

DENDROMETRICAL CHARACTERISTICS OF AN ATLANTIC FOREST FRAGMENT AT SANTA MARIA DE JETIBÁ COUNTY, STATE OF ESPIRITO SANTO, BRAZIL

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Abstract

This work analyzed the diameter distribution of one site of Atlantic Forest in natural succession, located at the Sítio Palmares Biological Reserve - state of Espírito Santo. In 2,400 m² all the trees with BDH equal or plus 5 cm were measured. The results reveal 195 trees distributed among 17 species and 15 families. The total population presented a mean BDH of 12.40 cm and a basal area of 2.86 m², corresponding to 11.90 m².ha⁻¹. Seven 5 cm interval diameter classes were constituted. The Normal model adjustment for the diameter distribution revealed for the total population an unimodal left-skewed tendency. The first two diameter classes, from 5 to 15 cm, accumulated 142 trees, concentrating 72.8% of the population density. Five species presented a population density of more than 10 woody individuals. The species *Vismia guianensis* (Aubl.) Seem. presented trees only in the first diameter class. *Cecropia catarinensis* Cautrec., *Miconia cinnamomifolia* (DC.) Naudin and *Miconia multiflora* Cong. presented unimodal and *Piptocarpha macropoda* (DC.) Baker presented inverse J diameter distribution curve. Accordingly to the successional stage of the studied fragment, after 30 years in preserved area, according the number of species and their diametric structure, the plant community is actually in the intermediate growth development, fairly distant to the climax stage.

Keywords: Floristic survey; diameter classes; equations.

Resumo

Características dendrométricas de um fragmento de Mata Atlântica no Município de Santa Maria de Jetibá, Estado do Espírito Santo, Brasil. Este trabalho analisou a distribuição diamétrica de uma área em regeneração natural da Mata Atlântica localizado na Reserva Biológica Sítio Palmares, ES. Em 2.400 m², foram medidas todas as árvores com DAP igual ou superior a 5 cm. Foram encontradas 195 árvores, distribuídas em 17 espécies e 15 famílias. O total da comunidade observada apresentou um DAP médio de 12,40 cm e área basal de 2,86 m², correspondendo a 11,90 m².ha⁻¹. Os indivíduos arbóreos ficaram distribuídos em sete classes diamétricas de 5 cm de intervalo. O ajuste da função normal mostrou, para o total da população, distribuição diamétrica unimodal com assimetria à esquerda. As duas primeiras classes diamétricas, de 5 a 15 cm, acumularam 142 árvores, concentrando 72,8% da densidade populacional. Cinco espécies apresentaram uma densidade populacional com mais de 10 indivíduos arbóreos. A espécie *Vismia guianensis* (Aubl.) Seem. apresentou árvores somente na primeira classe diamétrica. *Cecropia catarinenses* Cautrec., *Miconia cinnamomifolia* (DC.) Naudin e *Miconia multiflora* Cong. apresentaram curvas de distribuição diamétrica unimodais e *Piptocarpha macropoda* (DC.) Baker curva de distribuição diamétrica J-invertido. O estágio sucessional do fragmento estudado, com mais de três décadas de crescimento em área preservada, encontra-se, pelo número de espécies e estrutura diamétrica observadas, em fase intermediária de desenvolvimento, ainda longe do estado clímax.

Palavras-chave: Levantamento florístico; classes diamétricas; equações.

INTRODUCTION

Five centuries ago the Atlantic Forest used to cover the entire Brazilian Atlantic coast; however, nowadays there are only restricted fragments, mainly in mountainous coastal areas in the South and Southeast region of the country (RIBEIRO *et al.*, 2009).

If the diameter distribution enables to define the characterization of trees number per area unit and diameter class, then it becomes an essential tool to correct knowledge about dynamics and population structure of the plant community to be studied, allowing coherent subsidy for elaboration of corresponding silvicultural ordination and forest management plans (BRUKAS; SALLNÄS, 2012). Consequently, by the diameter distribution, it will be possible to infer as present as future behavior of the massive forest in observation. Therefore, studies about diameter distribution can allow inferring possible growing behaviors of the species that integrate the studied forest (BLUJDEA *et al.*, 2012; IMAÑA-ENCINAS *et al.*, 2011a; IMAÑA-ENCINAS *et al.*, 2011b).

This work aims to analyze the diameter distribution of the woody component of an Atlantic Forest fragment in natural succession, located at the Sitio Palmares Biological Reserve, Santa Maria de Jetibá county, state of Espírito Santo, in order to offer subsidies for its maintenance and corresponding forest ordination plan. The hypothesis of this work asks the possibility to obtain a consistent interpretation of the diametric distribution through a small plots area.

MATERIALS AND METHODS

The study area was located at Sitio Palmares Biological Reserve, specifically in Rio Claro District, Santa Maria de Jetibá County, in the state of Espírito Santo, at an altitude of 692 m. The local climate, according to Köppen classification, is the tropical altitude Cwb type, with dry and rainy seasons very well defined. The annual mean temperature is 18°C and the annual mean rainfall is 1,800 mm.

The Sitio Palmares Biological Reserve maintains fragments of the Atlantic Forest formation preserved. The areas surrounding these fragments had for many years an intense agricultural activity with coffee cultivation. More than 33 years ago, these coffee cultivations were completely shut down and abandoned, creating, so, areas in natural succession. For the present study, one of these areas from the 13 hectares was chosen randomly. In the focused area, six plots of 400 m² (20 x 20 m) were established, randomly distributed. The total sample area was, therefore, 2,400 m². The survey plot consistence was established through the variation coefficient of the DBH per plot, assuming lower homogeneous values like representatives for the observed plant community.

All live woody individuals, including the palm trees, with DBH equal or above 5 cm were identified and measured. The variation coefficient of the DBH per plot was calculated. The botanical identification was done by a Dendrology specialist, *in loco*. Some botanical materials from woody individuals were collected and later identified by comparison with fertile material at the University of Brasilia Herbarium (UB), where this material was deposited. The botanical nomenclature of the woody individuals that were identified followed the Angiosperm Phylogeny Group II (2003) system and the w³Trópicos classification from the University of Missouri's Botanical Garden (TROPICOS, 2010).

It was measured the diameter at breast height (DBH) of each woody individual. The basal area (BA) was calculated through the equation: $BA = DBH^2 \cdot 0,7854 \text{ (m}^2\text{)}$.

In order to verify the DBH's distribution patterns of the total population and by species in particular, the adjustment of the number of woody individuals per diameter classes was tested and analyzed by Meyer's model $N = \beta_0 \cdot e^{\beta_1 \cdot D_i}$ (MEYER, 1952), where: N = estimator of the number of trees in the correspondent diameter class, D = central value of diameter class, β = equation's coefficients, $e = 2.718281829$ (neperian logarithm base) and the Normal model (ZAR, 1996). After the adjustments, it was calculated the coefficient of determination $\bar{R}^2 = 1 - \frac{n-1}{n-(k-1)}(1-R^2) \therefore R^2 = 1 - \frac{SQ_{res}}{SQ_{tot}}$ the standard error of estimate

$\varepsilon = \frac{s}{\sqrt{n}}$ and the level of significance (p) of the equations, determined by the computer program Sigmaplot (SYSTAT, 2006).

The hypotheses of this work ask if a small number of survey plots may interpreted cohesively the diametric distribution of a forest fragment of the Atlantic Forest through the response of the coefficient variation.

RESULTS AND DISCUSSION

The floristic survey of the focused area (2,400 m²) recorded the existence of 17 woody species distributed in 14 families (Table 1). The most species-rich family was Melastomataceae with 3 species, amounting to 17.6% of the total number of species. The highest population densities were concentrated among the species *Miconia cinnamomifolia* (58 individuals) and *Cecropia catarinensis* (40 individuals),

which accounted 50% of all the studied population. Including the species *Miconia multiflora* (25 individuals) and *Vismia guianensis* (23 individuals), these four species reached 75% of the woody individuals. The variation coefficient of the DBH reveals similar results, between 28 to 31% on the six plots, validating that the survey can be representative to the studied vegetal community. Converting the founded population density to one hectare, it's possible to obtain 812 woody individuals with BDH higher than 5 cm in this successional growth stage.

The focused area is certainly still at an initial organization stage evolving toward a climax condition. It can be affirmed that 33 years of natural growth is still a very short period in order to reach the dynamics and structure of forest formations.

Alves Júnior *et al.* (2007), for the fragment analyzed in the metropolitan region of Recife, found 54 species in 25 families, with a population density of 1,657 trees.ha⁻¹. Studying the same region, Silva *et al.* (2009) registered 48 species distributed in 25 families, amounting to a woody population of 1,268 individuals per hectare. Drumond e Meira Neto (1999), to the region of Medio Rio Doce (MG), registered a population density of 1,247 trees per hectare, distributed in 43 species and 23 families. Souza *et al.* (2002) evaluating the succession dynamics of one site of the secondary ombrophilous dense forest, found 212 tree species with a basal area of 0.3939 m² ha⁻¹. Marangon *et al.* (2008) indicate the existence of 957 trees.ha⁻¹ in the Mata da Pedreira (MG), spread in 91 species and 30 families. For the focused area located at the Sítio Palmares Biological Reserve, thirty three natural succession years can be considered a very short period to be attempt a possible climax stage.

The arithmetic mean DBH of the 195 woody individuals was 12.40 cm. It may be implied that, nowadays, this plant community belongs, silviculturally, to small size woody structures.

Distributing the population DBH in diameter classes of 5 cm interval (Figure 1), it was verified that 7 classes were established in amplitude 5 cm to 38 cm. The distribution curve revealed an unimodal

left-skewed tendency $y = 74,7251 \cdot e^{\left(-0,5 \left(\frac{x-8,6027}{7,3836}\right)^2\right)}$, and presented a coefficient of determination (R²) of 0.99 with a standard model error of estimate (ϵ) of 0.034 and a level of significance (p) < 0.001. It may be clearly observed that only the first four diameter classes fully follow the constructed curve, making it possible to infer that in the following diameter classes, some woody individuals were left out and the species present in it (*Cecropia catarinensis* - 3 individuals, *Miconia cinnamomifolia* - 2 individuals, *Vochysia bifalcata* - 2 individuals and *Piptocarpha macropoda* - 1 individual) may probably be classified as pioneers and the ones in the beginning of the secondary stage. Another outstanding characteristic of the bar graph (Figure 1) is that the first two diameter classes, from 5 to 15 cm, concentrate 73% of the population density, confirming that the silvicultural structure of the fragment is of small size.

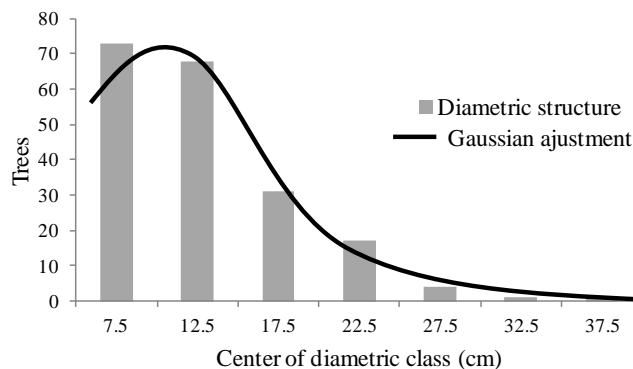


Figure 1. Observed and skewed (normal function) diametric distribution of the total studied community.
 Figura 1. Distribuição diamétrica observada e esperada (Função Normal) do total da comunidade estudada.

It was identified in the natural succession site an occupation surface or basal area of 2.86 m² in 2,400 m², which would correspond to 11.9084 m².ha⁻¹ (Table 1). The basal area natural equilibrium in the vegetation studied occurred in the 30-35 cm diameter class (Table 2), once this class contains the basal-area 50%.

Table 1. Number of tree individuals, mean diameter, diameter variation and basal area per species found in the Sitio Palmares Biological Reserve, Santa Maria de Jetibá, ES.

Tabela 1. Número de indivíduos arbóreos, diâmetro médio, variação diamétrica e área basal por espécie encontrados na Reserva Biológica Sítio Palmares, Santa Maria de Jetibá, ES.

Species	Family	n	Mean BDH cm	Diameter interval cm	BA m ²	BA m ² .ha ⁻¹
<i>Cecropia catarinensis</i> Cautrec.	URTICACEAE	40	15.49	7.0-26.0	0.840398	3.496056
<i>Dalbergia nigra</i> (Vell.) Allemao ex Benth.	FABACEAE	2	5.00	5.0-5.0	0.003927	0.016336
<i>Euterpe edulis</i> Mart.	ARECACEAE	1	12.00		0.011310	0.047050
<i>Guarea guidonia</i> (L.) Sleumer	MELIACEAE	5	8.50	5.0-13.0	0.033105	0.137717
<i>Guettarda viburnoides</i> Cham. & Schltdl.	RUBIACEAE	1	5.50		0.002376	0.009884
<i>Maprounea guianensis</i> Aubl.	EUPHORBIACEAE	8	10.31	9.0-13.0	0.068467	0.284823
<i>Miconia cinnamomifolia</i> (DC.) Naudin	MELASTOMATAACEAE	58	13.31	6.0-32.0	0.940536	3.912630
<i>Miconia minutiflora</i> (Bonpl.) DC.	MELASTOMATAACEAE	1	14.00		0.031416	0.130691
<i>Miconia multiflora</i> Cong.	MELASTOMATAACEAE	25	12.20	5.0-22.0	0.332185	1.381890
<i>Ocotea elegans</i> Mez.	LAURACEAE	2	8.25	7.5-9.0	0.010780	0.044845
<i>Piptocarpha macropoda</i> (DC.) Baker	ASTERACEAE	18	11.97	6.0-25.0	0.236229	0.982713
<i>Solanum verbascifolium</i> L.	SOLANACEAE	1	5.00		0.001964	0.008170
<i>Sorocea bonplandii</i> (Baill.) Burger, Lanj. & Wess. Boer.	MORACEAE	1	11.00		0.009503	0.039532
<i>Vanillosmopsis erythropappa</i> (DC.) Sch. Bip.	ASTERACEAE	3	11.83	5.0-19.0	0.040703	0.169324
<i>Vismia guianensis</i> (Aubl.) Seem.	HIPERICACEAE	23	7.06	5.0-9.5	0.094464	0.392970
<i>Vochysia bifalcata</i> Warm.	VOCHYSIACEAE	3	24.33	7.5-38.0	0.177226	0.737260
<i>Xylopia sericea</i> A. St.-Hil.	ANNONACEAE	3	10.83	9.5-12.5	0.028019	0.116559
Total		195			2.860230	11.908449

Table 2. Density and basal area per diametric class of the forest community.

Tabela 2. Densidade e Área basal por classe diamétrica da comunidade arbórea.

Diameter class (cm)	CDC cm	Density		Basal area	
		Absolute	Relative (%)	m ²	Accumulated (%)
5.00-10.00	7.5	73	37.4	0.325764	11.39
10.00-15.00	12.5	69	35.4	0.786225	38.88
15.00-20.00	17.5	30	15.4	0.710944	63.74
20.00-25.00	22.5	17	8.7	0.624629	85.58
25.00-30.00	27.5	4	2.0	0.218832	93.23
30.00-35.00	32.5	1	0.5	0.080425	96.04
35.00-40.00	37.5	1	0.5	0.113412	100.00
		195	100	2.860230	

CDC: Center of Diameter Class.

Braga *et al.* (2009) informed about the existence of an Atlantic Forest fragment situated at *Mata do Paraíso* Ecological and Forest Reserve, in *Minas Gerais*, with 21.27 to 60.35 m². ha⁻¹. Oliveira (2002) registered 26.3 and 32.4 m².ha⁻¹ of a coastal fragment area in the Atlantic Forest of *Ilha Grande* (RJ), that are 25 and 50 years old, respectively. Drumond e Meira Neto (1999) registered, after 25 years of natural succession in the *Medio Rio Doce* (MG) region, a basal area of 16.7 m². ha⁻¹. Alves Junior *et al.* (2007), in a study accomplished in Atlantic Forest fragments of the metropolitan region of *Recife*, encountered values between 24.7 and 41.68 m².ha⁻¹. Consequently, the basal area found in this research was below the values registered in bibliographic sources.

Among the five species with more than 10 tree individuals, *Vismia guianensis* presented 23 trees in a single diameter class (in the first 5-10 cm class). For the other four species, *Miconia cinnamomifolia* (58 trees), *Cecropia catarinensis* (40 trees) and *Miconia multiflora* (25 trees), it was done the correspondent diameter distribution's construction and analysis (Table 3 and Figure 2). The diameter distribution amplitude extended from 5 to 40 cm, whereby the highest concentration of woody individuals

is in the first three classes, revealing, therefore, that the correspondent populations evolve toward belonging to small size growth structures.

Table 3. Statistical parameters of the equations chosen to explain the diameter distribution of the species with higher number of individuals.

Tabela 3. Estatísticas das equações desenvolvidas para representar a distribuição diamétrica das espécies com maior número de indivíduos.

Species	Equation	R ²	S _{xy}	p
<i>Cecropia catarinensis</i>	$y = 15,751e^{\left[-0,5\left(\frac{x-15,141}{5,168}\right)^2\right]}$	0.97	0.069	<0.001
<i>Miconia cinnamomifolia</i>	$y = 22,931e^{\left[-0,5\left(\frac{x-12,031}{5,149}\right)^2\right]}$	0.98	0.032	<0.001
<i>Miconia multiflora</i>	$y = 16,101e^{\left[-0,5\left(\frac{x-11,054}{2,749}\right)^2\right]}$	0.94	0.041	0.004
<i>Piptocarpha macropoda</i>	$y = 12,451e^{-0,312x}$	0.98	0.054	0.019

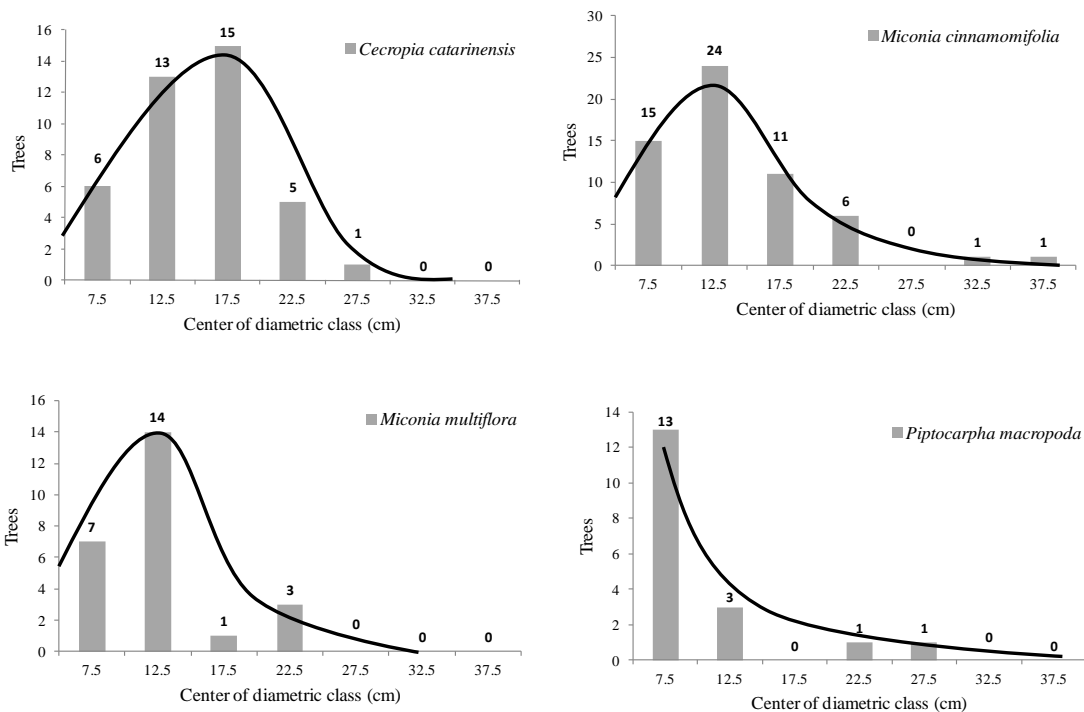


Figure 2. Observed and skewed diametric distribution of the four species with highest number of individuals.

Figura 2. Distribuição diamétrica observada e esperada das quatro espécies com maior número de indivíduos.

CONCLUSIONS

- The diameter distribution of the total population density showed that it follows an unimodal left-skewed curve tendency. The diameter analysis of the five species with higher number of individuals proved that they encounter themselves in an initial stage of natural succession.

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