# SPECIFICITY OF TREE SPECIES IN DIFFERENT FORMATIONS OF ATLANTIC FOREST IN SOUTH BRAZIL

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## INTRODUCTION

One of the most common aims in community ecology is to detect and describe species that indicate differences according to environmental conditions (Diekmann 2003). Ecological community studies describe habitats, listing one or many characteristic species for each habitat (Dufrene & Legendre 1997). The comparison between habitats through richness may not reflect the relative importance of species in the habitats set in landscape scale. Generalist species occurs in many or in the most habitats and, on the other hand, some of them can be restricted to one or few kinds of habitat (Wagner & Edwards 2001). Species rarity degree can be evaluated through the knowledge of the geographic distribution extent, habitat specificity, and population size.

The Brazilian Atlantic forest extend through the Brazilian coast, inlanding in south region until east Paraguay and northeast Argentina, covering a wide climatic variation with elevations that goes from the sea level until 2700m (Oliveira - Filho & fonts 2000). It is as well constituted by many forest types and associated ecosystems, presenting high environmental heterogeneity (Metzger 2009). According to Oliveira - Filho & Fontes (2000), the Atlantic forest can be classified in two main forms: *stricto sensu* (s.s.) and *lato sesu* (l.s.). The Atlantic forest (s.s.) comprises only tropical rain forests of the Atlantic coast (dense rain forest; DRF) that inland until 300km, where rainfall is locally influenced by ocean winds and mountain slopes. The Atlantic forest (l.s.) includes seasonal forests (Deciduous and Semi - deciduous), *Araucaria* forests (Mixed *Araucaria forest* ; MAF) and low coasts rain forests (Restingas).

In South Atlantic forest we can observe the following forest types: *Restinga* forests (RF) that occurs along the coast e suffers strong influence of littoral environmental conditions, restricting the number of species (Waechter 1985, Scarano 2002); DRF, which is characterized by the life forms diversity and high levels of temperature and moisture during the year; MAF is characterized by the physiognomy of *Araucaria angustifolia* , which occurs in the whole original MOF distribution, i.e. the major part of the Meridional Brazilian plateau (Hueck 1972); Cloud forest (CF) (Rambo 1953), also called Tropical Montane Cloud Forest ( *matinhas nebulares* ), which can be considered the most extreme altitudinal gradient of the Atlantic forest with peculiar features such as the almost constant presence of orographic cloud (Falkenberg 2003).

## OBJECTIVES

Considering habitat heterogeneity of forest types in South Brazilian Atlantic forests, the aim of this study is answer the following questions: (1) are there indicator species for each forest type in South Atlantic forest? In case of yes, (2) which are these species? and (3) how are the relationships between species distribution pattern of forest units and some of their environmental variables (temperature, rainfall, altitude and latitude)?

## MATERIAL AND METHODS

Data sampling

Data used in this study were obtained in phytosociological studies of tree component that covered different forest formations in South Atlantic forest, so that they are representing the types already mentioned (RF, DOF, MOF and CF). We selected 21 works in which were extracted species density (ind.ha - 1) of individuals with breast height diameter (BHD) equal or higher than 10cm, except for the RF (BHD $\geq$ 5cm), because it presents a minor tree size. Of these works, three were in FR, seven in DRF, eight in MAF and three in CF. Thus, the complete matrix resulted in 21 sampling units (SU) and 298 variables (species). However, species that occurred in only one site were excluded for this study, resulting in 163 variables. Moreover, the selected environmental variables were altitude, latitude, longitude, annual median rainfall, and annual median, minimum and maximum temperatures. These data were obtained for each SU. The rainfall and temperature values were obtained through the World Clim data - base (Hijmans *et al.*, 2005), and the others from the own phytosociological works.

Data analyses

The matrix was submitted to indicator species analysis to verify if any forest type present specificity of species. This analysis produces an indicator value for each species in each SU group (forest type), and these values are tested for significance by Monte Carlo technique. The matrices of SU per species and SU per environmental variables were submitted to Canonical Correspondence Analysis (CCA), to evaluate the relationship between species distribution patterns and environmental variables. The correlation of each environmental variable with the multidimensional pattern (obtained through the scores of ordination analysis) was evaluated through the correlation between both matrices (Mantel tests), and the significance was tested through randomization analyses. Indicator species analysis and the CCA were realized with the software PCORD4 (Mc Cune & Mefford 1999), while Mantel test and randomization analyses were with MULTIV (Pillar 2008).

## RESULTS AND DISCUSSION

Resultados

The first result to be pointed out is the species rarity degree. The initial group (complete matrix) was composed by 298 species, from which only 43.3% (163) have occurred in more than one place, i.e. most was locally rare. As for species that were exclusive of some forest type, 3.68% (n=6) occurred only in RF, 22.09% (n=36) in DRF, 6,75% (n=11) in MOF and 0.61% (n=1) in CF. On the other hand, species that were classified as indicator ($p \leq 0.05$) of any forest type of this study represented 20.86% (n=34) of the total. RF had the major percentage of indicator species, with 10.43% (n=17), followed by DOF with 6.13% (n=10), CF with 2.45% (n=4) and MOF with 1.84% (n=3). The species that indicated different forest types are presented below.

• RF: *Allophylus edulis*, *Casearia sylvestris*, *Celtis ehrenbergiana*, *Chrysophyllum marginatum*, *Coussapoa microcarpa*, *Erythroxylum argentinum*, *Eugenia neoaustralis*, *Eugenia uniflora*, *Ficus cestrifolia*, *Guapira opposita*, *Matayba guianensis*, *Myrceugenia glaucescens*, *Myrsine umbellata*, *Nectandra oppositifolia*, Sebastiania ommersoniana, Syderoxylum obtusifolium, *Zanthoxylum rhoifolium.*

• DRF: *Cabralea canjerana*, *Calyptranthes grandifolia*, *Cedrela fissilis*, *Chrysophyllum viride*, *Cinnamomum glaziovii*, *Eugenia schuechiana*, *Hirtella heblecada*, *Meliosma sellowii*, *Roupala brasiliensis*, *Schefflera morototoni.*

• MAF: *Araucaria angustifolia*, *Myrceugenia miersiana*, *Myrcia guianensis.*

• CF: *Ilex microdonta*, *Maytenus boaria*, *Siphoneugenia reitzii*, *Weinmannia paulliniifolia.*

Patterns revealed by CCA show a gradient along axis 1 related to altitude and temperature. In the left of the axes (higher altitude; lower temperature), CF sites were grouped and in the right DRF and RF were also grouped. Altitude was as well the most correlated variable of axis 2, driving cloud forests areas on the superior left quadrant in the ordination diagram. DRF sites with higher altitude and most of MAF sites are in intermediary positions, grouping the last ones in inferior portion, which is an indicative of different floristic pattern, apparently associated to major annual rainfall (this variable was slightly related with axis 2). Mantel correlation analyses indicated altitude as the best environmental variable associated to species composition variation (r2 =0.49; p=0.001).

Discussão

The rarity degree presented by species reflects the complexity and heterogeneity of habitats presented in South Atlantic forest, which favors forest species richness (Metzger 2009) and an elevated rarity degree (Gaston 1994). Another feature that demonstrates the heterogeneity of habitats is the fact that only *Prunus myrtifolia* occurred in the all four forest types. Reitz (1996) and Carvalho (2003) quotes this species as adapted to many soil conditions with leaf structure that allows a wide distribution, including xeric environments.

The results found for DRF are in accordance to current literature, where it is attributed to Atlantic forest s.s. a higher number of species in relation to the others associated ecosystems. Leite (2002) reported that already Professor Miguel Klein listed 700 tree species for DRF, being more than 50% of them exclusive.

Species that indicated RF (13 species) present wide geographic distribution (Sobral *et al.*, 2006). This can be associated to the fact that RF is a recent geological formation, approximately 4000 year (Macedo 2007) and it would not have time enough to suffer speciation that could award endemic species (Scarano 2002). Other factor can be related to environmental adversity in these forest areas, because it occurs over poverty nutrients soils, with water deficiency, it is influenced by salinity from the sea and by strong winds (Waechter 1985). Species with wide geographic distribution usually present large ecological plasticity, being able to colonize this forest type as well as moist dense forests.

From ten indicator species of DRF, seven presents tropical distributions, which characterizes the south limit of tropical rain forest (Klein 1984; Leite 2002). Due to the high richness (79.14% of total species occurred in this forest type), it was expected a small number of indicator species, because most of them presents small abundance and frequency. It is important to emphasize that some indicator species of this forest type (the most tropical conditions), *Cabralea canjerana*) e *Calyptranthes grandifolia*, are finding in MAF as seedlings and saplings (pers. obs.), which may are indicating a potential expansion of DRF over MAF (Rambo 1951) under actual climate conditions.

The mixture of temperate (austral - anthartic - andinean) and tropical (afro - brazilian) floras (Rambo 1951a; 1951b; 1953; Leite 2002) seems to be decisive to MAF presents only three indicator species. Leite (2002) indicates 352 species for this forest type in South Atlantic forest and relates that 41% prefer and are characteristics of other forest formations, being inexpressive in this one. Of all three indicators, *Myrceugenia miersiana* e *Myrcia guianensis* are from tropical mountains of Central Brazil and *Araucaria angustifolia*have a temperate origin (Rambo 1953; Leite 2002).

CF occurs in a peculiar and adverse environment (Falkenberg 2003), just like RF, but the first presented four species while RF had 17. CF presents high air relative moisture due to constant cloud, also low levels of decomposition and temperature, which seems be a strong limiting factor to many tree species. Another factor that may influence the low number of indicator species is the total distribution area of this forest type that is small and very restrictive (Falkenberg 2003). Of all four indicators, three species have temperate distribution, typical from low temperature environments.

The influence of altitude over forest species composition observed in the present study is similar to what was found by Oliveira - Filho & Fonte (2000), where the authors explored the influence of altitude on species composition of Atlantic forest l.s. in southeast Brazil. Some species like *Ilex microdonta*, *Drymis angustifolia* e *Weinmannia paulliniifolia* directly respond to increase of altitude, and they are considered diagnostic for Neotropical Cloud Forests (Webster 1995) and also are known to present a distribution pattern along the Brazilian mountains (Giulietii & Piani 1988). Rainfall is indicated as a determinant factor on Atlantic forests differentiation in southeast Brazil (Oliveira - Filho & Fontes 2000), but in this study, temperature showed higher correlation with floristic distribution pattern ($r2=0.44$ e $p=0.001$) than rainfall ($r2=0.37$ e $p=0.002$). It is noted that in the present study it was not considered Seasonal forests of southwest region. However, considering that south Brazil does not presents a pronounced dry season, Marchiori (2002) already had referenced temperature as responsible for decidual character of these forests, and not rainfall. <p/ >

## CONCLUSION

The high number of rare species found in South Atlantic forest (just next to the subtropical zone) strengthens the idea that this biome (Atlantic forest s.s. and their associated ecosystems) is one of the 25 *hotspots* of biodiversity conservation in the world.

Different forest types present indicator species, being altitude the main variable associated to floristic patterns observed for this study region. The sites explored in this study presents rainfall regimes well distributed along the year, so that rainfall is not a limiting factor for species distribution. Besides altitude, temperature (both are strong correlated) also differenced RF and DRF from CF and MAF.

During the selection of works that were included in this study, we have had difficulty to find studies that covered RF and CF areas in South Atlantic forest, which demonstrates that such environments with peculiar abiotic conditions are poorly studied, and deserves more attention.

The presence of indicator species from DRF (e.g. *Cabralea canjerana* e *Calyptranthes grandifolia*) as seedlings/saplings in MAF opens possibilities for future studies on expansion and retraction dynamics of these ecosystems in relation to climate change, specially related to temperature, which seems to be a important factor in the region.

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