Acta Botanica Brasilica 29(3): 327-338. 2015.
doi: 10.1590/0102-33062014abb3697

Species composition, diversity, and vegetation structure in a gallery forest-*cerrado sensu stricto* transition zone in eastern Mato Grosso, Brazil

Eddie Lenza[1]*, Josias O. Santos[1] and Leonardo Maracahipes-Santos[1]

Received: August 29, 2014. Accepted: March 11, 2015

ABSTRACT

We investigated the existence of an ecotone in the species composition, diversity and vegetation structure in the transition between gallery forest and *cerrado sensu stricto* in central Brazil. We tested two hypotheses: 1) a ecotone can be found between gallery forest and *cerrado*; 2) a gradient exists in the species composition of the *cerrado*. We established three parallel transects of 5 m × 350 m running between gallery forest and *cerrado*, which were divided into subplots of 5 m × 10 m, perpendicular to the margin of the Bacaba stream in Nova Xavantina (Mato Grosso, Brazil). We identified and measured the height and diameter of individual plants in the plots with a diameter of at least 3 cm at 30 cm above the ground. We recorded 140 species, of which 26 were exclusive to the gallery forest, and 95 to the *cerrado*. The *cerrado* presented higher species richness (observed and estimated) and diversity (diversity profiles) than the gallery forest. Both hypotheses were accepted: a distinct ecotone was observed between gallery the forest and *cerrado*, and a pronounced gradient was found in species composition among the *cerrado* plots, apparently in response to the variation in soil moisture content, probably related to topography.

Keywords: Brazilian savanna, *continuum*, environmental heterogeneity, species turnover, vegetation type

Introduction

To date, 11,242 native species of vascular plants have been identified in the Cerrado savanna biome of central South America, making this one of the biologically richest savannas found anywhere in the world (Mendonça *et al*. 2008). On a local scale, high plant species richness is related to variation in the physical-chemical conditions of the soil, relief, and topography, which may result in the formation of gradients of diversity (Oliveira-Filho *et al*. 1989; Oliveira-Filho *et al*. 2004; Marimon *et al*. 1998; Moreno & Schiavini 2001; Carvalho *et al*. 2013; Loschi *et al*. 2013). These local factors result in the formation of a distinct mosaic of forests, savannas, and grasslands, which is typical of the Cerrado Biome (Ribeiro & Walter 2008; Reatto *et al*. 2008).

Gallery forests and the *cerrado sensu stricto* are also found within this mosaic. The gallery forest is an evergreen habitat that forms on mesotrophic soils associated with streams (Ribeiro & Walter 2008). The Cerrado is a brevi-deciduous savanna formation (Lenza & Klink 2006), which is generally found on distrophic soils and in interfluvial areas (Ribeiro & Walter 2008). The transition between forest and savanna vegetation types may be either abrupt, with marked changes in species composition and structure (Askew *et al*. 1970; Moreno *et al*. 2008; Marimon *et al*. 2010; Loschi *et al*. 2013) or gradual, with species being substituted over a gradient (Askew *et al*. 1970; Oliveira-Filho *et al*. 1989; Oliveira-Filho & Fluminham-Filho 1999; Moreno *et al*. 2008).

In the eastern region of the Brazilian state of Mato Grosso, gallery forests and *cerrado* can often be found in close proximity to one another, but these plant communities are characterized by a distinct transition in terms of species composition and other characteristics (Askew *et al*. 1970). However, more gradual variation can be observed within a given vegetation type, as found by Marimon *et al*. (1998) in *cerrado* on a scarp slope and by Marimon-Junior & Haridasan (2005) in a transition zone between *cerrado* (savanna) and *cerradão* (savanna woodland). These studies indicate that changes in the species composition and structure of the vegetation are determined by the variation in relief or edaphic characteristics. In more subtle gradients, changes in the vegetation and species composition are more difficult to observe, and can only be understood more conclusively through the integration of studies of species richness and composition, and the vertical and horizontal structure of the vegetation (Marimon *et al*. 1998; Cardoso & Schiavini 2002; Juhász *et al*. 2006; Gonçalves *et al*. 2011).

[1] Programa de Pós Graduação em Ecologia e Conservação, Universidade do Estado de Mato Grosso, PO Box 08, 78690-000, Nova Xavantina, MT, Brazil
* Corresponding author: eddielenza@yahoo.com.br

A number of different studies in the Cerrado Biome have indicated that the differences in the composition and structure between the savanna formations and interfluvial forests (*cerrado stricto sensu*, savanna woodland, and mesophilic forest), and the forest formations associated with bodies of water (gallery and riparian forests) are related to changes in the physical (moisture and flooding levels) and chemical (availability of nutrients) properties of the soils, which are determined primarily by relief and the topography of the terrain (Oliveira-Filho *et al*. 1990; Moreno & Schiavini 2001; Carvalho *et al*. 2005; Gonçalves *et al*. 2011; Loschi *et al*. 2013; Carvalho *et al*. 2013). Given these considerations, the present study compared the variation in the structure and species diversity and composition of the woody, non-woody and liana vegetation of gallery forest and *cerrado sensu stricto* in eastern Mato Grosso state, Brazil. Two hypotheses were tested: 1) there is an abrupt shift in the species composition and diversity and structure between the two types of vegetation, and 2) within the *cerrado*, this transition is more gradual in response to variation in the height of the terrain in relation to the level of the water in the adjacent stream.

Material and methods

The present study focused on the Bacaba Municipal Park, a conservation unit located within the transition zone between the Amazon forest and Cerrado savanna in the municipality of Nova Xavantina, in the east of the Brazilian state of Mato Grosso. The region's climate is Aw in the Köppen system, with well-defined rainy and dry seasons. Mean monthly temperature is 25°C, and annual precipitation is typically between 1300 mm and 1500 mm (Marimon *et al*. 2010). The park is dominated by *cerrado strictu senso* vegetation, primarily typical *cerrado* (Marimon *et al*. 1998; Marimon-Junior & Haridasan 2005; Gomes *et al*. 2011), but also rocky *cerrado* (Marimon *et al*. 1998; Maracahipes *et al*. 2011). Other forest formations, such as cerradão (savanna woodland) (Marimon-Junior & Haridasan 2005) and gallery forests (Marimon *et al*. 2010), can also be found within the park.

We established three parallel transects of 350 m × 5 m separated by 100 m and perpendicular to the right margin of the Bacaba stream (Fig. 1). Each transect was subdivided into 35 plots of 5 m × 10 m. All three transects traverse a road (3 m in width) perpendicularly, although this area was not included in the samples (Fig. 1). The slope of the terrain along each transect was measured using a clinometer made from a 15 m long flexible crystal quarter-inch PVC hose (1.5 mm thick) to determine the height of the center of each plot in relation to the level of the water in the Bacaba stream during the dry season (May, 2014). To investigate the possible existence of a gradient in the characteristics of the vegetation along the three *cerrado sensu stricto* transects, the plots were grouped into three sectors of 100 m, according to their distance from the edge of the water – sector 1 = 50–150 m from the water; sector 2 = 150–250 m; sector 3 = 250–350 m.

With regard to the vertical structure of the vegetation, we visually classified the five plots nearest to the Bacaba stream as gallery forest and the 30 more distant plots as *cerrado*, resulting in a total sample of 15 plots (750 m²) in the gallery forest and 90 plots (4,500 m²) in the *cerrado*. Eight of the *cerrado* plots were characterized by dense stands of bamboo

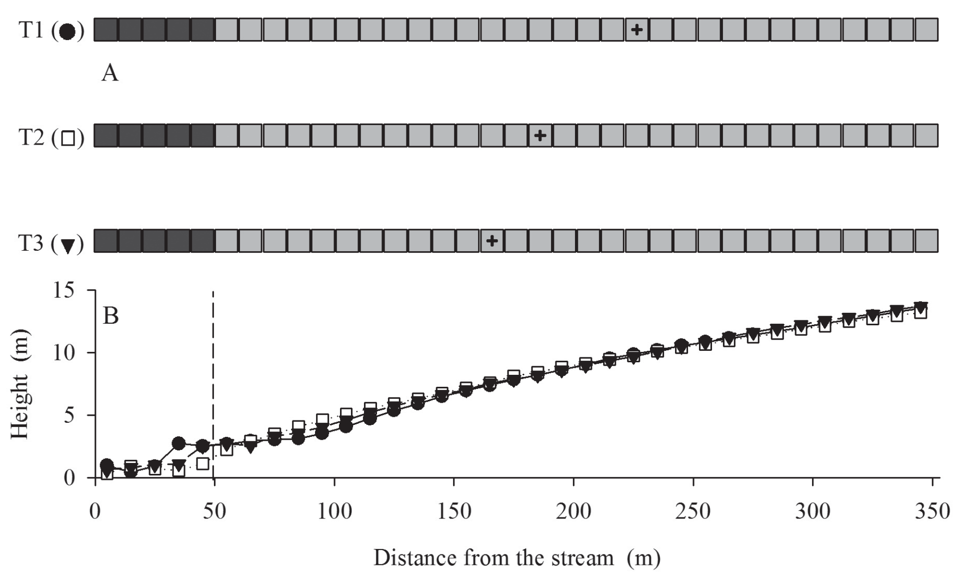

Figure 1. A: Schematic diagram of the transects (T1, T2 and T3) established in an area of transition between gallery forest and *cerrado sensu stricto* in Bacaba Municipal Park in Nova Xavantina, Mato Grosso (Brazil). ■ gallery forest; □ *cerrado sensu stricto*; ✚ Road. B: Distance from the stream and height of the plots in relation to the level of the water in the stream.

Actinocladum verticillatum (Nees) McClure ex Soderstr. (Poaceae). These plots were excluded from the analyses due to the effects of this feature on the species composition and structure of the Cerrado vegetation (Silvério *et al.* 2010), which may have biased the results.

We measured the trunk diameter and height of all live individuals, including woody and non-woody plants, and lianas, with a diameter of at least 3 cm at a height of 30 cm above the soil (D_{30cm}). We identified the species in the field and through comparisons with the specimens available in the NX herbarium of the Nova Xavantina *campus* of Mato Grosso State University (UNEMAT). We assigned the species to families according to the system proposed by the Angiosperm Phylogeny Group (APG III 2009) and we revised the taxon names based on the "Flora do Brasil" database, available on http://floradobrasil.jbrj.gov.br/2014/.

Species similarity between areas was evaluated using Morisita's quantitative coefficient (Magurran 2011) and Sørensen's qualitative coefficient (Brower & Zar 1984). We used an Indicator Species Analysis (ISA) to verify the existence of the species characteristic of each vegetation type (Dufrêne & Legendre 1997; McCune & Mefford 1999). We calculated the Importance Value Index (IVI) of the species (Curtis & Mcintosh 1950; Mueller-Dombois & Ellemberg 1974) found in each vegetation type to compare the horizontal structure of the vegetation between the gallery forest and *cerrado*. We ordinated the plots using Principal Coordinates Analysis, or PCoA (Felfili *et al.* 2011) in order to evaluate the existence of a gradient or ecotone in the species composition between gallery forest and *cerrado*, and tested the significance of the groups generated using ANOSIM with the Bonferroni correction (Clarke & Warwick 1994).

In the specific case of the *cerrado*, we also evaluated the influence of the topographic gradient on the substitution of species with an abundance of at least 15 individuals through the interpretation of a taxon density graph, an approach proposed by Landeiro *et al.* (2010).

We compared species richness between the gallery forest and *cerrado* using rarefaction with 1,000 randomizations, adjusting the sampling effort by the number of individuals recorded in the smallest sample (Gotelli & Colwell 2001; Magurran 2011), and by using the Mao Tau estimator. We estimated plant species richness using the Jackknife I estimator, and used diversity profiles derived from the Rényi exponential series (Tóthmérész 1995) to compare diversity between vegetation types.

We compared the density of individuals per plot and the mean height of the plants in the gallery forest and *cerrado* using Student's *t* test with unequal variance, given the lack of homogeneity in variance between the samples (Zar 2010). We applied the nonparametric Mann-Whitney test (U) to the comparison of trunk diameter between vegetation types, given that the assumption of normality was not satisfied, even after the logarithmic transformation of the data (Zar 2010).

We used linear regression to assess the possible existence of a structural gradient in the *cerrado* determined by the height of the plots in relation to the level of the water in the Bacaba stream (Zar 2010). For this, we used the height of the plots in relation to the level of the stream as the independent variable, and the mean height, trunk diameter and densities recorded per plot as the response variables.

The ISA and PCoA were run in PCOrd version 6.07 (McCune & Mefford 2011). Phytosociological parameters were determined in FITOPAC 2.1.2 (Shepherd 2009). Species similarity coefficients, ANOSIM, rarefaction, diversity profiles, the *t* and Mann-Whitney tests, and linear regression, were run in PAST (PAleontological STatistics) version 2.15 (Hammer *et al.* 2001), while the taxon density graph was produced in R 3.0.2 (R Core Team 2013).

Results

We recorded a total of 140 species, of which, only 19 (13.6%) were found in both vegetation types. We sampled 1667 individuals in the *cerrado sensu stricto*, representing 114 species (of which 95 or 83% were exclusive to this habitat type), 86 genera, and 40 plant families. In the gallery forest, we recorded 135 individuals belonging to 45 species (26 or 58% exclusive), 39 genera, and 26 families (Tab. 1).

The similarity in the species composition between the gallery forest and *cerrado* was low, whether estimated by the Sørensen's qualitative index (0.24) or in particular by the quantitative index of Morisita (0.07). The analysis of indicator species (Tab. 1) identified 10 indicator species for the *cerrado* and 12 for the gallery forest (Monte Carlo: $p < 0.001$), reinforcing the lack of similarity between the vegetation types. In addition, none of the 10 species with the highest IVI scores in the *cerrado* (36.52% of the total) were included in the 10 most important species in the gallery forest (64.87 % of the total), further reinforcing the distinction in the species composition of the two communities.

The Principal Coordinates Analysis (PCoA) of species density and composition, in which the first (eigenvalue of 4.65) and second (eigenvalue of 2.81) axes explained 11.9% and 7.2% of the variation, respectively, differentiated four distinct groups. The first group was formed by the gallery forest plots, and the other three groups by the three sectors of the *cerrado* located at different distances from the Bacaba Stream (Fig. 2). The groups formed in this analysis were considered to be consistent, according to the results of the ANOSIM ($R = 0.41$; $p < 0.001$). The more ample dispersal of the *cerrado* plots in comparison with those of the gallery forest indicates that the *cerrado* encompasses a gradient and is more heterogeneous than the gallery forest. This conclusion is reinforced by the separation of the *cerrado* plots located at different distances from the Bacaba stream, in particular those located at distances of between 50 and 150 m (sector 1) from this watercourse (Fig. 2).

Table 1. Phytosociological parameters of the species and families sampled along a gradient of gallery forest (GF) and *cerrado sensu stricto* (CE), in decreasing order of the IVI values recorded for the *cerrado sensu stricto* species in the Bacaba Municipal Park in Nova Xavantina, Mato Grosso (Brazil). N = number of individuals sampled; BA = basal area; IVI = Importance Value Index; *= 10 species with the highest IVI values in the gallery forest; [IC] = indicator species of the *cerrado sensu stricto*; [IM] = indicator species of the gallery forest; T= Total.

	Species	Family	N		BA		IVI	
			CE	GF	CE	GF	CE	GF
1.	*Davilla elliptica* A.St.-Hil. [IC]	Dilleniaceae	106	-	0.530	-	16.25	-
2.	*Syagrus flexuosa* (Mart.) Becc. [IC]	Arecaceae	103	-	0.464	-	15.09	-
3.	*Qualea parviflora* Mart. [IC]	Vochysiaceae	78	-	0.502	-	14.34	-
4.	*Guapira graciliflora* (Mart. ex Schmidt) Lundell [IC]	Nyctaginaceae	84	1	0.299	0.013	11.95	2.37
5.	*Roupala montana* Aubl. [IC]	Proteaceae	68	-	0.331	-	11.16	-
6.	*Vatairea macrocarpa* (Benth.) Ducke [IC]	Fabaceae	50	-	0.313	-	8.86	-
7.	*Eriotheca gracilipes* (K.Schum.) A.Robyns	Malvaceae	27	-	0.469	-	8.69	-
8.	*Byrsonima pachyphylla* A.Juss.	Malpighiaceae	53	2	0.173	0.007	7.92	2.89
9.	*Ouratea spectabilis* (Mart.) Engl. [IC]	Ochnaceae	40	-	0.294	-	7.71	-
10.	*Qualea multiflora* Mart. [IC]	Vochysiaceae	50	-	0.135	-	7.58	-
11.	*Pseudobombax longiflorum* (Mart. & Zucc.) A.Robyns [IC]	Malvaceae	40	-	0.188	-	7.05	-
12.	*Erythroxylum suberosum* A.St.-Hil.	Erythroxylaceae	46	3	0.111	0.021	6.47	4.19
13.	*Emmotum nitens* (Benth.) Miers	Icacinaceae	18	1	0.390	0.011	6.42	2.30
14.	*Lafoensia pacari* A.St.-Hil. [IC]	Lythraceae	37	-	0.103	-	5.85	-
15.	*Ouratea hexasperma* (A.St.-Hil.) Baill.	Ochnaceae	37	-	0.117	-	5.58	-
16.	*Byrsonima coccolobifolia* Kunth	Malpighiaceae	26	-	0.162	-	5.49	-
17.	*Guapira noxia* (Netto) Lundell	Nyctaginaceae	18	-	0.263	-	5.18	-
18.	*Aspidosperma multiflorum* A.DC.	Apocynaceae	30	-	0.133	-	5.16	-
19.	*Qualea grandiflora* Mart.	Vochysiaceae	23	-	0.168	-	5.04	-
20.	*Terminalia argentea* Mart.	Combretaceae	26	-	0.145	-	4.79	-
21.	*Dalbergia miscolobium* Benth.	Fabaceae	32	-	0.074	-	4.71	-
22.	*Astronium fraxinifolium* Schott	Anacardiaceae	21	1	0.195	0.009	4.70	2.21
23.	*Euplassa inaequalis* (Pohl) Engl.	Proteaceae	13	-	0.267	-	4.68	-
24.	*Callisthene fasciculata* Mart.	Vochysiaceae	23	-	0.165	-	4.66	-
25.	*Buchenavia tomentosa* Eichler	Combretaceae	18	-	0.200	-	4.50	-
26.	*Aspidosperma tomentosum* Mart.	Apocynaceae	26	-	0.102	-	4.23	-
27.	*Myrcia lanuginosa* O.Berg	Myrtaceae	32	-	0.041	-	4.00	-
28.	*Eugenia aurata* O.Berg	Myrtaceae	23	-	0.084	-	3.85	-
29.	*Salvertia convallariodora* A.St.-Hil.	Vochysiaceae	17	-	0.170	-	3.76	-
30.	*Mimosa laticifera* Rizzini & A.Mattos	Fabaceae	22	1	0.059	0.005	3.68	2.05
31.	*Handroanthus ochraceus* (Cham.) Mattos	Bignoniaceae	11	-	0.171	-	3.49	-
32.	*Curatella americana* L. *	Dilleniaceae	15	3	0.122	0.215	3.45	14.19
33.	*Magonia pubescens* A.St.-Hil.	Sapindaceae	16	1	0.099	0.008	3.25	2.20
34.	*Kielmeyera rubriflora* Cambess.	Calophyllaceae	21	-	0.047	-	3.24	-
35.	*Myrcia splendens* (Sw.) DC.	Myrtaceae	15	-	0.109	-	3.14	-
36.	*Kielmeyera coriacea* Mart.	Calophyllaceae	18	-	0.053	-	3.04	-
37.	*Syagrus comosa* (Mart.) Mart.	Arecaceae	19	-	0.068	-	2.92	-
38.	*Vochysia rufa* Mart.	Vochysiaceae	14	-	0.090	-	2.86	-
39.	*Connarus suberosus* Planch.	Connaraceae	20	-	0.033	-	2.77	-
40.	*Mouriri elliptica* Mart.	Melastomataceae	9	-	0.088	-	2.29	-
41.	*Annona coriacea* Mart.	Annonaceae	10	-	0.066	-	2.19	-

Continues.

Table 1. Continuation.

	Species	Family	N		BA		IVI	
			CE	GF	CE	GF	CE	GF
42.	*Dimorphandra mollis* Benth.	Fabaceae	10	-	0.073	-	2.18	-
43.	*Erythroxylum tortuosum* Mart.	Erythroxylaceae	15	-	0.025	-	2.12	-
44.	*Cordiera sessilis* (Vell.) Kuntze	Rubiaceae	12	-	0.038	-	2.00	-
45.	*Xylopia aromatica* (Lam.) Mart. * IM	Annonaceae	11	9	0.057	0.196	1.98	22.39
46.	*Rourea induta* Planch.	Connaraceae	13	-	0.020	-	1.86	-
47.	*Tapirira guianensis* Aubl. * IM	Anacardiaceae	7	10	0.080	0.525	1.74	35.18
48.	*Eugenia gemmiflora* O.Berg	Myrtaceae	10	-	0.047	-	1.72	-
49.	*Protium heptaphylum* (Aubl.) Marchand	Burseraceae	6	5	0.090	0.030	1.69	7.17
50.	*Pterodon pubescens* (Benth.) Benth.	Fabaceae	5	-	0.084	-	1.65	-
51.	*Bowdichia virgilioides* Kunth	Fabaceae	8	-	0.043	-	1.64	-
52.	*Mezilaurus crassiramea* (Meisn.) Taub. ex Mez	Lauraceae	8	-	0.039	-	1.59	-
53.	*Andira cujabensis* Benth.	Fabaceae	7	-	0.051	-	1.58	-
54.	*Hymenaea stigonocarpa* Mart. ex Hayne	Fabaceae	10	-	0.035	-	1.58	-
55.	*Heteropterys byrsonimifolia* A.Juss.	Malpighiaceae	10	-	0.014	-	1.52	-
56.	*Tachigali aurea* Tul.	Fabaceae	6	-	0.040	-	1.31	-
57.	*Casearia sylvestris* Sw.	Salicaceae	9	-	0.013	-	1.28	-
58.	*Himatanthus obovatus* (Müll.Arg.) Woodson	Apocynaceae	9	-	0.012	-	1.27	-
59.	*Diospyros hispida* A.DC.	Ebenaceae	7	1	0.019	0.030	1.23	3.08
60.	*Luetzelburgia praecox* (Harms) Harms	Fabaceae	6	-	0.028	-	1.18	-
61.	*Peltogyne confertiflora* (Mart. ex Hayne) Benth.	Fabaceae	6	-	0.035	-	1.18	-
62.	*Couepia grandiflora* (Mart. & Zucc.) Benth.	Chrysobalanaceae	5	-	0.033	-	1.09	-
63.	*Diplopterys pubipetala* (A.Juss.) W.R.Anderson & C.C.Davis	Malpighiaceae	7	-	0.019	-	1.06	-
64.	*Machaerium acutifolium* Vogel	Fabaceae	5	1	0.029	0.006	1.05	2.09
65.	*Agonandra brasiliensis* Miers ex Benth. & Hook.f.	Opiliaceae	6	-	0.013	-	1.02	-
66.	*Erythroxylum engleri* O.E.Schulz	Erythroxylaceae	6	-	0.009	-	0.97	-
67.	*Licania humilis* Cham. & Schltdl.	Chrysobalanaceae	5	-	0.024	-	0.90	-
68.	*Guettarda viburnoides* Cham. & Schltdl.	Rubiaceae	6	-	0.017	-	0.89	-
69.	*Myrcia tomentosa* (Aubl.) DC.	Myrtaceae	5	-	0.019	-	0.86	-
70.	*Aspidosperma subincanum* Mart.	Apocynaceae	5	3	0.008	0.019	0.82	5.23
71.	*Hancornia speciosa* Gomes	Apocynaceae	5	-	0.015	-	0.81	-
72.	*Myrcia multiflora* (Lam.) DC.	Myrtaceae	4	-	0.018	-	0.79	-
73.	*Anacardium occidentale* L.	Anacardiaceae	5	-	0.013	-	0.78	-
74.	*Plathymenia reticulata* Benth.	Fabaceae	4	-	0.017	-	0.77	-
75.	*Matayba guianensis* Aubl.	Sapindaceae	4	-	0.006	-	0.65	-
76.	*Physocalymma scaberrimum* Pohl * IM	Lythraceae	2	7	0.032	0.162	0.64	17.31
77.	*Simarouba versicolor* A.St.-Hil.	Simaroubaceae	2	-	0.029	-	0.61	-
78.	*Dipterix alata* Vogel	Fabaceae	1	-	0.039	-	0.58	-
79.	*Strychnos pseudoquina* A.St.-Hil.	Loganiaceae	2	-	0.026	-	0.58	-
80.	*Pouteria ramiflora* (Mart.) Radlk.	Sapotaceae	3	-	0.011	-	0.56	-
81.	*Tachigali vulgaris* L.G.Silva & H.C.Lima	Fabaceae	2	-	0.023	-	0.55	-
82.	*Antonia ovata* Pohl	Loganiaceae	3	-	0.010	-	0.54	-
83.	*Aspidosperma nobile* Müll.Arg.	Apocynaceae	3	-	0.007	-	0.52	-
84.	*Tabebuia aurea* (Silva Manso) Benth. & Hook.f. ex S.Moore	Bignoniaceae	3	-	0.007	-	0.51	-

Continues.

Table 1. Continuation.

	Species	Family	N		BA		IVI	
			CE	GF	CE	GF	CE	GF
85.	*Tocoyena formosa* (Cham. & Schltdl.) K.Schum.	Rubiaceae	3	-	0.006	-	0.51	-
86.	*Aspidosperma macrocarpon* Mart.	Apocynaceae	2	-	0.019	-	0.50	-
87.	*Erythroxylum daphnites* Mart.	Erythroxylaceae	3	-	0.004	-	0.49	-
88.	*Myrcia camapuanensis* N.Silveira	Myrtaceae	2	-	0.013	-	0.44	-
89.	*Styrax camporum* Pohl	Styracaceae	3	-	0.006	-	0.42	-
90.	*Luehea* sp.	Malvaceae	1	-	0.021	-	0.38	-
91.	*Cybianthus detergens* Mart.	Primulaceae	2	-	0.007	-	0.37	-
92.	*Leptolobium dasycarpum* Vogel	Fabaceae	2	-	0.004	-	0.33	-
93.	*Aegiphila* sp.	Lamiaceae	2	-	0.003	-	0.32	-
94.	*Psidium* sp.1	Myrtaceae	1	-	0.016	-	0.32	-
95.	*Eugenia* sp.	Myrtaceae	2	-	0.004	-	0.25	-
96.	*Ferdinandusa elliptica* (Pohl) Pohl	Rubiaceae	1	-	0.010	-	0.25	-
97.	*Himatanthus sucuuba* (Spruce ex Müll.Arg.) Woodson	Apocynaceae	1	1	0.009	0.024	0.25	2.82
98.	*Aegiphila verticillata* Vell.	Lamiaceae	2	-	0.002	-	0.23	-
99.	*Amphilophium crucigerum* (L.) L.G.Lohmann	Bignoniaceae	2	1	0.002	0.003	0.23	1.97
100.	*Enterolobium contortisiliquum* (Vell.) Morong	Fabaceae	1	1	0.008	0.008	0.23	2.17
101.	*Hirtella glandulosa* Spreng.	Chrysobalanaceae	1	-	0.007	-	0.23	-
102.	*Pterodon emarginatus* Vogel	Fabaceae	1	-	0.008	-	0.23	-
103.	*Byrsonima verbascifolia* (L.) DC.	Malpighiaceae	1	-	0.007	-	0.22	-
104.	*Andira vermifuga* (Mart.) Benth.	Fabaceae	1	-	0.005	-	0.21	-
105.	*Psidium* sp.2	Myrtaceae	1	-	0.005	-	0.20	-
106.	*Virola sebifera* Aubl.	Myristicaceae	1	2	0.004	0.009	0.19	4.07
107.	*Alibertia edullis* (Rich.) A.Rich.	Rubiaceae	1	-	0.003	-	0.18	-
108.	*Caryocar brasiliensis* Cambess.	Caryocaraceae	1	-	0.003	-	0.18	-
109.	Myrtaceae NI	Myrtaceae	1	-	0.004	-	0.18	-
110.	*Fridericia cinnamomea* (DC.) L.G.Lohmann	Bignoniaceae	1	-	0.002	-	0.17	-
111.	*Brosimum gaudichaudii* Trécul	Moraceae	1	-	0.001	-	0.16	-
112.	*Heisteria ovata* Benth.	Olacaceae	1	-	0.002	-	0.16	-
113.	*Miconia* sp.	Melastomataceae	1	-	0.001	-	0.16	-
114.	Asteraceae NI	Asteraceae	1	-	0.001	-	0.15	-
115.	*Astrocaryum vulgare* Mart. * IM	Arecaceae	-	25	-	0.181	-	33.66
116.	*Bauhinia longifolia* (Bong.) Steud.	Fabaceae	-	2	-	0.008	-	2.94
117.	*Phanera outimouta* (Aubl.) L.P.Queiroz	Fabaceae	-	1	-	0.007	-	2.15
118.	*Byrsonima intermedia* A.Juss.	Malpighiaceae	-	1	-	0.034	-	3.21
119.	*Byrsonima* sp.	Malpighiaceae	-	1	-	0.010	-	2.27
120.	*Cecropia pachystachya* Trécul IM	Urticaceae	-	3	-	0.075	-	8.61
121.	*Cecropia* sp.	Urticaceae	-	1	-	0.004	-	2.02
122.	*Cordia* sp.	Boraginaceae	-	1	-	0.001	-	1.91
123.	*Dendropanax cuneatus* (DC.) Decne. & Planch.	Araliaceae	-	1	-	0.001	-	1.90
124.	*Eriotheca* sp.	Malvaceae	-	1	-	0.021	-	2.70
125.	*Forsteronia rufa* Müll.Arg.	Apocynaceae	-	1	-	0.002	-	1.95
126.	*Inga heterophyla* Willd. IM	Fabaceae	-	3	-	0.025	-	5.46
127.	*Inga thibaudiana* DC. * IM	Fabaceae	-	3	-	0.103	-	9.73

Continues.

Table 1. Continuation.

	Species	Family	N		BA		IVI	
			CE	GF	CE	GF	CE	GF
128.	Lauraceae NI [IM]	Lauraceae	-	2	-	0.004	-	3.88
129.	*Licania apetala* (E.Mey.) Fritsch	Chrysobalanaceae	-	1	-	0.038	-	3.39
130.	*Licania blackii* Prance	Chrysobalanaceae	-	1	-	0.010	-	2.26
131.	*Luehea candicans* Mart. & Zucc.	Malvaceae	-	1	-	0.001	-	1.89
132.	*Mabea pohliana* (Benth.) Müll.Arg. * [IM]	Euphorbiaceae	-	6	-	0.069	-	12.82
133.	*Mauritia flexuosa* L.f. * [IM]	Arecaceae	-	6	-	0.490	-	29.71
134.	*Mauritiella armata* (Mart.) Burret * [IM]	Arecaceae	-	8	-	0.048	-	10.11
135.	*Ormosia excelsa* Benth.	Fabaceae	-	1	-	0.006	-	2.11
136.	*Piper* sp.	Piperaceae	-	1	-	0.002	-	1.95
137.	*Platypodium elegans* Vogel	Fabaceae	-	1	-	0.027	-	2.94
138.	*Siparuna guianensis* Aubl. * [IM]	Siparunaceae	-	6	-	0.014	-	9.50
139.	*Tetragastris altissima* (Aubl.) Swart	Burseraceae	-	1	-	0.005	-	2.08
140.	*Trema micrantha* (L.) Blume	Cannabaceae	-	2	-	0.009	-	2.95
T		**47**	**1,667**	**135**	**9.046**	**2.494**	**300.00**	**300.00**

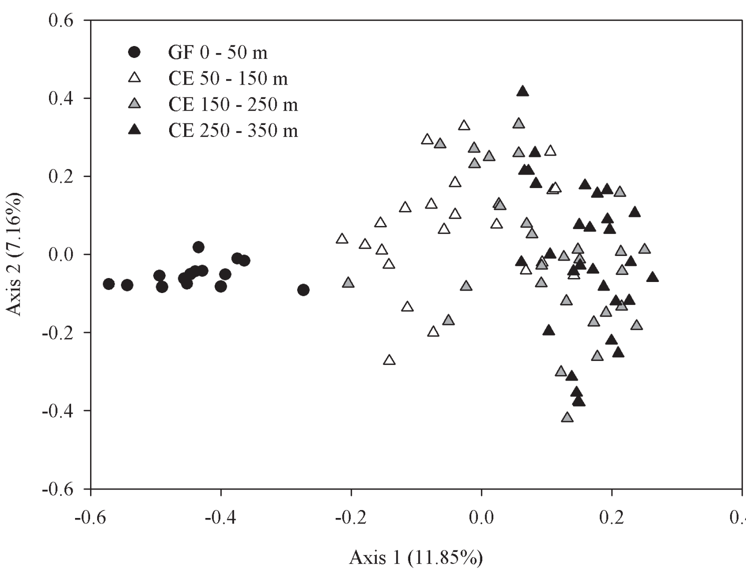

Figure 2. Principal Coordinates Analysis (PCoA) of the plant species composition of the *cerrado sensu stricto* and gallery forest in the plots sampled in the Bacaba Municipal Park in Nova Xavantina, Mato Grosso (Brazil). GF = gallery forest; CE1 = *cerrado sensu stricto* 50–150 m from the stream; CE2 = *cerrado sensu stricto* 150–250 m from the stream, and CE3 = *cerrado sensu stricto* 250–350 m from the stream.

We also noted a gradient in the substitution of species along the *cerrado* transects. For example, *Erythroxylum tortuosum*, *Syagrus flexuosa*, *Aspidosperma tomentosum*, *Salvertia convallariodora* and *Davilla elliptica* presented high densities in the plots furthest from the stream (between 150 m and 350 m), and much lower densities in the adjacent plots (50 m to 150 m). At the opposite extreme, *Buchenavia tomentosa*, *Callisthene fasciculata*, *Myrcia splendens*, *Astronium fraxinifolium* and *Magonia pubescens* were found at the lowest densities in the most distant sector (3), while the highest densities were recorded in sectors 2 and 3 (Fig. 3).

After adjustment for sampling effort (Fig. 4), the rarefaction curve indicated higher species richness for the *cerrado* (55±7 species) in comparison with the gallery forest (45 species). Observed species richness in the *cerrado* represented 85.1% of that estimated by Jackknife 1 (134±4 species), while that of the gallery forest represented 64.3% of the estimated richness, i.e. 70±4 species. Diversity was also higher in the *cerrado*, irrespective of the index considered (Fig. 5).

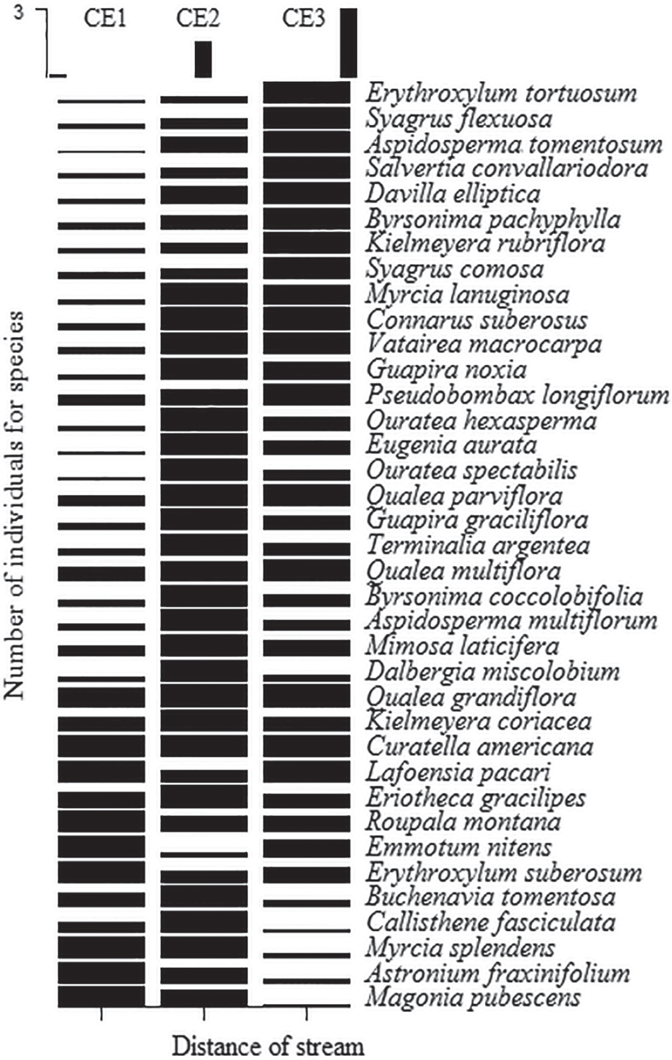

Figure 3. Density of taxa (Landeiro *et al.* 2010) showing the gradient of species substitution in the *cerrado sensu stricto* in the Bacaba Municipal Park in Nova Xavantina, Mato Grosso (Brazil). CE1 = *cerrado sensu stricto* 50–150 m from the stream; CE2 = *cerrado sensu stricto* 150–250 m from the stream, and CE3 = *cerrado sensu stricto* 250–350 m from the stream.

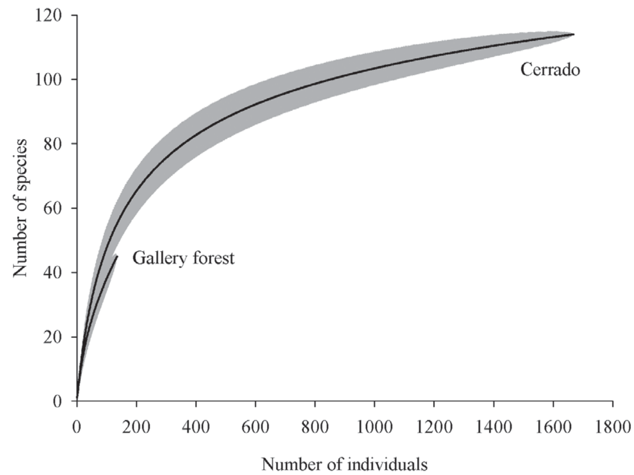

Figure 4. Rarefaction curve standardized by the sampling effort (number of individuals) of the smallest sample for the *cerrado sensu stricto* and gallery forest in the Bacaba Municipal Park in Nova Xavantina, Mato Grosso (Brazil). The gray area represents the 95% confidence interval.

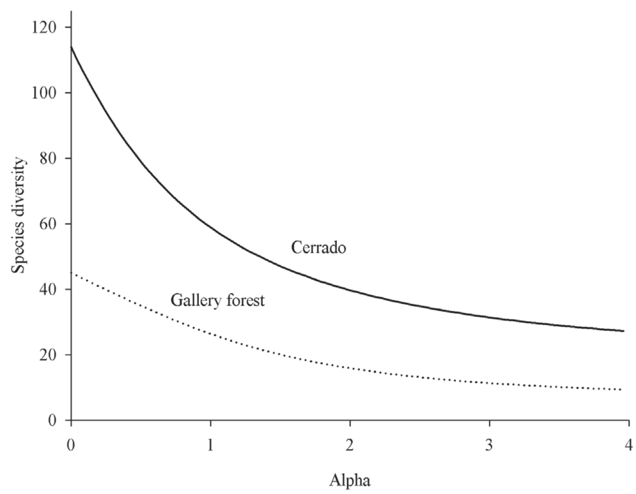

Figure 5. Rényi diversity profiles (Tóthmérész 1995) for the gallery forest and *cerrado sensu stricto* in the Bacaba Municipal Park in Nova Xavantina, Mato Grosso (Brazil).

The extrapolated density per hectare in the *cerrado* was 4066 ind.ha^{-1}, with a basal area of 22.1 m^2.ha^{-1}, whereas in the gallery forest, density was 1800 ind.ha^{-1} and basal area, 33.3 m^2.ha^{-1}. The mean abundance per plot in the gallery forest (9.0±3.9) was significantly lower (t = 6.69, d.f. = 95; p < 0.001) than that recorded in the *cerrado* (20.3±6.9). However, individual plants were significantly taller (t = -2.15, d.f. = 14.47; p < 0.049) in the gallery forest (mean = 7.3±1.3 m) than in the *cerrado* (3.7±0.2 m), and trunks were significantly thicker (U = 45, p < 0.001) in the *cerrado* (median diameter = 6.3 cm) than in the gallery forest (median diameter = 11.6 cm).

In the *cerrado*, the mean trunk diameter (r^2 = 0.24; p < 0.001; y = 9.6005-0.2377 ×) and height (r^2 = 0.45; p < 0.001; y = 5.4019-0.1924 ×) recorded in the plots were related negatively to the height of the plot above the Bacaba stream. A positive relationship was found, by contrast, between the height of the plot and the density of individuals (r^2 = 0.05; p = 0.02; y = 15.7180+0.5141 ×).

Discussion

A number of studies have compared forest and savanna habitats in the Cerrado biome (e.g. Oliveira-Filho & Fluminham-Filho 1999; Juhász *et al.* 2006; Moreno *et al.* 2008; Carvalho *et al.* 2013; Loschi *et al.* 2013) and other South American savanas (e.g. Sarmiento *et al.* 1984), as well as in

African (e.g. Müller *et al.* 2012) and Australian savannas (e.g. Taylor & Dunlop 1985). All these studies found that variation in species composition and diversity, and habitat structure are determined by local environmentl factors such as relief, topography, and the physical-chemical properties of the soil. In the Cerrado biome, the gallery forests that border watercourses are typically found in valley bottoms, where soils tend to contain more nutrients and moisture, and may even be flooded seasonally, whereas the savanna vegetation (*cerrado sensu stricto*) is normally found on the higher terrain, on well-drained, weathered, dystrophic soils that are never flooded (Ribeiro & Walter 2001; Oliveira-Filho & Ratter 2002; Ribeiro & Walter 2008).

These local differences in environmental conditions between the gallery forest and in the *cerrado* probably underpin the marked differentiation observed in the species composition of the two types of vegetation, due to the high percentage of exclusive species. In a *cerrado* in the Brazilian state of São Paulo, Carvalho *et al.* (2013) also recorded a low percentage of typical *cerrado* species in the gallery forest, which they related to the distinct environmental conditions found in the two types of habitat. These findings reinforce the accuracy of the preliminary visual classification of the vegetation conducted in the field, considering only the physical structure of the two habitats. A marked distinction in the species composition of the savanna and gallery forest vegetation was also recorded by Loschi *et al.* (2013) in the Cerrado, and by Müller *et al.* (2012) in Africa. In forest ecotones, however, the transition between two types of vegetation is more subtle, and demands more complex analyses, as observed by Cardoso & Schiavini (2002) and Moreno & Schiavini (2001) in a continuum of gallery forest, seasonal forest, and savanna (*cerradão*) woodland, and by Juhász *et al.* (2006) and Gonçalves *et al.* (2011) in gradients of savanna woodland and gallery forest. In some cases, the transition between savanna and gallery forest can be characterized as a distinct type of vegetation, known as "candeal" (see Oliveira-Filho & Fluminham-Filho (1999).

In other words, the characteristics of the transition within and between the different types of habitats found in the Cerrado biome may vary considerably among sites and regions, being related intimately to local variations in edaphic conditions. In some cases, such as that observed in the present study in the gallery forest and *cerrado* in the Bacaba park, there may be an abrupt ecotonal change between habitats. In other cases, the transition may be more gradual or subtle, such as that observed within the *cerrado* in the present study. Despite the reduced interpretational power of the first two axes of the PCoA (19%) for the separation of the gallery forest and *cerrado*, which indicates the need for caution in the interpretation of the data, the analyses of similarity and indicator species, as well as other phytosociological parameters, were emphatic in their differentiation of the characteristics of the two types of vegetation.

It interesting to note that the percentage of indicator species identified in the *cerrado* (8.8%; n = 10) was considerably lower than that recorded in the gallery forest (26.7%; n = 12). The *cerrado* plots were also more amply dispersed in the ordination analysis, with a marked tendency for the distance from the Bacaba stream (50–150 m, 150–250 m, 250–350 m) to affect the clustering of the plots. In addition, the taxon density graph for the *cerrado* plots indicated the presence of a marked gradient in the substitution of species, with some species predominating in the plots closest to the stream, and others being more abundant in the plots furthest away. A similar pattern has been observed by Oliveira-Filho *et al.* (1989) in interfluvial *cerrado* in the Brazilian state of Mato Grosso do Sul. Similarly, in their comparison of interfluvial and valley *cerrado* in the Brazilian Federal District, Sarmento & Silva-Júnior (2006) recorded a high number of exclusive species for both types of vegetation, and Fonseca & Silva-Júnior (2004) found a clear difference in their species composition.

The higher species richness and diversity recorded in the arboreal-shrubby *cerrado* community in comparison with that of the gallery forest is typical of the Cerrado biome. Felfili *et al.* (2007) recorded high plant species richness and diversity in five areas of Cerrado in comparison with six areas of floodplain gallery forest on the central Brazilian plateau. In the basins of the Araguaia and das Mortes rivers in eastern Mato Grosso, Marimon & Lima (2001) also recorded higher species richness in *cerrado* habitats in comparison with gallery forest. In their survey of three tracts of the same gallery forest sampled in the present study, Marimon *et al.* (2002) recorded between 74 and 86 species, that is, values lower than those recorded in the adjacent *cerrado* here studied.

In the *cerrado sensu stricto* of Bacaba Municipal Park, Marimon *et al.* (1998) recorded 103 species on a scarp slope, Maracahipes *et al.* (2011) identified 85 species in rocky *cerrado*, and Gomes *et al.* (2011) registered 89 species in typical *cerrado* one year after a bushfire. Felfili *et al.* (2002) concluded that areas of *cerrado sensu stricto* in proximity to the Amazon forest suffer the influence of this biome and are characterized by higher species richness and diversity. This does in fact appear to be the case, considering the results obtained in the present study area, and in other areas of Cerrado in eastern Mato Grosso, such as that studied by Nogueira *et al.* (2001) in the municipality of Canarana, approximately 130 km north of Bacaba park, which recorded 88 species, and that of Felfili *et al.* (2002) in Água Boa (75 km north), where 80 species were recorded.

Both the present study and that of Marimon *et al.* (1998), who also assessed the characteristics of the *cerrado* along a topographic gradient in Bacaba park, recorded the highest levels of species richness found to date in areas of Cerrado (see Lenza *et al.* 2011; Mews *et al.* 2014; Felfili & Silva-Júnior 1993). Marimon *et al.* (1998) concluded that this high species richness was related to the slope of the terrain and the inclusion of relatively small individuals, given that the minimum trunk diameter (D_{30cm}) in these studies (present study and Marimon *et al.* 1998) was 3 cm rather than 5 cm, as in Lenza *et al.* (2011), Mews *et al.* (2014), and Felfili & Silva-Júnior (1993). However, even if the individuals with a D_{30cm} of less than 5 cm are excluded from the database of the present study, the species richness of the *cerrado* (n = 104 species) would still be the highest ever recorded for this vegetation type. This permits us to suggest that the topographic gradient was the factor determining the high plant species richness recorded in the present study of the *cerrado*, although at the present time, we are unable to determine which edaphic factors may have produced this result.

The low species richness observed in the gallery forest may have been related not only to the reduced sampling effort (total area of 750 m² in comparison with 4100 m² in the *cerrado*), but also the seasonal flooding of this habitat. In the same tract of gallery forest sampled in the present study, Marimon *et al.* (2002) recorded 77 species (minimum D_{30cm} = 5 cm, total plot area = 4700 m²). While Marimon *et al.* (2002) surveyed a much larger plot than that of the present study, the number of species is still well below the 104 recorded here in the *cerrado* (minimum D_{30cm} = 5 cm, total plot area = 4100 m²). This is reinforced by both the Jackknife and Mao Tau estimates, which both indicated higher species richness in the *cerrado*, contradicting the idea that the smaller size of the gallery forest sample may have biased the results. In fact, reduced species richness is typical of floodplain forests in the Cerrado biome, given that the seasonal flooding restricts the establishment of many species (Nogueira & Schiavini 2003). This alone may account for a large part of the difference in species richness between gallery forest and *cerrado* found in the present study.

The difference between the cerrado and gallery forest in the height and diameter of the individuals sampled further emphasizes the formation of an ecotone, in this case based on structural features, between the two environments, which facilitated the visual differentiation of the vegetation types during the preliminary survey of the sample plots. This shift is not always so apparent, however, where changes in species composition and vegetation structure occur over a gradient or continuum (Cardoso & Schiavini 2002).

Differences in the density recorded in the gallery forest and *cerrado* further emphasized the existence of an ecotone in the study area. The higher densities recorded in the *cerrado* in comparison with the gallery forest are related to the typically arboreal-shrubby characteristics of the *cerrado sensu stricto* (Oliveira-Filho & Ratter 2002; Ribeiro & Walter 2008). By contrast, the gallery forest is formed primarily by arboreal individuals of larger size (Oliveira-Filho & Ratter 2002; Ribeiro & Walter 2008), which is reflected in the greater basal area recorded in this habitat in comparison with the *cerrado*. The application of a relatively small lower limit for trunk diameter ($D_{30cm} \geq 3$ cm) would also have increased the possibility of the inclusion of smaller shrubs – which are more typical of the Cerrado – in the samples. Using a more rigorous criterion of trunk size (diameter at breast height - $D_{130cm} \geq 10$ cm), Felfili (1995) recorded densities of individuals in gallery forest almost twice as high as those recorded in the *cerrado*, confirming the more arboreal nature of the vegetation in the gallery forest.

A systematic gradient was also found in the structure of the vegetation along the *cerrado* transects, with plots nearest the stream being characterized by lower density, but larger plants, in terms of their height and diameter. This may be related to the greater availability of moisture in the lower plots (Oliveira-Filho *et al.* 1989; Fonseca & Silva-Júnior 2004), as well as the more clayey texture of the soil in this part of the terrain (Marimon *et al.* 1998). Plants in areas with less hydrological stress tend to invest more in their aerial biomass, as suggested by Marimon *et al.* (1998) and Oliveira-Filho *et al.* (1989). The reduced determinant coefficients found for the relationship between plot elevation and plant size (diameter and height) and in particular density nevertheless indicate that other factors, not analyzed here, may also affect plant size and density in Cerrado communities. In this case, the confirmation of any direct causal relationship would require more detailed studies of the physical-chemical properties of the soils on which the *cerrado* community analyzed in the present study is based.

In the present study, we demonstrated an abrupt ecotone in both species composition and diversity and vegetation structure between *cerrado* and gallery forest, which could be easily observed under field conditions, confirming our first hypothesis. The analysis of the *cerrado* plots nevertheless indicated the presence of a more subtle gradient in species composition and the size of individuals in relation to the distance of the plot from the body of water, confirming our second hypothesis. Both the ecotone and the habitat gradient found here appear to be related to the indirect influence of topography on the moisture content and fertility of the soil, as shown in a number of previous studies of local transitions found within and among different Cerrado vegetation types (e.g. Oliveira-Filho *et al.* 1994; Oliveira-Filho & Fluminham-Filho 1999; Cardoso & Schiavini 2002; Juhász *et al.* 2006; Gonçalves *et al.* 2011; Loschi *et al.* 2013). However, physical-chemical analyses of this soil will be needed to elucidate the edaphic factors involved in the differentiation of the two types of vegetation studied here.

Acknowledgments

We are grateful to the Graduate Program in Ecology and Conservation at UNEMAT, the UnB/UNEMAT PROCAD project, for logistic and financial support, and Adevanio Oliveira dos Santos, Bianca de Oliveira, Handerson Batista de Castro, James Machado Bilce, Jaqueline Ribeiro Tavares, Leandro Schlemmer Brasil, Márcia Luiza Santos, Marco Bruno Xavier Valadão, Tatiane Pires de Sousa, Mônica Forsthofer, Letícia Gomes and Mariângela Fernandes Abreu for their assistance with the collection of data in the field.

References

APG III - Angiosperm Phylogeny Group. 2009. An update of the angiosperm Phylogeny group classification for the orders and families of flowering plants: APG III. Botanical Journal of the Linnean Society 161: 105-121.

Askew GP, Moffatt DJ, Montgomery RF, Searl PL. 1970. Soil landscapes in north eastern Mato Grosso. The Geographical Journal 136: 211-227.

Brower JE, Zar JH. 1984. Field and laboratory methods for general ecology. Dubuque, W.C. Brown Publishers.

Cardoso E, Schiavini I. 2002. Relação entre distribuição de espécies arbóreas e topografia em um gradiente florestal na Estação Ecológica do Panga (Uberlândia, MG). Revista Brasileira de Botânica 25: 277-289.

Carvalho DA, Oliveira-Filho AT, Vilela EA, *et al*. 2005. Distribuição de espécies arbóreo-arbustivas ao longo de um gradiente de solos e topografia em um trecho de floresta ripária do Rio São Francisco em Três Marias, MG, Brasil. Revista Brasileira de Botânica 28: 329-345.

Carvalho MB, Bernacci LC, Coelho RM. 2013. Floristic and phytosociology in a physiognomic gradient of riverine forest in Cerrado, Campinas, SP. Biota Neotropica 13: 110-120.

Clarke KR, Warwick RM. 1994. Similarity-based testing for community pattern: the two-way layout with no replication. Marine Biology 118: 167-176.

Curtis JT, McIntosh RP. 1950. The interrelations of certain analytic and synthetic phytosociological characters. Ecology 31: 434-455.

Dufrêne M, Legendre A. 1997. Ecological Society of America species assemblages and indicator species: the need for a flexible asymmetrical approach. Ecological Monographs 67: 345-366.

Felfili JM. 1995. Diversity, structure and dynamics of a Gallery Forest in Central Brazil. Vegetatio 117: 1-15.

Felfili JM, Carvalho FA, Libano AM, Venturoli F, Pereira BAS, Machado ELM. 2011. Análise multivariada: princípios e métodos em estudos de vegetação. In: Felfili JM, Eisenlohr PV, Melo MMRF, Andrade LA, Meira Neto JAA. (eds.) Fitossociologia no Brasil: métodos e estudos de casos. Viçosa, UFV. p. 122-155.

Felfili JM, Nogueira PE, Silva-Júnior MC, Marimon BS, Delitti WBC. 2002. Composição florística e fitossociologia do Cerrado sentido restrito no município de Água Boa - MT. Acta Botanica Brasilica 16: 103-112.

Felfili JM, Silva-Júnior MC. 1993. A comparative study of cerrado (*sensu stricto*) vegetation in central Brasil. Journal of Tropical Ecology 9: 277-289.

Felfili JM, Rezende AV, Silva-Júnior MC, *et al*. 2007. Fitossociologia da vegetação arbórea. In: Felfili JM, Rezende AV, Silva Júnior MC. (eds.) Biogeografia do bioma Cerrado: vegetação e solos da Chapada dos Veadeiros. Brasília, Editora da Universidade de Brasília, Finatec. p. 45-96.

Fonseca MS, Silva-Júnior MC. 2004. Fitossociologia e similaridade florística entre trechos de Cerrado sentido restrito em interflúvio e em vale no Jardim Botânico de Brasília, DF. Acta Botanica Brasilica 18: 19-29.

Gomes L, Lenza E, Maracahipes L, Marimon BS, Oliveira EA. 2011. Comparações florísticas e estruturais entre duas comunidades lenhosas de cerrado típico e cerrado rupestre, Mato Grosso, Brasil. Acta Botanica Brasilica 25: 865-875.

Gonçalves IS, Dias HCT, Martins SV, Souza AL. 2011. Fatores edáficos e as variações florísticas de um trecho de mata ciliar do Rio Gualaxo do Norte, Mariana, MG. Revista Árvore 35: 1235-1243.

Gotelli NJ, Colwell RK. 2001. Quantifying biodiversity; procedures and pitfalls in the measurement and comparison of species richness. Ecology Letters 4: 379-391.

Hammer Ø, Harper DAT, Ryan PD. 2001. Past: Paleontological Statistics Software Package for Education and Data Analysis. Paleontologica Electronica 4: 9.

Juhász CEP, Cursi PR, Cooper M, Oliveira TC, Rodrigues RR. 2006. Dinâmica físico-hídrica de uma toposseqüência de solos sob savana florestada (cerradão) em Assis, SP. Revista Brasileira de Ciências do Solo 30: 401-412.

Landeiro VL, Hamada N, Godoy BS, Melo AS. 2010. Effects of litter patch area on macroinvertebrate assemblage structure and leaf breakdown in Central Amazonian streams. Hydrobiologia 649: 355-363.

Lenza E, Klink CA. 2006. Comportamento fenológico de espécies lenhosas em um cerrado sentido restrito de Brasília, DF. Revista Brasileira de Botânica. 29: 627-638.

Lenza E, Pinto JRR, Pinto AS, Maracahipes L, Bruziguessi EP. 2011. Comparação da vegetação arbustivo-arbórea de uma área de cerrado rupestre na Chapada dos Veadeiros, Goiás, e áreas de cerrado sentido restrito do Bioma Cerrado. Revista Brasileira de Botânica 34: 247-259.

Loschi RA, Pereira JAA, Machado ELM, *et al*. 2013. Variações estruturais e ambientais em um contínuo de mata de galeria/cerrado *stricto sensu* em Itumirim, MG. Cerne 19: 213-227.

Magurran AE. 2011. Medindo a diversidade biológica. Curitiba, UFPR.

Maracahipes L, Lenza E, Marimon BS, Oliveira EA, Pinto JRR, Marimon-Junior BH. 2011. Estrutura e composição florística da vegetação lenhosa em cerrado rupestre na transição Cerrado Floresta Amazônica, Mato Grosso, Brasil. Biota Neotropica 11: 133-141.

Marimon BS, Felfili JM, Lima ES. 2002. Floristics and phytosociology of the gallery forest of the Bacaba Stream, Nova Xavantina, Mato Grosso, Brazil. Edinburgh Journal of Botany 59: 303-318.

Marimon BS, Felfili JM, Lima ES, Duarte WMG, Marimon-Junior BH. 2010. Environmental determinants for natural regeneration of gallery forest at the Cerrado/Amazonia boundaries in Brazil. Acta Amazonica 40: 107-118.

Marimon BS, Lima ES. 2001. Caracterização fitofisionômica e levantamento florístico preliminar no Pantanal dos Rios Mortes-Araguaia, Cocalinho, Mato Grosso, Brasil. Acta Botanica Brasilica 15: 213-229.

Marimon BS, Varella RF, Marimon-Junior BH. 1998. Fitossociologia de uma área de cerrado de encosta em Nova Xavantina, Mato Grosso. Boletim do Herbário Ezechias Paulo Heringer 3: 82-101.

Marimon-Junior BH, Haridasan M. 2005. Comparação da vegetação arbórea e características edáficas de um cerradão e um cerrado sensu stricto em áreas adjacentes sobre solo distrófico no leste de Mato Grosso, Brasil. Acta Botanica Brasilica 19: 913-926.

McCune B, Mefford MJ. 1999. Multivariate Analysis of Ecological Data. Gleneden Beach, MjM Software.

McCune B, Mefford MJ. 2011. PC-ORD Multivariate Analysis of Ecological Data. version 6.07. Gleneden Beach, MjM Software.

Mendonça RC, Felfili JM, Walter BMT, *et al*. 2008. Flora vascular do cerrado. In: Sano SM, Almeida SP. (eds.) Cerrado: ambiente e flora. Planaltina, Embrapa-CPAC. p. 421-1279.

Mews H, Pinto JRR, Eisenlohr PV, Lenza E. 2014. Does size matter? Conservation implications of differing woody population sizes with equivalent occurrence and diversity of species for threatened savanna habitats. Biodiversity and Conservation 23: 1119-1131.

Moreno MIC, Schiavini I. 2001. Relação entre vegetação e solo em um gradiente florestal na Estação Ecológica do Panga, Uberlândia (MG). Revista Brasileira de Botânica 24: 537-544.

Moreno MIC, Schiavini I, Haridasan M. 2008. Fatores edáficos influenciando na estrutura de fitofisionomias do Cerrado. Caminhos de Geografia 9: 173-194.

Mueller-Dombois D, Ellemberg H. 1974. Aims and methods of vegetation ecology. New York, J. Wiley & Sons.

Müller JV, Sieglstetter R, Csontos P. 2012. A multivariate approach to identify vegetation belts: Gallery forest and its surrounding savanna along the river Kota in north Benin. Plant Biosystems 146: 878-888.

Nogueira MF, Schiavini I. 2003. Composição florística e estrutura da comunidade arbórea de uma mata de galeria inundável em Uberlândia, MG, Brasil. Bioscience Journal 19: 89-98.

Nogueira PE, Felfili JM, Silva-Júnior MC. 2001. Composição Florística e fitossociologia do cerrado sentido restrito no município de Canarana - MT. Boletim do Herbário Ezechias Paulo Heringer 8: 28-43.

Oliveira-Filho AT, Carvalho DA, Fontes MAL, Berg EVD, Curi N, Carvalho WAC. 2004. Variações estruturais do compartimento arbóreo de uma floresta semidecídua alto-montana na chapada das Perdizes, Carrancas, MG. Revista Brasileira de Botanica 27: 291-309.

Oliveira-Filho AT, Fluminhan-Filho M. 1999. Ecologia da vegetação do Parque Florestal Quedas do Rio Bonito. Cerne 5:51-64.

Oliveira-Filho AT, Ratter JA. 2002. Vegetation physiognomies and woody flora of the Cerrado Biome. In: Oliveira PS, Marquis RJ. (eds.) The cerrados of Brazil. New York, Columbia University Press. p. 91-120.

Oliveira-Filho AT, Ratter JA, Shepherd GJ. 1990. Floristic composition and community structure of a Central Brazilian Gallery Forest. Flora 184: 103-117.

Oliveira-Filho AT, Shepherd GD, Martins FR, Stubblebine WH. 1989. Environmental factors affecting physiognomic and floristic variation in an area of cerrado in Central Brazil. Journal of Tropical Ecology 5: 413-431.

Oliveira-Filho AT, Vilela EA, Carvalho DA, Gavilanes ML. 1994. Effect of soils and topography on the distribution of tree species in a tropical riverine Forest in south-eastern Brasil. Journal of Tropical Ecology 10: 483-508.

R Core Team 2013. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. http://www.R-project.org/.

Reatto A, Correia JR, Spera ST, Martins ES. 2008. Solos do Bioma Cerrado: aspectos pedológicos. In: Sano SM, Almeida SP, Ribeiro JF. (eds.) Cerrado: ecologia e flora. Brasília, Embrapa Cerrados. p. 107-149.

Ribeiro JF, Walter BMT. 2001. As Matas de Galeria no context do Bioma Cerrado. In: Ribeiro JF, Fonseca CEL, Silva CEL. (eds.) Cerrado caracterização de Matas de Galerias. Planaltina, Embrapa Cerrados. p.29-47.

Ribeiro JF, Walter BMT. 2008. As principais fitofisionomias do bioma Cerrado. In: Sano SM, Almeida SP, Ribeiro JF (eds.) Cerrado: Ecologia e Flora Embrapa. Brasília, Informação Tecnológica. p. 151-212.

Sarmento TR, Silva-Júnior MC. 2006. Composição florística e fitossociologia das comunidades lenhosas do Cerrado sentido restrito em das posições topográficas no Jardim Botânico de Brasília, DF. Boletim do Herbário Ezechias Paulo Heringer 17: 79-92.

Sarmiento G. 1984. The Ecology of Neotropical Savannas. Cambridge, Harvard University Press.

Shepherd GJ. 2009. FITOPAC 2.1 (versão preliminar). Campinas, Departamento de Biologia Vegetal, UNICAMP.

Silvério DV, Mews HA, Lenza E, Marimon BS. 2010. Impactos do agrupamento do bambu *Actinocladum verticillatum* (Nees) McClure ex Soderstr. (POACEAE) sobre a vegetação lenhosa de duas fitofisionomias de Cerrado na transição Cerrado-Floresta Amazônica. Acta Amazonica 40: 347-356.

Taylor JA, Dunlop CR. 1985. Plant communities of the wet-dry tropics: the Alligator Rivers Region. Proceedings of the Ecological Society of Australia. 13: 83-127.

Tóthmérész B. 1995. Comparison of different methods for diversity ordering. Journal of Vegetation Science 6: 283-290.

Zar JH. 2010. Biostatistical analysis. New Jersey, Prentice Hall.