FUNCTIONAL STRUCTURE OF WOODY ARBOREAL-SHRUB PLANT COMMUNITIES AT DIFFERENT PRECIPITATION CONDITION IN THE CAATINGA, NORTHEASTERN BRAZIL

ESTRUTURA FUNCIONAL DE COMUNIDADES DE PLANTAS LENHOSAS ARBÓREAS-ARBUSTIVAS EM DIFERENTES CONDIÇÕES DE PRECIPITAÇÃO NA CAATINGA, NORDESTE DO BRASIL

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ABSTRACT

The regional pool of caatinga species is mainly affected by the precipitation gradient that modifies ecological strategies of plant assemblages and may help predict global climate change especially under seasonal extremes of precipitation and drought. This work evaluated the functional composition of communities in a precipitation gradient (environments with high, medium and low annual precipitation) in the Catimbau National Park, using three plots of 10 m x 20 m at each level. Sampling three individuals by morphospecies to measure attributes associated with resource saving strategies. Compare the community-weighted mean trait values (CWM) of each attribute between treatments by ANOVA. Leaf thickness was the only trait that differed between treatments, which can be attributed to phenology that changes temporal patterns of leaf senescence reflected in the strategies of perennial Caatinga species.

Keywords: Environmental Filters. Functional traits. Dry forest; Arboreal-shrub stratum

RESUMO

O *pool* regional de espécies da caatinga pode ser afetado principalmente pelo gradiente de precipitação que modifica estratégias ecológicas de assembleias de plantas, podendo auxiliar na previsão de mudanças climáticas globais sobretudo sob extremos sazonais de precipitação e seca. Neste trabalho avaliei a composição funcional de comunidades em um gradiente de precipitação (ambientes com alta, média e baixa precipitação anual) no Parque Nacional do Catimbau, utilizando três parcelas de 10 m x 20 m em cada nível. Eu registrei e generalizei todos os indivíduos com DAP> 3 cm, amostrando três indivíduos por morfoespécie para mensuração de atributos associados a estratégias de economia de recursos. Comparei a média ponderada (CWM) de cada atributo entre os tratamentos por meio de uma ANOVA. A espessura foliar foi o único atributo que diferiu entre os tratamentos, o que pode ser atribuído à fenologia que altera padrões temporais de senescência foliar refletidos nas estratégias de espécies perenifólias da Caatinga.

Palavras-chaves: Filtros ambientais. Atributos funcionais. Floresta seca; Estrato arbóreo-arbustivo

Community structuring is associated with abiotic factors (i.e., edaphic factors, light availability and precipitation) and biotic (i.e., competition, predation) defined as "environmental filters", which act in a dynamic equilibrium in the maintenance of the species under different aspects of the occupied niche. The relationship between the environment characteristics and the species adaptation, results in a set of interactions that individuals seek to satisfy in order to meet conflicting demands (*trade-offs*) intended for their development, survival or reproduction (KNEITEL; CHASE, 2004). However, co-occurrence limits these convergences through limiting similarity, in which characteristics diverge so that different niche spaces are shared by different species (CORNWELL; SCHWILK; ACKERLY, 2006). Plants adapted to the desert, for example, seek to reduce desiccation by promoting water balance between their vegetative structures. This can occur from the reduction of your leaf area, closure of the stomata or cuticular thickening to adapt the evapotranspiration to the consequent water loss (TAIZ; ZEIGER, 2004). Other characteristics, such as the plant phenological cycle, may undergo temporal modification as a result of severe seasons of prolonged droughts (BORCHERT, 1994). The attributes selection is associated to the investigation of phenotypic characteristics that clarify the relation of such attributes to patterns of niche occupation or ecosystem functioning, verifying how species respond to the peculiarities of the environment or how such attributes relate to ecosystem properties (DÍAZ et al., 2013). Response attributes can help in the identification of adaptive strategies favorable to the establishment and development of species in restrictive environments and may result in the convergence of conservative features when they are submitted to environmental filters or to divergence of acquisitive traits when they are submitted to competition for co-occurrence (DÍAZ et al., 2013; PÉREZ-HARGUINDEGUY et al., 2013). An example of the response attribute is the specific leaf area (SLA) which is associated with plant saving strategies. The growth rate and consequent survival can respond directly to extreme desiccation conditions and lead to the reduction of the SLA in order to avoid excessive water loss by evapotranspiration (GARNIER; SHIPLEY, 2001). Other phenotypic characteristics, such as presence of reflective foliar trichomes, foliar waxes, foliar winding besides small and divided leaves, are part of the adaptations that plants from dry environments develop to reduce water loss (TAIZ; ZEIGER, 2004).

Seasonally dry tropical forests are environments prone to the study of community processes, since they have explicit environmental gradients (LEBRIJA-TREJOS et al., 2010). Thus, the aim of this study was to investigate how the functional composition of woody plant assemblage varies along a precipitation gradient in the Caatinga, investigating response attributes that explain resource saving strategies. The hyphotesis I tested is that it would had an increase of the specific leaf area, reduction of leaf thickness and reduction of wood density in treatments with higher precipitation intensity.

This study was developed in the Catimbau National Park (8°32’ to 8°35’S and 37°14’ to 37°15’02’’W), between the municipalities of Tupanatinga, Buíque and Ibimirim, in the State of

Pernambuco. The park presents different vegetation types with forest physiognomies of the type savannah-steep with predominance of trees and deciduous thorny shrubs; and soils of the type planossolos haplico eutrophic to the east and neosols quartzipsamments ortic to the west (IBGE, 2012; RIZZINI, 1997). The predominant climate is the semi-arid of the type Bsh, with transition to rainy tropical type As (Köppen). Precipitation ranges from 650 mm to 1100 mm per year and it vary at different locations within the park, in function of the altitude variation, promoting an ideal scenario for studies on with precipitation treatments (AB’SABER, 1974).

From the permanent plots of the LETP with standardized 50 m x 20 m, I selected three plots that represented different precipitation treatments: high (913 mm, 8°30'59.88"S and 37°14'41.80"W), intermediate (843 mm, 8°33'14.90"S and 37°15'24.40"W) and low (555 mm, 8° 29'7.36"S and 37°19'19.94"W) precipitation environment. In each plot I selected three subplot of 10 m x 20 m, in each subplot I collected individuals that were identifield by morfospecies using taxonomic keys/with help of specialists and I selected more than three individuals above 3cm in diameter at soil height (DSH).

I have selected attributes that are easy to measure but that respond well to variations in resource availability. The SLA ($mm^2.mg$-1) consists of the fresh leaf area divided by its dry mass and it is an attribute that represents conflicting demand (*trade-off*) between water loss and light absorption, being part of characteristics set associated to the economic leaf spectrum (WRIGHT et al., 2004); Stem-specific density (SSD, expressed in $mg.m^{-3}$), consists of the dry mass of the main plant branch divided by its fresh volume, reflects a trade-off between hydraulic conductivity and cavitation tolerance in dry soils; and the Leaf thickness (L_{th}, mm) represented by the direct measurement of the thickness of a leaf median portion, is associated with reduction strategies of water loss with cuticular increase (DÍAZ et al., 2013; PÉREZ-HARGUINDEGUY et al., 2013), in which thin leaves may represent a response to low light availability, while its opposite is associated with lower water availability (HODGSON et al., 2011).

In each plant individual, I selected three branches with good integrity, keeping them in plastic bags, with cotton moistened at the ends. In the laboratory I selected three leaves of each branch and a branch section approximately 7 cm in length, keeping them humid with paper towel at low temperature for 24 hours to obtain turgid masses. The leaves were digitalized and had their area measured using the program Image J (ABRÀMOFFF; MAGALHÃES; RAM, 2004), as well as their turgid and dry mass measured using a digital scale. The branches sections had their volume measured in analytical balance with the aid of a container with a known water volume in order to measure the mass of the displaced water (PÉREZ-HARGUINDEGUY et al., 2013). Then the samples were dried in an oven at 70 °C to obtain the dry mass.

To analyze the functional composition of each attribute in each community I used the community-weighted mean trait values (CWM). To verify the existence of significant differences ($p < 0.05$) among the values of the attributes in each treatment (i.e., low, intermediate and high precipitation) I applied the analysis of variance (ANOVA) and the Tukey's test a posteriori when it was necessary, from the confirmation of the assumptions of normality and homoscedasticity. The statistical analyses were performed using R program (TEAM, 2014).

I sampled 187 individuals and 25 species in the inventory areas, being 4 species in the low, 8 in the intermediate and 12 in the high precipitation environment.

The hypothesis that there would be higher SLA and lower SSD in treatments with higher precipitation intensity was not corroborated, since the chance of explaining the observed variation was high (ANOVA: $F_{2.7} = 2.284$, p = 0.183, F2.7 = 1.489, P = 0.298, respectively). However, Lth presented a significant difference, since the probability of chance explaining the variation observed was very low (F2,7 = 14,149, p = 0.005, figure 1). On average, the Lth values between treatments with intermediate and high precipitation did not present a significant difference (Tukey-p = 0.72), differently from low to intermediate (Tukey- p = 0.006) and low and high (Tukey-p = 0.01). However, its variation was contrary to what was expected and to what was found by Menezes

(2014). Despite the necessary care in relation to the pseudoreplicated samples, the fact that leaf thickness is being attributed to environments with low precipitation may be reflecting the variation of other attributes in different contexts. It can be perceived by the fact that leaf thickness is highly variable in environments subjected to extreme precipitation oscillations, functioning as an alternative strategy to the deciduous species phenology, for example. In fact, phenology is strongly influenced by soil water availability (BORCHERT, 1994). In this way, perennial plants may present greater leaf thickness to persist for longer in more rainy environments, while drier environments may have deciduous species with less thick leaves (BORCHERT, 1994).

There was no difference in the mean values of SSD and SLA between precipitation environments. This result may be associated with other strategies of desiccation resistance did not analyze in this study, such as mechanical strategies of delay and tolerance to desiccation, mechanisms of escape of drought and deepening of the roots (TAIZ; ZEIGER, 2004). For example, Borchert (1994) found that water storage in the trunk varies according to the rainy season, and this can be variable throughout the year.

The evaluation of the functional composition of communities submitted to extreme water stress regimes can help to the identification of the characteristics favorable to the persistence of the assembly subject to climate change. It becomes increasingly important in seasonally dry tropical forests, in which the desertification process associated with land use, can lead to the loss of resilience of these systems, as well as, to the reduction of functional diversity (BHASKAR; DAWSON; BALVANERA, 2014).

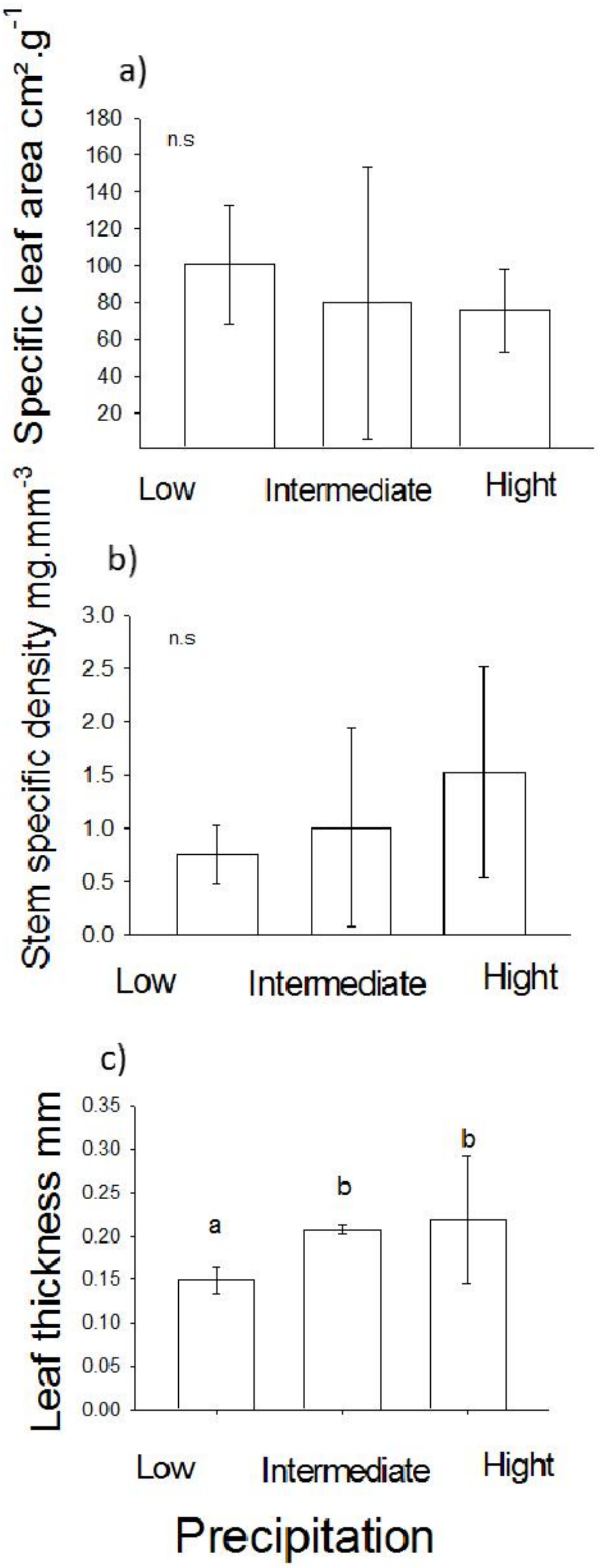

Figure 1. Mean values of attributes: a) specific leaf area (n.s. = no significant differences); B) specific stem density (n.s. = no significant differences); C) leaf thickness (distinct letters indicate significant difference), evaluated in the communities in the different precipitation conditions. n.s = not significant.

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