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Original Paper

Influence of palm trees on the richness and distribution of plant species on the *murundus* at a Caatinga/Cerrado ecotone

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Abstract

Understand the role of the drivers in vegetation pattern is essential in ecology since diversity plays a major role in the stability and maintenance of plant communities. The *murundus* are small and scattered earthmounds with a differentiated flora of its surrounding. In our study site (Campo Maior, Piauí, Northeastern Brazil), we classified them in three categories: presence of carnaúba (PC), presence of tucum (PT), and with the absence of palm trees (AP). Here, our goals were (1) to explore alpha diversity using the richness estimator and abundance distribution rank, expecting that palm trees could influence the richness of plant species on *murundus*; (2) analyzing the species richness-area relationship in the *murundus*, following the assumptions that the largest one holds more species; (3) find the changes in the species composition (beta diversity) between the three categories of *murundus*, assuming which the presence of palm trees influence the species composition; and (4) investigate if the distance between *murundus* is a decisive factor in the species composition, where the closest *murundus* are the most similar in species composition. Ours results showed that palms trees do not influence the richness of the *murundus*, the largest *murundus* are the richest ones, and the turnover predominantly determines beta diversity in the different *murundus* categories. Furthermore, the distance between the *murundus* did not determine its floristic similarity. Overall, we demonstrated which the species of palm trees are not the main drive of the plant assemblage in the *murundus*, however its size comprises a major factor in the richness, with great species substitution, which explains the high plant diversity.

Key words: biogeography, dispersion, earthmounds, floristic, phytosociology.

Resumo

Compreender o papel dos condutores nos padrões de diversidade é essencial na ecologia, uma vez que a diversidade desempenha um papel importante na estabilidade e manutenção das comunidades de plantas. Os murundus são montes de terra pequenos e dispersos com uma flora diferenciada em seu entorno. Em nosso local de estudo (Campo Maior, Piauí, Nordeste do Brasil), os classificamos nas categorias: presença de carnaúba (PC), presença de tucum (PT) e ausência de palmeiras (AP). Aqui, nossos objetivos foram (1) explorar a diversidade alfa usando o estimador de riqueza e a classificação de distribuição de abundância, uma vez que esperávamos que as palmeiras pudessem influenciar a riqueza de espécies de plantas em murundus; (2) explorar as relações de espécies-área no murundus, partindo do pressuposto de que o maior contém mais espécies; (3) encontrar as mudanças na composição de espécies (diversidade beta) entre as três categorias de

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murundus, supondo que a presença de palmeiras influencia na composição de espécies; e (4) investigar se a distância entre os murundus é um fator decisivo na composição das espécies, onde os murundus mais próximos são os mais semelhantes na composição das espécies. Nossos resultados demonstraram que as palmeiras não influenciam a riqueza dos murundus, os maiores murundus são os mais ricos, e o turnover determina predominantemente a diversidade beta nas diferentes categorias de murundus. Além disso, a distância entre os murundus não determinou sua similaridade florística. De maneira geral, demonstramos que as espécies de palmeiras não são o principal impulsionador da assembleia de plantas nos murundus, porém seu tamanho constitui um fator preponderante na riqueza, com grande substituição de espécies, o que explica a elevada diversidade vegetal.

Palavras-chave: biogeografia, dispersão, murundus, florística, fitossociologia.

Introduction

The species-area relationship is well known for describing scale dependence on diversity components when measured by species richness (MacArthur & Wilson 1967; Zhang *et al*. 2015). In this context, the organization of species diversity across a region can be characterized by alpha, beta, and gamma diversity (Whittaker 1972; Magurran 2004). Alpha diversity constitutes the total number of species in one location, while beta diversity represents the change in species composition along an environmental gradient, and gamma diversity is defined as the total number of species observed in a region (Whittaker 1972; Nogueira *et al*. 2008; Baselga & Orme 2012; Zhang *et al*. 2015; Thukral 2017). Understanding the role of drivers in diversity patterns is a fundamental issue in ecology, since diversity plays a major role in the stability and maintenance of communities (Piroozi *et al*. 2018; Willis 2019). Thus, understanding the patterns of species distribution is useful in determining conservation strategies and policies (Budka *et al*. 2019; Li *et al*. 2019).

Alpha diversity is measured at the local level and is the most widely used component in community characterization, using indices based on species richness and equity of abundance (Gotelli & Colwell 2011; Magurran 2004; Willis 2019). On the other hand, beta diversity can be explained by two spatial components: turnover and nesting. Turnover implies the substitution of species between sites, while nesting occurs when sites with a smaller number of species represent a subset of species from species-rich sites (Baselga 2010). Thus, even at very fine scales, beta diversity increases rapidly with spatial growth due to the high variation in stochastic species distribution patterns between sampling units, which is a species response to habitat heterogeneity (Barton *et al*. 2013). Understanding, separating, and quantifying these two components of beta diversity can be useful in revealing ecological processes responsible for patterns, as well as planning conservation strategies (Koleff *et al.* 2003; Baselga 2010).

Measuring the alpha and beta diversity components summarizes species diversity and allows for a better understanding of the processes that lead to species distribution patterns (Scofield *et al.* 2012; Baselga 2010). This approach has been used to infer the processes of species coexistence and helps interpret patterns of divergence and convergence in community composition and structure (Baselga 2010). Differentiating the turnover and nesting components of beta diversity is crucial to improving our understanding of ecological and conservation issues (Baselga 2010).

Therefore, analysis of beta diversity patterns and positive interactions between species are important in the formation of species composition, as well as the diversity and dynamics of the plant community (Callaway & Walker1997; Stachowicz 2012), which enables the identification of processes involved in diversity patterns and species richness. In a transition zone between Cerrado and Caatinga in the state of Piauí, there is the *murundus* phytophysiognomy (earthmounds), which is characterized by the presence of microreliefs occupied by tree and shrub vegetation that are distributed along flood lands or swamps, acting as environmental filters (Marimon *et al.* 2015), with an herbaceous layer and some isolated woody trees, locally called *capões* (Farias & Castro 2004). These *capões* are phytophysiognomies similar to those found in the midwestern Cerrado and Pantanal, where they are called *campos de murundus* (earthmound fields) and whose many aspects have already been studied including the formation of microreliefs (Oliveira-Filho 1992; Silva *et al*. 2010), the floristic composition (Ponce & Cunha 1993; Marimon *et al*. 2012) and the species-area or volume relationships (Oliveira-Filho 1992; Resende *et al*. 2004; Marimon *et al.* 2012; Morais *et al*. 2014). However, the colonization process and the changes in species composition of these earthmounds still remains unclear.

In the state of Piauí, the ocurrence of murundus is common together with the presence of two species of Arecaceae, *Copernicia prunifera* (Mill.) H.E.Moore (carnaúba) and *Astrocaryum vulgare* Mart. (tucum). Some studies have demonstrated the importance of Arecaceae in structuring communities since they can influence the formation of a seed bank, nucleations (Pott & Pott 2002), seed rain and attract dispersers (Andreazzi *et al*. 2009; Torquarto 2015). Thus, we expected that *C. prunifera* and *A. vulgare* can act as natural perches and as nucleators (Santos & Pillar 2007; Dias *et al.* 2014; Reis *et al*. 2014). They can also facilitate ecological processes that encourage significant changes in resource conditions close to its stipe, promoting the abundance and richness of plant species (Montesinos 2015; Michalet & Pugnaire 2016). It is possible that in the *murundus* of the Campo Maior Vegetation Complex, the distribution and richness of tree species are more influenced by palm species than by the geographical distance between *murundus*. Thus, the beta diversity approach can help in understanding the patterns of diversity on a spatial scale (Gaston 2000; Leibold *et al.* 2004; Cottenie 2005), allowing to verify whether differences in species composition between *murundus* (beta diversity) is explained by nesting or turnover.

Therefore, we conducted a survey of tree and shrub vegetation in *murundus* with the presence of carnaúba (PC), presence of tucum (PT), and with the absence of palm trees (AP). First, we investigated the alpha diversity (species richness) using a richness estimator and abundance distribution rank, aiming to explore if palm trees can influence the richness species on *murundus.* Second, we expect an increase in species richness with an increase in the area of *murundus*, following the well-known assumptions of the species-area relationship. Third, we hope to find divergence in species composition between the three categories of *murundus*, analyzing if the presence of palm trees could influence species composition. And, finally, if the distance between *murundus* is a decisive factor for species composition, where *murundus* that are closer have a similar composition. For this is expected that turnover is a predominant factor in determining beta diversity.

Material and Methods

Study area

The present study was carried out at Fazenda Pequizeiro (04°51'10"S and 42°12'07"W), in the municipality of Campo Maior, state of Piauí, Northeast Brazil. The studied *murundus* are located in the legal reserve area of the property a natural (Brasil 1965). According with local residents, the studied *murundus* have not been deforested in the past and have little evidence of fire, also the area is fenced to prevent entry of cattle, goats and horses.

The regional vegetation is characterized by a park and *cerrado* field with predominantly herbaceous vegetation, a phytophysiognomy similar to savannahs and a strong presence of *carnaubais* (stand of carnaúba trees) (Velloso *et al*. 2002; Sousa *et al*. 2009). It is located at 200 meters of altitude with an Aw climate (wet and dry tropical) (Kottek *et al*. 2006). The average temperature is 26.8 °C and the average annual rainfall is 1,360 mm, with well-defined seasonality between the months of June to November. The soil is red-yellow podzolic latosol associated with quartz (CEPRO 2000).

Data collection

We surveyed the trees and shrubs of 42 *murundus*, 15 with the presence of *Copernicia prunifera*, 12 with the presence of *Astrocaryum vulgare*, and 15 where both were absent. Geographic locations (UTM) of the *murundus* was obtained using GPS in order to make an Euclidean distance matrix. The length, width, and height of all trees and shrubs were sampled in each *murundu*. We used a tape measure to measure the length and width, where length was considered the largest extension of the *murundu*. The values of length, width, and height were used to define the area and volume of the *murundus*. In order to calculate the area (m^2) we used the equation: area = $(\pi/4) \times (\text{length} \times \text{width})$ (Oliveira-Filho 1992).

We sampled living individuals from the entire *murundu* with a PGH (Perimeter to Ground Height) > 10 cm to obtain the number of individuals and species for the tree and shrub community. Collection and herborization were conducted according to Fidalgo & Bononi (1984). Identification was carried out through consultation with specialized bibliographies and comparison with exsiccates from the TEPB Herbarium of the Universidade Federal do Piauí. The taxon distribution was conducted according to APG IV

(2016), and synonyms were verified in the Flora do Brasil 2020 (continuously updated).

Data analysis

In order to compare the species richness among the three *murundus* categories (PC, PT and AP), sample-size-based rarefaction and extrapolation species accumulation curves (Gotelli & Colwell 2011) were constructed using the iNEXTfunction in the package iNEXT (Hsieh *et al*. 2016) and Hill numbers for interpolation and extrapolation (Chao *et al*. 2014).

Rank-abundance curves were made for the three categories of *murundus* (PC, PT and AP). In the graphical representation, the rankings of species' abundances are presented along the horizontal axis in decreasing order of relative abundance, which facilitates community comparisons. The abundance rank is commonly used to infer which species abundance model best describes the community (Magurran 2004; Gotelli & Ellison 2011). Chi-square tests were used with the relative species abundance values to verify the best hypothetical model for the distribution of species abundances for each category of *murundus*. We selected four abundance distribution models (Log-series, geometric, Broken-stick, and Log-Normal) (Magurran 2004).

The influence of the *murundus*' area on species richness and number of individuals from the tree and shrub community were assessed using linear regressions (Gotelli & Ellison 2011). A Mantel test was used to assess the effect of distance between *murundus* on species composition, and the significance was tested with a Monte Carlo test using 999 permutations (Legendre & Legendre 2012). The Mantel test assesses the correlation between two distance matrices, in this case a spatial distance matrix (Euclidean distance) and a floristic distance (Jaccard index) (Eisenlohr *et al*. 2015).

To assess whether species composition changes among the three categories of *murundus*, a PERMANOVA with 999 permutations was used (MacArdle & Anderson 2001). The comparison in species composition among the category of *murundus* was performed using the "pairwise.perm.amanova" function of the package "RVAideMemoire". A Non-Parametric Multidimensional Scaling (NMDS) ordination was used to reduce the dimensionality of the data and gave a visual representation of the compared groups using PERMANOVA. We used a species presence and absence matrix, which was then used to calculate a distance matrix using the Jaccard index.

To check if the difference in species composition between *murundus* (beta diversity) is explained by nesting or turnover, we used the "beta.multi" and "parwise" functions of the *betapart* package (Baselga & Orme 2012). The *beta.multi* function was used to calculate the values of the turnover and nesting components. The Sørensen index was used to obtain total dissimilarity. The *beta.pair* function calculates the same three dissimilarity metrics as the previous function. Instead of returning three unique values, as in the *beta.multi* function, *beta.pair* generates three dissimilarity matrices (total dissimilarity, turnover component, and nesting). The generated dissimilarity matrices can be used to construct a cluster, where the component that best explains beta diversity is selected (Baselga & Orme 2012; Maechler *et al*. 2005). All the analyzes were performed using R program (R Core Team 2020), and a value of $p < 0.05$ was used for all analyzes (Callegari-Jacques 2004).

Results

The species with the greatest abundance in the *murundus* were: *Combretum leprosum* Mart. (257ndividuals), *Mouriri elliptica* Mart. (195), *Curatella americana* L. (118), *Ocotea brachybotrya* (Meisn.) Mez. (115), *Mimosa caesalpiniifolia* Benth. (108), and *Agonandra brasiliensis* Miers *ex* Benth. & Hook. f. (88). Together, these species totaled 763 individuals (46.5%). For the three categories of *murundus*, we found that the six most abundant species added up to values greater than 50% of the community abundance (Tab. 1). For *murundus* with carnaúba, the six most abundant species totaled 330 individuals (61.57% of the relative abundance). For *murundus* with tucum, these six species totaled 371 individuals (58.99%). In *murundus* without palms, the six species constituted 308 individuals (64.84%). Species richness of *murundus* AP did not differ from m*urundus* PC and PT, since we verified overlapping confidence intervals, and the rarefaction curves showed asymptotes (Fig. 1).

A few abundant species were found for the three categories of *murundus*. The rank-abundance curves (Fig. 2) showed all categories of *murundus* presented the abundance curve adjusted to the Log Series model (PC: $X2 = 17.2$ and $p = 0.9445$; PR - $X2 = 17.31$ and $p = 0.8353$; AP - $X2 = 19.5$ and $p = 0.7725$).

For all categories of *murundus*, we found positive relationships (Fig. 3a-b) between area and

Table 1 – Families, species and number of individuals of tree-shrub species found in *murundus* with carnaúba (PC), with tucum (PT) and with the absence of Palms (AP), from the Vegetation Complex of Campo Maior, Piauí, Northeast Brazil. NT = total number of individuals; * = species with the greatest contribution to community abundance.

Family	Species	PC	PT	AP	NT
Anacardiacae	*Anacardium occidentale* L.	4	9	7	20
Anacardiacae	*Astronium fraxinifolium* Schott	1			1
Apocynaceae	*Aspidosperma cuspa* (Kunth) S.F.Blake		1	2	3
Arecaceae	*Astrocaryum vulgare* Mart.		42*		42
Arecaceae	*Bactris setosa* Mart.	9			9
Arecaceae	*Copernicia prunifera* (Mill.) H.E.Moore	58*	3		61
Bignoniaceae	*Handroanthus heptaphyllus* (Vell.) Mattos	1			1
Bignoniaceae	*Handroanthus serratifolius* (Vahl) S.Grose			2	2
Bignoniaceae	*Handroanthus vellosoi* (Toledo) Mattos	1			1
Bignoniaceae	*Jacaranda brasiliana* (Lam.) Pers.	2			2
Bignoniaceae	*Tabebuia aurea* (Silva Manso) Benth. & Hook.f. *ex* S.Moore	15	14	21	50
Bixaceae	*Cochlospermum regium* (Mart. *ex* Schrank) Pilg.	7	3	3	13
Combretaceae	*Combretum lanceolatum* Pohl *ex* Eichler	1			1
Combretaceae	*Combretum leprosum* Mart.	36*	102*	119*	257
Combretaceae	*Terminalia actinophylla* Mart.	6		1	7
Dilleniaceae	*Curatella americana* L.	49*	41*	28*	118
Euphorbiaceae	*Croton campestris* A.St.-Hil.	3	2	2	7
Fabaceae	*Amburana cearensis* (Allemão) A.C. Sm.	3	3	10	16
Fabaceae	*Andira cujabensis* Benth.	5	20	13	38
Fabaceae	*Bauhinia dubia* G. Don		15	3	18
Fabaceae	*Bauhinia ungulata* L.	2			2
Fabaceae	*Libidibia ferrea* Mart.	3		1	4
Fabaceae	*Hymenaea courbaril* L.		4	7	11
Fabaceae	*Luetzelburgia auriculata* (Allemão) Ducke.	16	34	14	64
Fabaceae	*Machaerium acutifolium* Vogel.	1			1
Fabaceae	*Mimosa caesalpiniifolia* Benth.	39*	52*	17	108
Fabaceae	*Mimosa arenosa* (Willd.) Poir.	8		2	10
Fabaceae	*Mimosa tenuiflora* (Willd.) Poir.	1			1
Fabaceae	*Mimosa* sp.1		2		2
Fabaceae	*Senna acuruensis* (Benth.) H.S. Irwin & Barneby.	7	11	51*	69
Fabaceae	*Tachigali aurea* Tul.			1	1
Lamiaceae	*Vitex cymosa* Bertero *ex* Spreng.		1	2	3
Lauraceae	*Ocotea brachybotrya* (Meisn.) Mez.	17	64*	34*	115
Malpighiaceae	*Byrsonima crassifolia* (L.) Kunth			1	1
Malvaceae	*Helicteres sacarolha* A.St.-Hil., Juss. & Cambess.		1		1
Malvaceae	*Sterculia striata* A. St.-Hil. & Naudin	3		3	6
Melastomataceae	*Mouriri elliptica* Mart.	114*	33	48*	195

Family	Species	PC	PT	AP	NT
Moraceae	*Ficus* sp.1		1		1
Myrtaceae	*Eugenia* sp.1				0
Myrtaceae	*Myrcia retorta* Cambess.	4	17	1	22
Myrtaceae	*Myrcia* sp.1	9	3	3	15
Myrtaceae	*Myrcia* sp.2	11		6	17
Ochnaceae	*Ouratea ceacearensis* (Tiegh.) Sastre	4	5	2	11
Olacaceae	*Ximenia americana* L.	5	5		10
Opiliaceae	*Agonandra brasiliensis* Miers *ex* Benth. &Hook.f.	3	70*	15	88
Proteaceae	*Roupala montana* Aubl.	1			1
Rubiaceae	*Alibertia edulis* (Rich.) A.Rich.	9	6	3	18
Rubiaceae	*Genipa americana* L.	1			1
Rubiaceae	*Randia armata* (Sw.) DC.	10	11	5	26
Rubiaceae	*Rudgea* sp.1	4			4
Rubiaceae	*Tocoyena formosa* (Cham. & Schltdl.) K. Schum.	18	4	3	25
Sapotaceae	*Pouteria ramiflora* (Mart.) Radlk.		9	1	10
Simaroubaceae	*Simarouba versicolor* A.St.-Hil..		2	1	3
Vochysiaceae	*Callisthene fasciculata* Mart.	34*	8	3	45
Vochysiaceae	*Chomelia obtusa* Cham. & Schltdl.	2	1	1	4
Vochysiaceae	*Qualea grandiflora* Mart.	4	9	28*	41
Vochysiaceae	*Qualea parviflora* Mart.	4	21	11	36

species richness (PC: $R^2 = 0.67$ and $p < 0.001$; PT $R^2 = 0.82$ and $p = 0.001$; AP $R^2 = 0.42$ and $p < 0.001$; Fig. 3a), and between area and number of individuals (PC R2 = 0.73 and $p = 0.01$; PT $R^2 = 0.87$ and $p < 0.001$; AP $R^2 = 0.85$ and $p = 0.008$; Fig. 3b).

The distance between *murundus* showed no influence on tree and shrub species composition (Mantel test; $r = 0.005$; $p = 0.44$). On the other

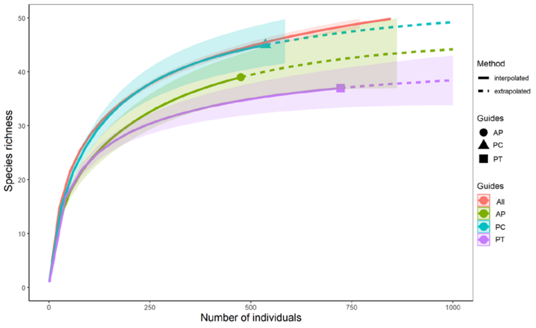

Figure 1 – Rarefaction curve for tree and shrub species in murundus with carnaúba (PC), with tucum (PT), and absence of palms (AP), from the Complexo Vegetacional de Campo Maior, Piauí, Northeast Brazil.

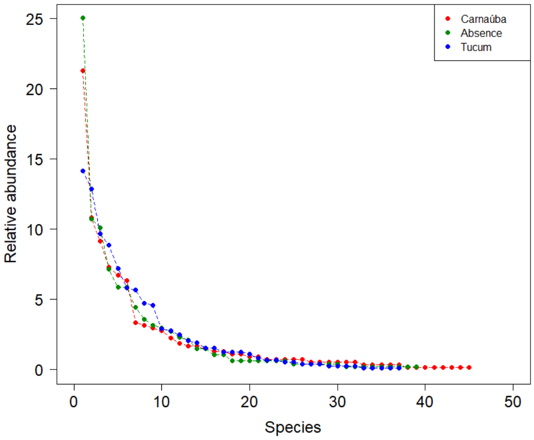

Figure 2 – Rank of relative abundances of tree and shrub species in murundus with carnaúba, tucum, and absence of palms, from the Complexo Vegetacional de Campo Maior, Piauí, Northeast Brazil.

hand, the PERMANOVA showed that there is a difference in composition between the three types of *murundus* studied (p = 0.001). All categories of *murundus* present differences in species composition as shown by the *a posteriori* test (p < 0.001), and therefore, are distinct communities. The NMDS ordination showed the separation of three groups (Fig. 4), the first group without palms, the second with tucum, and lastly, *murundus* with the presence of carnaúba (stress = 0.223). The beta diversity analysis showed that the change in species composition was mainly influenced by turnover (0.89 or 89%), and there was little influence from nesting (0.11 or 11%). Figure 5 corroborates the NMDS analysis, reinforcing the hypothesis that the three categories of *murundus* have different tree and shrub communities and contribute to the increase in regional richness.

Discussion

The similarities in species richness and differences in species composition between the three categories of *murundus* (with carnaúba, with tucum and absence of palms) shows the importance of palm trees in the distribution of species in *murundu*s. Palm trees can provide resources for fauna dispersers, reducing the dispersion limitations imposed by the swamps or flooded plains on *murundus*, thus, promoting species diversity.

The ranking of species' abundances shows that the increase in community richness in the three categories of *murundus* was influenced by the equity of species abundances (Margurran 2004). The log-series model verified in the three *murundus* categories demonstrates the prevalence of rare species with the presence of a few high abundance species (Magurran 2004; Gotelli & Colwell 2011; Soares *et al*. 2020), which shows the importance of rare species in increasing local richness (alpha diversity) (Magurran 2004). The log-series model is also considered a niche partition model, and assumes that species occur randomly in a fraction of the niche as colonization by new species occurs (Magurran 2004). In this model, the dispersion capacity, environmental characteristics, and interspecific interactions will jointly determine community composition (Ferreira & Petrere-Jr 2008).

Our results show that the observed and estimated richness were close among the *murundus* categories, negating our hypothesis that palm trees favor local richness. On the other hand, the positive relationships found between *murundus* area and species richness and abundance support the hypothesis raised in this study and corroborate the assumption of the island biogeography theory (MacArthur & Wilson 1967). Our results also corroborate other studies that found a positive relationship between species-area in *murundus* (Oliveira-Filho 1992; Morais *et al*. 2014), and

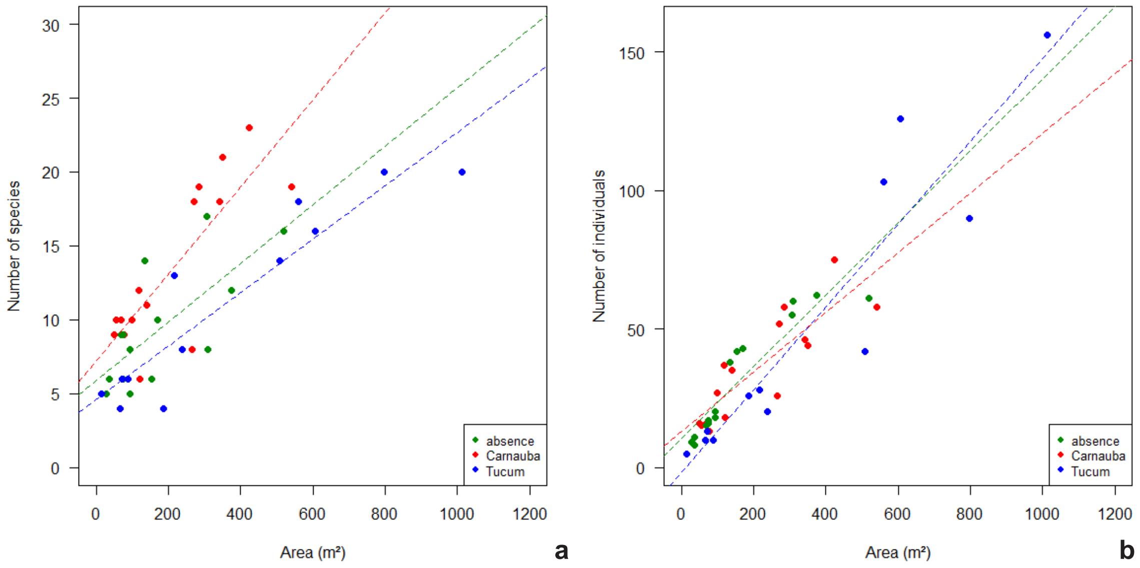

Figure 3 – Relationship between area with number of species and number of individuals in murundus with carnaúba, tucum and absence of palms, from the Complexo Vegetacional de Campo Maior, Piauí, Northeast Brazil.

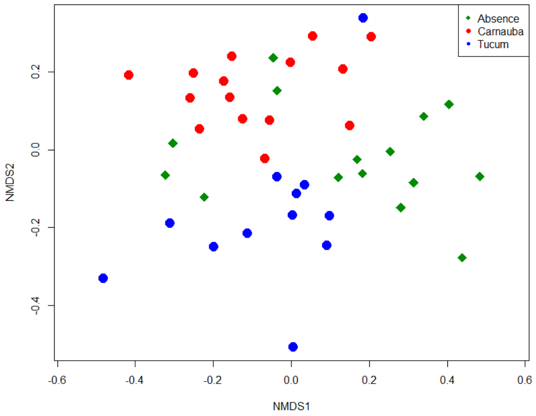

Figure 4 – Ordination (NMDS) of tree and shrub species from murundus with carnaúba, tucum and absence of palms, of the Complexo Vegetacional de Campo Maior, Piauí, Piauí, Northeast Brazil.

shows the importance of these microreliefs on local richness.

Our observations pointed that *murundus* with larger areas present more drained soils, allowing the occupation and establishment of woody vegetation, since water saturation during the rainy season is a limiting factor for the occupation of tree species (Furley 1986; Oliveira-Filho 1992). Studies conducted in *murundu* fields, showed that soil's water saturation can cause differences in species distribution, as some individuals cannot tolerate hydromorphic soils, and therefore, vegetation is restricted to *murundus* (Resende *et al*. 2004; Barros & Castro 2006). In this way, the great size (1,000 m^2) of the largest *murundus* and the well-drained soils also explain the high species richness in these ones.

On the other hand, we did not find a relationship between distance and species composition in *murundus*; thus, the hypothesis that the distance between *murundus* may determine species composition is negated. However, our hypothesis that *murundus* with palms have a different species composition than *murundus* without palms was confirmed. We believe that due to the distance between the *murundus*, species dispersed by the wind or by autochory are less successful in establishing themselves in *murundus*, and therefore, zoochory, is a more favorable type of dispersion mainly for those *murundus* that attract fauna.

Open areas, for example the *murundu* fields, have a low seed rain density due to low tree density, so the investment in dispersion strategies to attract fauna can guarantee seed dispersion to suitable places for germination (Fragoso *et al*. 2017), and the palms present in the *murundus* would be the attraction for dispersing fauna. Thus, from dispersion to the establishment of species, there are environmental filters that can eliminate many species and restrict occupation in certain habitats or reduce the community to a small number of species (Lambers *et al*. 2008), in our case, water is one of these environmental filters (Marinon *et al.* 2015).

Our study shows that changes in species composition among the three categories of *murundus* are influenced by turnover, confirming our hypothesis, that the presence of palms can influence the composition and distribution of species. The main findings of the present study were that different types of communities (PC, PT and AP)

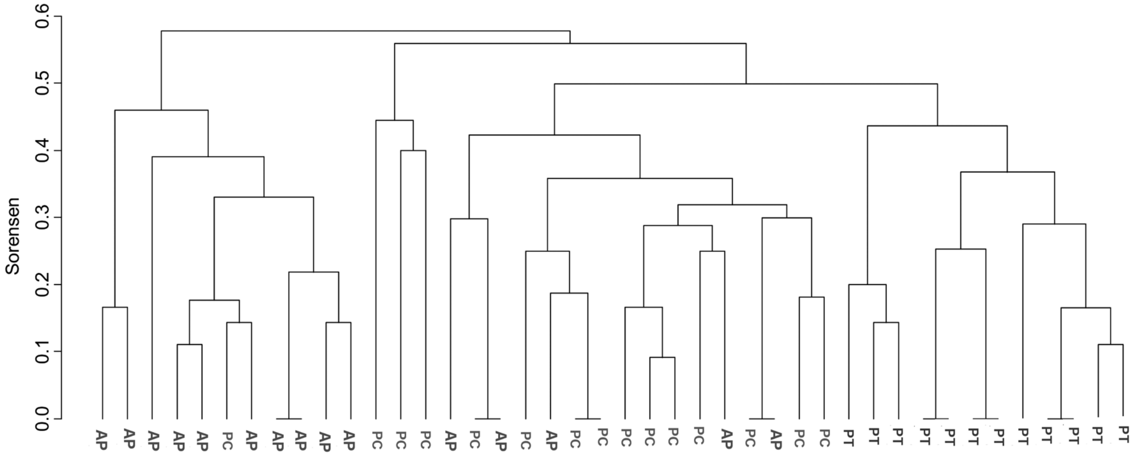

Figure 5 – Dendrogram generated using the turnover component dissimilarity matrix, for murundus with the absence of palms (AP), presence of carnaúba (PC), and presence of tucum (PT).

within the same phytophysiognomy have different species composition.

The dispersion can be a determining factor for differences in species composition between *murundus* with and without palm trees, since palm trees are attractive to dispersing fauna, and thus, influence the colonization of these *murundus* by increasing the entry of diaspores and seeds. We believe that carnaúba and tucum can, not only act as artificial perches, but also exercise the function of natural perches because they attract dispersers by offering fruits and seeds. Additionally, their height makes them more attractive to birds, thus being able to cause an increase in seed rain (Reis *et al*. 2014; Fragoso *et al*. 2017).

The architectural differences between the two palm species can attract different types of dispersers, by the differences in the species composition between *murundus* with the presence of palms. Carnaúba presents a solitary stem without spines, reaching up to 15 m in height. The leaves are numerous and in the shape of a fan, a globose crown, with curved spines on the margins of the petiole, and fruits between 1.8 to 2.17 cm in length (Lorenzi *et al*. 2010). tucum has agglomerated stems, with stipe up to 20 m high, internodes are covered with thorns, numerous leaves, long sheath, and petiole covered with thorns, the fruits are globose with 3.5 to 5 cm in length, and 2.5 to 2.7 cm in diameter (Lorenzi *et al* 2010). Also, the architectural features of the plant can influence the availability of landing areas and reflects animal contributions in the seed rain (Fragoso *et al*. 2017). As they works as live perches, tall individuals are considered more effective and attractive to dispersers (Reis *et al*. 2014). Live perches with fruits can act as a feed, and thus, intensify the visitation of dispersers, this can be seen in the study area where the soil was upturned by mammals and rodents that were foraging for fruits deposited by carnaúba and tucum in the soil around the studied palm trees, as also verified by Torquato (2015) and Andreazzi *et al.* (2009). Seeds and fruits deposited in the soil can also stimulate secondary dispersion by rodents or other mammals (Hamäläinen *et al*. 2017).

Finally, in this study we found that carnaúba and tucum do not influence the richness (alpha diversity) in *murundus*, and that the species richness in the three *murundus* categories is influenced by less abundant species. Our results corroborate the theories that address the positive species-area relationship; however, distance between *murundus* did not determine similarity. The difference in species composition between the three categories of *murundus* is determined by species substitution, which shows that the presence of the studied palms influences the dispersion and colonization process. Thus, the three categories are comprised of distinct communities, which explains the high plant diversity of this phytophysiognomy.

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