SPECIES ABUNDANCE DISTRIBUTION INDICATES NICHE PARTITIONING IN FERN'S COMMUNITY

DISTRIBUIÇÃO DA ABUNDÂCIA DAS ESPÉCIES INDICA PARTIÇÃO DE NICHO NA COMUNIDADE DE SAMAMBAIAS

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ABSTRACT

This study aimed to analyze species abundance distribution (SAD) of the fern's community at local scale in an Atlantic Forest remnant (470 ha), northeastern Brazil. We delimited 10 plots (10 x 20 m) along the forest remnant. The observed SAD was fitted to theoretical models: lognormal, logarithmic series, broken-stick and geometric series. The floristic relation between plots was analyzed using detrended correspondence analysis (DCA). The community was significantly fitted to geometric series distribution and showed a high local floristic heterogeneity. These results indicate that the studied community have low niche overlap, structured by niche partitioning. The observed pattern seems to be associated with the local distribution of the community (i.e. associated with microhabitats) and with the low ferns richness in the studied remnant.

Keywords: Atlantic Forest. Floristic heterogeneity. Geometric series. Local scale. Rank-abundance plots.

RESUMO

Este estudo teve como objetivo avaliar a distribuição de abundância de espécies da comunidade de samambaias em escala local em um remanescente de Floresta Atlântica (470 ha) no Nordeste do

Brasil. Foram demarcadas 10 plots (10 x 20 m) ao longo do remanescente. A distribuição da abundância observada foi comparada com modelos teóricos (lognormal, log-series, “vara-quebrada” e série geométrica). A relação florística entre as parcelas foi analisada através de uma análise de correspondência segmentada (DCA). A comunidade apresentou ajuste significativo ao modelo série geométrica e apresentou elevada heterogeneidade florística ao longo das parcelas. Esses resultados indicam que a comunidade estudada apresenta baixa sobreposição de nicho, estruturada por partição de nicho. O padrão observado parece estar associado a distribuição local da comunidade (i.e. associada a microhabitats) e com a baixa riqueza de samambaias no remanescente estudado.

Palavras-chaves: Floresta Atlântica. Heterogeneidade florística. Escala local. Rank-abundancia. Série geométrica.

The study of species abundance distribution (SAD) represent an efficient tool to identify patterns or trends in communities and could be useful to test the hypothesis about assembly rules (MAY, 1975; ALONSO; MCKANE, 2004; ETIENNE, 2005; MCGILL et al., 2007). In a review of the current literature, McGill et al. (2007) analyzed both classic SADs models (e.g. geometric series, logarithmic series, log-normal and broken-stick) and the newest ones (e.g. multifractal, logistic-j and neutral models) organizing the models and theories in well-defined groups: purely statistical, branching process, population dynamics, niche partitioning and spatial distribution.

SADs generalizations include predictions over species diversity patterns (HE; LEGENDRE, 2002), the role of environmental variables on community structure (SMALL; MCCARTHY, 2002), ecosystem organization (SOLÉ et al., 2002), as well as to the explanation of general biogeographic patterns (HUBBELL, 2001). Thus, understanding SADs represents an important stepping stone to understanding communities in general (MCGILL et al., 2007). Studies on this theme are especially important for the Atlantic Forest, a hotspot for biodiversity conservation that presents low integrity of its remnants (MYERS et al., 2000; GALINDO-LEAL; CÂMARA, 2005; TABARELLI et al., 2006). The knowledge of how these remnant communities are structured represents an important way to deal with the impacts of fragmentation and anthropogenic processes.

In this sense, the aim of this study was to analysis SAD pattern of the fern's community in an Atlantic Forest remnant. Ferns represents an important component of tropical forest biodiversity (PHARO et al., 1999), offering several advantages as a model to analyze local community structure. First, it comprises a representative and manageable group of the tropical forest when considered both quantitative sample and statistical inferences (KESSLER, 2010; KESSLER; BACH 1999), being recognized as an important surrogate group for megadiverse regions (LANDEIRO, 2012). Second, despites the high capacity of dispersion of the spores (PAGE, 2002), which implies that distances along the remnant do not represent a significant barrier, fern's assemblages have local distribution related to environmental factors (RICHARD et al., 2000; FERRER-CASTÁN; VETAAS, 2005; PAGE, 2002). In this sense, fern's responses are more related to environmental factors when compared to others vascular plants, being cited as a good ecological indicator of environmental factors, specially, edaphic conditions (TUOMISTO et al., 2003; SALOVAARA et al., 2004; ZUQUIN, 2014). Finally, the alternation of generations in fern's life cycle allows for a direct comparison of "moss-like" (gametophytic form) and "angiosperm-like" (sporophytic form) within the same taxon comprising a reliable model for the knowledge of land plants responses to environmental factors (KESSLER, 2010).

The study was developed in a lowland Atlantic Forest remnant of 470 ha, surrounded by sugar cane monoculture in Pernambuco state, northeastern Brazil. The region presents hot and wet tropical climate (As), according to Köppen (1948). The average annual temperature is 25.2 C° and the average annual rainfall is 2300 mm (ITEP/ LAMEPE, 2010).

We delimited ten plots (10 x 20 m) along the remnant with at least 40 m apart from each other. We counted and collected all ferns in plots, including epiphytes in the first three meters of phorophyte. The identification was realized by consulting specialized identification keys.

We plotted SAD per plot and compared the observed data with classic theoretical models: geometric series, logarithmic series, lognormal and broken-stick (MAGURRAN, 1988). The goodness of fit of each model to the observed data was assessed using maximum likelihood estimation. We considered significant values $p \leq 0.05$. We applied a detrended correspondence analysis (DCA) to analyze the floristic relation between plots. The analyses were performed in the R environment using “sads” package (PRADO et al., 2016) for SADs analysis and the vegan package (OKSANEN et al., 2011) for DCA.

The floristic survey reported 25 species, distributed in 20 genera and 12 families (Table 1). Species with intermediate abundance values were representative in the community (16 spp. with abundance values 10-40 individuals, N=25), while abundant (core) and rare ones (satellite) presents three (≥ 50 individuals in the community) and six species (≤ 10 individuals in the community), respectively (Table 1). Goodness of fit test was significant for geometric series distribution ($Z = 0.001468$; $p = 0.001$) (Figure 1). DCA showed a gradient length of 5.6480 and the two first axes present 0.7863 and 0.5862, respectively, indicating a long floristic gradient (two first axis ≥ 0.3) (Figure 2).

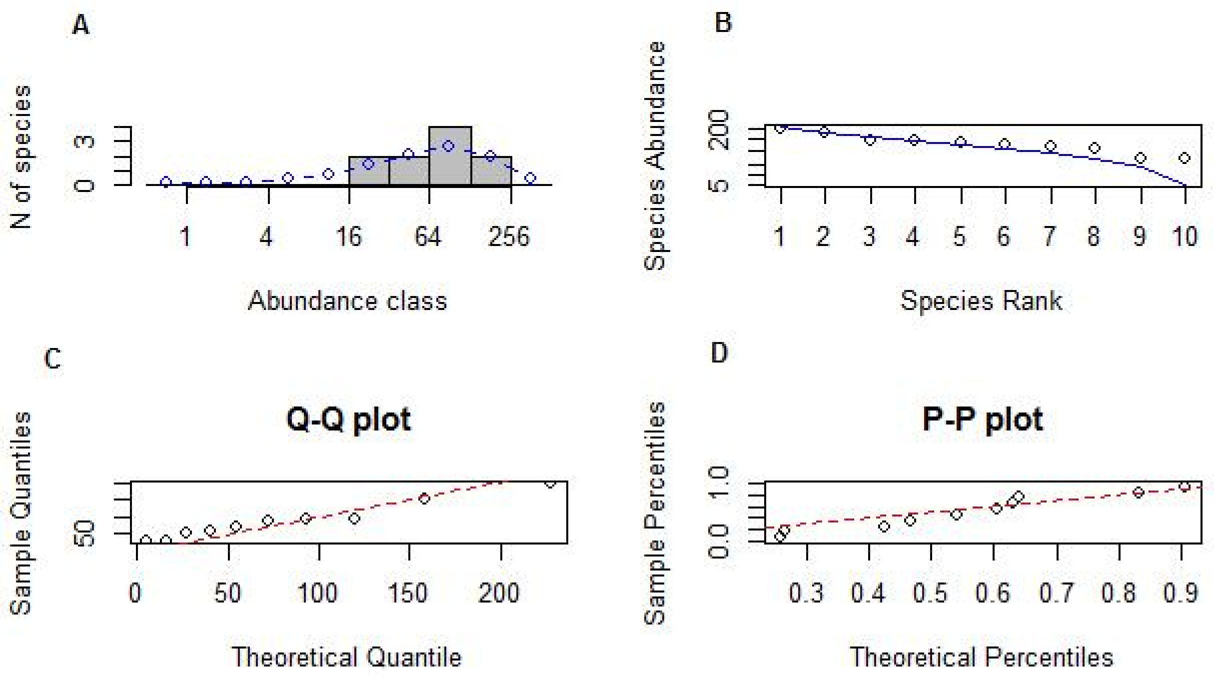

Figure 1. Species abundance distribution (SAD) for fern's community in an Atlantic Forest remnant and the goodness of fit to geometric series model (Z = 0.001468; p = 0.001) based on maximum likelihood estimation. **(A)** Grey bars represent observed SAD based on abundance class and the blue line indicate the goodness of fit to the geometric series model. **(B)** Species-rank abundance for observed data (open circles) and estimated by the geometric series model (blue line). **(C)** The relation between observed sample quantiles (open circles) and estimated quantiles based geometric series model. **(D)** The relation between observed sample percentiles and estimated percentiles based geometric series model.

In literature, the geometric series distribution indicates a niche partitioning with low or absent niche overlap (niche preemption model) (MARTÍ; GARCÍA-ÁLVAREZ, 2002; MCGILL et al., 2007). This biological model indicates that the division of niche space can be limited (MAGURRAN, 1988; MCGILL et al., 2007). The adjustment to this model seems to be related to the fact that fern's assemblages tend to be concentrated along specific microhabitats ("preferential microhabitats") in the Atlantic Forest remnants in Northeast of Brazil (AMBRÓSIO; BARROS, 1997; PEREIRA et al., 2014). The “spatial limitation” may favor this niche-based pattern to facilitate species coexistence in microhabitats.

Communities fitted to geometric series model tends to present low species richness as the result of stressful conditions as low resource environments, initial stages of succession, or disturbed environments (MAGURRAN, 1998), as wells as prevalence of non-abundant and rare species (MCGILL, et al., 2007). Indeed, the studied forest remnant showed low species richness, which is commonly reported to other Atlantic Forest remnants in the Northeast (e.g. SILVA et al., 2011). This pattern arises from historical processes, which was intensified by destruction and fragmentation of Atlantic Forest, which was higher in the Northeast of Brazil (TABARELLI et al., 2006) increasing the rarity of species (GALINDO-LEAL; CÂMARA, 2005). These processes had also threatened a large number of fern species (WINDISCH, 2002), with declines in species richness, abundance, and distribution (e.g. SILVA et al., 2011, 2014),

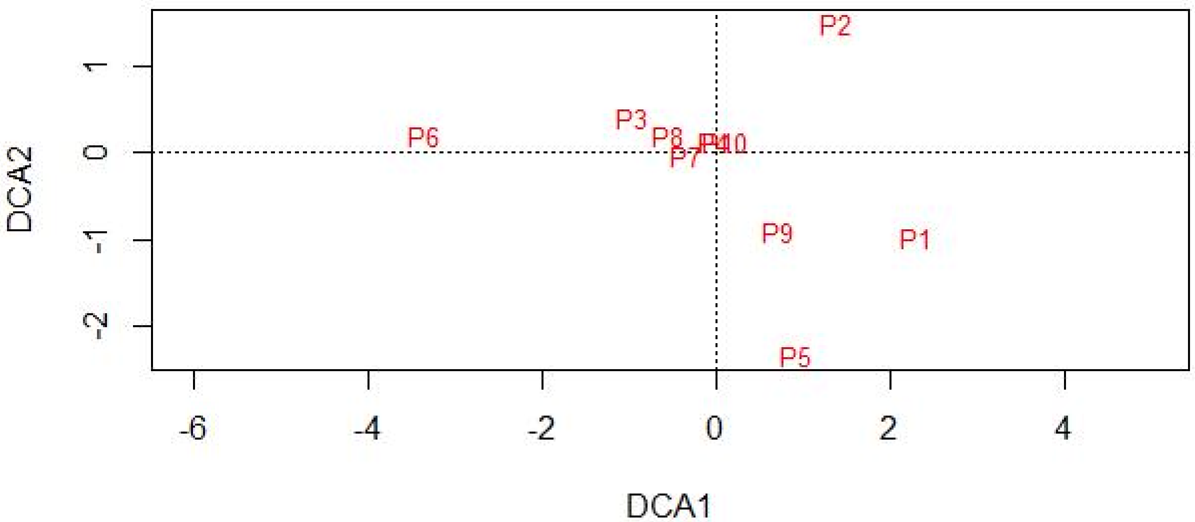

Figure 2. Detrended correspondence analysis for fern’s community in an Atlantic Forest remnant. DCA1 = 0.7863; DCA2 = 0.5862.

The long floristic gradient observed in DCA represents a high heterogeneity along the local remnant, which indicates that the dominant species along plots may be not the same. This indirect gradient analysis indicates a high resource partitioning in the community (FELFILI et al., 2005) corroborating with SAD analysis that also indicates low homogeneity (MAGURRAN, 1988). Finally, fern's community in the studied remnant seems to be structured by niche-based processes of resource partitioning associated with high floristic heterogeneity.

Table 1. Species list and abundance for 10 plots in an Atlantic Forest Remnant, northeastern Brazil (Pernambuco, Brazil).

	Species Abundance per plot									
Family/ Species	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**	**P10**
Anemiaceae										
Anemia hirta (L.) Sw.	-	-	-	2	-	-	-	-	9	1
Aspleniaceae										
Asplenium serratum L.	-	3	-	-	-	-	-	-	-	-
Blechnaceae										
Neoblechnum brasiliense (Desv.) Gasper & V.A.O Dittrich	-	-	96	15	-	-	38	56	1	6
Blechnum occidentale L.	1	-	-	24	-	2	3	-	-	22
Cyatheaceae										
Cyathea microdonta (Desv.) Domin.	-	-	-	8	-	-	-	3	10	2
Cyathea phalerata Mart.	7	-	-	-	5	-	-	-	-	-
Dennstaedtiaceae										
Hypolepis repens (L.) C. Presl.	-	4	5	-	-	-	-	-	-	-
Dryopteridaceae										
Ctenitis falciculata (Raddi) Ching.	14	5	-	-	-	-	-	-	-	-
Ctenitis paranaensis (C. Chr.) Sehnem	2	-	-	-	4	-	-	-	-	-
Cyclodium heterodon (Schrad.) T. Moore.	-	-	-	-	-	11	-	-	-	-
Megalastrum eugenii (Brade) A.R. Sm. & R.C. Moran.	1	6	-	-	-	-	-	-	-	-
Hymenophyllaceae										
Didymoglossum kraussii C.Presl.	-	20	-	-	-	-	-	-	-	-
Lygodiaceae										
Lygodium venustum Sw.	-	-	-	-	-	-	-	-	3	-
Lygodium volubile Sw.	-	-	7	-	-	-	-	-	2	1
Marattiaceae										
Danaea geniculata Raddi.	32	-	-	-	-	-	-	-	-	-
Pteridaceae										
Adiantum latifolium Lam.	-	-	-	3	4	-	-	-	24	-

Adiantum petiolatum Desv.	-	-	5	-	-	1	-	14	-	-
Anetium citrifolium (L.) Splitg.	2	2	-	3	-	-	-	-	-	6
Pityrogramma calomelanos (L.) Link.	-	-	15	6	1	1	-	14	-	2
Tectariaceae										
Tectaria incisa Cav.	-	6	-	7	7	-	29	108	-	43
Telypteridaceae										
Goniopteris abrupta (Desv.). A.R.Sm.	17	-	-	-	6	-	4	-	8	4
Christella hispidula (Decne.) Holttum	-	-	-	-	-	-	10	-	-	-
Steiropteris polypoidioides (Raddi) Salino & T.E Almeida	6	5	-	-	-	-	-	-	-	-
Meniscium serratum (Cav.)	-	-	20	-	-	-	-	2	1	-

REFERENCES

ALONSO, D.; MCKANE, A. J. Sampling Hubbell's neutral theory of biodiversity. **Ecology Letters**, v. 7, p. 901–910, 2004.

AMBRÓSIO, S. T.; BARROS, I. C. L. Pteridófitas de uma área remanescente de Floresta Atlântica do Estado de Pernambuco, Brasil. **Acta Botanica Brasilica**, v. 11, p. 105–113, 1997.

ETIENNE, R. S. A new sampling formula for neutral biodiversity. **Ecology Letters**, v. 8, p. 253–260, 2005.

FELFILI, J. M.; CARVALHO, F. A.; LIBANO, A. M.; VENTUROLI, F.; PEREIRA, B. A. **Análises multivariadas em estudos de vegetação**. Brasília: Universidade de Brasília, Departamento de Engenharia Florestal, 2005.

FERRER-CASTÁN, D.; VETAAS, O. R. Pteridophyte richness, climate and topography in the Iberian Peninsula: comparing spatial and nonspatial models of richness patterns. **Global Ecology and Biogeography**, v. 14, n. 2, p. 155–165, 2005.

GALINDO-LEAL, C.; CÂMARA, I. G. Mata Atlântica, Biodiversidade, Ameaças e Perspectivas. In: TABARELLI, M.; PINTO, L. P.; SILVA, J. M. C.; COSTA, C. M. R. (org.). **Espécies ameaçadas e planejamento da conservação**, 2005, p. 86–94.

HE, F.; LEGENDRE, P. Species diversity patterns derived from species area models. **Ecology**, v. 83, p. 1185–1198, 2002.

HUBBELL, S. P. **The Unified Neutral Theory of Biodiversity and Biogeography**. Princeton: Princeton University Press, 2001.

Instituto de Tecnologia de Pernambuco e Laboratório de Meteorologia de Pernambuco (**ITEP/LAMEPE**). 2010. Disponível em: <http://www.itep.br/meteorologia/lamepe>. Acesso em 20 dez. 2016.

KESSLER, M. Biogeography of ferns. In: MEHLTRETER, K.; WALKER, L. R.; SHARPE, J. M. (org.). **Fern Ecology**. New York: Cambridge University Press, 2010. p. 22–60.

KESSLER, M.; BACH, K. Using indicator groups for vegetation classification in species rich Neotropical forests. **Phytocoenologia**, v. 29, p. 485–502, 1999.

KÖPPEN, W. **Climatologia**. México: Fondo de Cultura Económica, 1948.

LANDEIRO, V. L.; BINI, L. M.; COSTA, F. R.; FRANKLIN, E.; NOGUEIRA, A.; de SOUZA, J. L; ...; MAGNUSSON, W. E. How far can we go in simplifying biomonitoring assessments? An integrated analysis of taxonomic surrogacy, taxonomic sufficiency and numerical resolution in a megadiverse region. **Ecological Indicators**, v. 23, p. 366–373, 2012.

MAGURRAN, A. E. **Ecological Diversity and Its Measurement**. Princeton: Princeton University, 1988.

MARTÍ, J. J. I.; GARCÍA-ÁLVAREZ, A. Diversidad: biodiversidad edáfica e geodiversidad. **Edafología**, v. 9, n. 3 p. 329–385, 2002.

MAY, R. M. Patterns of species abundance and diversity. **Ecology and evolution of communities**, p. 81–120, 1975.

McGILL, B. J.; ETIENNE, R. S.; GRAY, J. S.; ALONSO, D.; ANDERSON, M. J.; BENECHA, H. K.; DORNELAS, M.; ENQUIST, B. J.; GREEN, J. L.; HE, F.; HURLBERT, A. H.; MAGURRAN, A. E.; MARQUET, P. A.; MAURER, B. A.; OSTLING, A.; SOYKAN, C. U.; UGLAND, K. I.; WHITE, E. P. Species abundance distributions: moving beyond single prediction theories to integration within an ecological framework. **Ecology Letters**, v. 10, n. 10, p. 995–1015, 2007.

MYERS, N.; MITTERMEIER, R. A.; MITTERMEIER, C. G.; FONSECA, G. A. B.; KENTS, J. Biodiversity hotspots for conservation priorities. **Nature**, v. 403, p. 853–845, 2000.

OKSANEN, J.; BLANCHET, F. G.; KINDT, R.; LEGENDRE, P.; O’HARA, R. B.; SIMPSON, G. L.; SOLYMOS, P.; STEVENS, M. H. H.; WAGNER, H. **vegan: Community Ecology Package**. 2011. Disponível em: <http://CRAN.R-project.org/package=vegan>.

PAGE, C. N. Ecological strategies in fern evolution: a neopteridological overview. **Review of Palaeobotany and Palynology**, v. 119, p. 01–33, 2002.

PERREIRA, A. F. N.; SILVA, I. A. A.; SANTIAGO, A. C. P.; BARROS, I. C. L. Efeito de borda sobre a comunidade de samambaias em fragmento de Floresta Atlântica (Bonito, Pernambuco, Brasil). **Interciencia**, v. 39, n. 4, p. 1–7, 2014.

PHARO, E. J.; BEATTIE, A. J.; BINNS, D. Vascular plant diversity as a surrogate for bryophyte and lichen diversity. **Conservation Biology**, v. 13, n. 2, p. 282–292, 1999.

PRADO, P. I.; MIRANDA, M. D.; CHALOM, A. Sads: maximum likelihood models for species. **abundance distributions – r package ver. 0.2.3**. 2015. Disponível em: <https://cran.r-project.org/web/packages/sads/index.html>.

RICHARD, M.; BERNARD, T.; BELL, G. Environmental heterogeneity and the spatial structure of fern species diversity in one hectare of old-growth forest. **Ecography**, v. 23, p. 231–245, 2000.

SALOVAARA, K. J.; CARDENAS, G. G.; TUOMISTO, H. Forest classification in an Amazonian rainforest landscape using pteridophytes as indicator species. **Ecography**, v. 27, p. 689–700, 2004.

SILVA, I. A. A.; PEREIRA, A. F. N.; BARROS, I. C. L. Edge effects on fern community in na Atlantic Forest remnant of Rio Formoso, PE, Brazil. **Brazilian Journal of Biology**, v. 71, n. 2, p. 421–430, 2011.

SILVA, I. A.; PEREIRA, A. F. D. N.; BARROS, I. C. Fragmentation and loss of habitat: consequences for the fern communities in Atlantic forest remnants in Alagoas, north-eastern Brazil. **Plant Ecology & Diversity**, v. 7, n. 4, p. 509-517. 2014.

SMALL, C.J.; MCCARTHY, B. C. Spatial and temporal variability of herbaceous vegetation in an eastern deciduous forest. **Plant Ecology**, v. 164, p. 37–48, 2002.

SOLÉ, R.V.; ALONSO, D.; MCKANE, A. Self-organized instability in complex ecosystems. **Philosophical Transactions of the Royal Society of London B: Biological Sciences**, v. 357, n. 1421, p. 667–681, 2002.

TABARELLI, M.; SIQUEIRA FILHO, J. A.; SANTOS, A. M. M. A Floresta Atlântica ao Norte do Rio São Francisco. In: TABARELLI, M.; ALMEIDA-CORTEZ, J. S.; PORTO, K. C. (org.). **Diversidade Biológica e conservação de Floresta Atlântica ao Norte do Rio São Francisco**. Brasília: Ministério do Meio Ambiente, 2006. p. 23-37.

TUOMISTO, H.; RUOKOLAINEN, K.; YLI-HALLA, M. Dispersal, environmental, and floristic variation of Western Amazonian forests. **Science**, v. 299, p. 241–244, 2003.

WINDISCH, P. G. Fern conservation in Brazil. **Fern Gazette**, v. 16, p. 295-300, 2002.

ZUQUIM, G.; TUOMISTO, H.; JONES, M.; PRADO, J.; FIGUEIREDO, F. O. G.; MOULATLET, G. M.; COSTA, F. R. C.; QUESADA, C. A.; EMILIO, T. Predicting environmental gradients with fern species composition in Brazilian Amazonia. **Journal of Vegetation Science**, v. 25, n. 5, p. 1195-1207, 2014.