been reported as one of the birds that most enjoy artificial perches (Holl, 1998).

According to the study by Vogel et al. (2018), the species *Tyrannus savana* and *Pitangus sulphuratus* have been frequently observed on artificial perches in ecological restoration of Cerrado and Atlantic Forest biomes in Brazil. The same authors mentioned that these species are generalist and dispersing seeds under the perches may favor the ecological restoration process, thus demonstrating the importance of these artificial structures for the maintenance of bird diversity and consequently the provision of ecosystem services.

The results observed in T2 regarding the number of individuals was intriguing, since it was expected a greater recruitment of seedlings in treatments where the perches were combined with food supply and brushwood transposition, because the seeds that fell on the screen were collected. Therefore, it is suggested that the higher number of individuals in T2 may be due to the establishment of a microclimate created by the seed collector (monofilament screen) that favored germination providing 70% shading.

Regarding the diversity of regenerants observed in the treatments, anemochory was the predominant dispersion syndrome in all treatments, and considering that the area of artificial perches is characterized as an open area and is directly influenced by the wind, the presence of anemochoric seeds was expected. The occurrence of anemochoric species was also observed in other studies with artificial perches and brushwood transposition (Tres et al., 2007; Tomazi et al., 2010; Fragoso et al., 2017).

The presence of regenerants of the anemochoric and autochoric tree species *M. urundeuva*, *H. heptaphyllus*, *S. brasiliensis*, and *L. elegans* in the treatments was due to the existence of adult individuals of these species at the edge of the area (Abreu, 2013). The implementation of restoration experiments near forest remnants, as seen in this study, was favored by the anemochoric dispersion syndrome as the abovementioned tree species have early to late secondary successional classification and are extremely important in the maintenance of the local successional process.

Pioneer zoochoric tree species, such as *L. molleoides*, *T. micranta*, *M. tinctoria*, and *C. pachystachya*, were observed in the adjacent fragment (Abreu, 2013); however, it is suggested that the presence of these species in the different treatments may be owing to seed dispersers that forage in-between areas. Bocchese et al. (2008) found that natural and artificial perches attract different birds'species, favoring a local diversity of dispersers which contributes to seed dispersion in the environment.

Among anemochoric individuals, it is observed that the predominant life form is herbaceous, so it is suggested that their abundance in treatments may be related to the seed bank richness and also the influence of adjacent pasture. However, the establishment of herbaceous species has been commonly observed in restoration projects, as they are considered facilitators because they provide an adequate microclimate due to the formation of a layer of litter in the soil, which provides the first decomposers (Tres et al., 2007).

Researchers have observed the potential of artificial perches to significantly increase the number of propagules in areas recently occupied by agricultural or livestock activities in forest formations belonging to the Atlantic Forest biome in Brazil (Almeida et al., 2016) and other phytophysiognomies in the south of Africa (Heelemann et al., 2012).

The natural succession processes in most restoration projects mainly comprise colonizing plants (Sevegnani, 2002) usually belonging to the botanical families Asteraceae, Euphorbiaceae, and Malvaceae. In studies with artificial perches and brushwood transposition, these families were also the most frequently found (Tomazi et al., 2010; Ronchi, 2013; Fragoso et al., 2017).

These colonizing species protect the soil against erosion and provide organic matter for the initiation of microbial decomposition activity, minimizing the impact of rain, maintaining a certain amount of moisture in the soil, reducing the incidence of light and heat (Zimmerman et al., 2000).

Analyzing the seed diversity found in T2, the only treatment with a seed's collector, it was observed that at the end of 365 days a total of 3,824 seeds were found, with a predominance of zoochoric species. Based on these data, the contribution of propagules dispersed by birds was considerable, and the dispersal could have been greater than it was found as the seeds dispersed by the birds may not have had favorable conditions for germination at the site. The absence of organic nutrients in degraded soils and competition with herbaceous vegetation, such as grasses, may not allow the germination of seeds arriving at the site (Zimmerman et al., 2000; Heelemann et al., 2012; Ronchi, 2013).

In degraded areas belonging to the Atlantic Forest biome, some researchers have also recorded a higher number of seeds with the adoption of artificial perches. Almeida et al. (2016), in addition to artificial perches, included seed traps in the degraded area and recorded

25,755 seeds in 2 years, with a seed density of 680 seeds $m^{-2}year^{-1}$ under the perches. Ronchi (2013) recorded 3,304 zoochoric seeds, corresponding to 81.6% of the total number of seeds collected after 1 year with dry perches in a remnant of the Atlantic Forest.

The presence of the anemochoric species *M. acutifolium* on the collectors was due to the existence of adult individuals at the edge of the fragment (Abreu, 2013). The pioneer zoochoric species *C. pachystachya*, *S. sisymbriifolium*, *M. tinctoria*, and *T. micrantha*, which presented a larger number of seeds in T2, were also present in other studies with artificial perches that evaluated seed fall (Bocchese et al., 2008; Tomazi et al., 2010; Ronchi 2013; Almeida et al., 2016). These species were also found as regenerants in other treatments (Table 1), showing the preference of avifauna for these species and their easy germination in degraded, low-fertility soil.

These species are indicated for the restoration of degraded areas, because they act as "nurse plants" (Reis et al., 2003), thus speeding up the succession process, attracting seed dispersers, gradually replacing grasses due to increasing shading, increasing soil nutrients, and changing the microclimate conditions (Holl, 1998; Reis et al., 1999), thereby adding other functions to the artificial perches despite their very short life cycle.

Even though the seed bank has influenced seedling recruitment in the treatments, we believe that the diversity of regenerants was strongly influenced by the foraging birds in the artificial perches since we registered a large number of seeds in the artificial collectors, especially in the T2.

The nucleation function in the degraded environment can be favored combining artificial perches with brushwood transposition and food supply. Studies have shown that artificial perches increase the seed rain in the area, therefore the regenerating species ones contribute to the increase of species richness in the degraded area (McClanahan & Wolfe, 1993; Zanini & Ganade, 2005; Graham & Page 2012; Heelemann et al., 2012; Guidetti et al., 2016).

From an economic point of view, it is believed that the use of artificial perches and other restoration techniques can be applied in restoration projects due to the viability of affordable low-cost materials such as bamboo (*Bambusa* sp.). The use of artificial perches in the restoration of degraded areas has been considered a promising nucleation technique due to its ease construction, low maintenance, and low cost when compared to more conventional forms of restoration (Silveira et al., 2015).

Thus, these data confirm the hypothesis suggested in this study that the diversification of nucleation techniques may favor the increase in seedling recruitment in degraded environments. In this sense, it is recommended artificial perches with brushwood transposition at the base and food supply to intensify the frugivores visitation in the area to be restored and consequently enhance the natural succession of the environment through seedling recruitment.

5. Conclusion and Suggestions

Our results allow us to conclude that the construction of artificial perches allied to the brushwood transposition and food supply provide a greater increase in the diversity of seed rain and in the recruitment of seedlings as a result of the foraging of seed dispersers using the artificial perches for fallow.

It can also be said that this nucleation technique favors the increase of zoochoric species regenerators (nurse plants) in the seed bank that, under favorable conditions, can germinate; in addition to being a viable and economical technique to be used in restoration projects.

Artificial perches are believed to be functional nucleation techniques that attract wildlife and contribute to the enrichment of native species in degraded areas. Therefore, it is suggested that research of this nature be replicated in the field, always seeking to combine artificial perches with other nucleation techniques in degraded areas, especially in areas that have reference ecosystems with different phytophysiognomies; because such studies can provide subsidies for a better understanding of the functionality of these techniques in the resilience of degraded environments.

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