

Seed rain in two areas with different relief types in a tropical rainforest

Chuva de sementes em duas áreas com diferentes tipos de relevo em uma floresta tropical

Lluvia de semillas en dos áreas con diferentes tipos de relieve en una selva tropical

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Priscila Silva dos Santos

ORCID: <https://orcid.org/0000-0001-8902-9691>
Universidade Federal Rural de Pernambuco, Brazil
E-mail: biopri13@hotmail.com

Kleber Andrade da Silva

ORCID: <https://orcid.org/0000-0002-7011-8800>
Universidade Federal de Pernambuco, Brazil
E-mail: kleber.andrade@ufpe.br

Elcida de Lima Araújo

ORCID: <https://orcid.org/0000-0002-3379-3540>
Universidade Federal Rural de Pernambuco, Brazil
E-mail: elcida.araujo@ufpe.br

Elba Maria Nogueira Ferraz

ORCID: <https://orcid.org/0000-0003-4998-9772>
Instituto Federal de Pernambuco, Brazil
E-mail: elbanogueira08@gmail.com

Abstract

Seed rain participates in species enrichment during the natural regeneration of terrestrial ecosystems, as this ecological process promotes gene flow and the maintenance of forest biodiversity. However, few studies assessed variations in seed rain related to environmental heterogeneity inside forests. We studied the influence of relief (flat or slope areas) on the seasonal and monthly variation in density, floristic composition, and richness of the seed rain in an urban fragment of Atlantic Forest. We carried out the present study in Rain Tropical Forest, Northeastern Brazil. We selected two areas within the fragment: one with flat relief and the other on a slope. In each relief type we set up 20 0.25-m² seed collectors, in a total of 40 units, to quantify seed rain. After ten months of study, we counted 9,474 seeds: 8,061 in the flat area and 1,413 in the slope area. There were significant differences in dispersal syndromes and plants habit between relief types. The seed density in the flat area differed between seasons and the species richness varied seasonally in both areas. There were variations in floristic composition between seasons in the flat and slope areas. Seed density was higher in December and January in the flat area. Differences in seed rain suggest that it is influenced by spatial heterogeneity and climate seasonality, and that the areas with different kinds of relief are important for the biodiversity conservation.

Keywords: Flat area; Slope area; Seed dispersal; Topography; Space-time variation.

Resumo

A chuva de sementes participa do enriquecimento de espécies durante a regeneração natural dos ecossistemas terrestres, pois esse processo ecológico promove o fluxo gênico e a manutenção da biodiversidade florestal. No entanto, poucos estudos avaliaram as variações na chuva de sementes relacionadas à heterogeneidade ambiental no interior das florestas. Estudamos a influência do relevo (áreas planas ou de encosta) na variação sazonal e mensal da densidade, composição florística e riqueza da chuva de sementes em um fragmento urbano de Mata Atlântica. Realizamos o presente estudo em uma Floresta Tropical Úmida, no Nordeste do Brasil. Seleccionamos duas áreas dentro do fragmento: uma com relevo plano e, sendo a outra, uma encosta. Em cada tipo de relevo foram instalados 20 coletores de sementes de 0,25 m², num total de 40 unidades, para quantificar a chuva de sementes. Após dez meses de estudo, contabilizamos 9.474 sementes, das quais, 8.061 foram observadas na área de relevo plano e 1.413 na área de encosta. Houveram diferenças significativas nas síndromes de dispersão e hábito das plantas entre os tipos de relevo. A densidade de sementes na área plana diferiu entre as estações e a riqueza de espécies variou sazonalmente em ambas as áreas. Houve variações na composição florística entre as estações nas áreas plana e de encosta. A densidade de sementes foi maior nos meses de dezembro e Janeiro na área plana. Diferenças na chuva de sementes sugerem que ela é influenciada pela heterogeneidade espacial e sazonalidade climática, e que as áreas com diferentes tipos de relevo são importantes para a conservação da biodiversidade.

Palavras-chave: Área plana; Área de encosta; Dispersão de sementes; Topografia; Variação espaço-temporal.

Resumen

La lluvia de semillas participa en el enriquecimiento de especies durante la regeneración natural de los ecosistemas terrestres, ya que este proceso ecológico promueve el flujo de genes y el mantenimiento de la biodiversidad forestal. Estudiamos la influencia del relieve (áreas planas o en pendiente) sobre la variación estacional y mensual de la densidad, composición florística y riqueza de la lluvia de semillas en un fragmento urbano de Mata Atlántica. Realizamos el presente estudio en Bosque Tropical Lluvioso, en Noreste de Brasil. Seleccionamos dos áreas dentro del fragmento: una con relieve plano y la otra en pendiente. En cada tipo de relieve instalamos 20 recolectores de semillas de 0,25 m², en un total de 40 unidades, para cuantificar la lluvia de semillas. Luego de diez meses de estudio, contamos 9.474 semillas: 8.061 en el área plana y 1.413 en el área pendiente. Hubo diferencias significativas en los síndromes de dispersión y las hábitos de la planta entre los tipos de relieve. La densidad de semillas en el área plana difiere entre las estaciones y que la riqueza de especies varía estacionalmente en ambas áreas. Hubo variaciones en la composición florística entre estaciones en las áreas planas y en pendiente. La densidad de semillas fue mayor en diciembre y enero en la zona llana. Las diferencias en la lluvia de semillas sugieren que está influenciada por la heterogeneidad espacial y la estacionalidad climática, y que las áreas con diferentes tipos de relieve son importantes para la conservación de la biodiversidad.

Palabras clave: Área plana; Área de pendiente; Dispersión de semillas; Topografía; Variación espacio-temporal.

1. Introduction

Seed rain, both autochthonous and allochthonous, plays a very important role in the natural regeneration of terrestrial ecosystems, as this ecological process promotes gene flow and the maintenance of forest biodiversity (Jara-Guerrero, et al., 2020, Yang, et al., 2020, Werden, et al., 2021). Most studies on seed rain in tropical rainforests assessed variations in density between fragments according to different factors, such as seasonality, fragment size, and disturbance level (Du, et al., 2009, Sheldon & Nadkarni, 2013, Gratzner, et al., 2022), and only few studies assessed variations in seed rain related to environmental heterogeneity inside forests (Sheldon & Nadkarni, 2013, César et al., 2020, Plohák, et al., 2021, Gratzner, et al., 2022).

Tropical rainforest fragments are characterized by topographical variations at a local scale. The slope areas have more clayey soils, with low fertility and more weathered conditions. The flat areas have more sandy soils, more fertile and less weathered conditions (Martins, et al., 2003). These factors create different environments for the establishment of plants. Consequently, the species richness found in slope areas may be different from the species richness found in flat area (Martins, et al., 2003). In addition, climatic seasonality influences the fruiting period and dispersion of diaspores (Sheldon & Nadkarni, 2013, Gratzner, et al., 2022). For example, fruit production and dispersion of diaspores occur at the end of the dry season and the beginning of the rainy season (Dosch, et al., 2007, Du, et al., 2009, Sheldon & Nadkarni, 2013). Therefore, seed rain may be a reflection of spatial heterogeneity, due to the distribution of species in a topographical gradient and temporal due to seasonal variation in the period of fruit production and dispersion of diaspores.

In the Northeast region of Brazil, the tropical rainforests are well represented by the Atlantic Forest, located in the coastal region. The Atlantic Forest has high biodiversity and a high level of endemism (Tabarelli, et al., 2009, Lima, 2016, Rezende et al., 2018). Since the European occupation in Brazil, the Atlantic Forest has been suffering the consequences of anthropogenic actions, such as agriculture and livestock. Most of the original vegetation has been destroyed, with only 11% - 16% of the original vegetation remaining forming a highly fragmented landscape (Tabarelli, et al., 2009, Lima, 2016, Rezende et al., 2018). Fragmentation is considered the main factor related to the loss of biodiversity in tropical rainforests (Benítez-Malvido, et al., 2022). The remaining fragments present great spatial heterogeneity, with flat and sloping areas for the establishment of plants (Rezende et al., 2018). Therefore, the Atlantic Forest is a good example to monitor the effect of spatial and temporal heterogeneity on seed rain attributes.

Considering that the topographic heterogeneity (relief) of a forest fragment may influence the species composition, richness, density, plants habit, dispersal syndromes, and successional stage of the seed rain, we aimed at assessing seed rain dynamics over time in two areas with different types of relief (flat and slope areas) in a fragment of Atlantic Forest, in Pernambuco, Northeast region of Brazil, in order to answer the following questions: (1) Is species composition of the seed rain

similar between flat and slope areas? (2) Do the density and richness of the seed rain differ between these areas and seasons? (3) Do density and species richness vary monthly? (4) Among the species present in the seed rain, which dispersal syndromes predominate in each area and to which life forms and successional categories do those species belong?

2. Methodology

Study Area – We carried out the present study in Tejipió Forest (08° 06”S and 34° 57”W), an urban forest fragment of 172 ha located in the municipality of Tejipió, state of Pernambuco, northeastern Brazil, with altitudes ranging from 15 to 64 m a.s.l. (Feitosa, 2004). The climate, according to the Köppen (1928) system is type As’ (humid tropical), with annual average rainfall of 1.651 mm and annual average temperature of 24 °C (CPRH, 2003). The soils are formed by dystrophic red-yellow argisols and dystrophic red-yellow latosols (CPRH, 2003). The local relief is diverse: flat relief (lower and flat area of the forest), slope of approximately 45°, and high and flat relief, which forms a small plateau. The vegetation is classified as lowland rainforest (IBGE, 2004).

The native vegetation that existed in the area was subjected to clear-cutting and latter to agropastoral practices until 1966. After that, the area was transformed into an Experimental Zone of Environmental Protection by the Army and the vegetation has been naturally regenerating since then (Feitosa, 2004).

To test whether the seed rain varies with the relief, we selected two areas within the fragment: one with flat relief and the other on a slope, hereafter named “flat area” and “slope area”, respectively. The distance between areas is ca. 2 km.

Sampling and statistical analyses – In each relief type we installed randomly 20 square collectors (0.5 m x 0.5 m) with a 1-mm nylon mesh and depth of approximately 20 cm. These collectors were set up at 30 cm above ground, fixed on tree trunks with nylon threads (Pessoa, 2011), and identified with a numbered tag.

We carried out monthly monitoring from October 2012 to July 2013. We stored each sample in a properly labeled polyethylene bag. In the laboratory, we manually separated seeds from other materials (Hardesty & Parker, 2002), and classified them under a stereoscopic microscope. We opened the fruits to remove seeds, which we separated and classified into morphotypes. We numbered each morphotype before their taxonomic identification following APG III (2009). The number of seeds was expressed per m².

To identify the seeds, we consulted the specialized literature (Lorenzi, 1998a, 1998b), the herbarium Professor Vasconcelos-Sobrinho (PEUFR) and Dárdano de Andrade-Lima (IPA) and compared the seeds with voucher material collected in the surroundings of the collectors in both areas. Unidentified species were named morphospecies

We classified the seeds by dispersal syndrome (Van der Pijl, 1982) as: anemochorous, autochorous, or zoochorous; by life form (Raunkiaer, 1934) as: tree, shrub, liana, or herb; and by successional category (Gandolfi, et al., 1995) as: pioneer, initial secondary, or late secondary.

To test the effect of the predictor variables (relief and seasonal and monthly variation) on the density and species richness of seeds we used a GLM (generalized linear model). We tested for differences in density and species richness between areas with different relief types, seasons, and months with a post hoc Tukey test. All analyses were performed in the program Statistica 7.0.

We used a chi-squared test to verify whether dispersal syndrome, life form, and successional category differed between areas. We excluded morphospecies from this analysis, as it was not possible to identify their successional category, dispersal syndrome, and life form.

We compared the floristic composition of the seed rain in the two areas with a non-metric multidimensional scaling (NMDS), based on the Bray-Curtis dissimilarity calculated using the species densities of all 40 seed collectors. We used an ANOSIM to estimate the significance of the groups formed in the NMDS. The explanatory power of the predictor variables on

the floristic similarity was determined by the R-global. NMDS and ANOSIM were run in the program Primer 6.1.6 (Clarke & Gorley, 2006).

3. Results

The seed rain was composed of 9,474 seeds of 47 species and 22 families. In the flat area we found a total of 8,061 seeds (1,612 seeds/m²) of 21 species and 15 families, and three additional morphospecies. In the slope area we found 1,413 (283 seeds/m²) seeds of 29 species and 20 families, and six additional morphospecies. Seven species were exclusive to the flat area, 20 were exclusive to the slope area, and 19 species were found in both areas (Table 1).

The GLM analysis showed that relief and climatic seasonality explained the variations in seed density [$F_{(1, 396)} = 6.68$, $p = 0.010$] and species richness [$F_{(1, 396)} = 6.2645$, $p = 0.013$] (Figure 1A and 1B). Only in the flat area seed density varied with seasonality; the highest seed incidence occurred in the dry season (Figure 1A). Species richness varied seasonally between sites, but in both areas the dry season had a higher number of species (Figure 1B). In the dry season, species richness was significantly higher in the flat area than in the slope area, whereas in the rainy season species richness did not differ significantly between areas (Figure 1B).

Table 1. Species recorded in the seed rain in two areas with different relief types (F = Flat and S = Slope) in an Atlantic Forest fragment in Pernambuco, northeastern Brazil. LF = Life form (Tr = Tree; Sh = Shrub, He = Herb; Li = Liana), DS = Dispersal Syndrome (Zoo = Zoochorous; Ane = Anemochorous; Aut = Autochorous); SC = Successional Category (PI = Pioneer; IS = Initial Secondary; LS = Late Secondary and NC = No Category); - = Absence of the species; Morphospecies = unidentified species.

Family	Species	LF	DS	SC	F	S
Anacardiaceae	<i>Tapirira guianensis</i> Aubl.	Tr	Zoo	PI	X	X
	<i>Thyrsodium spruceanum</i> Benth.	Tr	Zoo	IS	-	X
Annonaceae	<i>Anaxagorea dolichocarpa</i> Sprad & Sandwith	Tr	Zoo	IS	X	X
	<i>Xylopia frutescens</i> Aubl.	Tr	Zoo	IS	X	X
Araliaceae	<i>Schefflera morototoni</i> (Aubl.) Manguire, Steyer. & Frodi	Tr	Zoo	PI	X	X
Asteraceae	<i>Asteraceae sp1</i>				X	-
	<i>Asteraceae sp2</i>				-	X
Boraginaceae	<i>Cordia nodosa</i> Lam.	Tr	Ane	PI	X	X
Cecropiaceae	<i>Cecropia pachystachya</i> Trécul.	Tr	Zoo	PI	X	X
Chrysobalanaceae	<i>Hirtella racemosa</i> (Lam.) Willd. ex Roem. & Schult	Sh	Zoo	LS	X	X
	<i>Licania kunthiana</i> Hook.f.	Tr	Zoo	LS	-	X
Dilleniaceae	<i>Davilla nitida</i> (Vahl.) Kubitzki	Tr	Zoo	IS	X	X
Erythroxylaceae	<i>Erythroxylum citrifolium</i> A. St. - Hil.	Sh	Zoo	LS	X	X
Fabaceae	<i>Bauhinia outimouta</i> Aubl.	Li			-	X
	<i>Bauhinia sp.</i>				X	X
	<i>Crotalaria sp.</i>	Li			-	X
	<i>Dialium guianense</i> (Aubl.) Sandwith	Tr	Aut	LS	X	-
	<i>Albizia polycephala</i> (Benth.) Killip.	Tr	Aut	IS	X	X
	<i>Stryphnodendron pulcherrimum</i> (Willd.) Hochr.	Tr	Zoo	PI	-	X
	<i>Parkia pendula</i> (Willd.) Benth. ex Walper.	Tr	Zoo	LS	X	X
Lauraceae	<i>Inga fagifolia</i> (L.) Willd. Ex. Benth	Tr	Zoo	PI	X	X
	<i>Nectandra cuspidata</i> (Ness ex Mart.) Nees	Tr	Zoo	IS	X	-
Lecythidaceae	<i>Gustavia augusta</i> L.	Tr	Zoo	IS	X	X
Malpighiaceae	<i>Byrsonima sericea</i> DC.	Tr	Zoo	IS	-	X
	<i>Banisteriopsis sp.</i>	Li			-	X
Melastomataceae	<i>Miconia albicans</i> (SW) Triana	Sh	Zoo	PI	X	X
	<i>Miconia prasina</i> (Sw.) DC.	Tr	Zoo	PI	X	-
	<i>Miconia minutiflora</i> (Bonpl.) DC.	Tr	Zoo	IS	X	X
Monimiaceae	<i>Siparuna guianensis</i> A.DC.	Sh	Zoo	LS	-	X
Moraceae	<i>Brosimum guianense</i> (Aubl.) Huber	Tr	Zoo	IS	-	X
Myrtaceae	<i>Myrcia sylvatica</i> (G. Mey.) DC.	Tr	Zoo	LS	X	X
	<i>Syzygium jambolanum</i> (Lam.) DC.	Tr	Zoo	NC	X	X
Poaceae	<i>Olyra latifolia</i> L.	He	Ane	IS	X	-

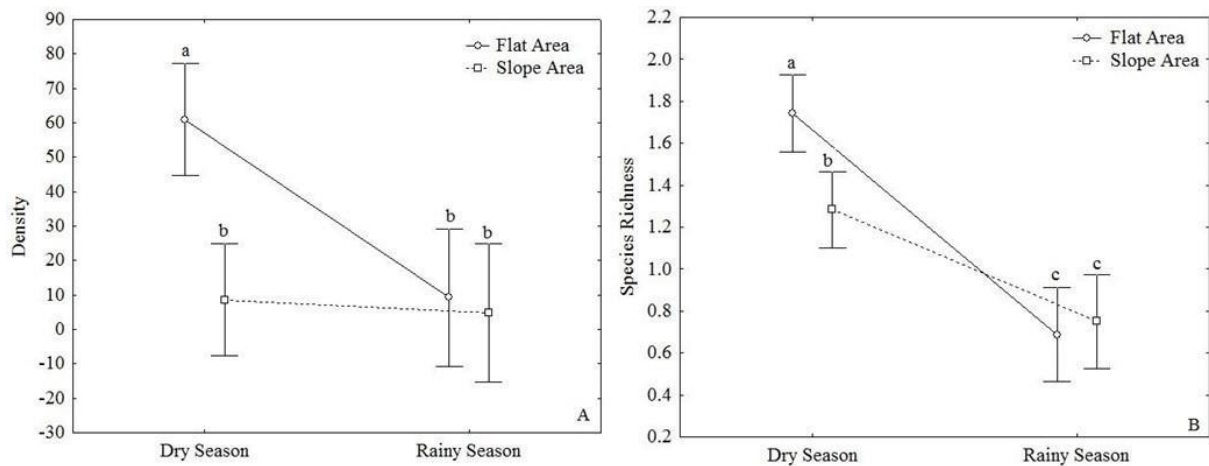
Table 1. Continuation

Family	Species	LF	DS	SC	F	S
Salicaceae	<i>Casearia commersoniana</i> Cambess	Tr	Zoo	LS	-	X
Sapindaceae	<i>Cupania racemosa</i> (Vell.) Radlk.	Tr	Zoo	IS	-	X
	<i>Serjania salzmanniana</i> Schledit	Li	Ane	PI	-	X
Rhamnaceae	<i>Gouania blanchetiana</i> Miq.	Li			-	X
Rubiaceae	<i>Psychotria barbiflora</i> DC.	Sh	Zoo	IS	-	X

Morphospecies 1	-	X
Morphospecies 2	X	X
Morphospecies 3	-	X
Morphospecies 4	-	-
Morphospecies 5	-	X
Morphospecies 6	-	X
Morphospecies 7	-	X
Morphospecies 8	X	-
Morphospecies 9	X	-

Source: Authors.

Figure 1. Variation in average values of seed density (A – seeds/0,25m²) and species richness (B – species/0,25m²) in two areas with different relief types during the rainy and dry seasons, in an Atlantic Forest fragment in Pernambuco, northeastern Brazil. Different letters indicate a significant difference detected by the Tukey HSD test at 5%. Vertical bars represent the 95% of confidence interval.

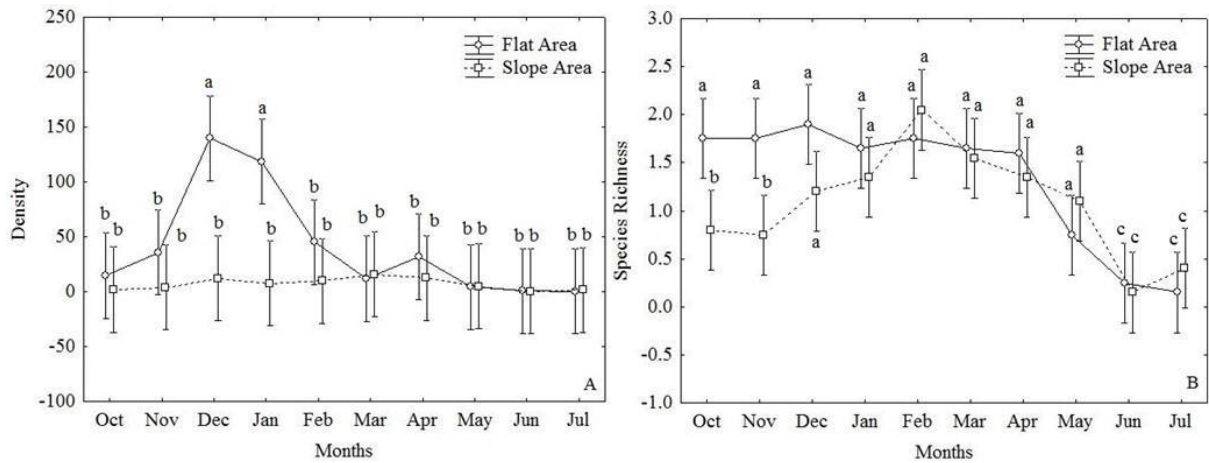


Source: Authors.

Monthly differences in density and species richness were also explained by the GLM. Seed density varied monthly in the flat area. The highest incidence of seeds in the flat area occurred in December and January (dry season) and the lowest in June and July (rainy season) (Figure 2A). Species richness varied significantly between months in both areas (Figure 2B). In the flat area, richness was higher in the dry season, with a drastic reduction in the rainy season. The same pattern was observed in the slope area, but this area had lower richness (Figure 2B).

The chi-squared test detected significant differences between dispersal syndromes in the flat ($\chi^2 = 21.429$; $df = 2$; $p = < 0.0001$) and slope areas ($\chi^2 = 37.556$; $df = 2$; $p = < 0.0001$); zoochory was the predominant syndrome in both areas. A similar result was observed for the life form category “tree”, which predominated both in the flat ($\chi^2 = 24.70$; $df = 2$; $p = < 0.0001$) and slope areas ($\chi^2 = 16.516$; $df = 2$; $p = 0.0003$) and differed significantly from other life form categories. There was no significant difference between the successional categories in both areas (Table 2).

Figure 2. Monthly variation in density (A – seeds/0,25m²) and species richness (B – species/0,25m²) in two areas with different relief types in an Atlantic Forest fragment in Pernambuco, northeastern Brazil. (Rain season – Mar, Apr, May, Jun and Jul; Dry season – Oct, Nov, Dec, Jan and Feb)



Source: Authors.

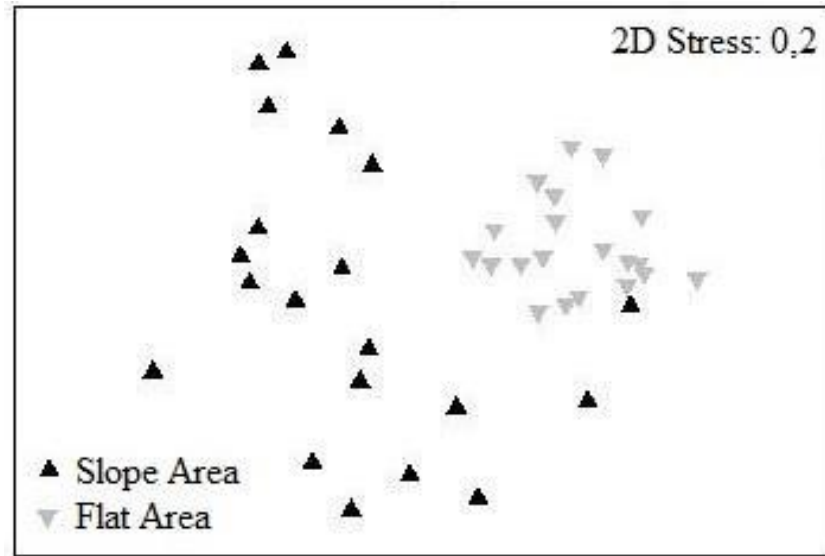
The ordination analysis detected a marked formation of two floristic groups (Figure 3): one composed of species present in the flat area and the other composed of species present in the slope area ($R_{\text{global}} = 0.53$ and $p = 0.001$). The floristic composition of the seed rain differed between seasons in both areas ($R_{\text{global}} = 0.18$ and $p = 0.001$), especially in the dry season (Figure 4).

Table 2. Number of species (or morphospecies) for successional category, dispersal syndrome and life form of the seed rain in two areas with different relief types in an Atlantic Forest fragment in Pernambuco, northeastern Brazil. Different letters indicate statistical differences detected by the chi-squared test.

Variables	Flat Area	Slope Area
Successional Category		
Pioneer	7 ^a	8 ^a
Initial Secondary	8 ^a	11 ^a
Late Secondary	5 ^a	7 ^a
Dispersal Syndrome		
Zoochorous	17 ^a	24 ^a
Anemochorous	2 ^b	2 ^b
Autochorous	2 ^b	1 ^b
Life Form		
Tree	17 ^a	21 ^a
Shrub	3 ^b	5 ^b
Liana	0 ^b	5 ^b

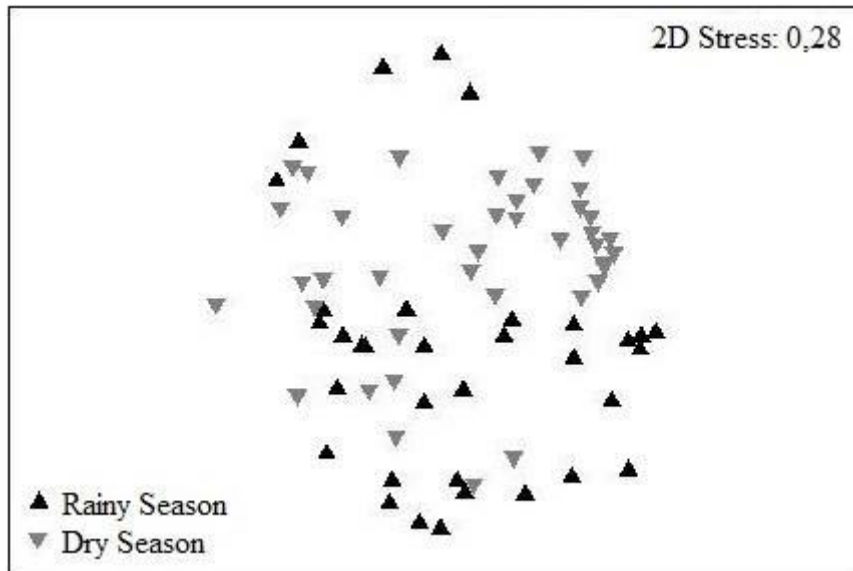
Source: Authors.

Figure 3. Ordination made by a multidimensional scaling analysis (MDS) of seed rain species in two areas with different relief types in an Atlantic Forest fragment in Pernambuco, northeastern Brazil, based on species richness. The symbols in the figure represent the collectors of the seed rain.



Source: Authors.

Figure 4. Ordination made by the multidimensional scaling analysis (MDS) of seed rain species in an Atlantic Forest fragment in Pernambuco, Brazil, in the rainy and dry seasons, based on species richness. The symbols in the figure represent the collectors of the seed rain.



Source: Authors.

4. Discussion

Studies on seed rain in tropical rainforests evidence the huge variation in the total number of seeds (12 to 1,670 seed/m²) that are annually dispersed inside forest fragments (Du, et al., 2009, Hardesty & Parker, 2002, Sheldon & Nadkarni, 2013, Gratzner, et al., 2022). The seed density found in the present study is within the range recorded for the Atlantic Forest of northeastern Brazil, which varies from 442 to 2,603 seed/m² (Grombone-Guaratini & Rodrigues, 2002, Martini & Santos,

2007, Campos, et al., 2009, Knorr & Gottsberger, 2012) and other tropical rainforests (Gratzer, et al., 2022). The variation in the total number of seeds in these studies probably results from differences in vegetation, successional stages of the fragments, sampling methods, and time of seed rain sampling.

We observed that the seed rain varies also at the fragment scale, as in our study seed density was higher in the flat area than in the slope area. This difference is probably related to the heterogeneous relief within the forest fragment (César, et al., 2020, Plohák, et al., 2021). A slope relief may negatively influence the seed rain, whereas a flat relief may have a positive influence, as wind increases dispersal and propagules are carried downhill. Marimon, et al. (2010) stated that a high declivity in the higher part of a forest probably results in seed loss during the rainy season and that factors, such as topographic gradient and groundwater level in the soil, have a direct influence on species establishment and immigration.

Lagos and Marimon (2012) studied seed rain in a riparian forest, in the state of Mato Grosso, Brazil, with different relief types and observed that the largest number of seeds was recorded in the forest interior, where fertility was higher. Their results corroborate the hypothesis that the density of the seed rain in forests varies with environmental, temporal, and spatial heterogeneity (César, et al., 2020, Plohák, et al., 2021 Gratzer, et al., 2022). Hence, to understand the seed rain dynamics of forest fragments it is important to sample different habitats present within forest fragments.

We observed in the flat area a strong influence of seasonality on seed density and species richness, with higher diversity in the dry season. We already expected a higher amount of seeds in the dry season, because studies carried out in rainforests in general suggest that the peak of seed deposition occurs between the late dry season and the early or middle rainy season (Vieira & Gandolfi, 2006, Du, et al., 2009, Sheldon & Nadkarni, 2013, Jara-Guerrero, et al., 2020). It is not a good strategy for plants to invest in flowers and fruits during the rainy season in tropical forests, as the rain may cause flowers, fruits, and seeds to fall, and, therefore, pollination, fecundation, and gene flow may be compromised. We recorded a higher incidence of seeds in the dry season for the trees and zoochorous species *Xylopia frutescens* and *Tapirira guianensis*, which are usually found in the vegetation of the flat area.

An effect of seasonality on the seed rain was already recorded for tropical rainforests (Grombone-Guaratini & Rodrigues, 2002, Hardesty & Parker, 2002, Vieira & Gandolfi, 2006, Dosch, et al., 2007). However, seasonal density variation may not occur throughout the fragment. In the studied slope area, density did not vary as a result of seasonality, contrary to species richness in seed rain, which varied significantly in time (dry vs. rainy season) and space (flat vs. slope area).

Habitat heterogeneity in the fragment did not affect the predominant dispersal syndrome: zoochory predominated in both areas with values close to or higher than 80%. Anemochorous and autochorous syndromes were better represented in the flat area. The inclination of the slope area seems to correspond to an increase in the density of anemochorous and autochorous seeds in the flat area, as these seeds are more easily carried by the wind from the upper to the lower area of the forest.

A similar pattern of zoochory predominance was found for small and large tropical rainforest fragments, where the percentage of zoochorous seeds is around 80.66%. The predominance of zoochorous species in the tropical rainforest evidences the high importance of animals in this environment, as they are responsible for propagule movements (Hardesty & Parker, 2002, Dosch, et al., 2007, Knorr & Gottsberger, 2012, Sheldon & Nadkarni, 2013). The maintenance of animals is essential for the dynamics of forest fragments, especially because the loss of frugivores compromises the entire dynamics of plants (Jara-Guerrero, et al., 2020, Werden, et al., 2021, Benítez-Malvido, et al., 2022).

The dominant life form in the seed rain in both areas was tree, similarly as recorded by Guevara and Laborde (1993) and Dosch, et al. (2007). The pattern of a smaller number of herb seeds recorded in their studies was also observed in both areas. The low percentage of herbs in their studies probably occurred due to the shapes and heights of collectors and the dispersal form of the seeds. In tropical rainforest the herbaceous density decreases with increasing shading. Consequently, decreases the herbaceous seed production of local vegetation. In addition, the height of the collectors can reduce the chances of

the herbaceous seeds be found. Although the collectors used in the present study were set up at 30 cm above ground, the percentage of herb species in the fragment (2.9%) was in general lower than in other tropical rainforest fragments.

The relief heterogeneity observed in the studied fragment resulted in differences in floristic composition between the flat and slope areas. In the tropical rainforests there is a marked change in the species composition of the seed rain between lowlands and hilltops (Martins, et al., 2003). They associated this difference in tree composition with variations in chemical fertility, acidity, and soil texture along the topographic gradient.

5. Conclusion

We verified that the floristic-structural composition of the seed rain in the flat area is different from the sloping area. In both areas, the set of species present during the rainy season is different from the set of species present in the dry season. Species richness and seed density are higher in the flat area and during the dry season. Most of the seeds are from arboreal species and with zoochoric dispersion syndrome. Hence, the larger plant cover in the flat area compared to the slope area, expressed as differences in vertical strata, light conditions, height, and diversity, may have contributed to a richer and denser seed rain in the flat area. Future studies are needed to test this hypothesis.

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