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FLORISTIC SIMILARITY IN A FOREST-SAVANNAH ECOTONE IN WESTERN BAHIA STATE, BRAZIL

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Resumo

Similaridade florística em um ecótono entre Cerrado e floresta no oeste do estado da Bahia, Brasil. O objetivo deste estudo foi gerar conhecimento sobre áreas de transição entre fitofisionomias para o entendimento e conservação desses ambientes singulares. Dessa forma, analisou-se a existência de diferentes grupamentos florísticos em um gradiente espacial inserido em um ecótono no município de São Desidério, Bahia. Para tanto, estabeleceu-se um transecto de aproximadamente 4,7 km, com orientação de nordeste para sudoeste, ao longo de um gradiente espacial. Doze (12) unidades amostrais, com dimensões de 10x50 m (500 m² cada) foram distribuídas ao longo do transecto. A seguinte metodologia foi empregada: primeiramente, as medidas de similaridade florística entre as parcelas amostrais foram calculadas; em seguida, essas parcelas foram agrupadas e os dados foram apresentados graficamente em um dendrograma (Cluster) e um diagrama de ordenação (nMDS); finalmente, os parâmetros fitossociológicos por grupo ordenado foram obtidos. Os resultados mostraram a presença de três grupamentos: Grupos I, II e III, classificados como savana arborizada, floresta estacional decidual e savana florestada, respectivamente. Os grupamentos florísticos se formaram gradualmente ao longo do gradiente espacial, e a transição entre as fitofisionomias não ocorre de forma abrupta, uma vez que a ordenação por grupos se dá mais por conta da diferença entre a abundância das espécies do que pela sua presença e/ou ausência. O padrão de distribuição das fitofisionomias ao longo do gradiente espacial indica associação com fatores abióticos, como as características pedológicas e o relevo incidentes ao longo do transecto, possivelmente criando um gradiente ambiental.
Palavras-chave: Diversidade beta, ecótono, savana arborizada, floresta estacional decidual, ecologia.

Abstract

This study aimed to generate knowledge about transition areas between phytophysiognomies for the understanding and conservation of these unique environments. Thus, the existence of different floristic groups was analyzed in a spatial gradient of an ecotone in the municipality of São Desidério, state of Bahia, Brazil. To this end, a transect of approximately 4.7 km, with orientation from Northeast to Southwest, was established along a spatial gradient. Twelve (12) 10x50 m sampling plots (500 m² each) were distributed throughout this transect. The following methodology was employed: First, the floristic similarity between the sampling plots was measured. These sampling plots were then grouped and the data were graphically presented in a dendrogram (Cluster analysis) and an ordering diagram (nMDS). Finally, the phytosociological parameters by ordered group were obtained. The results showed the presence of three floristic groups: Groups I, II and III, classified as wooded savannah, seasonal deciduous forest, and forested savannah, respectively. The floristic groups were formed gradually along the spatial gradient, and transition between phytophysiognomies does not occur abruptly, since the ordering by groups is more due to the difference between the abundance of species than to their presence and/or absence. The distribution pattern of the phytophysiognomies along the spatial gradient indicates association with abiotic factors, such as the pedological characteristics and the relief found along the transect, possibly creating an environmental gradient.
Keywords: Beta-diversity, ecotone, savannah, tropical dry forest, ecology.

INTRODUCTION

In northeastern Brazilian states, the Cerrado (wooded savannah) biome presents diverse vegetation landscapes and is closely associated with the existence of ecotonal zones, which are characterized by floristic mixture between vegetation types. As a result, tree communities located relatively close to each other present different floristic and structural characteristics, thus providing this biome with high beta-diversity (WALTER *et al*., 2008).

In the West region of the state of Bahia, seasonal semi-deciduous forest (7.8%), (10.6%), wooded savannah (57.5%), and forested savannah (1,8%) are the main phytophysiognomies present in vegetation use and cover (BORGES; SANO, 2014). Located in the aforementioned region, the municipality of São Desidério has a unique environmental diversity, mainly in the region of the João Rodrigues River karst system, which houses two conservation units (CU) where there is a transition between seasonal deciduous forest on limestone outcrops and wooded savannah on sandstone (UFPR-ITTI, 2020).

Thus, with the aim of generating knowledge about transition areas between phytophysiognomies for the understanding and conservation of these unique environments, this study sought to answer the following questions: 1) Are there different floristic groups in a spatial gradient of an ecotone in the municipality of São Desidério, state of Bahia? 2) Does transition between floristic groups occur abruptly or gradually? 3) Do abiotic factors influence the distribution of floristic groups along this ecotone?

MATERIALS AND METHODS

Study area

The study area is located in the West region of the state of Bahia, in the municipality of São Desidério, micro-basin of the São Desidério River, sub-basin of the High Grande River, which is located in the physiographic region of the Middle São Francisco River (CBHSF, 2016). According to the Köppen climate classification, climate in the region is Aw, thus presenting characteristics of hot and humid tropical climate, with annual rainfall >750 mm, characterized by two seasons: dry (from May to October) and rainy (from November to April) (UFPR-ITTI, 2020).

Regarding vegetation cover, the area is located in a transition between phytophysiognomies of two main vegetation landscapes: savannah, established in a plateau region, consisting mainly of small trees with high incidence of shrubs/subshrubs; deciduous forest, established in rugged relief, usually associated with rocky limestone outcrops (UFPR-ITTI, 2020).

As for geology, the area is located in the Northwest region of the São Francisco Craton geologic province - a thick and stable portion of the continental crust that covers part of the territory of the states of Minas Gerais, Bahia, Goiás, Piauí, Sergipe, Pernambuco, and Tocantins. In the study region, this lithostratigraphic unit is composed of metasedimentary rocks of the São Francisco River Basin that are superimposed by sedimentary rocks. The most representative lithostratigraphic units occurring in the area are the Bambuí Group and the Urucuia Group (DANTAS, 2018; UFPR-ITTI, 2020). Concerning pedology, the region is composed predominantly of latosols and cambisols (BARBOSA *et al*., 2018; UFPR-ITTI, 2020).

Data collection and analysis

For this study, a transect of approximately 4.7 km, with orientation from Northeast to Southwest, was established along a spatial gradient (Figure 1). Twelve (12) 10x50 m sampling plots (500 m² each) were distributed throughout this transect.

Floristic analysis considered all arboreal individuals with diameter at breast height (DBH - 1.30 m above the ground) ≥5.0 cm. Taxonomic information at the species level, as well as total height (*h*), were obtained from all inventoried trees. The Angiosperm Phylogeny Group (APG IV, 2016) botanical classification was used. The botanical nomenclature was verified against the List of Species of the Brazilian Flora electronic database, made available and updated (http://floradobrasil. jbrj. gov.br/), and the Brazil Flora Group (BFG) (2015).

Floristic similarity between the sampling plots, with recording of presence and/or absence and abundance of each tree species, was assessed through application of the Jaccard and Bray-Curtis similarity indexes, respectively, with subsequent cluster analysis by the unweighted pair-group method with arithmetic mean (UPGMA) (LEGENDRE; LEGENDRE, 2012). After that, non-metric multidimensional scaling (nMDS) analysis was used to determine the phytophysiognomies. This analysis was performed from the Bray-Curtis similarity index, applied to the species abundance matrix between the sampling units, and confirmed by 95% confidence ellipse (convex hull) (EISENLOHR et al. 2015; MANLY; NAVARRO ALBERTO, 2017).

Multivariate analysis of similarities (ANOSIM) was conducted to verify whether the composition differed between the clusters. This is a particular type of nonparametric multivariate analysis of variance that measures the difference between two or more groups, from any measure of distance, and then converts these measures into ranks and compares them within and between groups (LEGENDRE; LEGENDRE, 2012).

Additionally, after the clusters were verified and established, the parameters described in Eisenlohr *et al.* (2015) were calculated, namely, absolute (AD) and relative (RD) density, absolute (ADo) and relative (RDo) dominance, absolute (AF) and relative (RF) frequency, and importance value index (IVI).

RESULTS

The 12 sampling plots were calculated from the Jaccard and Bray-Curtis similarity indexes, resulting in a 12x12 matrix where it is assumed that the closer to 1, the more similar the plot is to its pair (Table 1). With the structuring of the similarity matrix, an UPMGA dendrogram was created, and the result showed the presence of three similar groups of sampling plots by both the presence and/or absence (Jaccard) and abundance (Bray-Curtis) methods.

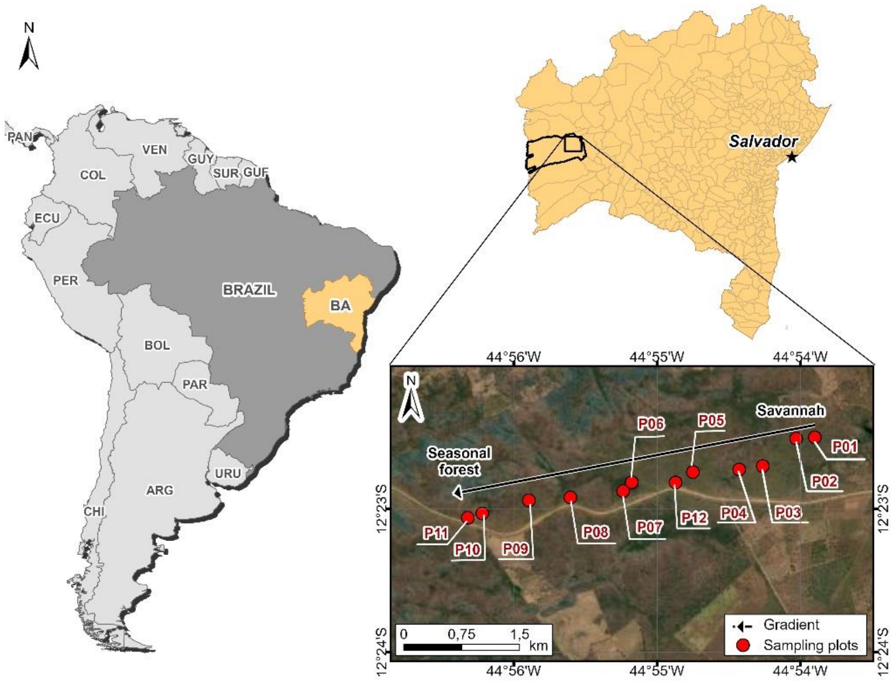
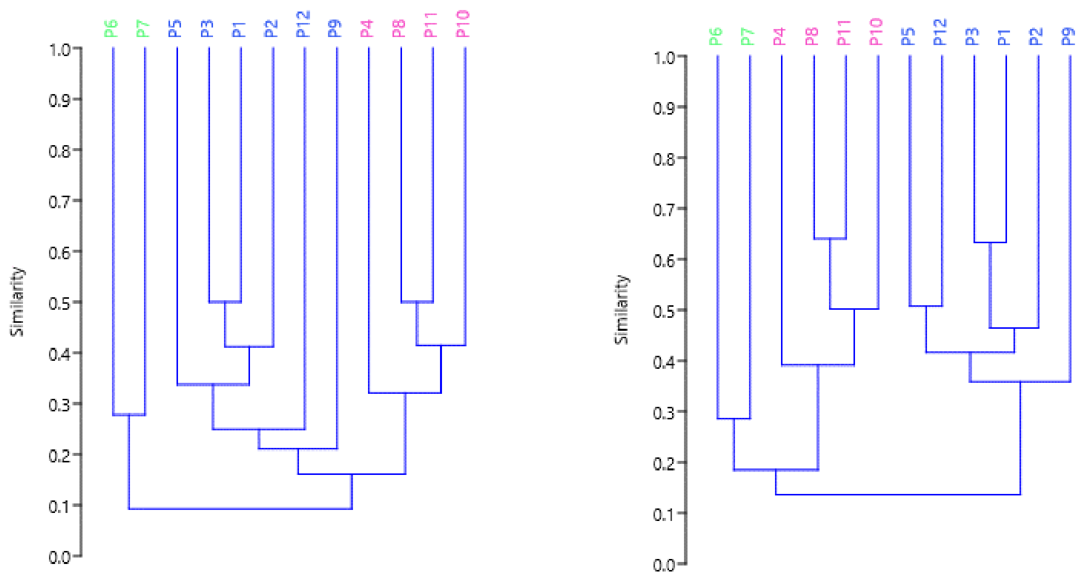


Figura 1. Localização do transecto e espacialização das parcelas amostrais na área de estudo.
Figure 1. Transect localization and spatial distribution of sampling plots in the study area.

Tabela 1. Matriz de similaridade para os índices de Jaccard e Bray-Curtis.
Table 1. Similarity matrix for the Jaccard and Bray-Curtis indexes.

Plot	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
P1	1	0.42	0.63	0.29	0.48	0.00	0.05	0.16	0.35	0.04	0.07	0.40
P2	0.41	1	0.51	0.38	0.42	0.03	0.05	0.32	0.37	0.18	0.23	0.36
P3	0.50	0.41	1	0.34	0.47	0.00	0.03	0.20	0.37	0.04	0.07	0.38
P4	0.29	0.32	0.17	1	0.24	0.25	0.13	0.51	0.30	0.27	0.39	0.31
P5	0.36	0.39	0.27	0.17	1	0.04	0.10	0.18	0.33	0.07	0.11	0.51
P6	0.00	0.04	0.00	0.11	0.05	1	0.29	0.29	0.06	0.19	0.29	0.03
P7	0.12	0.09	0.06	0.12	0.11	0.28	1	0.13	0.18	0.10	0.10	0.18
P8	0.10	0.22	0.16	0.35	0.21	0.18	0.15	1	0.22	0.53	0.64	0.14
P9	0.16	0.25	0.16	0.19	0.25	0.10	0.15	0.27	1	0.06	0.10	0.37
P10	0.08	0.10	0.08	0.30	0.13	0.11	0.08	0.43	0.12	1	0.47	0.04
P11	0.11	0.13	0.11	0.32	0.17	0.14	0.05	0.50	0.19	0.40	1	0.07
P12	0.30	0.23	0.24	0.30	0.23	0.03	0.17	0.11	0.23	0.06	0.08	1

Captions: = Jaccard similarity index; = Bray-Curtis similarity index.



A) B)

Figure 2. Results of cluster analysis by the Jaccard (A) and Bray-Curtis (B) similarity indexes for the 12 sampling plots.

Figura 2. Análise de cluster das 12 parcelas para os índices de Jaccard (A) e Bray-Curtis (B).

The three groups formed resulted from a visual interpretation of the hierarchy associated with the *in loco* knowledge of the spatial gradient where the sampling plots were established. Thus, Group I was composed of Plots 1, 2, 3, 5, 9 and 12; Group II comprised Plots 4, 8, 10 and 11; Group III included Plots 6 and 7. The floristic similarity and vegetation phytophysiognomy of the clustered plots were verified, generating the following classification: Group I - wooded savannah, Group II - seasonal deciduous forest, and Group II - forested savannah (Figure 2). The cophenetic coefficients (CC) were calculated for both dendrograms, and the results showed good clustering correlations for both presence and/or absence (CC=0.88) and abundance (CC=0.85) of species.

Results of the nMDS analysis showed that the groups followed the trend observed in the hierarchical clustering, where both the ordering by presence and/or absence and that by abundance of species presented adequate data clustering, as stress values ranging from 0.10 to 0.16 were observed, demonstrating good ordering of the processed data (Figures 3 and 4). According to the established methodology, ANOSIM was also performed to verify the statistical reliability of the order. Thus, a good correlation was obtained for the orders established by the Jaccard and Bray-Curtis similarity indexes, with R values of 0.87 and 0.95, respectively, considering a total of 9,999 permutations.

In Group I (wooded savannah), an average tree community of 933.3 $ind.ha^{-1}$ was identified, representing an average basal area of 12.3 $m^2.ha^{-1}$. Based on the IVI, these were the most characteristic species of the community: *Eugenia dysenterica* (Mart.) DC. (cagaita), *Astronium urundeuva* (M.Allemão) Engl. (aroeira), *Qualea grandiflora* Mart. (pau-terra), *Copaifera langsdorffii* Desf. (pau-d'óleo), and *Machaerium opacum* Vogel (jacarandá-do-cerrado). Collectively, these five species corresponded to 40.86% of the IVI, 46.07% of the total density, and 50.92% of the total dominance. In addition, this group presented mean DBH of 10.37 cm mean h of 5.8 m.

In Group II (seasonal deciduous forest), an average tree community of 1,170.0 $ind.ha^{-1}$ was observed, corresponding to an average basal area of 20.3 $m^2.ha^{-1}$. According to the IVI, these were the most characteristic species of the community: *Combretum leprosum* Mart. (vaqueteira), *Astronium urundeuva* (M.Allemão) Engl. (aroeira), *Aspidosperma subincanum* Mart. (pereiro), *Anadenanthera colubrina* var. *cebil* (Griseb.) Altschul (angico), and *Callisthene fasciculata* Mart. (tapicuru). Together, these five species represented 51.63% of the IVI, 63.68% of the total density, 60.58% of the total dominance. Also, this group showed average DBH of 11.11 cm and average h of 8.9 m.

In Group III (forested savannah), an average tree community of 660.0 $ind.ha^{-1}$ was found, accounting for an average basal area of 12.29 $m^2.ha^{-1}$. Based on the IVI, these were the most characteristic species of the community: *Combretum leprosum* Mart. (vaqueteira), *Amburana cearensis* (Allemão) A.C.Sm. (amburana-de-cheiro), *Combretum glaucocarpum* Mart. (mofumbo), *Machaerium stipitatum* Vogel (sapuva), and *Zeyheria tuberculosa* (Vell.) Bureau ex Verl. (ipê-tabaco). Collectively, these five species corresponded to 56.41% of the

IVI, 65.15% of the total density, and 70.73% of the total dominance. In addition, this group presented mean DBH of 10.87 cm and mean *h* of 7.4 m.

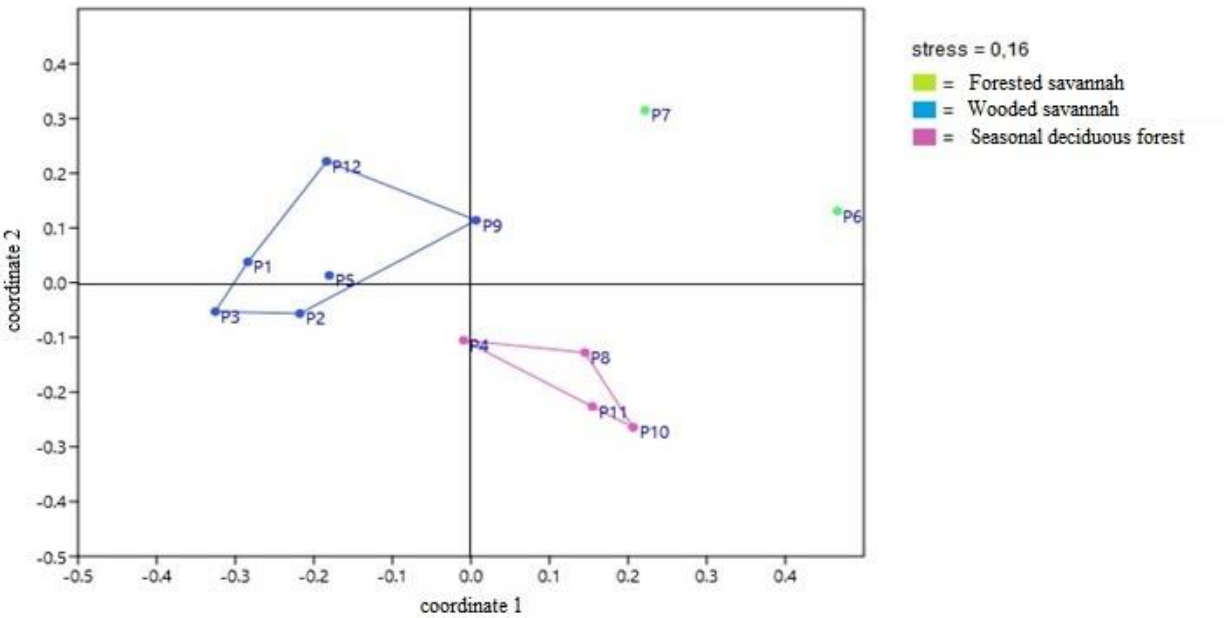


Figure 3. nMDS plot of the 12 samples considering the Jaccard similarity index.
Figura 3. Diagrama de ordenação nMDS para as 12 parcelas, considerando o índice de Jaccard.

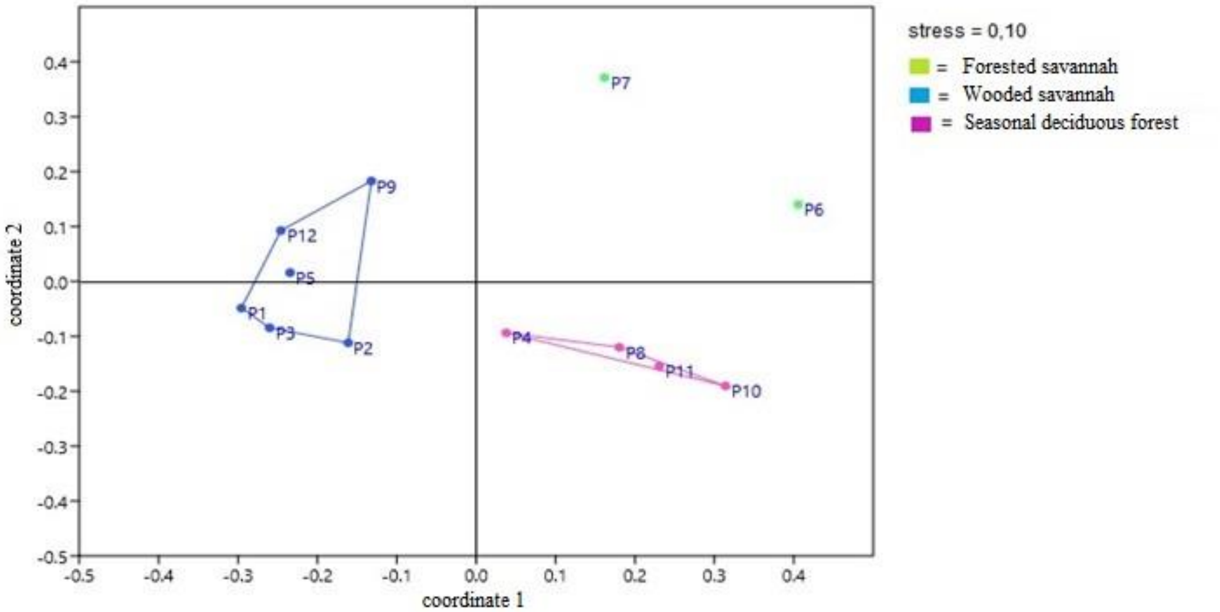


Figure 4. nMDS plot of the 12 samples considering the Bray-Curtis similarity index.
Figura 4. Diagrama de ordenação NMDS para as 12 parcelas considerando o índice de Bray-Curtis.

Table 3. Phytosociological parameters of absolute density (AD) and dominance (ADo) and importance value index (IVI) for the vegetation formations.
Tabela 3. Parâmetros fitossociológicos de densidade, dominância e valor de importância para os grupos I, II e III.

Species	AD			Ado			IVI		
	WS	SDF	FS	WS	SDF	FS	WS	SDF	FS
Combretum leprosum Mart.	-	315.00	130.00	-	3.62	1.67	-	17.01	13.87
Eugenia dysenterica (Mart.) DC.	213.33	65.00	-	2.42	0.44	-	16.52	4.19	-
Amburana cearensis (Allemão) A.C.Sm.	-	-	20.00	-	-	3.49	-	-	11.85
Combretum glaucocarpum Mart.	-	-	70.00	-	-	1.71	-	-	10.94
Machaerium stipitatum Vogel	26.67	5.00	150.00	0.26	0.08	0.72	2.44	0.81	10.92
Astronium urundeuva (M.Allemão) Engl.	80.00	90.00	10.00	1.13	3.06	0.09	8.25	9.21	2.14
Aspidosperma subincanum Mart.	26.67	160.00	10.00	0.15	1.47	0.57	1.76	3.45	9.12
Zeyheria tuberculosa (Vell.) Bureau...	-	-	60.00	-	-	1.11	-	-	8.82
Anadenanthera colubrina var. *cebil* (Gri...	-	105.00	-	-	2.2	-	-	8.76	-
Qualea grandiflora Mart.	86.67	5.00	-	0.91	0.01	-	7.49	0.70	-
Callisthene fasciculata Mart.	3.33	75.00	-	0.01	1.93	-	0.53	7.47	-
Platypodium elegans Vogel	-	-	50.00	-	-	0.66	-	-	7.09
Dalbergia sp.	46.67	-	40.00	0.51	-	0.53	4.23	-	6.23
Machaerium nyctitans (Vell.) Benth.	6.67	55.00	-	0.06	1.35	-	1.18	5.94	-
Copaifera langsdorffii Desf.	3.33	5.00	-	1.42	0.17	-	4.36	0.96	-
Machaerium opacum Vogel	46.67	-	-	0.37	-	-	4.23	-	-
Magonia pubescens A.St.-Hil.	16.67	5.00	-	0.89	0.27	-	4.17	1.12	-
Handroanthus impetiginosus (Mart...	-	-	10.00	-	-	0.78	-	-	4.00
Astronium fraxinifolium Schott	50.00	15.00	-	0.37	0.38	-	3.94	2.67	-
Cordia trichotoma (Vell.) Arráb. ex...	-	35.00	-	-	0.68	-	-	3.74	-
Enterolobium contortisiliquum (Vell.)...	10.00	5.00	-	0.95	1.02	-	3.33	2.36	-
Aspidosperma tomentosum Mart. & Zucc.	23.33	-	-	0.25	-	-	3.06	-	-
Aspidosperma pyrifolium Mart. & Zucc.	3.33	30.00	10.00	0.04	0.29	0.05	0.61	2.95	2.04
Hymenaea courbaril L.	-	-	10.00	-	-	0.36	-	-	2.86
Annona leptopetala (R.E.Fr.) H.Rainer	26.67	20.00	10.00	0.12	0.08	0.02	2.82	1.24	1.96
Sapium glandulosum (L.) Morong	6.67	25.00	-	0.02	0.14	-	1.06	2.56	-
Pseudobombax tomentosum (Mart.)...	-	10.00	-	-	0.93	-	-	2.35	-
Margaritaria nobilis L.f.	-	-	10.00	-	-	0.13	-	-	2.25
Mimosa arenosa (Willd.) Poir.	20.00	-	-	0.12	-	-	2.20	-	-
Eugenia sp.	23.33	-	-	0.20	-	-	2.16	-	-
Cordia glabrata (Mart.) A.DC.	26.67	-	-	0.29	-	-	2.14	-	-
Machaerium acutifolium Vogel	3.33	5.00	10.00	0.04	0.41	0.08	0.62	1.35	2.11
Aspidosperma cylindrocarpon Müll.Arg.	-	25.00	-	-	0.46	-	-	2.01	-
Pterocarpus rohrii Vahl	-	-	10.00	-	-	0.04	-	-	1.99
Alseis sp.	-	5.00	10.00	-	0.05	0.03	-	0.77	1.98
Aspidosperma sp.	-	-	10.00	-	-	0.03	-	-	1.98
Hymenaea stigonocarpa Mart. ex Hayne	13.33	-	-	0.19	-	-	1.77	-	-
Senna macranthera (DC. ex Collad.)...	13.33	-	-	0.03	-	-	1.72	-	-
Erythroxylum caatingae Plowman	10.00	-	-	0.07	-	-	1.72	-	-
Handroanthus ochraceus (Cham.) Mattos	13.33	5.00	-	0.16	0.06	-	1.68	0.78	-
Dilodrendron bipinnatum Radlk.	10.00	-	-	0.05	-	-	1.65	-	-

Luetzelburgia auriculata (Allemao)...	13.33	10.00	-	0.05	0.21	-	1.38	1.16	-
Erythroxylum deciduum A.St.-Hil.	-	10.00	-	-	0.21	-	-	1.16	-
Cordiera macrophylla (K.Schum.)...	13.33	10	-	0.07	0.05	-	1.04	0.90	-
Tabebuia roseoalba (Ridl.) Sandwith	-	10.00	-	-	0.08	-	-	0.96	-
Terminalia argentea Mart. & Zucc.	3.33	10.00	-	0.04	0.06	-	0.61	0.92	-
Sterculia striata A.St.-Hil. & Naudin	-	5.00	-	-	0.08	-	-	0.81	-
Simarouba versicolor A.St.-Hil.	-	5.00	-	-	0.07	-	-	0.80	-
Cochlospermum vitifolium (Willd.)...	-	5.00	-	-	0.06	-	-	0.78	-
Ficus sp.	-	5.00	-	-	0.04	-	-	0.75	-
Pouteria sp.	-	5.00	-	-	0.03	-	-	0.72	-
Maclura tinctoria (L.) D.Don ex Steud.	3.33	-	-	0.04	-	-	0.62	-	-
Zanthoxylum caribaeum Lam.	3.33	-	-	0.02	-	-	0.56	-	-
Lafoensia pacari A.St.-Hil.	3.33	-	-	0.02	-	-	0.56	-	-
Fabaceae	3.33	-	-	0.01	-	-	0.54	-	-
Commiphora leptophloeos (Mart.)...	3.33	-	-	0.01	-	-	0.54	-	-
Psidium myrsinites DC.	3.33	-	-	0.01	-	-	0.53	-	-
Pterodon emarginatus Vogel	3.33	-	-	0.01	-	-	0.53	-	-
Dead individuals	70.00	30.00	30.00	0.98	0.33	0.22	7.49	3.01	3.51

Captions: AD = absolute density (ind.ha^{-1}); ADo = absolute dominance (m².ha^{-1}); IVI = importance value index (%); WS = wooded savannah (Group I); SDF = seasonal deciduous forest (Group II), and FS = forested savannah (Group III).

DISCUSSION

A gradual transition of vegetation cover from savannah to forest, with orientation from Northeast to Southwest, was observed in the transect established in the ecotonal area studied. This visual perception of physiognomic differentiation between the two vegetation covers was verified using a dendrogram (Cluster analysis) and an ordering diagram (nMDS) - both methods considering the Jaccard (presence and/or absence) and Bray-Curtis (abundance) similarity measures, as well as by the analysis of the floristic composition and horizontal structure of the tree community found in each group.

The methodology employed revealed three similar phytophysiognomies: Group I (wooded savannah), composed of Plots 1, 2, 3, 5, 9 and 12; Group II (seasonal deciduous forest), comprising Plots 4, 8, 10 and 11; Group III (forested savannah), including Plots 6 and 7. When the groups are spatialized on the transition gradient established by the transect, a gradual (not abrupt) transition is observed. This finding corroborates the study by Nóbrega and Vilas Boas (2020), who highlight the penetration of forest species in savannah areas, thus configuring a successional process of occupation – often associated with lithological, pedological and topographic changes – that enhances the floristic heterogeneity along the transition gradient.

Generally, along the transition between savannah and forest, attributes such as soil fertility and relative humidity increase towards the forest area, whereas variables such as luminosity are intensified in the savannah area, thus causing a sharp divergence between environmental factors, consequently influencing the distribution of species in this ecotone, hindering the detection and mapping of the tree communities associated with each type of vegetation (SILVA *et al.*, 2019).

In this study, the gradual transition between savannah and forest was verified by ANOSIM, which showed a good correlation for the nMDS orders established by the Jaccard and Bray-Curtis similarity indexes, with R values of 0.87 and 0.95, respectively. In other words, the higher correlation values for similarity according to the abundance of species (Bray-Curtis) along the transect show that they have a greater tendency to transit between the groups and are differentiated by their abundance along the sampling plots, instead of disappearing as they advance towards different typologies. This evidences that the beta-diversity by spatial substitution is more significantly associated with the abundance of species along the transect (ANDERSON, *et al.* 2011). In addition, analysis of the dendrograms evidenced that the clusters found showed great dissimilarity and that, even in an ecotone, it was possible to differentiate convergent floristic behaviors (Groups I, II and III). According to the calculated CC, the ordering was considered satisfactory, with values of 0.88 for the presence and/or absence and 0.85 for the abundance of species (BORCARD *et al.*, 2011).

Considering the floristic composition and the horizontal structure for Group I (wooded savannah), the total density value (933.33 ind.ha^{-1}) found was lower than those reported by Costa *et al.* (2010) and Oliveira *et al.*

(2015). Costa *et al.* (2010) studied two areas of wooded savannah in the municipality of Grão Mogol, state of Minas Gerais, and found total density values of 1,275.51 and 1,580.67 ind.ha^{-1}. Oliveira *et al.* (2015) conducted a study in the municipality of Jaborandi, in the West region of the state of Bahia, and observed a total density value of 951.00 ind.ha^{-1}. The mean basal area (12.29 m².ha^{-1}) found for Group III (forested savannah) was larger than those reported by Oliveira et al. (2015) in the musicality of Jaborandi, state of Bahia, and Assunção *et al.* (2004) in the Federal District, for the same typology, 8.24 and 9.53 m².ha^{-1}, respectively.

As for the average diameter of trees in the forested savannah, the value obtained in this study (10.37 cm) corroborates those observed by Finger and Finger (2015) in the state of Mato Grosso, 10.47 cm, and by Ferreira *et al.* (2015) and Silva Neto *et al.* (2016) in the state of Tocantins, 9.49 and 12.10 cm, respectively, for the same typology.

Still regarding the same vegetation formation - forested savannah, the mean value for the variable *h* observed in this study (7.4 m) was similar to those found by Ribeiro and Walter (2008) (3-6 m) and Silva Neto *et al.* (2016) (5.3 m) in the state of Tocantins, and by Finger and Finger (2015) (4.8 m) in the state of Mato Grosso.

Analysis of the floristic composition and horizontal structure for Group II (seasonal deciduous forest) showed values of 1,170.0 ind.ha^{-1} and 12.29 m².ha^{-1}. Apgaua *et al.* (2014) reported values of 761 ind.ha^{-1} and 16.94 m².ha^{-1} in a study conducted in the municipality of Juvenília, state of Minas Gerais, with the species *Astronium urundeuva* (M.Allemão) Engl. (aroeira), *Anadenanthera colubrina* (Vell.) Brenan (angico), and *Cavanillesia umbellata* Ruiz & Pav. (barriguda) as the most significant of the tree community according to the IVI. Nascimento *et al.* (2004) found values of 662.51 ind.ha^{-1} and 19.36 m².ha^{-1} in a study carried out in the municipality of Monte Alegre, state of Goiás, where the genus *Combretum* sp. and the species *Astronium urundeuva* (M.Allemão) Engl (aroeira) and *Pseudobombax tomentosum* (Mart.) A.Robyns (embiruçú) were the most significant of the tree community based on the IVI.

In Group II, the mean values of DBH and *h* were 11.11 cm and 8.9 m, respectively. Scolforo *et al.* (2008) analyzed 15 fragments of seasonal deciduous forest in the state of Minas Gerais and concluded that the frequency of trees is significantly higher in the smaller diameter classes than in the larger ones, with 5-10 cm as the most expressive diameter class. In this group, tree size can occasionally reach the 165-170 cm class, although most of them are in the 45-50 cm class. As for the variable *h*, most trees are in the 4.5-7.5 m class; some of them can reach 31.5 m, but the vast majority do not exceed 22.5 m.

Group III (forested savannah) is a real ecotone, as arboreal components from both the wooded savannah and the seasonal forest areas were observed, such as *Combretum leprosum* Mart. (vaqueteira), *Astronium urundeuva* (M.Allemão) Engl. (aroeira), *Aspidosperma subincanum* Mart. (pereiro), *Annona leptopetala* (R.E.Fr.) H.Rainer (bananinha), and *Machaerium stipitatum* Vogel (sapuva). Arboreal individuals occurring only within this zone were also found, as in the case of the species *Combretum glaucocarpum* Mart. (mofumbo), *Zeyheria tuberculosa* (Vell.) Bureau ex Verl. (ipê-tabaco), and *Platypodium elegans* Vogel (canzil). The dendrometric structure related to the average DBH and *h* was located between Groups I and II: DBH=10.87 cm and *h*=7.4 m.

CONCLUSIONS

- The results showed the presence of floristic groups (Groups I, II and III) along a spatial gradient of the ecotone studied, thus confirming the premise that there would be different phytophysiognomies along this gradient. The groups were classified as wooded savannah, seasonal deciduous forest, and forested savannah according to the species present in each sampling plot clustered in its respective group (Question 1).
- It is worth noting that the floristic groups were formed gradually along the spatial gradient, and transition between phytophysiognomies does not occur abruptly, since the ordering by groups is more due to the difference between the abundance of species than to their presence and/or absence (Question 2).
- The distribution pattern of the phytophysiognomies along the spatial gradient indicates association with abiotic factors, such as the pedological characteristics and the relief found along the transect, possibly creating an environmental gradient (Question 3). Therefore, further studies are needed to understand the influence of these factors on the formation of clusters in the study area.

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