Structure and floristic relationships between Cerrado *sensu stricto* sites on two types of substrate in northern Cerrado, Brazil

Helena Lara Lemos[1,4], José Roberto Rodrigues Pinto[2], Henrique Augusto Mews[1] & Eddie Lenza[3]

[1]Programa de Pós-graduação em Ciências Florestais, Universidade de Brasília – UnB, CP 4357, CEP 70919-970, Brasília, DF, Brazil
[2]Departamento de Engenharia Florestal, Universidade de Brasília – UnB, CP 4357, CEP 70919-970, Brasília, DF, Brazil
[3]Departamento de Ciências Biológicas, Universidade do Estado de Mato Grosso – UNEMAT, CP 08, CEP 78690-000, Nova Xavantina, MT, Brazil
[4]Corresponding author: Helena Lara Lemos, e-mail: lena_bio@yahoo.com.br

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Abstract: We described and compared the floristic composition, richness, species diversity and structure of the tree-shrub component in pairs of Typical Cerrado (*Cerrado Típico*) and rocky outcrop Cerrado (*Cerrado Rupestre*) in two localities in Tocantins State. In each locality, we set up 10 plots of 20 × 50 m at a site, the *Cerrado Típico* and other *Cerrado Rupestre*, and sampled the individuals with $Db_{30cm} \geq 5$ cm. The rocky outcrop Cerrado did not present any trend towards lower richness and basal area compared to the Cerrado on deep soil. Few species occurred across the four sites and only two important species (*Anacardium occidentale* and *Qualea parviflora*) in the four vegetation structure were common to both environments assessed. Furthermore, the occurrence of habitat-specialist species of rocky outcrops and high altitudes (*Mimosa claussenii*, *Tibouchina papyrus*, *Schwartzia adamantium* and *Wunderlichia cruelsiana*) and the high dissimilarity among sites suggest that altitude is the main responsible for the floristic dissimilarity, followed by the influence of substrate type. Therefore, the information with respect to phytophysiognomy type as a parameter to select areas for conservation, by itself, does not effectively ensure biodiversity preservation, owing to the existing flora heterogeneity not only at local but also at regional scale, revealed by the floristic and structural particularity of each site.
Keywords: *Brazilian savanna, Cerrado Rupestre, Cerrado Típico, conservation, floristic similarity.*

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Resumo: Descrevemos e comparamos a composição florística, a riqueza, a diversidade de espécies e a estrutura do componente arbustivo-arbóreo em pares de Cerrado Típico e Cerrado Rupestre em duas localidades no Estado de Tocantins. Em cada localidade, alocamos 10 parcelas de 20 × 50 m em um sítio de Cerrado Típico e em outro de Cerrado Rupestre e amostramos os indivíduos com $Db_{30cm} \geq 5$ cm. Não identificamos tendência de que o Cerrado sobre solo raso com afloramentos rochosos tivesse riqueza e área basal inferiores ao Cerrado sobre solo profundo. Poucas espécies ocorreram nos quatro sítios e apenas duas espécies (*Anacardium occidentale* e *Qualea parviflora*) importantes para a estruturação das quatro vegetações foram comuns aos dois ambientes analisados. Aliado a isso, a ocorrência de espécies habitat-especialistas de ambientes com afloramentos rochosos e de elevadas altitudes (*Mimosa claussenii*, *Tibouchina papyrus*, *Schwartzia adamantium* e *Wunderlichia cruelsiana*) e a elevada dissimilaridade entre os sítios sugerem a altitude como principal responsável pela dissimilaridade florística, seguida pela influência do tipo de substrato. Assim, a utilização apenas da informação sobre o tipo fitofisionômico como parâmetro para escolha de áreas para conservação não garante a preservação efetiva da biodiversidade devido à heterogeneidade das floras existentes, tanto em escala local como regional, demonstrada pela particularidade florística e estrutural de cada sítio.
Palavras-chave: *Savana brasileira, Cerrado Rupestre, Cerrado Típico, conservação, similaridade florística.*

Introduction

Cerrado is considered the tropical savanna with the world's greatest species richness (Silva et al. 2006), comprising nearly 33% of the Brazilian biodiversity (Aguiar et al. 2004). According to Ribeiro & Walter (2008), the high biodiversity found in the Cerrado biome is partially due to its mosaic of plant formations as well as the different substrates on which the vegetation is established, addition of past climate changes (Oliveira-Filho & Ratter 2002). In spite of this mosaic, the Cerrado is best characterized by the savannic formation locally named Cerrado *sensu stricto*, which occupies nearly 85% of the biome's core area (Eiten 1993). The Cerrado *sensu stricto* was subdivided by Ribeiro & Walter (2008) into *Cerrado Denso* (Dense Cerrado), *Cerrado Típico* (Typical Cerrado), *Cerrado Ralo* (Sparse Cerrado) and *Cerrado Rupestre* (rocky outcrop Cerrado), whereas the first three occur on deep soils and the latter on shallow soils with rocky outcrops and rugged relief.

Several studies assessed phytogeographic patterns in Cerrado *sensu stricto* (Rizzini 1963, Warming 1973, Rizzo 1981, Felfili & Felfili 2001, Ratter et al. 2003, Silva et al. 2006, Costa et al. 2010). Nonetheless, such studies focused on Cerrado *sensu stricto* sites on deep soil and mostly in the core portion of the biome, without considering the vegetation on rocky outcrops and that in peripheral, transitional or regions in contact with adjacent biomes.

Recent floristic and phytogeographic studies conducted in Cerrado *sensu stricto* have focused particularly on *Cerrado Rupestre* sites in Goiás (Lenza et al. 2011, Maracahipes et al. 2011, Santos et al. 2012) and Mato Grosso States (Felfili et al. 2002, Gomes et al. 2011) as well as in the Federal District (Amaral et al. 2006). Gomes et al. (2011) and Abreu et al. (2012) compared the Cerrado *sensu stricto* flora and structure on different substrates. Such authors concluded that, at local scale, the floristic and structure difference between *Cerrado Rupestre* and other types of Cerrado *sensu stricto* is reflex of the substrate on the selection of specialist species in habitats which prefer soils with rocky outcrops, dominating the community structure. Nevertheless, these types of study are very recent in other regions wherein the Cerrado *sensu stricto* on shallow and rocky soils occur, such as the States of Bahia, Minas Gerais and Tocantins, resulting in a gap in knowledge concerning this phytophysiognomy's flora and structure.

The fact that the Tocantins State is located in the most preserved portion of the biome (Sano et al. 2009) and in the zone of contact between Cerrado, Caatinga and Amazon Forest biomes, makes it a major source of scientific information (Instituto... 1992). This State's native vegetation presents 53.4% of its area covered by savannic and grassland formations (Cerrado *sensu lato*), 11.7% by forest formations (seasonal, ombrophilous and those associated with watercourses) and 34.9% by planted and natural pastures as well as anthropized areas, whereas nearly 70% of this State's terrain is suitable for agropastoral activities (Tocantins 2012). As a result, there is an inverse relation between anthropic activity expansion and knowledge regarding its vegetation diversity, floristic composition and structure. On the other hand, few studies have been conducted in the region, within which some were conducted at a single moment and presented characteristics of environmental diagnosis (Brito et al. 2002, Carvalho 2009), while others assessed the vegetation floristic and structure (Santos et al. 2006, Rezende 2007, Martins et al. 2011).

In this context, we described and compared the floristic composition, richness and diversity of species as well as the structure of the tree-shrub component of *Cerrado Típico* and *Cerrado Rupestre* pairs in two localities in Tocantins State in order to answer the following questions: 1) Are there differences in richness and diversity of tree-shrub species between adjacent *Cerrado Típico* and *Cerrado Rupestre* sites? 2) Do both the vegetation floristic composition and structure differ between the studied sites, despite their adjacent location in the landscape? We hope that the answers to the questions can support actions aiming at conserving Cerrado's threatened biodiversity, especially its northern portion.

Material and Methods

Study areas – We selected two localities across the latitudinal gradient of Tocantins State, Brazil (Figure 1). The first locality is in the municipality of Palmas, Central portion of the State and at the margin of the Luiz Eduardo Magalhães Hydroelectric Power Plant lake, at coordinates 10°10'S and 48°16'W (Figure 1). The altitude in the region ranges from 200 to 400 m (Table 2) and the average annual rainfall from 1,800 to 1,900 mm, and the main soil types are Latosols and Plinthosols (Tocantins 2012). The second location is in the municipality of Natividade, southeastern Tocantins, at coordinates 11°41'S and 47°42'W (Figure 1). The altitude ranges from 300 to 1,000 m (Table 2), the average annual rainfall is 1,600 mm and the main soil types are Latosols and Litholic, Fluvic and Quartzarenic Neosols (Tocantins 2012).

1. *Sampling*

In each locality we selected one *Cerrado Típico* site (Palmas = TP and Natividade = TN) and one *Cerrado Rupestre* site (Palmas = RP and Natividade = RN). In each site, we set up 10 plots of 20 × 50 m and measured diameter and height of all tree-shrub individuals with base diameter measured at 30 cm above ground level (Db_{30}) ≥ 5 cm, as recommended by Felfili et al. (2005). We calculated the quadratic diameter of the ramifications (square root of the sum of the diameters' squares) for all individuals with forked stems below the 30 cm, which equal the sum of the sectional areas of the branches as a descriptor of the basal area of the individual (Moro & Martins 2011).

We used the APG III (Angiosperm… 2009) botanical classification system and the taxa names were updated from the *Lista de Espécies da Flora do Brasil* (Jardim… 2013). The botanical material collected will be deposited at HUTO Herbarium, University of Tocantins (UNITINS).

Data analysis – In order to compare species richness among sites we used the rarefaction method based on the number of individuals (Gotelli & Colwell 2001) in software EcoSim 7 (Gotelli & Entsminger 2001) and calculated the *p* value based on the normal distribution Z test (Zar 1999). We also performed the chi-squared test so as to investigate differences in the proportion of exclusive species and those shared among sites in software PAST 2.0 (Hammer et al. 2001). We elaborated Diversity Profiles (Tóthmérész 1995) in order to compare species diversity among sites through the Rényi exponential series in software PAST 2.0 (Hammer et al. 2001). According to Tóthmérész (1995) and Melo (2008), Diversity Profiles generalize the different weights that diversity indices provide to rare species, that is, low abundant, so that they avoid choosing one index to the detriment of the other.

In order to compare the vegetation structure among sites we assessed density and basal area per hectare, and compared diameter and height medians through Kruskal-Wallis and Mann-Whitney U test, respectively, in software PAST 2.0 (Hammer et al. 2001). In addition, we calculated the conventional phytosociological parameters (Mueller-Dombois & Ellenberg, 1974) in software Mata Nativa 2 (CIENTEC 2006).

Furthermore, we performed the TWINSPAN (Two-Way Indicator Species Analysis) classification analysis in software PC-ORD 6 (McCune & Mefford 2011) using the default cutoff level of pseudospecies (0:2:5:10:20). We used this analysis to grouping

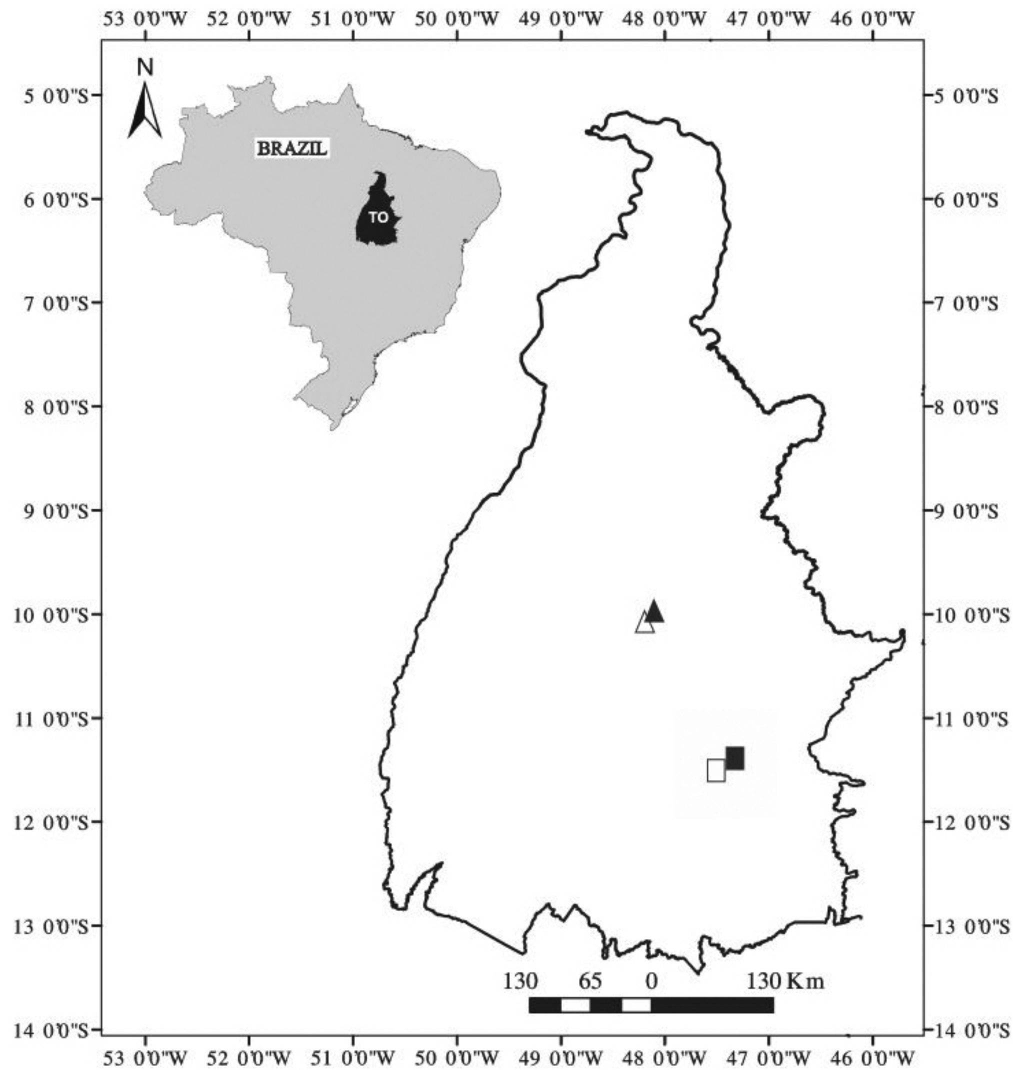

Figure 1. Locations of the Cerrado *sensu stricto* sites sampled on two types of substrate in Tocantins State, Brazil, pointing out the sites: *Cerrado Típico* Palmas (▲), *Cerrado Rupestre* Palmas (Δ), *Cerrado Típico* Natividade (■) and *Cerrado Rupestre* Natividade (□).

the sampling units according to floristic similarities based on species abundance in the plots (Kent & Coker 1992). We tested the consistency of the groups formed by TWINSPAN through ANOSIM (Clarke 1993) with Bray-Curtis coefficient in software PAST 2.0 (Hammer et al. 2001). We calculated the test's significance (p) after 9,999 permutations with sequential Bonferroni correction in the pair to pair p comparison, as suggested by Quinn & Keough (2002).

We used Jaccard similarity index (qualitative) and Bray-Curtis index (quantitative) (Magurran 2011) so as to compare the floristic composition among sites. At last, we conducted the Indicator Species Analysis (ISA) (Dufrêne & Legendre 1997) in software PC-ORD 6 (McCune & Mefford 2011) aiming at identifying species preference among sites. A 5% level of significance was considered in all statistical analyses.

Results

We registered, in the four sites, 144 species distributed in 87 genera and 46 botanical families (Tables 1 and 2). We identified nine species (6.25%) at gender level and four (2.77%) at family level (Table 1). Within the 144 species sampled, 19 (13.19%) were considered of wide regional distribution owing to their occurrence in the four sites, 23 (15.97%) were common to three and 31 (21.53%) to two sites. On the other hand, most species (71 or 49.31%) were considered of restricted distribution since they occurred in only one site. Within the total of species registered, 24 (16.7%) occurred in only one of the 40 plots sampled and, within these, 21 species (14.6%) occurred with only one individual and were locally considered rare.

The *Cerrado Típico* of Natividade (TN) presented the greatest number of exclusive species, followed by RP, TP and RN (Table 2). Moreover, in TN it was also found a greater number of species, while the *Cerrado Rupestre* of Palmas (RP), considering its lower number of individuals, presented higher estimated and observed richness than the *Cerrado Rupestre* of Natividade (RN) and the *Cerrado Típico* of Palmas (TP).

Once the same sampling effort in terms of number of individuals (857 per area) is considered, the estimated richness in TN (S' = 75) was higher than RN (S' = 53; z = -22.00; p < 0.0001) and TP (S' = 61; z = -6.26; p < 0.0001) but lower than RP (S' = 80; z = -2.24; p = 0.0127). In TP, 61 species would be sampled, while 80 in TP (z = -18.12; p < 0.0001) and 53 in RN (z = -7.30; p < 0.0001). Yet, 53 species would be sampled in RN, which is lower than the observed richness in RP (S' = 80; z = 1.10; p < 0.0001). Thus, the following decreasing order of species richness would be registered: RP (80) >

Table 1. Tree-shrub species in Cerrado *sensu stricto* sites sampled on two types of substrate in Tocantins State, Brazil, and their respective phytosociological parameters. RP = *Cerrado Rupestre* Palmas; RN = *Cerrado Rupestre* Natividade; TP = *Cerrado Típico* Palmas; TN = *Cerrado Típico* Natividade; D = Absolute Density (ind.ha^{-1}); F = Absolute Frequency (number of plots of 20 × 50 m, a total of 10 plots per area); DoA = Absolute Dominance in basal area (m^2.ha^{-1}); IVI = Importance Value Index (%).

FAMILY/ SPECIES	RP				RN				TP				TN			
	D	F	DoA	IVI	D	F	DoA	IVI	D	F	DoA	IVI	D	F	DoA	IVI
ANACARDIACEAE																
Anacardium occidentale L.	25	9	0.6788	13.19	36	8	0.5770	13.18	44	9	0.2898	10.95	29	10	1.1616	15.31
Astronium fraxinifolium Schott	-	-	-	-	-	-	-	-	-	-	-	-	3	3	0.0297	1.35
Tapirira guianensis Aubl.	-	-	-	-	-	-	-	-	-	-	-	-	1	1	0.0029	0.39
ANNONACEAE																
Annona coriacea Mart.	-	-	-	-	-	-	-	-	-	-	-	-	1	1	0.0020	0.38
Annona crassiflora Mart.	1	1	0.0326	0.83	-	-	-	-	2	2	0.0119	1.03	-	-	-	-
Xylopia aromatica (Lam.) Mart.	-	-	-	-	-	-	-	-	-	-	-	-	8	3	0.0987	2.36
APOCYNACEAE																
Aspidosperma discolor A.DC.	1	1	0.0250	0.75	-	-	-	-	-	-	-	-	-	-	-	-
Aspidosperma macrocarpon Mart.	4	3	0.0774	2.39	6	3	0.0398	2.36	27	9	0.1410	7.47	-	-	-	-
Aspidosperma multiflorum A.DC.	1	1	0.0127	0.63	-	-	-	-	-	-	-	-	-	-	-	-
Aspidosperma nobile Mull.Arg.	-	-	-	-	-	-	-	-	1	1	0.0033	0.48	-	-	-	-
Aspidosperma sp.	-	-	-	-	-	-	-	-	-	-	-	-	1	1	0.0046	0.40
Aspidosperma tomentosum Mart.	-	-	-	-	-	-	-	-	-	-	-	-	3	3	0.0092	1.17
Hancornia speciosa Gomes	1	1	0.0206	0.71	-	-	-	-	21	8	0.0772	5.76	25	9	0.1209	5.64
Himatanthus obovatus (Mull.Arg.) Woodson	1	1	0.0058	0.56	3	3	0.0162	1.82	-	-	-	-	1	1	0.0072	0.43
ARALIACEAE																
Schefflera vinosa (Cham. and Schltdl.) Frodin and Fiaschi	3	2	0.0272	1.39	-	-	-	-	-	-	-	-	-	-	-	-
ARECACEAE																
Syagrus comosa (Mart.) Mart.	13	6	0.0927	4.75	-	-	-	-	-	-	-	-	1	1	0.0054	0.41
Syagrus flexuosa (Mart.) Becc.	5	4	0.0252	2.37	-	-	-	-	-	-	-	-	3	3	0.0123	1.20
ASTERACEAE																
Asteraceae NI	-	-	-	-	3	3	0.0103	1.76	-	-	-	-	-	-	-	-
Piptocarpha rotundifolia (Less.) Baker	5	2	0.0325	1.68	-	-	-	-	4	2	0.0135	1.25	-	-	-	-
Wunderlichia cruelsiana Taub.	-	-	-	-	9	6	0.2206	5.88	-	-	-	-	-	-	-	-
BIGNONIACEAE																
Handroanthus ochraceus (Cham.) Mattos	6	4	0.0724	2.96	1	1	0.0072	0.62	11	6	0.0568	3.84	-	-	-	-
Handroanthus serratifolius (A.H.Gentry) S.Grose	3	3	0.0390	1.89	-	-	-	-	-	-	-	-	-	-	-	-
Tabebuia aurea (Silva Manso) Benth. and Hook.f. ex S.Moore	-	-	-	-	-	-	-	-	-	-	-	-	1	1	0.0046	0.40
BURSERACEAE																
Protium heptaphyllum (Aubl.) Marchand	-	-	-	-	-	-	-	-	-	-	-	-	1	1	0.0025	0.38
CALOPHYLLACEAE																
Kielmeyera coriacea Mart. and Zucc.	2	2	0.0096	1.10	1	1	0.0026	0.58	11	5	0.0416	3.31	1	1	0.0019	0.38
Kielmeyera lathrophyton Saddi	2	1	0.0093	0.71	5	2	0.0322	1.73	37	10	0.2730	10.40	-	-	-	-
Kielmeyera rubriflora Cambess.	2	2	0.0064	1.06	-	-	-	-	35	9	0.1340	8.16	-	-	-	-
CARYOCARACEAE																
Caryocar coriaceum Wittm.	10	3	0.5797	8.14	-	-	-	-	27	8	0.3331	9.46	23	9	0.8076	11.45
CELASTRACEAE																
Plenckia populnea Reissek	-	-	-	-	45	9	0.4107	12.81	-	-	-	-	2	2	0.0057	0.77
Salacia crassifolia (Mart. Ex Schult.) G.Don	1	1	0.0127	0.63	8	6	0.0844	4.38	4	3	0.0101	1.55	8	4	0.0532	2.25
CHRYSOBALANACEAE																
Couepia grandiflora (Mart. and Zuuc.) Benth.	-	-	-	-	51	9	0.7492	16.91	-	-	-	-	1	1	0.0072	0.43
Hirtella ciliata Mart. and Zucc.	4	2	0.0346	1.58	-	-	-	-	24	8	0.1030	6.36	-	-	-	-
COMBRETACEAE																
Terminalia argentea Mart.	-	-	-	-	-	-	-	-	-	-	-	-	1	1	0.0046	0.40
Terminalia fagifolia Mart.	-	-	-	-	6	2	0.0732	2.26	-	-	-	-	-	-	-	-
CONNARACEAE																
Connarus suberosus Planch.	23	7	0.1083	6.45	7	6	0.0332	3.75	12	5	0.0884	3.98	8	6	0.0342	2.64
Rourea induta Planch.	37	8	0.1454	8.84	5	1	0.0129	1.09	2	2	0.0048	0.94	7	4	0.0239	1.91
DILLENIACEAE																

Table 1. Continued...

FAMILY/ SPECIES	RP				RN				TP				TN			
	D	F	DoA	IVI	D	F	DoA	IVI	D	F	DoA	IVI	D	F	DoA	IVI
Curatella americana L.	-	-	-	-	-	-	-	-	-	-	-	-	82	10	0.9020	17.43
Davilla grandiflora A.St.-Hil.	-	-	-	-	-	-	-	-	-	-	-	-	2	2	0.0064	0.78
Davilla elliptica A.St.-Hil.	65	8	0.3730	14.40	-	-	-	-	15	5	0.0504	3.81	29	9	0.1037	5.82
EBENACEAE																
Diospyros coccolobifolia Mart. ex Miq.	2	2	0.0166	1.17	-	-	-	-	3	2	0.0157	1.18	-	-	-	-
Diospyros hispida A.DC.	15	5	0.1033	4.70	1	1	0.0026	0.58	3	2	0.0250	1.29	47	10	0.2874	9.19
ERYTHROXYLACEAE																
Erythroxylum deciduum A. St.-Hil	-	-	-	-	-	-	-	-	-	-	-	-	5	4	0.0285	1.78
Erythroxylum sp. 1	1	1	0.0065	0.57	-	-	-	-	-	-	-	-	-	-	-	-
Erythroxylum sp. 2	-	-	-	-	-	-	-	-	-	-	-	-	1	1	0.0032	0.39
Erythroxylum suberosum A. St.-Hil.	11	6	0.0411	4.00	20	8	0.0632	6.26	8	3	0.0243	2.11	1	1	0.0024	0.38
Erythroxylum tortuosum Mart.	-	-	-	-	1	1	0.0023	0.57	-	-	-	-	15	9	0.0474	4.17
EUPHORBIACEAE																
Manihot sp.	-	-	-	-	-	-	-	-	3	2	0.0076	1.08	-	-	-	-
FABACEAE																
Andira cujabensis Benth.	3	2	0.0917	2.04	-	-	-	-	13	5	0.1507	4.83	-	-	-	-
Andira vermifuga (Mart.) Benth.	7	2	0.0486	2.07	7	5	0.1892	4.91	25	8	0.1552	7.10	3	3	0.0488	1.51
Bowdichia virgilioides Kunth	5	3	0.0756	2.49	9	6	0.1931	5.60	29	9	0.2113	8.52	10	7	0.0770	3.46
Cenostigma tocantinum Ducke	-	-	-	-	-	-	-	-	3	1	0.0077	0.73	-	-	-	-
Chamaecrista orbiculata (Benth.) H.S.Irwin and Barneby	-	-	-	-	3	1	0.0099	0.85	-	-	-	-	-	-	-	-
Copaifera coriacea Mart.	1	1	0.0316	0.82	-	-	-	-	10	3	0.0307	2.39	-	-	-	-
Copaifera langsdorffii Desf.	-	-	-	-	8	4	0.1805	4.47	-	-	-	-	1	1	0.0027	0.39
Dalbergia miscolobium Benth.	-	-	-	-	-	-	-	-	19	8	0.0883	5.70	-	-	-	-
Dimorphandra gardneriana Tul.	13	6	0.1023	4.84	-	-	-	-	43	10	0.3231	11.60	8	4	0.0341	2.08
Dimorphandra mollis Benth.	1	1	0.0030	0.53	-	-	-	-	-	-	-	-	-	-	-	-
Dipteryx alata Vogel	1	1	0.0097	0.60	-	-	-	-	-	-	-	-	-	-	-	-
Enterolobium gummiferum (Mart.) J.F.Macbr.	-	-	-	-	-	-	-	-	1	1	0.0021	0.47	1	1	0.0140	0.49
Hymenaea courbaril L.	1	1	0.0046	0.55	-	-	-	-	-	-	-	-	-	-	-	-
Hymenaea stigonocarpa Mart. Ex Hayne	16	6	0.1774	5.95	2	2	0.0238	1.35	-	-	-	-	9	5	0.0538	2.61
Machaerium acutifolium Vogel	-	-	-	-	-	-	-	-	-	-	-	-	5	4	0.0852	2.28
Machaerium opacum Vogel	-	-	-	-	1	1	0.0024	0.58	-	-	-	-	6	5	0.1516	3.22
Martiodendron mediterraneum (Mart. Ex Benth.) R.C.Koeppen	-	-	-	-	-	-	-	-	5	1	0.0166	1.04	-	-	-	-
Mimosa claussenii Benth.	-	-	-	-	1	1	0.0033	0.59	-	-	-	-	-	-	-	-
Plathymenia reticulata Benth.	3	2	0.0751	1.87	-	-	-	-	24	7	0.1356	6.42	6	5	0.0680	2.49
Pterodon emarginatus Vogel	-	-	-	-	-	-	-	-	5	3	0.0210	1.78	-	-	-	-
Pterodon pubescens (Benth.) Benth.	-	-	-	-	1	1	0.0424	0.99	-	-	-	-	8	6	0.1274	3.45
Stryphnodendron adstringens (Mart.) Coville	-	-	-	-	-	-	-	-	1	1	0.0024	0.47	-	-	-	-
Stryphnodendron rotundifolium Mart.	1	1	0.0079	0.58	-	-	-	-	-	-	-	-	2	2	0.0124	0.83
Tachigali aurea Tul.	14	7	0.0995	5.32	33	5	0.4115	9.81	4	2	0.0167	1.29	28	10	0.2576	7.36
Tachigali vulgaris L.G. Silva and H. C. Lima	-	-	-	-	-	-	-	-	26	6	0.1870	6.89	72	10	0.8200	15.89
Vatairea macrocarpa (Benth.) Ducke	1	1	0.0095	0.60	2	2	0.0243	1.35	34	9	0.1351	8.08	7	4	0.0337	1.99
ICACINACEAE																
Emmotum nitens (Benth.) Miers	2	1	0.0269	0.89	1	1	0.0595	1.17	24	6	0.3949	9.23	1	1	0.0024	0.38
LAMIACEAE																
Vitex polygama Cham.	1	1	0.0147	0.65	-	-	-	-	-	-	-	-	-	-	-	-
LAURACEAE																
Lauraceae NI	-	-	-	-	-	-	-	-	2	1	0.0043	0.59	-	-	-	-
LOGANIACEAE																
Strychnos pseudoquina A.St.-Hil.	4	2	0.0711	1.95	-	-	-	-	4	3	0.0569	2.12	-	-	-	-
LYTHRACEAE																
Lafoensia pacari A.St.-Hil	1	1	0.0115	0.62	5	1	0.0592	1.56	-	-	-	-	9	6	0.0229	2.62
MALPIGHIACEAE																
Banisteriopsis latifolia (A.Juss.) B.Gates	-	-	-	-	18	6	0.1330	5.88	-	-	-	-	-	-	-	-
Byrsonima coccolobifolia Kunth	2	2	0.0308	1.31	28	7	0.1764	7.78	38	10	0.1634	9.16	85	10	0.4630	13.86

Table 1. Continued...

FAMILY/ SPECIES	RP				RN				TP				TN			
	D	F	DoA	IVI	D	F	DoA	IVI	D	F	DoA	IVI	D	F	DoA	IVI
Byrsonima crassifolia (L.) Kunth	-	-	-	-	-	-	-	-	1	1	0.0131	0.60	-	-	-	-
Byrsonima pachyphylla A.Juss.	75	10	0.7706	20.33	35	5	0.1778	7.60	9	4	0.0311	2.64	41	10	0.2648	8.50
Byrsonima verbascifolia (L.) DC.	-	-	-	-	2	1	0.0074	0.73	2	2	0.0052	0.95	1	1	0.0286	0.61
Heteropterys byrsonimifolia A. Juss.	25	6	0.1404	6.63	8	6	0.0476	4.00	2	1	0.0046	0.60	20	8	0.0688	4.49
MALVACEAE																
Eriotheca gracilipes (K.Schum.) A. Robyns	1	1	0.0039	0.54	26	7	0.2133	7.96	4	2	0.0434	1.61	1	1	0.0115	0.46
Eriotheca pubescens (Mart. and Zucc.) Schott and Encl.	-	-	-	-	-	-	-	-	-	-	-	-	2	2	0.0126	0.84
Eriotheca sp.	6	4	0.1712	3.95	-	-	-	-	-	-	-	-	-	-	-	-
Pseudobombax longiflorum (Mart. and Zucc.) A.Robyns	-	-	-	-	-	-	-	-	-	-	-	-	4	4	0.0341	1.75
MARCGRAVIACEAE																
Schwartzia adamantium (Cambess.) Bedell ex Gir.-Cañas	-	-	-	-	33	9	0.8944	16.60	-	-	-	-	-	-	-	-
MELASTOMATACEAE																
Miconia albicans (Sw.) Triana	8	4	0.0377	2.85	-	-	-	-	2	2	0.0049	0.94	2	2	0.0065	0.78
Miconia ferruginata DC.	13	5	0.0929	4.37	8	2	0.0675	2.40	-	-	-	-	3	1	0.0364	0.84
Miconia leucarpa DC.	1	1	0.0020	0.52	-	-	-	-	-	-	-	-	-	-	-	-
Mouriri cf. *guianensis* Aubl.	-	-	-	-	-	-	-	-	-	-	-	-	3	3	0.0373	1.41
Mouriri pusa Gardner	1	1	0.0183	0.68	-	-	-	-	31	9	1.4586	23.92	-	-	-	-
Tibouchina papyrus (Pohl) Toledo	-	-	-	-	39	7	0.2072	9.21	-	-	-	-	-	-	-	-
MORACEAE																
Brosimum gaudichaudii Trécul	-	-	-	-	-	-	-	-	-	-	-	-	4	3	0.0091	1.25
MYRTACEAE																
Eugenia aurata O.Berg.	-	-	-	-	5	2	0.0232	1.64	-	-	-	-	-	-	-	-
Eugenia dysenterica DC.	-	-	-	-	-	-	-	-	-	-	-	-	6	4	0.0377	1.94
Myrcia cf. *guianensis* (Aubl.) DC.	-	-	-	-	-	-	-	-	-	-	-	-	13	8	0.1095	4.27
Myrcia cf. *multiflora* (Lam.) DC.	-	-	-	-	-	-	-	-	-	-	-	-	3	2	0.0256	1.03
Myrcia cf. *tomentosa* (Aubl.) DC.	-	-	-	-	-	-	-	-	-	-	-	-	5	3	0.0294	1.51
Myrcia multiflora (Lam.) DC.	21	4	0.2477	6.47	-	-	-	-	-	-	-	-	-	-	-	-
Myrcia splendens (Sw.) DC.	6	3	0.1247	3.10	9	5	0.0532	3.70	113	10	0.7006	23.06	9	3	0.0399	1.93
Psidium myrsinites DC.	86	10	0.8132	22.04	10	4	0.0501	3.32	-	-	-	-	20	8	0.1129	4.88
Psidium guianeense Sw.	-	-	-	-	34	8	0.1406	8.47	-	-	-	-	-	-	-	-
NYCTAGINACEAE																
Guapira graciliflora (Mart. Ex Schmidt) Lundell	-	-	-	-	3	3	0.0244	1.90	28	6	0.0931	5.95	-	-	-	-
Neea theifera Oerst.	1	1	0.0035	0.54	-	-	-	-	-	-	-	-	-	-	-	-
OCHNACEAE																
Ouratea castaneifolia (DC.) Engl.	1	1	0.0064	0.56	-	-	-	-	-	-	-	-	-	-	-	-
Ouratea riedeliana Engl.	2	2	0.0114	1.11	-	-	-	-	-	-	-	-	-	-	-	-
Ouratea hexasperma (A.St.-Hil.) Baill.	24	8	0.2090	7.97	5	2	0.0182	1.59	43	9	0.2242	10.05	39	9	0.1655	7.19
Ouratea spectabilis (Mart.) Engl.	4	4	0.0168	2.17	-	-	-	-	-	-	-	-	-	-	-	-
OLACACEAE																
Heisteria ovata Benth.	2	1	0.0100	0.72	-	-	-	-	7	4	0.0221	2.33	-	-	-	-
OPILIACEAE																
Agonandra brasiliensis Miers ex Benth. & Hook.f.	6	3	0.0281	2.13	1	1	0.0056	0.61	4	2	0.0098	1.20	-	-	-	-
PROTEACEAE																
Roupala montana Aubl.	2	2	0.0184	1.18	-	-	-	-	3	1	0.0076	0.73	-	-	-	-
RUBIACEAE																
Chomelia ribesioides Benth. ex A.Gray	23	7	0.2042	7.42	4	3	0.0181	1.94	-	-	-	-	-	-	-	-
Cordiera cf. *elliptica* (Cham.) Kuntze	-	-	-	-	23	7	0.1164	6.66	-	-	-	-	-	-	-	-
Ferdinandusa elliptica (Pohl) Pohl	5	2	0.1256	2.61	9	2	0.0518	2.34	-	-	-	-	29	8	0.1894	6.29
Palicourea rigida Kunth	4	2	0.0215	1.45	-	-	-	-	-	-	-	-	2	2	0.0064	0.78
Rubiaceae 1	7	3	0.0364	2.33	-	-	-	-	-	-	-	-	-	-	-	-
Rubiaceae 2	-	-	-	-	-	-	-	-	-	-	-	-	2	2	0.0074	0.79
Tocoyena formosa (Cham. and Schltdl.) K. Schum.	12	5	0.0586	3.91	-	-	-	-	1	1	0.0032	0.48	3	3	0.0090	1.17

Table 1. Continued...

FAMILY/ SPECIES	RP				RN				TP				TN			
	D	F	DoA	IVI	D	F	DoA	IVI	D	F	DoA	IVI	D	F	DoA	IVI
SALICACEAE																
Casearia sylvestris Sw.	9	5	0.0361	3.33	-	-	-	-	-	-	-	-	7	5	0.0257	2.20
SAPINDACEAE																
Magonia pubescens A.St.-Hil.	-	-	-	-	-	-	-	-	3	1	0.0080	0.74	6	4	0.0605	2.14
SAPOTACEAE																
Pouteria ramiflora (Mart.) Radlk.	-	-	-	-	8	2	0.1230	2.97	29	7	0.2475	8.27	21	9	0.1325	5.41
Pouteria sp. 1	-	-	-	-	-	-	-	-	2	2	0.0130	1.04	-	-	-	-
Sapotaceae 1	1	1	0.0027	0.53	-	-	-	-	-	-	-	-	-	-	-	-
SIMAROUBACEAE																
Simarouba versicolor A. St.-Hil.	4	2	0.0294	1.53	-	-	-	-	-	-	-	-	3	3	0.0112	1.19
SOLANACEAE																
Solanum lycocarpum A. St.-Hil.	-	-	-	-	-	-	-	-	-	-	-	-	1	1	0.0022	0.38
STYRACACEAE																
Styrax ferrugineus Nees and Mart.	-	-	-	-	2	2	0.0116	1.22	1	1	0.0026	0.47	-	-	-	-
SYMPLOCACEAE																
Symplocos sp. 1	-	-	-	-	-	-	-	-	-	-	-	-	1	1	0.0072	0.43
URTICACEAE																
Cecropia pachystachya Trécul	1	1	0.0101	0.60	-	-	-	-	-	-	-	-	-	-	-	-
Cecropia sp. 1	1	1	0.0039	0.54	-	-	-	-	-	-	-	-	-	-	-	-
VELLOZIACEAE																
Vellozia squamata Pohl	3	1	0.0144	0.88	204	10	1.0357	35.67	-	-	-	-	17	5	0.0604	3.33
VOCHYSIACEAE																
Callisthene cf. *minor* Mart	17	5	0.4434	8.36	22	2	0.2534	5.73	11	3	0.0467	2.68	-	-	-	-
Callisthene major Mart and Zucc.	-	-	-	-	-	-	-	-	-	-	-	-	91	8	0.5357	14.43
Qualea grandiflora Mart.	16	4	0.2247	5.66	-	-	-	-	7	4	0.0927	3.19	148	10	1.5295	28.35
Qualea multiflora Mart.	-	-	-	-	-	-	-	-	-	-	-	-	1	1	0.0042	0.40
Qualea parviflora Mart.	94	10	1.9008	33.91	103	10	1.6009	31.37	39	9	0.6906	15.34	92	10	1.3964	22.57
Salvertia convallariodora A.St.-Hil.	28	7	0.4524	10.50	-	-	-	-	9	4	0.2023	4.73	22	7	0.3617	6.93
Vochysia cinnamomea Pohl	-	-	-	-	-	-	-	-	66	10	0.4719	15.67	-	-	-	-
Vochysia elliptica Mart.	-	-	-	-	-	-	-	-	-	-	-	-	9	4	0.0370	2.19
Vochysia gardneri Warm.	23	5	0.1598	6.21	77	9	0.6921	18.93	-	-	-	-	-	-	-	-
Vochysia rufa Mart.	3	2	0.0170	1.29	-	-	-	-	-	-	-	-	3	2	0.0087	0.88
Vochysia thyrsoidea Pohl	-	-	-	-	-	-	-	-	-	-	-	-	4	4	0.0122	1.56
Total	**857**	**-**	**9.9469**	**-**	**997**	**-**	**9.6797**	**-**	**1.021**	**-**	**8.2042**	**-**	**1.210**	**-**	**11.4828**	**-**

Table 2. Characteristics of the tree-shrub vegetation in the Cerrado *sensu stricto* sites sampled on two types of substrate in Tocantins State, Brazil. Alt. = Minimum and maximum altitude, S = Number of observed species, S' = Number of estimated species, G = genera, F = families, D = individuals, AB = basal area and Se = exclusive species to each site.

SITES	Alt. (m)	S	S'	G	F	D (ind.ha^{-1})	AB (m^2)	Se
Cerrado Típico Palmas (TP)	225-238	62	61 (±1.1)	51	32	1,021	8.20	11 (7.64%)
Cerrado Rupestre Palmas (RP)	374-414	80	80 (±0.0)	58	36	857	9.95	20 (13.89%)
Cerrado Típico Natividade (TN)	338-351	82	75 (±5.0)	61	33	1,210	11.48	29 (20.14%)
Cerrado Rupestre Natividade (RN)	491-847	54	53 (±1.2)	49	27	997	9.68	11 (7.64%)
Total	–	**144**	–	**87**	**46**	**4,085**	**39.31**	–

TN (75) > TP (61) > RN (54), evincing that there is no trend towards higher observed and estimated richness in *Cerrado Típico* sites compared to *Cerrado Rupestre* (Table 2).

The Diversity Profiles analysis reinforced the particularity of each site, since three out of four curves crossed each other (Figure 2), showing that the communities are not comparable in terms of diversity according to Tóthmérész (1995). RN was the less diverse, regardless of the diversity metric considered (Figure 2), while TN, RN and TP alternate in position with the increase in equability weight (*alpha*) in the diversity calculation.

Density ranged from 857 to 1,210 individuals per hectare across the sites, whereas we registered the lowest and greatest values in *Cerrado Rupestre* sites. Moreover, the *Cerrado Típico* sites had the highest value (TN = 11.48 m^2.ha^{-1}), as well as the lowest value (TP = 8.20 m^2.ha^{-1}) of basal area (Table 1). Diameter medians were higher in *Cerrado Rupestre* sites than *Cerrado Típico* (Kruskal-Wallis, Hc = 135.2; $p < 0.05$; Mann-Whitney test, $p < 0.05$). On the other hand, height medians were greater in *Cerrado Típico* sites (Kruskal-Wallis, Hc = 342.2; $p < 0.05$; Mann-Whitney test, $p < 0.05$), that is, *Cerrado Rupestre* plants tended to be thicker and smaller than *Cerrado Típico* plants.

With respect to the phytosociological parameters, the 10 species with the highest Importance Value Indices (IVIs) accounted for 46% (TP), 54% (RP), 59% (TN) and 66% (RN) of the total density, 63% (TP), 64% (RP), 71% (TN) and 69% (RN) of the total dominance and 31% (TP), 30% (RP), 27% (TN) and 38% (RN) of the frequency in the four sites. Such species, altogether, accounted for 46%, 49%, 52% and 58% of total IVI total of the TP, RP, TN and RN, respectively (Table 1). When the 10 species with the highest IVI in TP and TN are compared to those in RN and RP, we verified that only *Anacardium occidentale* L. and *Qualea parviflora* Mart. occur in both environments. Apart from *Caryocar coriaceum* Wittm., which occurred in three sites (TP, TN and RP), no other species within the 10 species with highest IVI occur in more than one site.

The classification analysis presented consistent results with eigenvalues higher than 0.4. The first division separated most RN plots from the other sites (RP, TP and TN), except for the plot RN12, which remained with the RP group in the third division (Figure 3). The second division separated TP plots from the others (RP and TN), except for the plot RP01, which remained with the TP group in the second division. The third division separated the TN plots from RP plots and from the plot RN12 (Figure 3). The separations by TWINSPAN analysis generated consistent groups according to ANOSIM ($p = 0.0001$), with high dissimilarity between the groups ($R = 0.90$).

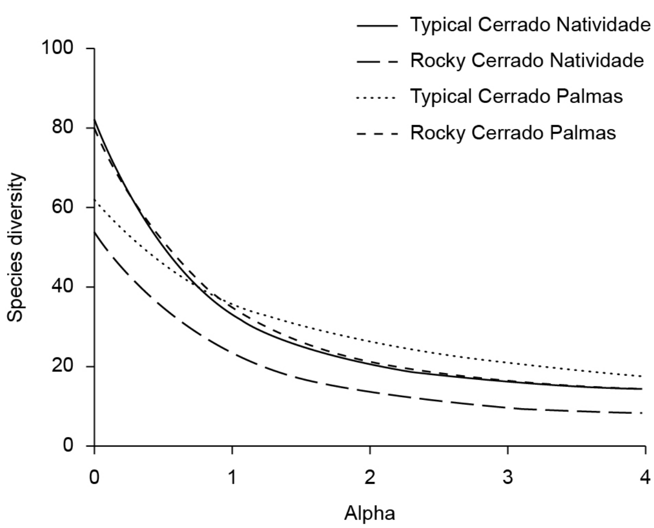

Figure 2. Diversity Profiles of tree-shrub species sampled in Cerrado *sensu stricto* sites on two types of substrate in Tocantins State, Brazil.

The qualitative (Jaccard) and quantitative (Bray-Curtis) similarity indices were low (< 0.45) between the four sites. However, TN and RP presented higher similarity to each other than to the other sites. In addition to this result, we verified that within the 144 species sampled, 66 (45.8%) presented preference for TP, 12 (8%) for RP, 19 (13%) for TN and 13 (9%) for RN (Table 3).

Discussion

The similarity in terms of richness verified among *Cerrado Típico* and *Cerrado Rupestre* sites corroborates the results of studies indicating that the Cerrado *sensu stricto* on deep soils does not present species richness higher than those on shallow and rocky soils (Pinto et al. 2009, Lima et al. 2010, Maracahipes et al. 2011, Abreu et al. 2012). Nevertheless, TN revealed high number of exclusive species (20.14%), as found by Bridgewater et al. (2004) for Cerrado *sensu lato*. Yet the lowest number of exclusive species to RN and TP (7.64%) suggests that the sites with higher richness presented more exclusive species. Thereunto, our results enable us to affirm that the environmental filter represented by rocky outcrops, shallow soils and rugged relief, typical of *Cerrado Rupestre*, was not a limiting factor for species richness in the RP and RN sites, according to the results found by Moura et al. (2010) and Abreu et al. (2012). This supports the theory that Cerrado's environmental heterogeneity confers pattern of floristic variation to the Cerrado *sensu stricto* woody component (Castro & Martins 1999, Felfili & Felfili 2001, Durigan et al. 2003, Ratter et al. 2003, Bridgewater et al. 2004, Silva et al. 2006).

With respect to diversity, three out of four profile curves crossed each other indicating differences in richness and/or equability in these sites, which limits to determine which community presents higher or lower diversity (Tóthmérész 1995), since they vary in relation to the component values of the species diversity indices. Nonetheless, it is clear that RN presents lower diversity regardless of the diversity metric applied. This result owes to the combination of the lowest richness and low equability found in this community. We can still infer that there is similarity in terms of richness and equability among TN and RP, which presented similar diversity regardless of the diversity metric assessed. Which reflected particularity in site diversity as well as peculiarity in structure, possibly as consequence of the environmental characteristics of each site.

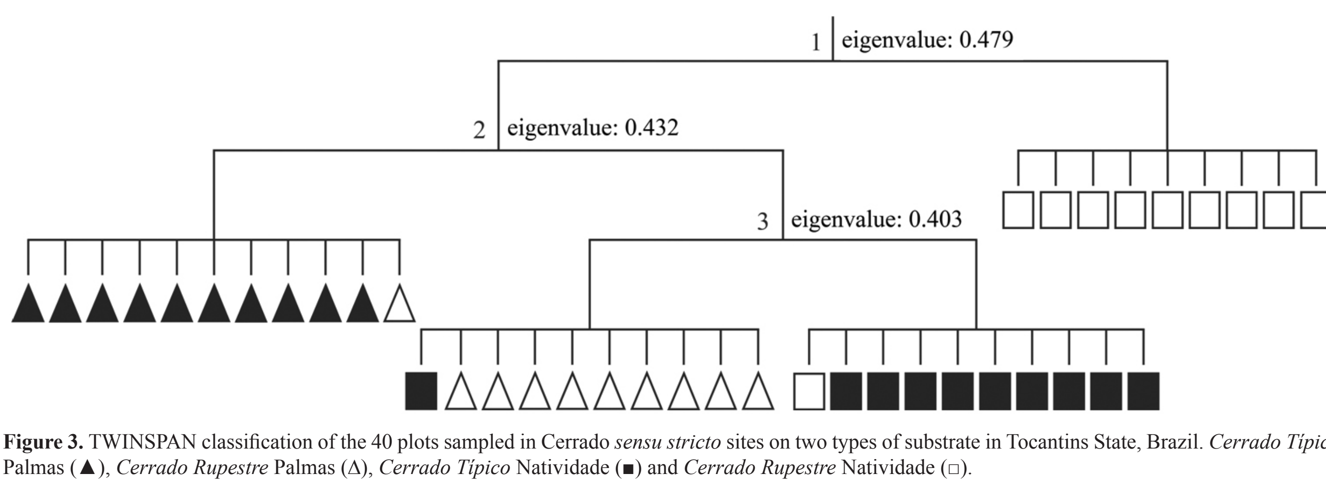

Figure 3. TWINSPAN classification of the 40 plots sampled in Cerrado *sensu stricto* sites on two types of substrate in Tocantins State, Brazil. *Cerrado Típico* Palmas (▲), *Cerrado Rupestre* Palmas (Δ), *Cerrado Típico* Natividade (■) and *Cerrado Rupestre* Natividade (□).

Table 3. Indicator Species Analysis (ISA) based on the abundance of tree-shrub species in the Cerrado *sensu stricto* sites sampled on two types of substrate in Tocantins State, Brazil. VIO = indicator value observed; VIE = indicator value estimated; Sd = standard deviation, *p* = significance, TP = *Cerrado Típico* Palmas; RP = *Cerrado Rupestre* Palmas; TN = *Cerrado Típico* Natividade; RN = *Cerrado Rupestre* Natividade. The species are organized in decreasing order of VIO in each site.

SITES/SPECIES		VIE		Abundance				
	VIO	Mean	Sd	*p*	RP	RN	TP	TN
TP								
Vochysia cinnamomea	100.0	17.0	6.77	0.0002	0	0	100	0
Mouriri pusa	87.2	17.6	7.17	0.0002	3	0	97	0
Kielmeyera rubriflora	85.1	18.4	7.23	0.0002	5	0	95	0
Kielmeyera lathrophyton	84.1	19.3	6.80	0.0002	5	11	84	0
Myrcia splendens	82.5	26.3	7.54	0.0002	4	7	82	7
Dalbergia miscolobium	80.0	17.5	7.98	0.0002	0	0	100	0
Vatairea macrocarpa	69.5	22.9	7.81	0.0002	2	5	77	16
Hirtella ciliata	68.6	19.1	7.94	0.0002	14	0	86	0
Dimorphandra gardneriana	67.2	23.4	6.06	0.0002	20	0	67	12
Aspidosperma macrocarpon	65.7	21.4	7.19	0.0002	11	16	73	0
Guapira graciliflora	54.2	16.9	7.48	0.0012	0	10	90	0
Emmotum nitens	51.4	16.8	7.25	0.0012	7	4	86	4
Plathymenia reticulata	50.9	20.0	6.67	0.0010	9	0	73	18
Bowdichia virgilioides	49.2	26.1	5.66	0.0012	9	17	55	19
Andira vermifuga	47.6	22.4	6.38	0.0024	17	17	60	7
Andira cujabensis	40.6	15.5	7.24	0.0098	19	0	81	0
Kielmeyera coriacea	36.7	16.1	6.70	0.0134	13	7	73	7
Handroanthus ochraceus	36.7	18.3	6.89	0.0266	33	6	61	0
Heisteria ovata	31.1	13.2	6.69	0.0340	22	0	78	0
RP								
Psidium myrsinites	74.1	25.2	6.49	0.0002	74	9	0	17
Chomelia ribesioides	59.6	17.4	7.16	0.0008	85	15	0	0
Rourea induta	58.0	20.8	6.77	0.0010	73	10	4	14
Syagrus comosa	55.7	14.7	6.92	0.0014	93	0	0	7
Davilla elliptica	47.7	25.7	6.72	0.0078	60	0	14	27
Byrsonima pachyphylla	46.9	30.0	6.30	0.0178	47	22	6	26
Myrcia multiflora	40.0	12.5	6.91	0.0092	100	0	0	0
Ouratea spectabilis	40.0	11.5	6.09	0.0098	100	0	0	0
Tocoyena formosa	37.5	16.6	7.13	0.0254	75	0	6	19
Hymenaea stigonocarpa	35.6	18.8	6.42	0.0248	59	7	0	33
Handroanthus serratifolius	30.0	10.1	6.60	0.0488	100	0	0	0
Miconia ferruginata	27.1	15.4	6.63	0.0432	54	33	0	13
TN								
Curatella americana	100.0	16.9	6.62	0.0002	0	0	0	100
Qualea grandiflora	86.5	23.3	6.92	0.0002	9	0	4	87
Erythroxylum tortuosum	84.4	17.6	7.35	0.0002	0	6	0	94
Callisthene major	80.0	16.2	7.28	0.0002	0	0	0	100
Tachigali vulgaris	73.5	21.2	6.55	0.0002	0	0	27	73
Diospyros hispida	71.2	22.7	6.68	0.0002	23	2	5	71
Byrsonima coccolobifolia	55.6	28.7	5.63	0.0006	1	18	25	56
Ferdinandusa elliptica	54.0	18.7	6.79	0.0008	12	21	0	67
Pterodon pubescens	53.3	14.4	6.77	0.0012	0	11	0	89
Hancornia speciosa	47.9	22.4	6.48	0.0032	2	0	45	53
Machaerium opacum	42.9	13.4	6.51	0.0072	0	14	0	86
Eugenia dysenterica	40.0	11.7	6.30	0.0090	0	0	0	100
Erythroxylum deciduum	40.0	11.8	6.10	0.0096	0	0	0	100
Vochysia thyrsoidea	40.0	11.6	6.25	0.0098	0	0	0	100
Vochysia elliptica	40.0	12.6	6.82	0.0106	0	0	0	100
Machaerium acutifolium	40.0	12.0	6.26	0.0110	0	0	0	100

Table 3. Continued...

SITES/SPECIES	VIE				Abundance			
	VIO	Mean	Sd	*p*	RP	RN	TP	TN
Pseudobombax longiflorum	40.0	11.6	6.31	0.0126	0	0	0	100
Lafoensia pacari	36.0	16.2	7.35	0.0274	7	33	0	60
Astronium fraxinifolium	30.0	10.1	6.54	0.0470	0	0	0	100
Brosimum gaudichaudii	30.0	10.9	6.14	0.0482	0	0	0	100
Aspidosperma tomentosum	30.0	10.1	6.60	0.0486	0	0	0	100
Magonia pubescens	26.7	12.7	6.44	0.0368	0	0	33	67
RN								
Vellozia squamata	91.1	22.9	7.85	0.0002	1	91	0	8
Schwartzia adamantium	90.0	15.9	6.48	0.0002	0	100	0	0
Couepia grandiflora	88.3	16.8	6.54	0.0002	0	98	0	2
Plenckia populnea	86.2	18.8	7.46	0.0002	0	96	0	4
Psidium guianeense	80.0	15.4	6.78	0.0002	0	100	0	0
Cordiera cf. *elliptica*	70.0	14.6	6.73	0.0002	0	100	0	0
Tibouchina papyrus	70.0	14.4	6.57	0.0002	0	100	0	0
Vochysia gardneri	69.3	19.7	6.46	0.0002	23	77	0	0
Banisteriopsis latifolia	60.0	14.0	6.75	0.0004	0	100	0	0
Wunderlichia cruelsiana	60.0	13.3	6.43	0.0006	0	100	0	0
Eriotheca gracilipes	56.9	19.2	7.78	0.0022	3	81	13	3
Erythroxylum suberosum	40.0	22.5	6.49	0.0146	28	50	20	3
Copaifera langsdorffii	35.6	13.2	6.82	0.0244	0	89	0	11

The highest density found in *Cerrado Típico* and the lowest in *Cerrado Rupestre*, and the lack of this trend in basal area corroborate the assertion that rocky outcrops and incipient soils, apparently limiting to the establishment of tree-shrub vegetation (Ribeiro & Walter 2008), did not act as barriers against development in terms of basal area. However, Lima et al. (2010) and Lenza et al. (2011) found similar density and basal area between *Cerrado Rupestre* and *Cerrado Típico* sites, showing the lack of clear pattern of separation between these two phytophysiognomy subtypes based on density and basal area. Nevertheless, the higher median diameter values and the lower height values of individuals in the *Cerrado Rupestre* sites allow us to assume that the substrate limits development in height but not in basal area.

The structural importance of *Qualea parviflora* Mart. and *Anacardium occidentale* L. registered in the four sites, both of wide distribution in the Cerrado biome (Ratter et al. 2003), was also pointed out by Gomes et al. (2011) as common and important species in the vegetation structure of Cerrado on deep and shallow soils with rocky outcrops in east of Mato Grosso State. *Caryocar coriaceum* Wittm. was important in terms of IVI in RP, TP and TN, which corroborates the assertion that this species is indicator of the North-Northeastern Group flora, as classified by Ratter et al. (2003), present in the transition between Cerrado and Caatinga. The difference in high-IVI species composition between the four sites, with two to three species in common, was strengthened by the high floristic dissimilarity between the sites, which can be a reflex of environmental particularities. The influence of the adjacent biomes, Caatinga and Amazonia (Felfili et al. 2002, Lenza et al. 2011), also reinforces the floristic and structural particularity of the sites with occurrence of *Dimorphandra gardneriana* Tul. (Castro et al. 1998) and *Cenostigma tocantinum* Ducke in TP, considering that Tocantins State is located in a transition zone between three major biomes: Amazonia, Cerrado and Caatinga (Instituto... 1992).

Our results corroborate Felfili & Felfili (2001), who observed that adjacent Cerrado *sensu stricto* sites in different conditions of substrate present reduced similarity. This can be explained by the fact that, at local scale, the physical-chemical properties of the soils drive the floristic differentiation of the tree-shrub vegetation between the *Cerrado Rupestre* and *Cerrado Típico* sites (Abreu et al. 2012). Moreover, the distance between sites does not seem to influence much on their similarity, since not only those of the same phytophysiognomy type distant from each other (RN and RP), but also those of different phytophysiognomy types adjacent to each other (TN and RN) were dissimilar.

RN separation from the other sites, including RP, on similar substrate conditions may be related to altitude, which is considered one of the responsible factors for Cerrado's floristic patterns (Munhoz & Proença 1998, Castro & Martins 1999, Ratter et al. 2003, Bridgewater et al. 2004, Lenza et al. 2011). The preference of specialist species to rocky outcrop and high altitude habitat registered in RN (> 400 m.a.s.l.), such as *Mimosa claussenii*, *Tibouchina papyrus*, *Schwartzia adamantium* and *Wunderlichia cruelsiana* (Ratter et al. 2000, Ribeiro & Walter 2008, Pinto et al. 2009), whereas the last three were present within the most important ones in the vegetation structure, increase the floristic particularity of the *Cerrado Rupestre* sampled in Natividade. On the other hand, the absence of these species in RP (< 400 m.a.s.l.) evinces the influence of altitude on *Cerrado Rupestre's* floristic composition and corroborates the results found by Gomes et al. (2011).

The separation of the other sites can be related to local edaphic factors since TP, on more sandy soil, was separated from the others, presenting *Vochysia cinnamomea* Pohl, normally associated with sandy environments (Finger 2008), as one of the 10 most important species in the community structure. Most of TP's preferential species indicated by ISA are frequent in Cerrado *sensu stricto*; however, species such as *Hirtella ciliata* Mart. and Zucc., whose distribution is restricted to the northeast region of the biome (Ratter et al. 2000), reveal the influence of adjacent biomes on the floristic composition of this site. The rocky outcrop was most likely responsible for separating TN and RP. Moreover, ISA's indication of *Astronium fraxinifolium*

Schott (Bridgewater et al. 2004), mainly found on mesotrophic soils (more fertile), and *Magonia pubescens* A.St.-Hil, indicator of fertile soils (Ratter et al. 2003), as preferential in TN suggests that this site presents more fertile soils. Our results corroborate the affirmation that local environmental characteristics are responsible for Cerrado's mosaic of vegetation and for the species distribution (Ratter et al. 2000). The non-formation of groups with similar characteristics such as presence of rocky outcrops or related to geographical proximity indicates that environmental peculiarities of each location influence on the floristic composition and structure of these communities.

At last, despite the similarity in species richness among the phytophysiognomies and the representativeness of this richness in terms of Cerrado biome, we did not register trend in *Cerrado Típico* sites towards higher tree-shrub species richness and diversity compared to *Cerrado Rupestre* sites. The floristic particularity of each site was evinced by the high number of species of limited geographic distribution, the low number of species shared among sites and by only two species in common, emphasizing RN, wherein it was found species considered indicator of rocky environments. Therefore, the information with regard to phytophysiognomy type as a parameter to select areas for conservation, by itself, does not effectively ensure biodiversity preservation, owing to the existing flora heterogeneity not only at local but also at regional scale, revealed by the floristic and structural particularity of each site.

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