REFERÊNCIA

MEDEIROS, Marcelo Brilhante de; WALTER, Bruno Machado Teles; OLIVEIRA, Washington Luis. Floristic and structural comparisons between woody communities of two seasonal forest fragments in the Tocantins river basin and other remnants of this forest physiognomy in Brazil. **Rodriguésia**, Rio de Janeiro, v. 65, n. 1, p. 21-33, jan./mar. 2014. Disponível em: <http://www.scielo.br/scielo.php?script=sci_arttext&pid=S2175-78602014000100002&lng=en&nrm=iso>. Acesso em: 15 maio 2018. doi: http://dx.doi.org/10.1590/S2175-78602014000100002.

Rodriguésia 65(1): 021-033. 2014
http://rodriguesia.jbrj.gov.br

Floristic and structural comparisons between woody communities of two seasonal forest fragments in the Tocantins river basin and other remnants of this forest physiognomy in Brazil

Comparações florísticas e estruturais entre comunidades arbóreas de dois fragmentos de florestas estacionais na bacia do rio Tocantins e outros remanescentes desta fisionomia florestal no Brasil

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Abstract
This work describes the woody layer composition and structure in two seasonal forest fragments in the Tocantins river basin and compares them to other remnants of this forest physiognomy in Brazil. The survey was carried out by using 17 plot samples (20 × 50 m) located in Palmeirópolis, state of Tocantins, and in Minaçú, state of Goiás. All woody individuals showing diameters ≥ 5 cm, at 1.30 cm above ground level, were recorded. The higher floristic similarity of these forest remnants compared with other closer seasonal forests did not show a distinct pattern. The floristic composition was more similar to that of a deciduous seasonal forest in the Paranã valley, and more dissimilar to other forests in this same valley. This result and a higher dissimilarity related to the southern forests in Goiás suggest that the forest fragments showed a floristic composition and structure typical of lowland seasonal forests in the Tocantins river basin. The results also indicated that the forest fragments have distinct floristic compositions with a relatively similar structure and diversity.
Key words: dry seasonal forests, diversity, composition.

Resumo
A composição e a estrutura do componente arbóreo foram caracterizadas em dois fragmentos de floresta estacional na bacia do médio rio Tocantins e comparadas com outros remanescentes dessa fitofisionomia em outras regiões do Brasil. Os indivíduos foram amostrados em 17 parcelas de 20 × 50 m, nos municípios de Palmeirópolis (TO) e Minaçú (GO). Em cada parcela foram mensurados todos os indivíduos lenhosos que apresentaram diâmetro igual ou superior a 5 cm, medido a 1,30 m do solo (DAP ≥ 5 cm). A maior similaridade florística desses dois remanescentes com outras florestas estacionais mais próximas não apresentou um padrão claro. A composição florística nos fragmentos estudados foi mais similar a uma floresta estacional decidual no vale do Paranã, embora muito dissimilar em relação à outra floresta decidual nesse mesmo vale. Esse resultado e a maior dissimilaridade em relação às florestas do sul de Goiás sugerem que as atuais florestas apresentaram composição e estrutura características de florestas estacionais de baixa altitude da bacia do médio/alto rio Tocantins. Os resultados também indicam que cada fragmento investigado apresenta uma flora própria, com estrutura e diversidade relativamente similares.
Palavras-chave: mata seca, diversidade, composição.

Introduction

From 2000 to 2010 tropical deforestation due to agricultural development showed signs of falling in a number of tropical countries, although the scale of this activity continues to cause concern (CDB 2010). During this time about 130,000 km^2 of forests were converted into other land uses each year and the data from the past decade showed deforestation rates of 160,000 km^2.year^{-1} (CDB 2010).

Seasonal forests, also known as dry forests, deciduous or semi-deciduous forests, are often considered the most endangered types of tropical

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forests because of the widespread fragmentation and area reduction caused by agriculture, logging of selected woods and mining (Janzen 1997; Scariot & Sevilha 2005; Espírito-Santo *et al.* 2009). It is common for seasonal forest to undergo disturbances such as fire and invasive species (Janzen 1997). In addition to these impacts, conservation efforts in recent decades have been directed toward tropical rain forests, and less attention has been paid to dry forests (Vieira & Scariot 2006a). This type of vegetation had estimated annual deforestation rates between 1981 and 1990 of 0.94%.year^{-1}, or 61 million hectares. year^{-1}. On the other hand, tropical rain forests showed lower deforestation rates of 0.64%.year^{-1} or 46 million hectares.year^{-1} (Whitmore 1997).

Knowledge about the floristic distribution patterns of seasonal forests could provide valuable information for conservation actions (Scariot & Sevilha 2000). The highest values of similarity of seasonal forests have been associated with the influence of nearby vegetation formations in northeastern and central Brazil (Garcia *et al.* 2011; Santos *et al.* 2012). However, there is a lack of studies comprising the seasonal forests in some regions of central Brazil such as the "mato grosso goiano" in northeastern Goiás and southern Tocantins.

The valley of the middle Tocantins river, located between the municipalities of Palmeirópolis, in the state of Tocantins (TO), and Minaçú, in Goiás (GO), has few and small seasonal forest remnants in an extensive agricultural landscape planted with exotic grasses for grazing. This region in central Brazil comprises the northeastern edge of the former forest swathe called the "mato grosso goiano", which originally covered large areas of the state of Goiás, from the south, through the valley of the Paranaíba river and stretching north to the valley of the Paranã river and some areas of the middle Tocantins (Faissol 1953; Veloso 1963). This forest was converted into an intensive agriculture landscape throughout the 20th century in a south-north direction, and nowadays these forest remnants are just disconnected fragments.

The aim of this study was to characterize the floristic composition and horizontal structure of the woody layer of two forest fragments in the region of the former "mato grosso goiano", in the middle Tocantins river basin, and to compare them to other remnants of this forest physiognomy in Brazil. The study also aims to evaluate the influence of nearby seasonal forests on the floristic distribution and structural patterns of these fragments in this region in order to provide information about the community ecology of these highly endangered seasonal forests.

Material and Methods

Study area

The two semi-deciduous seasonal forest fragments were sampled in the municipalities of Palmeirópolis-TO (13º08'47''S and 48º13'13''W) and Minaçú-GO (13º18'44''S and 48º10'45''W) (Figure 1). These forest fragments are inside a large belt of intensive agriculture with exotic grasses and some native remnants with savanna vegetation.

The climate in this region is classified as Aw in accordance with Köppen, which means wet tropical with two well marked climatic seasons (dry winters and wet summers). The mean annual rainfall is from 1,400 to 1,800 mm and the mean annual temperature is from 23 to 25ºC (Silva *et al.* 2008). The altitude of the fragments is between 300 and 370 m and the relief is from flat to smooth slopes located in the Tocantins valley, Tocantins middle river basin (BRASIL 1981). In Palmeirópolis, the plots were located on a flat site and in Minaçú the plots lay on a smooth slope.

The forest fragments are classified as sub-mountainous semi-deciduous seasonal forest in accordance with IBGE vegetation classification (IBGE 2012). In accordance with Ribeiro &

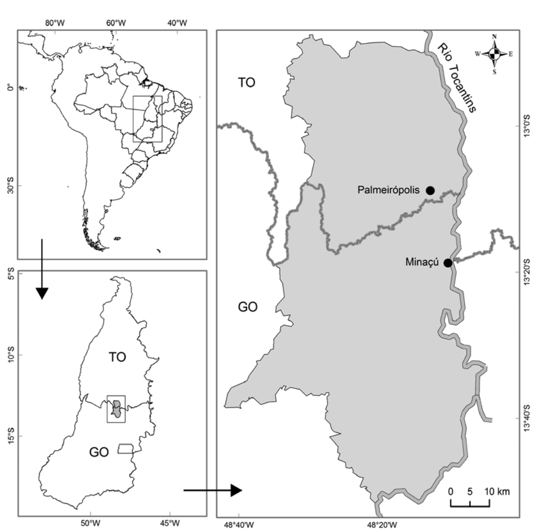

Figure 1 – Study area in the municipalities of the states of Goiás (GO) and Tocantins (TO), Brazil.

Walter (2008) these forests would be classified as semi-deciduous dry forests. The forests are not associated with bodies of water, and in the Cerrado biome three subtypes can be found (evergreen, semi-deciduous and deciduous), which are different because of the amount of foliage that persists in the dry season, the floristic composition and the soil type (Ribeiro & Walter 2008).

The most common soil type in both fragments is argisols, in addition to some sites with lithosols and red latosols (SEPLAN 2008; SIEG 2010). Soils such as the argisols of the Tocantins river basin are related to high levels of Ca and Mg in areas of seasonal forests (Scariot & Sevilha 2005).

The study areas were fragmented, with common evidence of human disturbances typical of this region. These human disturbances comprise agriculture, grazing, fire and logging, and the sites showed an abundance of lianas, bamboo invasion (*Guadua paniculata* Munro frequent) and exotic trees such as *Citrus*.

Vegetation survey

The vegetation was surveyed during the wet season in November 2009. Seventeen permanent plots (20 × 50 m) were randomly allocated, 10 plots were set up in Palmeirópolis and seven plots in Minaçú because of the smaller area in the latter site.

In each plot all the woody and palm individuals were sampled if their diameter was at least 5 cm at 1.30 cm from soil height (dbh ≥ 5cm), measured using a caliper, and their height was estimated by visual perception. Woody lianas were not included in this sampling and were considered only for analysis as a disturbance indicator, as explained below. The species identification was performed in the field surveys and in herbarium. The floristic survey follows the Angiosperm Phylogeny Group III (2009). Vouchers were incorporated into the Embrapa Recursos Genéticos e Biotecnologia herbarium (CEN herbarium).

A dissimilarity qualitative analysis was carried out by using the UPGMA (unweighted pair grouping method using arithmetic averages) linkage method and by Sørensen index (Legendre & Legendre 2012) regarding the selected fragments and literature data of seasonal forests in Goiás (Silva & Scariot 2003; Haidar *et al.* 2005; Nascimento *et al*. 2004; Imaña-Encinas *et al*. 2007; Garcia *et al*. 2011). The phytosociological parameters of horizontal structure (density, frequency, dominance and value of importance) were calculated for the woody communities in each fragment by using the Mata Nativa 2 software (CIENTEC 2004). The floristic diversity was calculated by using the Shannon index (H') with log *n* and the evenness was calculated by the Pielou (J') index (Magurran & McGill 2011). Rarefaction (sample based) was used to compare the richness between the fragments in accordance with Gotelli & Colwell (2001). Three richness estimators (Chao 1, Jackknife 1 and 2 and Bootstrap) were used to evaluate the number of non-sampled species in addition to the sampled richness in each fragment (Palmer 1990). The analyses were performed by using the statistical environment R (R Development Core Team 2011), with functions available from Vegan package (Oksanen *et al*. 2011).

In order to characterize the liana tangles, a variable used as human disturbance indicator (Oliveira-Filho *et al*. 1997), eight sub-samples of 25 m^2 were taken from an area of 20 × 10 m allocated randomly to each plot. Each liana tangle represented a set of at least four lianas in each sub-sample, even if the roots were inside or outside the sub-sample. A diameter at breast height (DBH) ≥ 3 cm was established to record the trunks, excluding ferns, Araceae and small vines (Oliveira-Filho *et al.* 1997).

Results

Similarity

The UPGMA dendrogram (Fig. 2) showed that the fragments in Palmeirópolis and Minaçú have a floristic composition that is more similar

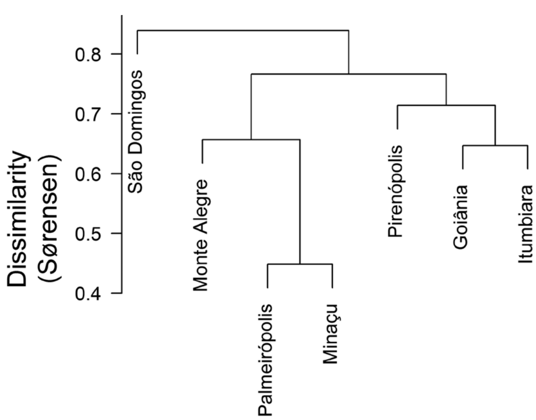

Figure 2 – Dissimilarity dendrogram by using Sorensen index for the woody communities in Palmeirópolis (TO), Minaçu (GO), Goiânia (GO), São Domingos (GO), Monte Alegre (GO), Itaituba (GO) and Pirenópolis (GO).

to the deciduous seasonal forest of Monte Alegre de Goiás, located in the valley of the Paranã River, in comparison to the other areas. The data from the deciduous forest in the municipality of São Domingos, located in the same valley, showed higher dissimilarity values than those in the current study. In comparison to some seasonal semi-deciduous forests in central-southern Goiás, the dissimilarity also showed high values, above 70% in comparison to this study. In fact, Palmeirópolis and Minaçú made a strong cluster in spite of the higher dissimilarity in relation to other studies with seasonal forests in Goiás, including areas of the same semi-deciduous sub-type.

Species richness and diversity

The data on species richness, Shannon diversity index, Pielou evenness, density, volume, basal area, dead individuals and liana density are described in Table 1. Some parameters commonly used in the phytosociology of other seasonal forests are described in Table 2.

In Palmeirópolis, 31 families, 63 genus and 68 species were sampled (Tab. 3). The ten species with the highest values of importance (*Anadenanthera colubrina*, *Eugenia dysenterica*, *Aspidosperma subincanum*, *Dilodendron bipinnatum*, *Aspidosperma pyrifolium*, *Myracrodruon urundeuva*, *Hymenaea courbaril*, *Bauhinia rufa*, *Handroanthus impetiginosus* and *Swartzia acutifolia*) comprised 57.8% of the total importance and 70.9% of the dominance. In the total of the 837 sampled individuals, 88 (10.5%) were dead but upright.

In the Minaçú fragment, 23 families, 45 genus and 49 species were sampled (Tab. 4). The ten species with the highest values of importance (*Pseudobombax tomentosum*, *Dilodendron bipinnatum*, *Tabebuia roseoalba*, *Anadenanthera colubrina*, *Luehea paniculata*, *Magonia pubescens*, *Callisthene fasciculata*, *Guettarda viburnoides*, *Myracrodruon urundeuva* and *Aspidosperma subincanum*) comprised 55% of the total value of importance and 70.1% of the value of dominance. Out of the total of 539 sampled individuals in 0.7 ha, 57 (10.57%) were dead individuals, but standing. In considering the density per hectare this percentage persists unaltered (10.58%).

Discussion

The low similarity between areas has been a common pattern in seasonal forests (Pennington *et al*. 2006), and the results of the dissimilarity analyses indicated distinct composition in relation to the deciduous and semi-deciduous seasonal forests from Goiás. The closer similarity between the semi-deciduous forests of Palmeirópolis and Minaçu in relation to the deciduous seasonal forest of Monte Alegre de Goiás sampled by Nascimento *et al*. (2004) could suggest the influence of nearby vegetation formations. This was a suggestion made by Garcia *et al*. (2011) and Santos *et al*. (2012), without considering the remnants of seasonal forests of the "mato grosso goiano", as performed in this study. However, in the same valley of the Paranã river, the deciduous forest of São Domingos municipality (Silva & Scariot 2003) showed the most dissimilar fragment in comparison to the current study, which left this analysis inconclusive. Also in a similar position, the semi-deciduous forests from Central and South Goiás (Haidar *et al*. 2005; Imaña-Encinas *et al*. 2007; Garcia *et al*. 2011) were dissimilar to this study. These forests belong to the same sub-type of vegetation as the fragments in this study, increasing the lack of precision regarding any patterns that might emerge. Hence, neither the geographic distances nor the same sub-type of vegetation were enough to explain the patterns of floristic similarity.

The biogeographic patterns of the seasonal forests have suggested a woody flora highly limited by dispersion in remnants of northeastern and central Brazil (Santos *et al.* 2012). The species observed in the current study, like the floristic studies carried

Table 1 – Patterns of woody communities of seasonal forest fragments in Palmeirópolis (TO) and Minaçú (GO), located in the middle Tocantins river basin. (*) Richness rarefaction values; (**) Richness estimators: Chao 1; Jackknife (1ª order); Jackknife (2ª order); Bootstrap.

Parameter	Palmeirópolis TO	Minaçú GO
Richness of the woody layer	68 (60)*	49 (49)*
Richness estimators**	111; 97; 113; 81	61; 63; 68; 55
Diversity (H')	3.15	3.28
Evenness (J')	0.75	0.84
Density ($n.ha^{-1}$)	749	688
Basal area ($m^2.ha^{-1}$)	16.5	11.9
Volume ($m^3.ha^{-1}$)	179.37	95.6
Dead standing individuals / VI (%)	88 / 9.11	57 / 7.23
Liana tangle frequency	80%	28.5%

Table 2 – Phytosociology of seasonal forests of Brazil. H' = Shannon index; J' = Pielouevenness; BA = basal area (m^2/ha); D = density (trees/ha); UF = federation unit; D = minimum diameter for sampling (in cm); DAP = diameter at breast height level; DAS = diameter at soil height level; Area = sample area (ha); p.q.= number of points. * more than one area of study ** study with two temporal scales.

Reference	Richness	H'	J'	BA	D	UF	Physiognomy (Forest)	D	Area	Method
Carvalho *et al.* (2007)	174	4.41	0.85	42.27	1481	MG	Seasonal semi-deciduous	DAP ≥ 5.0	1.2	plots
Lopes *et al.* (2002)	143	3.98	0.80	26.94	1569	MG	Pristine Forest	DAP ≥ 4.8	0.5	p.q. (200)
Botrel *et al.* (2002)	140	3.73	0.76	29.31	2683	MG	Seasonal semi-deciduous	DAP ≥ 5.0	1.0	plots
Silva *et al.* (2004)	124	3.56	-	28.70	2786	MG	Seasonal semi-deciduous	DAP ≥ 4.8	0.5	plots
Araújo & Haridasan (1997)*	93/96	3.70/4.10	-	23.80/28.00	2202/1632	MG	Seasonal semi-deciduous	DAP ≥ 3.2	1.0	plots
Silva & Araújo (2009)**	95/95	4.05/3.72	0.62/0.57	28.86/26.84	1636/1732	MG	Seasonal semi-deciduous	DAP ≥ 3.2	0.5	plots
Silva & Soares (2002)	84	-	-	-	1239	SP	Seasonal semi-deciduous	DAP ≥ 5.0	1.0	plots
Siqueira *et al.* (2009)*	64/46	2.76/2.59	0.66	16.25/14.02	1695/937	MG	Seasonal deciduous	DAP ≥ 4.8	1.2	plots
Nascimento & Rodal (2008)	62	2.99	-	39.00	1553	PE	Seasonal mountainnous	DAP ≥ 5.0	1.0	plots
Fonseca & Rodrigues (2000)	61	2.72	0.66	41.78	1280	SP	Seasonal semi-deciduous	DAP ≥ 4.8	1.0	plots
Cestaro & Soares (2004)*	56/45	3.19/3.26	0.79/0.86	15.88/15.86	1587/1924	RN	Seasonal deciduous	DAP ≥ 3.2	-	p.q. (200)
Jerenkow & Waechter (2001)	55	2.24	0.56	-	1855	RS	Seasonal	DAP ≥ 5.0	1.0	plots
Ivanauskas & Rodrigues (2000)	54	3.00	0.70	29.70	2176	SP	Seasonal deciduous	DAP ≥ 4.8	0.4	plots
Pereira *et al.* (2002)	54	2.99	-	34.77	3253	PB	Mountainous Woody Caatinga	DAS ≥ 3.0	0.6	plots
Kunz *et al.* (2010)	53	3.38	0.85	25.8	745	MT	Seasonal	DAP ≥ 10.0	-	p.q. (200)
Nascimento *et al.* (2004)	52	-	-	19.36	663	GO	Seasonal deciduous	DAP ≥ 5.0	1.0	plots
Silva & Scariot (2004a)	51	3.18	0.81	18.63	860	GO	Seasonal deciduous	DAP ≥ 5.0	1.0	plots
Silva & Scariot (2004)	48	2.99	0.77	9.90	924	GO	Seasonal deciduous	DAP ≥ 5.0	1.0	plots
Salis *et al.* (2004)*	47/25/ 32/24	-	-	-	3240/2960/ 1020/1350	MS	Seasonal deciduous	DAP ≥ 2.9	-	p.q. (110)
Silva & Scariot (2003)	36	2.99	0.83	8.45	536	GO	Seasonal deciduous	DAP ≥ 5.0	1.0	plots
Lima *et al.* (2010)	34/33	2.9/2.93	0.82/0.84	32.14/38.31	916/963	MS	Seasonal deciduous	DAP ≥ 4.8	-	p.q. (156)

Table 3 – Woody community in one hectare of semi-deciduous seasonal forest in the municipality of Palmeirópolis (TO). Decreasing Values of Importance (VI): D= Density (ind./ha), Do = Dominance (m²/ha), F = Frequency (%), A = absolute, R = relative.

Scientific name	Family	DA	DR	FA	FR	DoA	DoR	VI	VI (%)
Anadenanthera colubrina (Vell.) Brenan	Fabaceae	46.0	6.1	100.0	4.5	4.2	25.3	36.0	12.0
Eugenia dysenterica DC.	Myrtaceae	168.0	22.4	90.0	4.1	1.3	7.6	34.1	11.4
Aspidosperma subincanum Mart.	Apocynaceae	88.0	11.8	100.0	4.5	1.1	6.6	22.9	7.6
Dilodendron bipinnatum Radlk.	Sapindaceae	50.0	6.7	80.0	3.6	0.9	5.4	15.7	5.2
Aspidosperma pyrifolium Mart.	Apocynaceae	39.0	5.2	90.0	4.1	0.5	3.2	12.5	4.2
Myracrodruon urundeuva Allemão	Anacardiaceae	22.0	2.9	70.0	3.2	1.0	5.9	12.0	4.0
Hymenaea courbaril L.	Fabaceae	29.0	3.9	70.0	3.2	0.7	4.0	11.1	3.7
Bauhinia rufa (Bong.) Steud.	Fabaceae	36.0	4.8	80.0	3.6	0.3	1.8	10.2	3.4
Handroanthus impetiginosus (Mart. ex DC.) Mattos	Bignoniaceae	9.0	1.2	50.0	2.3	1.1	6.7	10.2	3.4
Swartzia acutifolia Vogel	Fabaceae	12.0	1.6	70.0	3.2	0.7	4.3	9.1	3.0
Agonandra brasiliensis Miers ex Benth. & Hook.f.	Opiliaceae	26.0	3.5	70.0	3.2	0.3	2.1	8.7	2.9
Tabebuia roseoalba (Ridl.) Sandwith	Bignoniaceae	18.0	2.4	80.0	3.6	0.3	1.9	7.9	2.6
Casearia rupestris Eichler	Salicaceae	14.0	1.9	60.0	2.7	0.2	1.0	5.6	1.9
Terminalia argentea Mart.	Combretaceae	6.0	0.8	40.0	1.8	0.5	2.8	5.4	1.8
Machaerium cf. *aculeatum* Raddi	Fabaceae	11.0	1.5	50.0	2.3	0.3	1.6	5.3	1.8
Guapira sp.1	Nyctaginaceae	9.0	1.2	70.0	3.2	0.1	0.5	4.8	1.6
Apeiba tibourbou Aubl.	Malvaceae	4.0	0.5	30.0	1.4	0.5	2.9	4.8	1.6
Callisthene fasciculata Mart.	Vochysiaceae	5.0	0.7	50.0	2.3	0.3	1.7	4.7	1.6
Psidium myrtoides O.Berg	Myrtaceae	11.0	1.5	60.0	2.7	0.1	0.3	4.5	1.5
Rhamnidium elaeocarpum Reissek	Rhamnaceae	10.0	1.3	50.0	2.3	0.1	0.8	4.3	1.5
Sapium glandulosum (L.) Morong	Euphorbiaceae	9.0	1.2	40.0	1.8	0.2	1.3	4.3	1.4
Senegalia polyphylla (DC.) Britton & Rose	Fabaceae	11.0	1.5	50.0	2.3	0.1	0.5	4.2	1.4
Campomanesia velutina (Cambess.) O.Berg	Myrtaceae	13.0	1.7	40.0	1.8	0.1	0.5	4.0	1.3
Sterculia striata A.St.-Hil. & Naudin	Malvaceae	4.0	0.5	40.0	1.8	0.2	1.2	3.5	1.2
Magonia pubescens A. St.-Hil.	Sapindaceae	5.0	0.7	30.0	1.4	0.2	1.3	3.3	1.1
Cheiloclinium cognatum (Miers) A.C. Sm.	Celastraceae	6.0	0.8	50.0	2.3	0.0	0.2	3.2	1.1
Guazuma ulmifolia Lam.	Malvaceae	9.0	1.2	30.0	1.4	0.0	0.2	2.8	0.9
Margaritaria nobilis L.f.	Phyllanthaceae	4.0	0.5	40.0	1.8	0.0	0.3	2.6	0.9
Pseudobombax longiflorum (Mart. & Zucc.) A. Robyns	Malvaceae	3.0	0.4	20.0	0.9	0.3	1.8	3.1	0.9
Syagrus oleracea (Mart.) Becc.	Arecaceae	5.0	0.6	30.0	1.4	0.1	0.6	2.6	0.9
Dipteryx alata Vogel	Fabaceae	4.0	0.5	20.0	0.9	0.1	0.7	2.1	0.7
Tetragastris altissima (Aubl.) Swart	Anacardiaceae	5.0	0.7	20.0	0.9	0.0	0.3	1.8	0.6

Scientific name	Family	DA	DR	FA	FR	DoA	DoR	VI	VI (%)
Astronium fraxinifolium Schott ex Spreng.	Anacardiaceae	3.0	0.4	20.0	0.9	0.1	0.5	1.8	0.6
Maclura tinctoria (L.) D. Don ex Steud.	Moraceae	3.0	0.4	10.0	0.5	0.2	0.9	1.8	0.6
Vatairea macrocarpa (Benth.) Ducke	Fabaceae	3.0	0.4	20.0	0.9	0.1	0.5	1.7	0.6
Albizia sp.	Fabaceae	2.0	0.3	10.0	0.5	0.1	0.9	1.6	0.5
Varronia sessilifolia (Cham.) Borhidi	Boraginaceae	4.0	0.5	20.0	0.9	0.0	0.1	1.5	0.5
Erythroxylum daphnites Mart.	Erythroxylaceae	3.0	0.4	20.0	0.9	0.0	0.1	1.4	0.5
Myrcia splendens (Sw.) DC.	Myrtaceae	3.0	0.4	20.0	0.9	0.0	0.1	1.4	0.5
Acrocomia aculeata (Jacq.) Lodd. ex Mart.	Arecaceae	2.0	0.3	20.0	0.9	0.0	0.2	1.3	0.5
Buchenavia tomentosa Eichler	Combretaceae	2.0	0.3	20.0	0.9	0.0	0.1	1.2	0.4
Tocoyena formosa (Cham. & Schltdl.) K. Schum.	Rubiaceae	2.0	0.3	20.0	0.9	0.0	0.1	1.2	0.4
Platypodium elegans Vogel	Fabaceae	2.0	0.3	20.0	0.9	0.0	0.1	1.2	0.4
Apuleia leiocarpa (Vogel) J.F. Macbr.	Fabaceae	2.0	0.3	10.0	0.5	0.0	0.2	0.9	0.3
Eugenia bimarginata DC.	Myrtaceae	2.0	0.3	10.0	0.5	0.0	0.2	0.9	0.3
Simira cf. *corumbensis* (Standl.) Steyerm.	Rubiaceae	2.0	0.3	10.0	0.5	0.0	0.1	0.8	0.3
Matayba guianensis Aubl.	Sapindaceae	1.0	0.1	10.0	0.5	0.0	0.2	0.8	0.3
Piper arboreum Aubl.	Piperaceae	2.0	0.3	10.0	0.5	0.0	0.0	0.7	0.3
Trichilia elegans A. Juss.	Meliaceae	1.0	0.1	10.0	0.5	0.0	0.2	0.7	0.2
Ximenia americana L.	Olacaceae	1.0	0.1	10.0	0.5	0.0	0.1	0.7	0.2
Guapira sp.2	Nyctaginaceae	1.0	0.1	10.0	0.5	0.0	0.1	0.7	0.2
Qualea multiflora Mart.	Vochysiaceae	1.0	0.1	10.0	0.5	0.0	0.1	0.7	0.2
Copaifera langsdorffii Desf.	Fabaceae	1.0	0.1	10.0	0.5	0.0	0.1	0.7	0.2
Diospyros hispida A.DC.	Ebenaceae	1.0	0.1	10.0	0.5	0.0	0.1	0.6	0.2
Siphoneugena densiflora O.Berg	Myrtaceae	1.0	0.1	10.0	0.5	0.0	0.0	0.6	0.2
Celtis iguanaea (Jacq.) Sarg.	Cannabaceae	1.0	0.1	10.0	0.5	0.0	0.0	0.6	0.2
Endlicheria sp.	Lauraceae	1.0	0.1	10.0	0.5	0.0	0.1	0.6	0.2
Genipa americana L.	Rubiaceae	1.0	0.1	10.0	0.5	0.0	0.0	0.6	0.2
Cybistax antisyphilitica (Mart.) Mart.	Bignoniaceae	1.0	0.1	10.0	0.5	0.0	0.0	0.6	0.2
Byrsonima pachyphylla A.Juss.	Malpighiaceae	1.0	0.1	10.0	0.5	0.0	0.0	0.6	0.2
Rudgea viburnoides (Cham.) Benth.	Rubiaceae	1.0	0.1	10.0	0.5	0.0	0.0	0.6	0.2
Myrcia tomentosa (Aubl.) DC.	Myrtaceae	1.0	0.1	10.0	0.5	0.0	0.0	0.6	0.2
Sebastiania brasiliensis Spreng.	Euphorbiaceae	1.0	0.1	10.0	0.5	0.0	0.0	0.6	0.2
Qualea grandiflora Mart.	Vochysiaceae	1.0	0.1	10.0	0.5	0.0	0.0	0.6	0.2
Pouteria ramiflora (Mart.) Radlk.	Sapotaceae	1.0	0.1	10.0	0.5	0.0	0.0	0.6	0.2
Cordia trichotoma (Vell.) Arráb. ex Steud.	Boraginaceae	1.0	0.1	10.0	0.5	0.0	0.0	0.6	0.2
Schefflera cf. *calva* (Cham.) Frodin & Fiaschi	Araliaceae	1.0	0.1	10.0	0.5	0.0	0.0	0.6	0.2
Citrus sp.	Rutaceae	1.0	0.1	10.0	0.5	0.0	0.0	0.6	0.2
Total		**749.0**	**100.0**	**2220.0**	**100.0**	**16.5**	**100.0**	**300.0**	**100.0**

Table 4 – Woody community in one hectare of semi-deciduous seasonal forest in the municipality of Minaçu (GO). Decreasing Values of Importance (VI): D= Density (ind./ha), Do = Dominance (m²/ha), F = Frequency (%), A = absolute, R = relative.

Scientific name	Family	DA	DR	FA	FR	DoA	DoR	VI	VI (%)
Pseudobombax tomentosum (Mart. & Zucc.) A.Robyns	Malvaceae	28.6	4.2	85.7	3.9	2.0	17.0	25.0	8.3
Dilodendron bipinnatum Radlk.	Sapindaceae	65.7	9.5	100.0	4.5	1.0	8.6	22.6	7.6
Tabebuia roseoalba (Ridl.) Sandwith	Bignoniaceae	77.1	11.2	100.0	4.5	0.7	6.2	21.9	7.3
Anadenanthera colubrina (Vell.) Brenan	Fabaceae	34.3	5.0	100.0	4.5	0.9	7.2	16.7	5.6
Luehea paniculata Mart. & Zucc.	Malvaceae	21.4	3.1	85.7	3.9	0.9	7.6	14.6	4.9
Magonia pubescens A. St.-Hil.	Sapindaceae	27.1	3.9	71.4	3.2	0.8	6.9	14.0	4.7
Callisthene fasciculata Mart.	Vochysiaceae	25.7	3.7	71.4	3.2	0.8	6.3	13.3	4.4
Guettarda viburnoides Cham. & Schltdl.	Rubiaceae	42.9	6.2	85.7	3.9	0.4	3.2	13.2	4.4
Myracrodruon urundeuva Allemão	Anacardiaceae	25.7	3.7	100.0	4.5	0.5	4.2	12.4	4.1
Aspidosperma subincanum Mart.	Apocynaceae	31.4	4.6	85.7	3.9	0.4	2.9	11.4	3.8
Erythroxylum daphnites Mart.	Erythroxylaceae	41.4	6.0	71.4	3.2	0.2	1.9	11.1	3.7
Campomanesia velutina (Cambess.) O.Berg	Myrtaceae	38.6	5.6	85.7	3.9	0.2	1.6	11.0	3.7
Acrocomia aculeata (Jacq.) Lodd. ex Mart.	Arecaceae	25.7	3.7	85.7	3.9	0.4	3.1	10.7	3.6
Eugenia dysenterica DC.	Myrtaceae	28.6	4.2	71.4	3.2	0.3	2.4	9.8	3.3
Astronium fraxinifolium Schott ex Spreng.	Anacardiaceae	18.6	2.7	100.0	4.5	0.3	2.3	9.5	3.2
Byrsonima pachyphylla A.Juss.	Malpighiaceae	22.9	3.3	57.1	2.6	0.2	1.5	7.4	2.5
Cordia trichotoma (Vell.) Arráb. ex Steud.	Boraginaceae	15.7	2.3	57.1	2.6	0.2	1.4	6.2	2.1
Dipteryx alata Vogel	Fabaceae	7.1	1.0	57.1	2.6	0.3	2.6	6.2	2.1
Andira sp.	Fabaceae	8.6	1.2	57.1	2.6	0.1	1.1	5.0	1.65
Terminalia argentea Mart.	Combretaceae	8.6	1.2	42.9	1.9	0.2	1.7	4.9	1.6
Syagrus flexuosa (Mart.) Becc.	Arecaceae	10.0	1.5	57.1	2.6	0.1	0.5	4.5	1.5
Swartzia acutifolia Vogel	Fabaceae	5.7	0.8	57.1	2.6	0.1	0.7	4.1	1.4
Pseudobombax longiflorum (Mart. & Zucc.) A. Robyns	Malvaceae	4.3	0.6	28.6	1.3	0.1	0.9	2.8	0.9
Tabebuia aurea (Silva Manso) Benth. & Hook. f. ex S. Moore	Bignoniaceae	2.9	0.4	28.6	1.3	0.1	1.1	2.8	0.9
Jacaranda brasiliana (Lam.) Pers.	Bignoniaceae	8.6	1.2	14.3	0.6	0.1	0.8	2.7	0.9
Agonandra brasiliensis Miers ex Benth. & Hook.f.	Opiliaceae	4.3	0.6	28.6	1.3	0.1	0.7	2.6	0.9
Copaifera langsdorffii Desf.	Fabaceae	1.4	0.2	14.3	0.6	0.2	1.7	2.5	0.9
Myrcia sp.	Myrtaceae	5.7	0.8	28.6	1.3	0.0	0.2	2.3	0.8
Pouteria macrophylla (Lam.) Eyma	Sapotaceae	5.7	0.8	28.6	1.3	0.0	0.2	2.3	0.8
Cordia sp.	Boraginaceae	5.7	0.8	28.6	1.3	0.0	0.2	2.3	0.76
Symplocos sp.	Symplocaceae	4.3	0.6	28.6	1.3	0.0	0.3	2.2	0.7
Handroanthus impetiginosus (Mart. ex DC.) Mattos	Bignoniaceae	1.4	0.2	14.3	0.6	0.2	1.3	2.2	0.7
Rhamnidium elaeocarpum Reissek	Rhamnaceae	4.3	0.6	28.6	1.3	0.0	0.2	2.1	0.7
Byrsonima sp.	Malpighiaceae	2.9	0.4	28.6	1.3	0.0	0.2	1.9	0.6
Psidium myrtoides O.Berg	Myrtaceae	2.9	0.4	28.6	1.3	0.0	0.1	1.8	0.6
Cordiera sessilis (Vell.) Kuntze	Rubiaceae	2.9	0.4	28.6	1.3	0.0	0.1	1.8	0.6

Scientific name	Family	DA	DR	FA	FR	DoA	DoR	VI	VI (%)
Simira cf. *corumbensis* (Standl.) Steyerm.	Rubiaceae	2.9	0.4	14.3	0.6	0.0	0.1	1.1	0.4
Alibertia edulis (Rich.) A. Rich.	Rubiaceae	1.4	0.2	14.3	0.6	0.0	0.3	1.1	0.4
Diospyros hispida A.DC.	Ebenaceae	1.4	0.2	14.3	0.6	0.0	0.1	1.0	0.3
Roupala montana Aubl.	Proteaceae	1.4	0.2	14.3	0.6	0.0	0.1	1.0	0.3
Eriotheca gracilipes (K. Schum.) A. Robyns	Malvaceae	1.4	0.2	14.3	0.6	0.0	0.1	0.9	0.3
Kielmeyera coriacea Mart. & Zucc.	Clusiaceae	1.4	0.2	14.3	0.6	0.0	0.1	0.9	0.3
Leptolobium elegans Vogel	Fabaceae	1.4	0.2	14.3	0.6	0.0	0.1	0.9	0.31
Tocoyena formosa (Cham. & Schltdl.) K. Schum.	Rubiaceae	1.4	0.2	14.3	0.6	0.0	0.0	0.9	0.3
Qualea grandiflora Mart.	Vochysiaceae	1.4	0.2	14.3	0.6	0.0	0.0	0.9	0.3
Machaerium acutifolium Vogel	Fabaceae Faboideae	1.4	0.2	14.3	0.6	0.0	0.1	0.9	0.3
Lafoensia pacari A. St.-Hil.	Lythraceae	1.4	0.2	14.3	0.6	0.0	0.1	0.9	0.3
Aspidosperma pyrifolium Mart.	Apocynaceae	1.4	0.2	14.3	0.6	0.0	0.1	0.9	0.3
Cheiloclinium cognatum (Miers) A.C. Sm.	Celastraceae	1.4	0.2	14.3	0.6	0.0	0.0	0.9	0.3
Total		**688.6**	**100.0**	**2228.6**	**100.0**	**12.0**	**100.0**	**300.0**	**100.0**

out in the fragments in the valley of Paranã (Silva & Scariot 2003, 2004, 2004a; Scariot & Sevilha 2005) suggest links with the seasonal forests of the Caatinga biome in the vegetation defined as "Caatinga Arbórea" (Santos *et al.* 2012), which has a high frequency of species such as *Anadenanthera colubrina*, *Aspidosperma pyrifolium*, *Myracrodruon urundeuva* and *Handroanthus impetiginosus*, besides other examples.

The species richness of the forest fragments was similar to a wide range of variation for this type of tropical ecosystem (Murphy & Lugo 1986; Gillespie *et al*. 2000), which occupies different Brazilian biomes such as the Cerrado, Caatinga and the Atlantic Forest. As regards the sampling in Palmeirópolis, the Chao and Jackknife richness estimators reported values higher than the observed richness. Krebs (1989) and Hellmann & Fowler (1999) suggested that, for samples smaller than 20 plots, the variations of the Jackknife method showed a better performance than estimates from the Bootstrap method, which provides more trustworthy data in larger samples. However, the results of the Bootstrap method were more similar to the observed richness of the current study.

The values the Shannon diversity index and evenness were lower than the diversity recorded in many preserved semi-deciduous forests in other regions in Brazil (Silva *et al*. 2003; Silva & Araújo 2009) and also presented lower values than those in semi-deciduous forests with some degree of human disturbance in the past (Araújo & Haridasan 1997; Garcia *et al.* 2011). However, the observed values of the Shannon diversity index and evenness are included in the wide range of variation found in surveys in intact and human-disturbed semi-deciduous and deciduous forests, being higher than the records from human-disturbed semi-deciduous forests (Fonseca & Rodrigues 2000). The evenness in both fragments did not indicate a powerful dominance of a few species over others, suggesting a relatively stability in the species distribution.

The occurrence of cattle, the abundance of *Guadua paniculata*, the evidence of fire inside the fragments and the logging observed in the field seem to have provided conditions for lianas to become abundant, as one could see in other South American seasonal forests (Fredericksen & Mostacedo 2000). The liana tangles can reduce the natural regeneration process in forest formations for years (Schnitzer *et al.* 2000; Tabanez & Viana 2000). In the deciduous forests of the Paranã valley, Vieira & Scariot (2006b) reported a liana occupation of 22% in a disturbed area, whereas preserved areas showed 6% of occupation. Both studied fragments showed especially high values for liana tangle frequency, which is typical of disturbed environments (Oliveira-Filho *et al*. 1997; Vieira & Scariot 2006b).

The values of density, volume and dominance/ basal area were included in the typical range of seasonal forests and were even higher than in some less disturbed deciduous forests (Scariot & Sevilha 2005). The comparison with these forests indicates the variability of density and basal area and that the studied fragments were a little denser and with more dominance than the deciduous forests in Table 2. However, the values were lower than other semi-deciduous forests from Goiás, Minas Gerais and São Paulo. Haidar *et al*. (2005) reported density values of 1097.8 ind.ha^{-1} in central-southern Goiás. Also in southern Goiás, Garcia *et al.* (2011) reported slightly lower density values, at between 882 and 1039 ind.ha^{-1}. These authors also calculated the value of 11.1 m^2.ha^{-1} for the basal area in semi-deciduous forest fragments in early regeneration stage, which is near the value recorded in Minaçú. Araújo & Haridasan (1997) indicated density values higher than 1800 ind.ha^{-1} and 2500 ind.ha^{-1} for two forest fragments in Uberlândia. In São Paulo, Ivanauskas *et al*. (2002) reported density of 2125 ind.ha^{-1} and a high value of 45.22m².ha^{-1} for basal area. The results of the current study suggest the fragments of seasonal forests in northeastern Goiás were structurally closer to the deciduous forests in Goiás recorded in the Paranã river valley than to the semi-deciduous forests sampled in areas located in the southern.

In spite of the high number of dead standing individuals in both studied forest fragments, these values were similar to those recorded in other surveys in a number of regions (Ivanauskas & Rodrigues 2000; Ivanauskas *et al*. 2002; Silva & Soares 2002; Lopes *et al*. 2002; Silva & Scariot 2003; Haidar *et al*. 2005). So this variable did not add information about possible patterns of the community structure.

Several species, such as *Anadenanthera colubrina*, *Aspidosperma pyrifolium*, *Aspidosperma subincanum*, *Dilodendron bipinnatum*, *Hymenaea courbaril*, *Myracrodruon urundeuva*, *Pseudobombax tomentosum*, *Handroanthus impetiginosus* and *Tabebuia roseoalba* also showed high values of importance in deciduous forest located in the Paranã river valley (Silva & Scariot 2003; 2004; 2004a; Nascimento *et al*. 2004; Scariot & Sevilha 2005). Are these results related to the geographic distance? Is it a remnant of the fragmentation in the former “mato grosso goiano”? With the current available data it is not possible to reach a final conclusion. Furthermore, the species *A. colubrina, D. bipinnatum, H. courbaril* and *M. urundeuva* also stood out in the semi-deciduous forest from central Goiás (Haidar *et al*. 2005) in spite of the lower similarity and higher geographic distance. These species were also highlighted by Oliveira-Filho *et al.* (2006), showing a high frequency on checklists from low-altitude tropical seasonal forests in the central-western region of Brazil. In particular, the value for *A. colubrina*, the first IV in Palmeirópolis and the fourth in Minaçú, is interesting given the high frequency of this species in Central Brazil, and which was not considered in past studies (Prado & Gibbs 1993; Pennington *et al*. 2000; Prado 2000) because of the lack of published data.

The small and human-disturbed forest fragments studied showed composition and structure that are typical of low-altitude seasonal forests in the middle/upper Tocantins river basin. The floristic composition was more similar to that of a deciduous seasonal forest in the Paranã valley, and more dissimilar to other forests in this same valley. This result and a higher dissimilarity related to the southern forests in Goiás suggest limitations on dispersion of the woody flora and a particular flora in each fragment with relatively similar structure and diversity. These floristically heterogeneous forest fragments are the last remnants of that endangered forest physiognomy in this region of Goiás.

Acknowledgments

The authors would like to thank Glocimar Pereira da Silva, Isabela Lustz Portela Lima, João Benedito Pereira, Juarez Amaral and Gledson Alves Moreira for field assistance and Susan Casement for English review. This research was supported by Consórcio de Energia São Salvador (CESS) and Fundação Arthur Bernardes (FUNARBE)

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Artigo recebido em 22/01/2013. Aceito para publicação em 16/06/2013.