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Original Article

Silviculture

Floristic Differentiation of a Deciduous Seasonal Forest Tree Stratum, Jaguari, RS, Brazil

Camila Andrzejewski[1], Rafael Marian Callegaro[2],
Solon Jonas Longhi[1], Leonardo Job Biali[3]

[1]Universidade Federal de Santa Maria (UFSM), Santa Maria, RS, Brasil
[2]Universidade Federal do Espírito Santo (UFES), Jerônimo Monteiro, ES, Brasil
[3]Universidade de Brasília (UnB), Brasília, DF, Brasil

ABSTRACT

This study aims at determining and differentiating the floristic groups of a Deciduous Seasonal Forest's arboreal component, located on the ridge of the Southern Plateau, in Southern Brazil. Individuals with diameter at breast height ≥ 5.0 cm were sampled in sixty-two plots measuring 10 m × 10 m, which were systematically installed in the forest. Three floristic groups were found: Middle Stage, including 54 species, with *Casearia sylvestris* as an indicator species; Advanced Stage, with 38 species and *Pilocarpus pennatifolius* as the indicator species; and Altered Forest, with 27 species and *Apuleia leiocarpa*, *Helietta apiculata*, and *Machaerium paraguariense* as indicator species. A higher proportion of climax light-demanding individuals was reported in the Middle Stage and Altered Forest groups, contrasting with the Advanced Stage group, in which climax shade-tolerant species were predominant. In addition, the groups were differentiated according to their dispersion strategy, with specific syndromes occurring in each group (Middle Stage: zoochory; Advanced Stage: autochory; Altered Forest: anemochory).

Keywords: cluster analysis, indicator species, spatial distribution.

1. INTRODUCTION

The replacement of forests by other forms of land occupation, such as agricultural crops and pastures, as well as the disorderly exploitation of timber and non-timber products, has diminished the natural resources available for use by the human population. The environmental functions of forests have also been adversely affected, such as maintenance of soil productive capacity and water quality in river basins.

The Deciduous Seasonal Forest of Rio Grande do Sul, the primary forest typology of that state (23.8% of the natural forests), partakes in this situation (Rio Grande do Sul, 2002). The forest's remnants, despite their range and significance, are actively threatened by rural and urban development (Kilca & Longhi, 2011). This condition evidences the need for studies that determine these forests' ability to support sustainable farming or the need to recover certain ecosystems.

Information on floristic composition, vegetation structure, and relationships between vegetation and the environment were contemplated by Scipioni et al. (2012) and Turchetto et al. (2017) regarding remnants of Deciduous Seasonal Forest located on the ridge of the Southern Plateau. However, existing data concerning the western portion of the Plateau is scarce, especially when considering hillside forests and floristic differentiation studies within a fragment, since hillside environments have not been the focus of research in the region.

The differentiation of communities into a forest fragment can be conducted by cluster analysis, which aims at gathering objects into homogeneous groups. The formation of distinct groups suggests the need for differentiated sustainable management in the forest. Similarly, knowledge of indicator species may foster future efforts of preservation and restoration (Marangon et al., 2016).

In this context, this study aimed at determining and differentiating floristic groups of the arboreal component of a Deciduous Seasonal Forest located in the western region of the Southern Plateau ridge of Rio Grande do Sul.

2. MATERIAL AND METHODS

A fragment of a Submontane Deciduous Seasonal Forest (IBGE, 2012), with an area of 10.5 ha, located in the municipality of Jaguari, Rio Grande do Sul, at coordinates 29º24'12" South and 54º38'06" West was assessed. According to the climatic Köppen classification, the region is considered of Cfa (subtropical) climate (Alvares et al., 2013), and the municipality's average annual precipitation is of 1,879 mm (Machado & Freitas, 2005).

The forest is situated in the western portion of the Southern Plateau ridge of Rio Grande do Sul, in an area with a steeply undulating relief (between 190 m and 260 m) and a predominantly western exposure, where the maximum slope is 40° (89%). Regosols and leptosols predominate in the area and exhibit lithic contact relatively close to the surface (Pedron & Dalmolin, 2011).

Five parallel sample strips were systematically installed from the base (west) to the top of the hill (east), approximately 50 m apart and with variable length (Figure 1). The sample area included the stretch of the forest fragment located inside a rural property that exhibited better conditions of preservation (3.8 ha), disregarding the section with visually more noticeable change. The second northernmost sampling range had an interruption due to the presence of rocky outcrop. The sampling strips were divided into contiguous plots with dimensions of 10 m × 10 m (100 m²), totaling 62 plots (0.62 ha of sample area). During the second semester of 2010 and the first half of 2011, all individuals with diameter at breast height (DBH) ≥ 5.0 cm in the plots were identified and measured.

Botanical material of unidentified species was collected for analysis and identification in the Herbarium of the Department of Forest Sciences of Universidade Federal de Santa Maria. In order to update and confirm the nomenclature of the species and their respective authors, the *Flora do Brasil 2020* catalog was utilized (Forzza et al., 2018). Family delimitation followed the Angiosperm Phylogeny Group IV classification system (Byng et al., 2016).

Sampling adequacy was verified using the species accumulation curve generated with the PC-ORD 4.41 program (McCune & Mefford, 1999). The plots were grouped based on the abundance of the species, using the agglomerative hierarchical method, with Ward attachment, and the Euclidian distance as a measure of dissimilarity. The data were organized in spreadsheets with 62 lines (sampled plots) and 57 columns (sampled

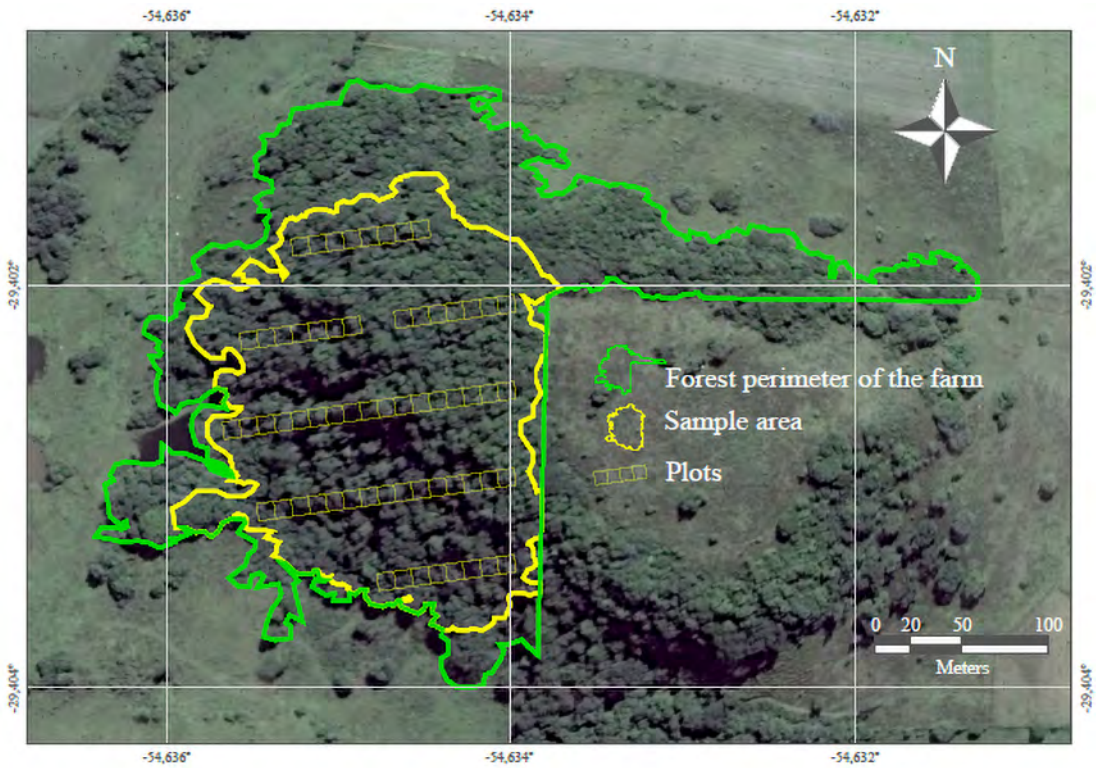

Figure 1. Representation of the sample plots in the forest, in Jaguari, RS, Brazil.

species), and the cluster analysis was processed using the SPSS 13.0 program for Windows (SPSS, 2004).

The formed clusters were differentiated by the occurrence of species, floristic similarity, analysis of indicator species, aggregation, successional group, and species dispersion strategy. The floristic similarity between the groups was obtained using the Jaccard index, which is based on the presence or absence of species, and ranges from 0 to 1, where 1 indicates maximum floristic similarity between the compared areas (*e.g.*, forests, clusters, and plots). In other words, all species that belonged to a sample also belonged to another sample (Souza & Soares, 2013).

Indicator species analysis (ISA) was employed to verify the species that characterize the floristic groups. The method provides the indicator value (IV) for each species in each group, with the statistical significance of the IV verified by the Monte Carlo test, which retained 500 iterations in this study. Such analysis, performed in the PC-ORD 4.41 program, utilized a matrix containing the abundance of species in the plots in each floristic group (Kent, 2012; McCune & Mefford, 1999; Valentin, 2012).

The spatial distribution pattern (aggregation) of the species was assessed using the Payandeh index (Pi), determined in three classes (Souza & Soares, 2013): random ($Pi \leq 1.0$), tend to aggregate ($1.0 < Pi \leq 1.5$), and aggregated ($Pi > 1.5$). In this analysis, species with one sampled individual were disregarded, given they exhibited a non-aggregated (random) distribution, a procedure also adopted by Watzlawick et al. (2011) and Nascimento et al. (2001). When one species presented in more than one floristic group, the Payandeh index was calculated in the groups where the species had two or more individuals sampled.

The species were classified into successional groups, according to Swaine & Whitmore (1988) and Oliveira-Filho et al. (1994): pioneers (P), climax light-demanding (CL), and climax shadow-tolerant (CS). The former group requires full solar luminosity in regeneration, growth, development, and survival processes. Light-demanding climatic species can germinate under shade, but young plants need abundant light to grow and reach the canopy and maturity. In turn, shade-tolerant species can develop under shading, and reach maturity at the canopy or beforehand.

As for the dispersion strategy, the species were classified into three categories, according to Pijl (1972): zoochorous, anemochorous, and autochorous. Zoochorous species are dispersed by animals and have attractive and/or alimentary diaspores, as well as diaspores with adhesive structures, such as hooks and bristles. Anemochorous species have diaspores with structures that provide wind dispersion (winged, feathery, or balloon-shaped). Autochorous species, on the other hand, do not fit into the two previous categories, presenting dispersion by gravity and explosion.

The successional group (P, CL, and CS) and the dispersion strategy (zoochory, anemochory, and autochory) were determined by bibliographic consultation. When the species exhibited different classification in the literature, field observations and researcher consultations were carried out.

3. RESULTS AND DISCUSSION

The species accumulation curve indicated that the sample was sufficient to represent the studied vegetation, given a tendency towards stabilization was observed (Figure 2). Such a trend was evidenced at the final portion of the curve, in which the 10% increase in the sample area resulted in an increment in new species of less than 5%, a condition mentioned by Kersten & Galvão (2011) as necessary to determine the minimum sample area.

A total of 1,107 individuals were sampled in the tree stratum, pertaining to 57 species and 25 botanical families (Table 1). The dendrogram generated by the cluster analysis (Figure 3) indicated the presence of three groups: Group 1 (36 plots), Group 2 (18 plots), and Group 3 (8 plots). The Group 1 was referred to as the Middle Stage, while Group 2 was denominated the Advanced Stage, and Group 3 the Altered Forest. These designations were applied to approximate the reality of the clusters with the floristic properties of forests in different stages or preservation conditions. Therefore, the aspects observed in the study area and the characteristics of the indicator species determined by ISA were considered.

In the ISA, the species that retained a significant observed indicator value (OIV) in the Monte Carlo test (p-value < 0.05) were considered as group indicators. Only five of the 57 observed species were deemed as group indicators: in the Middle Stage group, *Casearia sylvestris* Sw. (OIV = 39.0; p = 0.04); in Advanced Stage, *Pilocarpus pennatifolius* Lem. (OIV = 89.7; p = 0.02), and in Altered Forest, *Apuleia leiocarpa* (Vogel) J.F.Macbr. (OIV = 45.0; p = 0.02), *Helietta apiculata* Benth. (OIV = 89.9; p = 0.02), and *Machaerium paraguariense* Hassl. (OIV = 34.8; p = 0.02).

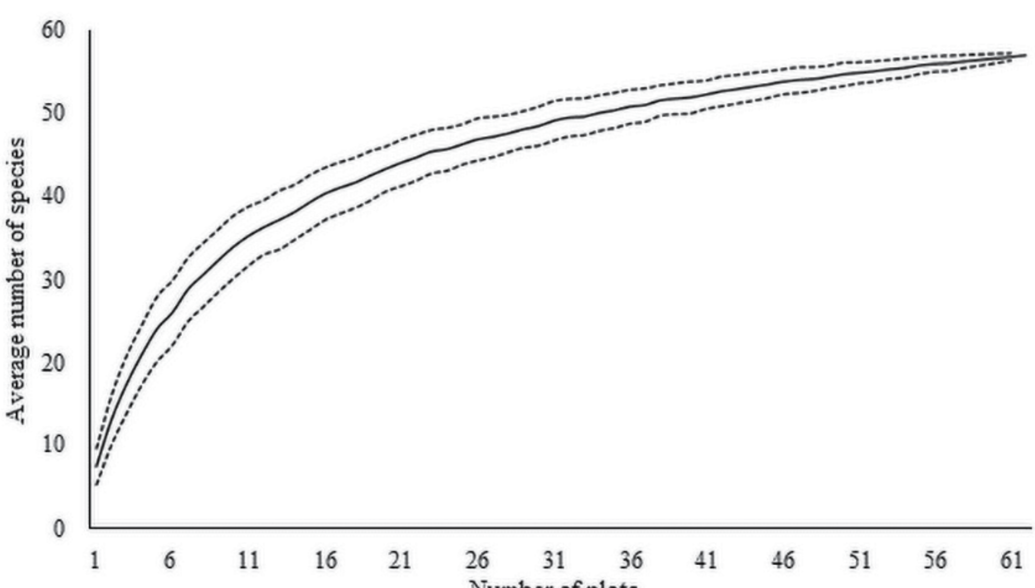

Figure 2. Species accumulation curve × sample area, in Jaguari, RS, Brazil.

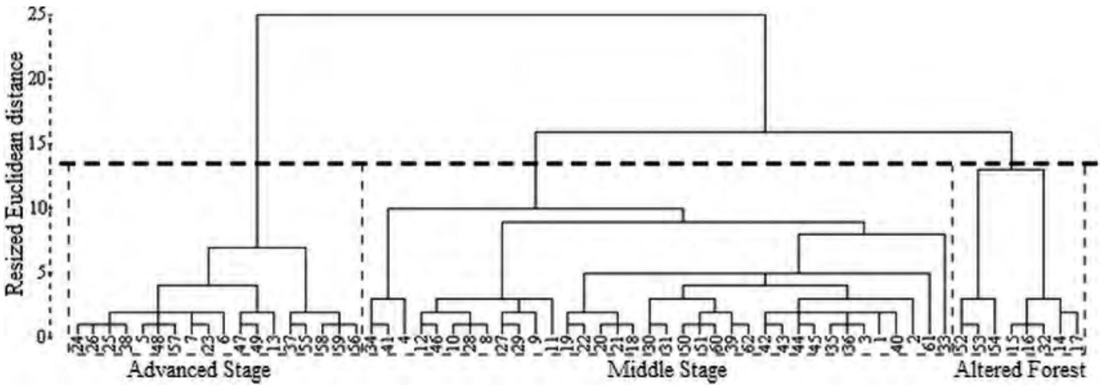

Figure 3. Dendrogram using the Ward method based on Euclidean distances among the 62 inventoried plots in a Deciduous Seasonal Forest in Jaguari, RS, Brazil.

The species *Casearia sylvestris* is considered climax light-demanding and generalist regarding environmental conditions, occurring in several types of soils, from low to high chemical fertility, wet or dry, and from sandy to clayey texture (Carvalho, 2007; Scipioni et al., 2013). In addition, Reitz et al. (1988) emphasized that the species also develops in rocky and shallow soils. Thus, its occurrence is explained as being an indicator of the Middle Stage group, which included plots with different environmental conditions.

In the Advanced Stage group, the occurrence of *Pilocarpus pennatifolius* (tolerant to shade) as an indicator species evidences that the forest structure provided shading conditions that were favorable to the development of a dense population, with an incidence of the species in all plots of the group. Also, the preference of this species is associated to the group by its form of dispersion (autochory), which, according to Giehl et al. (2007), is effective only for diaspore displacement at short distances and, therefore, hinders the spread of propagules to larger areas.

The preference of the species *Apuleia leiocarpa*, *Helietta apiculata*, and *Machaerium paraguariense* regarding the Altered Forest group is due to environmental characteristics, such as proximity to the edge of the forest, which favored the emergence of these species, classified as climax light-demanding. Moreover, the significant surface stoniness verified in the area possibly acted as a limiting ecological factor for the establishment of other species, but was tolerated by the three indicator species of the group. Such conditions were mentioned by Lorenzi (2008) when describing the environment where the species *Machaerium paraguariense* preferably occurs: in secondary forests and almost always in high rocky terrains, where drainage is swift.

The indicator species of the Altered Forest group are classified as anemochorous, which partially explains their high abundance. This syndrome is favored in more open forests that lack a continuous canopy (Howe & Smallwood, 1982), as observed in some points in the area. According to Morellato & Leitão Filho (1992), the presence of emergent arboreal individuals associated with forest deciduousness may enhance the dispersion of anemochorous diaspores, influencing forest structure.

The majority of the species sampled in the forest occurred in the Middle Stage group (53 species = 93% of the total), with the most abundant species being *Annona neosalicifolia* (50 individuals), *Casearia sylvestris* (44), *Gymnanthes klotzschiana* (41), *Actinostemon concolor* (38), and *Myrocarpus frondosus* (38). In the Advanced Stage group, 38 species (67% of the total) were observed, with *Pilocarpus pennatifolius* as the most significant, with 164 individuals, followed by *Annona neosalicifolia* (20), *Myrocarpus frondosus* (18), and *Casearia sylvestris* (14). In the Altered Forest group, the species *Helietta apiculata* (63), *Machaerium paraguariense* (45), *Sebastiania brasiliensis* (19), and *Apuleia leiocarpa* (12) retained the most substantial number of individuals among the 27 species found in the group (Table 1). The differences in richness may be related to the larger sample area attributed to the Middle Stage when compared to the other groups.

Table 1. Species sampled in a Deciduous Seasonal Forest on the ridge of the Southern Plateau, Jaguari, RS, Brazil.

Family/Species	Number of individuals				SG	DS
	Mid S	Adv S	Alter F	Σ		
Anacardiaceae						
Schinus terebinthifolia Raddi	2	0	0	2	P[6]	Zoo[6]
Annonaceae						
Annona neosalicifolia H.Rainer	50	20	1	71	CL[1]	Zoo[1]
Asteraceae						
Dasyphyllum spinescens (Less.) Cabrera	1	0	0	1	P[1]	Ane[1]
Boraginaceae						
Cordia americana (L.) Gottschling & J.S.Mill.	24	11	7	42	CL[3]	Ane[3]
Cordia ecalyculata Vell.	1	0	0	1	CL[2]	Zoo[2]
Cordia trichotoma (Vell.) Arráb. ex Steud.	3	1	3	7	CL[2]	Ane[1]
Cannabaceae						
Celtis iguanaea (Jacq.) Sarg.	9	3	0	12	P[1]	Zoo[1]
Celastraceae						
Schaefferia argentinensis Speg.	1	7	1	9	CS[6]	Zoo[6]
Ebenaceae						
Diospyros inconstans Jacq.	0	1	0	1	CL[1]	Zoo[1]
Euphorbiaceae						
Actinostemon concolor (Spreng.) Müll.Arg.	38	4	1	43	CS[1]	Aut[1]
Gymnanthes klotzschiana Müll.Arg.	41	2	0	43	CL[4]	Aut[1]
Sebastiania brasiliensis Spreng.	21	11	19	51	CS[6]	Aut[1]
Fabaceae						
Apuleia leiocarpa (Vogel) J.F.Macbr.	4	1	12	17	CL[2]	Ane[2]
Dalbergia frutescens (Vell.) Britton	7	0	0	7	CL[1]	Ane[1]
Enterolobium contortisiliquum (Vell.) Morong	4	5	2	11	CL[1]	Zoo[1]
Holocalyx balansae Micheli	5	4	1	10	CL[5]	Zoo
Machaerium paraguariense Hassl.	8	4	45	57	CL[1]	Ane[1]
Myrocarpus frondosus Allemão	38	18	6	62	CL[2]	Ane[2]
Parapiptadenia rigida (Benth.) Brenan	6	1	4	11	CL[2]	Ane[2]
Senegalia sp.	9	2	0	11	-	-
Lamiaceae						
Vitex megapotamica (Spreng.) Moldenke	1	0	0	1	CL[1]	Zoo[1]
Lauraceae						
Nectandra megapotamica (Spreng.) Mez	7	1	0	8	CL[1]	Zoo[1]
Loganiaceae						
Strychnos brasiliensis Mart.	26	3	1	30	P[4]	Zoo[1]
Malvaceae						
Luehea divaricata Mart. & Zucc.	2	0	1	3	CL[1]	Ane[1]
Meliaceae						
Cabralea canjerana (Vell.) Mart.	1	0	0	1	CL[3]	Zoo[3]
Cedrela fissilis Vell.	0	1	0	1	CL[2]	Ane[2]
Trichilia clausseni C.DC.	33	4	0	37	CS[1]	Zoo[1]
Trichilia elegans A.Juss.	1	0	1	2	CS[1]	Zoo[1]
Moraceae						
Ficus luschnathiana (Miq.) Miq.	3	0	0	3	CL[1]	Zoo[1]
Maclura tinctoria (L.) D. Don ex Steud.	1	0	0	1	CL[4]	Zoo[6]
Sorocea bonplandii (Baill.) W.C. Burger et al.	24	0	0	24	CS[1]	Zoo[1]

Table 1. Continued...

Family/Species	Number of individuals				SG	DS
	Mid S	Adv S	Alter F	Σ		
Myrtaceae						
Eugenia involucrata DC.	2	1	0	3	CS[4]	Zoo[1]
Eugenia rostrifolia D.Legrand	5	1	0	6	CS[4]	Zoo[1]
Eugenia uniflora L.	25	11	1	37	CL[1]	Zoo[1]
Myrcianthes pungens (O.Berg) D. Legrand	3	1	2	6	CS[4]	Zoo[1]
Phytolaccaceae						
Phytolacca dioica L.	2	1	1	4	CL[4]	Zoo[6]
Seguieria aculeata Jacq.	0	4	1	5	CL[2]	Ane[2]
Polygonaceae						
Ruprechtia laxiflora Meisn.	3	0	0	3	CL[1]	Ane[1]
Rubiaceae						
Randia ferox (Cham. & Schltdl.) DC.	4	5	0	9	CL[6]	Zoo[1]
Chomelia obtusa Cham. & Schltdl.	8	1	0	9	CL[3]	Zoo[3]
Rutaceae						
Helietta apiculata Benth.	14	9	63	86	CL[3]	Ane[3]
Pilocarpus pennatifolius Lem.	24	164	3	191	CS[2]	Aut[6]
Zanthoxylum fagara (L.) Sarg.	1	0	0	1	CL[3]	Zoo[1]
Zanthoxylum rhoifolium Lam.	15	0	3	18	CL[2]	Zoo[1]
Salicaceae						
Banara tomentosa Clos	4	0	0	4	CS[1]	Zoo[1]
Casearia decandra Jacq.	1	0	0	1	CS[1]	Zoo[1]
Casearia sylvestris Sw.	44	14	0	58	CL[1]	Zoo[1]
Xylosma pseudosalzmanii Sleumer	2	0	1	3	CL[4]	Zoo[1]
Sapindaceae						
Allophylus edulis (A.St.-Hil. et al.) Hieron. ex Niederl.	6	1	1	8	CL[1]	Zoo[1]
Cupania vernalis Cambess.	12	3	1	16	CL[1]	Zoo[1]
Matayba elaeagnoides Radlk.	1	0	0	1	CL[1]	Zoo[1]
Sapotaceae						
Chrysophyllum gonocarpum (Mart. & Eichler ex Miq.) Engl.	3	0	0	3	CS[1]	Zoo[1]
Chrysophyllum marginatum (Hook. & Arn.) Radlk.	5	2	2	9	CL[1]	Zoo[1]
Sideroxylon obtusifolium (Roem. & Schult.) T.D.Penn.	0	1	0	1	CL[1]	Zoo[1]
Solanaceae						
Brunfelsia uniflora (Pohl) D.Don	2	2	0	4	P	Zoo
Urticaceae						
Urera baccifera (L.) Gaudich. ex. Wedd.	1	1	0	2	P[6]	Zoo[6]
Liana	25	11	3	39	-	-
Overall	**583**	**337**	**187**	**1,107**	-	-

Mid S: Middle Stage; Adv S: Advanced Stage; Alter F: Altered Forest; SG: successional group (P: pioneer; CL: climax light-demanding; CS: climax shade-tolerant); DS: dispersion strategy (Ane: anemochorous; Aut: autochorous; Zoo: zoochorous); [1]: Scipioni et al. (2013); [2]: Santos et al. (2012); [3]: Lindenmaier & Budke (2006); [4]: Vaccaro et al. (1999); [5]: Adenesky-Filho et al. (2017); [6]: Grings & Brack (2009).

The Jaccard similarity index indicated that the Middle and Advanced Stage groups were more similar among each other (Jaccard = 0.60; 34 species in common) and that the lowest floristic similarity was verified between the Middle Stage and Altered Forest groups (0.48). The Advanced Stage and Altered Forest groups retained an index of 0.55. The difference in similarity is related to the presence or absence of the species in the groups. Twenty-two species, including *Helietta apiculata*, *Machaerium paraguariense*, *Myrocarpus frondosus*, *Pilocarpus* *pennatifolius*, and *Sebastiania brasiliensis*, were found in all three groups. In contrast, *Banara tomentosa* and *Ruprechtia laxiflora* and *Cedrela fissilis* and *Sideroxylon obtusifolium* occurred only in the Middle and Advanced Stages, respectively, while species exclusivity was not observed in the Altered Forest group.

In order to determine the degree of species aggregation, by means of the Payandeh index, 42, 24, and 14 species were considered for the Middle Stage, Advanced Stage and Altered Forest groups, respectively (Figure 4). An aggregated pattern was predominant in the arboreal stratum, indicating that most species tend to form population densities in specific areas.

The species *Gymnanthes klotzschiana* (8.29), *Annona neosalicifolia* (7.38), *Myrocarpus frondosus* (6.38), and *Eugenia uniflora* (5.50) were significantly aggregated in the Middle Stage group, and, in the Advanced Stage group, *Schaefferia argentinensis* (3.67) exhibited a higher aggregation index. In turn, the Altered Forest group retained higher values of aggregation of *Machaerium paraguariense* (11.68) and *Sebastiania brasiliensis* (4.32). The more significant aggregation of these species may be influenced by more favorable habitat conditions, such as landform and availability of light and water, species autoecology, and different rates of mortality and recruitment (Capretz et al., 2012; Crawley, 1986; Silva et al., 2012).

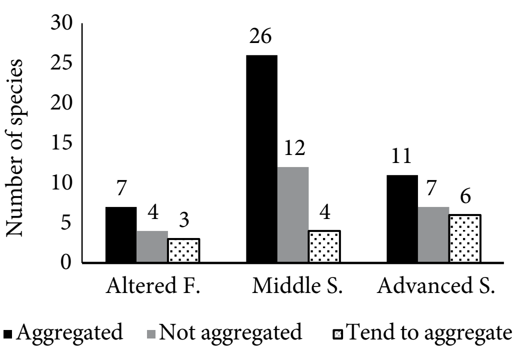

Figure 4. Spatial distribution patterns of arboreal species in floristic groups in a Deciduous Seasonal Forest of the Southern Plateau ridge, Jaguari, RS, Brazil.

The spatial pattern of some species was distinct between the groups. For example, *Gymnanthes klotzschiana* (Middle Stage group = 8.29 – aggregated; Advanced Stage group = 0.94 – not aggregated) and *Machaerium paraguariense* (Middle Stage = 1.57 – grouped; Advanced Stage = 1.35 – tend to aggregate; Altered Forest group = 11.68 – aggregated) occurred in a different manner. The strongly aggregated pattern of *Gymnanthes klotzschiana* in the Middle Stage group may be related to water influence, due to the presence of water bodies adjacent to some plots. According to Silva et al. (2012), such pattern occurs due to the greater tolerance of the species to soils with water excess, which favors recruitment.

Considering the succession categories, it was verified, regarding the totality of the forest, that the CL species occurred in a greater number of individuals (57% of the total forest individuals) and species (63% of the total

Table 2. Number of individuals and species of the successional guilds and dispersion strategies sampled in floristic groups, in a Deciduous Seasonal Forest in Jaguari, RS, Brazil.

Successional guild																		
Group	Pioneer				Climax Light				Climax Shade				Not determined				Total	
	ind	%	sp	%	ind	%	sp	%	ind	%	sp	%	ind	%	sp	%	ind	sp
Mid S	41	7	6	11	348	60	32	60	160	27	13	25	34	6	2	4	583	53
Adv S	9	3	4	11	122	36	24	63	193	57	8	21	13	4	2	5	337	38
Alter F	1	1	1	4	156	83	20	71	27	14	6	21	3	2	1	4	187	28
Overall	51	5	6	11	626	57	36	63	380	34	13	23	50	5	2	4	1107	57
Dispersion strategy																		
Group	Zoochory				Anemochory				Autochory				Not determined				Total	
	ind	%	sp	%	ind	%	sp	%	ind	%	sp	%	ind	%	sp	%	ind	sp
Mid S	315	54	36	68	110	19	11	21	124	21	4	8	34	6	2	4	583	53
Adv S	93	28	23	61	50	15	9	24	181	54	4	11	13	4	2	5	337	38
Alter F	19	10	14	52	142	76	9	33	23	12	3	11	3	2	1	4	187	27
Overall	427	39	38	67	302	27	13	23	328	30	4	7	50	5	2	4	1107	57

Mid S: Middle Stage; Adv S: Advanced Stage; Alter F: Altered Forest; ind: number of individuals; sp: number of species.

species of the forest), followed by CS (34% and 23%, respectively) and P (5% and 11%) species (Table 2).

Regarding the number of species, the three groups had a forest-like pattern, with greater CL richness, followed by CS and P. Similar results were reported by Scipioni et al. (2013) and Callegaro et al. (2014) in the same forest type, where light-demanding climactic species retained larger proportions of individuals and species. The higher floristic representativity of these species was also observed by Abreu et al. (2014), in a Semi-Deciduous Seasonal Forest located in the Chapada dos Guimarães National Park, who attributed this condition to canopy discontinuity due to the valley's rugged relief.

The Middle Stage and Altered Forest groups had a more substantial number of individuals pertaining to the successional CL category, contrasting with the Advanced Stage, where more CS individuals occurred. Such condition can be explained by the abundance of the species *Pilocarpus pennatifolius*, which is a known indicator of the Advanced Stage group, classified as climax shadow-tolerant.

The analyzed forest was primarily composed of species with zoochorous dispersion (67%), a result similar to other forests surveyed in several regions of Brazil, such as the Seasonal Forest in Querência, MT (Stefanello et al., 2010), the Mixed Ombrophylous Forest in Tijucas do Sul, PR (Liebsch & Acra, 2007), and the Dense Ombrophylous Forest in Rio de Janeiro (Carvalho, 2010). Similarly to the forest fragment as a whole, the three groups retained a more considerable richness of zoochorous species, followed by anemochorous and autochorous individuals.

The groups showed discrepancies when the number of individuals was analyzed: the Middle Stage had zoochory as its main syndrome (54%), the Advanced Stage retained autochory (54%), and the Altered Forest, anemochory (76%). The elevated proportion of individuals of the predominant dispersion syndromes was due to the abundance of some species, namely *Pilocarpus pennatifolius* (autochorous), with 164 species in the Advanced Stage, *Helietta apiculata* and *Machaerium paraguariense* (anemochorous), with 108 individuals in the Altered Forest, and *Casearia sylvestris* and *Annona neosalicifolia* (zoochorous), with a total of 94 individuals in the Middle Stage. The numerical predominance of different dispersion strategies in each floristic group evidences that this ecological characteristic was determinant of the differentiation of arboreal communities in the analyzed fragment. Moreover, this result corroborates that of Howe & Smallwood (1982), who stated that the prevalence of a specific dispersal mechanism in a given habitat indicates that dispersion agent pressures and physical conditions influenced species selection.

4. CONCLUSIONS

The presence of three floristic groups with distinct indicator species was detected: Middle Stage (*Casearia sylvestris*); Advanced Stage (*Pilocarpus pennatifolius*), and Altered Forest (*Apuleia leiocarpa, Helietta apiculata*, and *Machaerium paraguariense*). The clusters had a more significant richness of zoochorous species, while the incidence of trees with each dispersion strategy was distinct between the groups, predominating anemochory in the Altered Forest, zoochory in the Middle Stage, and autochory in the Advanced Stage.

The light-demanding climatic species predominated in terms of richness and abundance in the Middle Stage and Altered Forest, while in the Advanced Stage a greater proportion of individuals belonging to the shade-tolerant climatic species was observed. Both aspects used for cluster differentiation showed that the two are floristically and structurally distinct.

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CORRESPONDENCE TO

Camila Andrzejewski

Universidade Federal de Santa Maria, Programa de Pós-Graduação em Engenharia Florestal, Av. Roraima, 1.000, prédio 05D, sala 115, CEP 97105-900, Santa Maria, RS, Brasil.

e-mail: camila_andrzejewski@hotmail.com

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