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Plant functional groups of species in semiarid ecosystems in Brazil: wood basic density and SLA as an ecological indicator

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Abstract Deciduousness in arid and semiarid environments is an important adaptive strategy in tree and shrub species to prevent extensive leaf desiccation and nutrient loss during the drought. The loss of leaves benefits some species, since the seasonality of water resources and high temperatures restrict the survival of plants in xeric environments. The aim of this study was to characterize functional groups of caatinga species from soft traits by testing the hypothesis that the four soft trait measured will show a new pattern and thereby characterize plant functional groups, or if the analysis of the chosen traits will converge with deciduousness. The soft traits measured did not form groups based on deciduousness. Three statistically different groups of species could be identified after statistical analysis: (1) low wood basic density; (2) low specific leaf area and high leaf thickness; and (3) high wood basic density. The most important attributes of the first two Principal Component Analysis axis were wood basic density and specific leaf area explaining 40.8 % and 37.4 % of the variation respectively. Albeit no link has been found between SLA and deciduousness, this study represents an additional evidence that perhaps the severity of savanna environments limits leaf longevity, meaning that differences between evergreen and deciduous species are less important.

Keywords Deciduousness · Functional ecology · Soft traits

List of abbreviations

LA	Leaf area
LT	Leaf thickness
N	Nitrogen
P	Phosphorus
PFT	Plant functional types
SLA	Specific leaf area
WBD	Wood basic density

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Introduction

In ecosystems with a semiarid climate, plants with adaptive structures and strategies for this environment with restricted water are commonly seen (Trovão et al. 2004; Liao and Wang 2010). These structures include leaves modified to spines, their presence on stems and the presence of reserve tissues in stems and roots (Dombroski et al. 2011). Deciduousness is an important adaptive strategy in tree and shrub species to prevent extensive leaf desiccation and nutrient loss during the drought (Barbosa et al. 2003; Marchin et al. 2010). The loss of leaves benefits these species, since the seasonality of water resources and high temperatures restrict the survival of plants in xeric environments (Lima and Rodal 2010).

The plant functional groups (PFT) approach allows grouping of species that respond similarly to biotic and abiotic factors, independent of phylogenetic and taxonomic relations (Reich et al. 2003). Those groups show similarities in anatomo-morphological characteristics and physiological reaction patterns (Díaz et al. 2004). Thus, functional groups share similar adaption strategies to specific environmental conditions and thereby illustrate evolutional selection in plants (Cornelissen et al. 2003; Westoby and Wright 2006).

On the attempt of identifying plant functional groups, many traits can be used including leaf, stem, fruits, seed, root, and whole individual traits (Reich et al. 2003). Some of them are relatively easy and quick to quantify, know as "soft traits" (Hodgson et al. 1999). Due the seasonal water availability during the year, we choose traits that may be linked to deciduousness as leaf area (LA), leaf thickness (LT), and specific leaf area (SLA) (Reich et al. 1997) and one stem trait, wood basic density (WBD), due the possibility of the stem to store water and interfere with the other traits (Lima and Rodal 2010).

The aim of this study was to characterize functional groups of caatinga species from soft traits by testing the hypothesis that the four soft trait measured will show a new pattern and thereby characterize PFT, or if the analysis of the chosen traits will converge with deciduousness.

Materials and methods

Study area

The field studies were conducted on Fazenda Vereda Grande (7°31.613′S, 36°2.991′W, altitude of 514 m) and Fazenda Pocinhos (7°29.929′S, 35°58.237′W, altitude of 391 m), both situated in the municipality of Barra de Santana in the state of Paraíba, Brasil (Fig. 1). These areas are within the Cariri Oriental microregion, Borborema mesoregion (AESA 2006). According to the Köppen classification (Köppen 1948), the region including the study area has a BSwh' climate, i.e., warm, semiarid, with dry season lasting 9 to 10 months (Fig. 2), and annual mean rainfall less than 300 mm (AESA 2006; Paraiba 2007). The variations in temperature show monthly minima of 18 to 22 °C between July and August, and monthly maxima of 28 to 31 °C between November and December. Relative humidity has a monthly mean of 60 to 75 %, maximal values generally occur in June and the minima in December (Paraiba 2007; BioClim 2010). Fields make up the predominant vegetation, consisting of a savannah-steppe park (IBGE 2004).

Species investigated

The species studied were tree- and shrub-sized plants already sampled in past studies (Trovão et al. 2004, 2007; Andrade et al. 2005; Barbosa et al. 2007). On the basis of former surveys, 21 species with high values of density and basal area were selected. Redundant species, as well as those that accounted for samples of less than ten individuals, were not included, since the most abundant species, representing about 70 to 80 % of the aboveground biomass, are sufficient to measure the functional attributes (Cornelissen et al. 2003) and to provide statistical significance (Gotelli and Ellison 2010). Thereafter, we gathered the information on literature about the deciduousness of the species in order to pre-classify them (Table 1).

Leaf traits

Ten leaves of ten individuals of each species were collected to determine the leaf dry mass, SLA and LT. Mature, healthy, and fully expanded leaves on the north side, in the medial third of the tree canopy, were used for the measurements of these parameters. LT was measured with a digital pachymeter sparsing the central vein. Afterward, the leaves were placed in an oven at 60 °C for at least 78 h to obtain a constant dry weight. Next, the leaves were weighed in grams to determine the dry mass. SLA was obtained dividing the fresh area (m^2) of the leaf by the dry weight (kg) (Cornelissen et al. 2003). LA was measured using digital photographs with a resolution of 1,600 × 1,200: the leaves were placed on a whiteboard, pressed with a glass plate and photographed, along with a centimeter ruler. The area of the leaves then was calculated using the IMAGEJ program (Rasband 2011).

Wood traits

Five segments of stem approximately 2 cm in diameter and 10 cm long from the main stems (the first bifurcation of branches) of mature trees were collected for each species, and the bark with cambium, phelloderm, and phellogen were removed. Then the volume of all the wood stem segments was determined by placing the samples into water for at least half an hour to ensure adequate swelling. After that, the container was filled with water on the pan of the electronic scales and re-zero. Then the sample was removed from the water, wiped with a damp cloth, and then completely submerged in the container on the electronic scales, without touching the container. As the density of water under normal laboratory conditions is equal to 1,000 kg m^{-3}, the measured weight of the displaced water is equal to the volume of the sample. After the volume measurement, the sample was dried in the oven at 60 °C

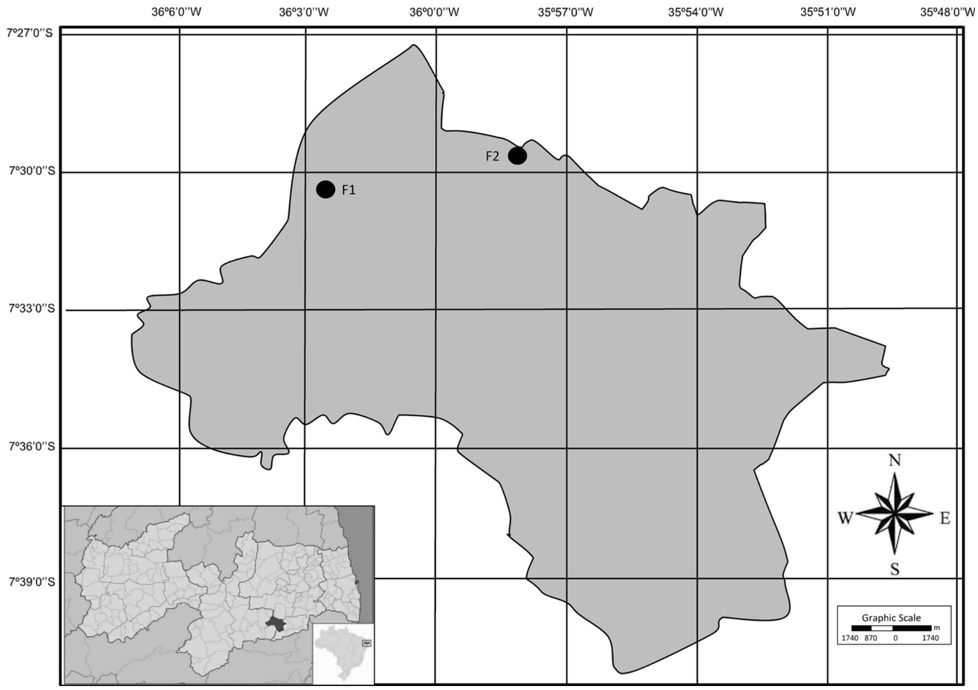

Fig. 1 Map of the study area. *F1* Fazenda Vereda Grande, *F2* Fazenda Pocinho

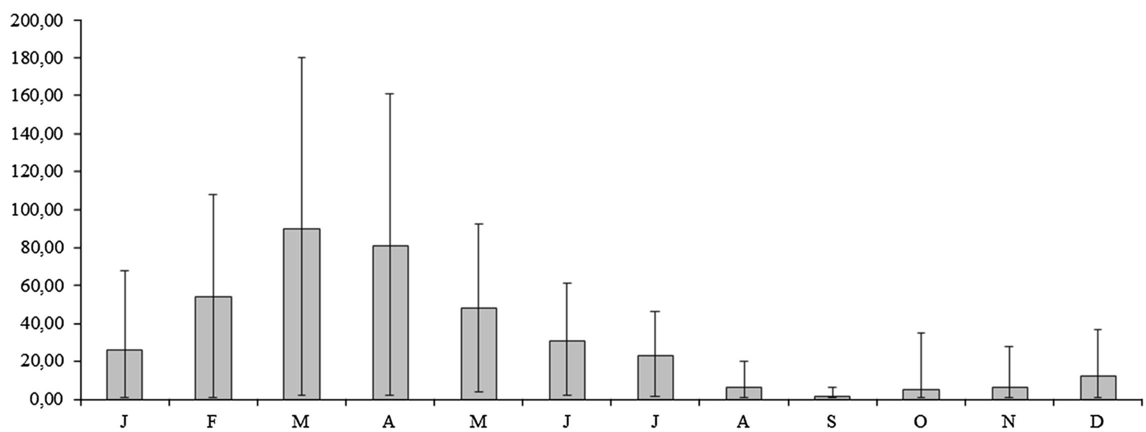

Fig. 2 Average rainfall (mm) between 1911–1991 in the region of S. João do Cariri

for at least 72 h until it reaches a constant weight to measure oven-dry mass (Australian Greenhouse Office 2000; Chave et al. 2006).

Statistical analysis

Aiming to fulfill the statistical assumptions of data's normality and homoscedasticity for further analysis the raw data (Table 2) was BOX–COX transformed and standardized (Hammer et al. 2001). Then the test of normal distribution of the data was confirmed using the Shapiro–Wilk test (Hammer et al. 2001). The variables were standardized to make the data comparable, albeit expressed in different units (Gotelli and Ellison 2010). These procedures were carried out using the program PRIMER 6.0 with PERMANOVA (Clarke and Gorley 2006).

Next, cluster analysis was performed using Euclidean distance with the Ward method to better visualize how the species were grouped, using Paleontological Statistics program (PAST 2.16) (Hammer et al. 2001). The cophenetic coefficient was utilized to measure the concordance between the dendrogram and the original matrix of distance (Sokal and Rohlf 1962).

After the formation of the groups, principal components analysis (PCA) was performed with Euclidean distance to determine which variables were most distinctive (Hammer

Table 1 List of studied species and their deciduousness

Species	Family	Deciduousness
Cynophalla flexuosa (L.) J.Presl	Capparaceae	E
Ziziphus joazeiro Mart.	Rhamnaceae	E
Sideroxylon obtusifolium (Roem. & Schult.) T.D.Penn.	Sapotaceae	E
Schinopsis brasiliensis Engl.	Anacardiaceae	FD
Croton blanchetianus Baill.	Euphorbiaceae	LD
Jatropha mollissima (Pohl) Baill.	Euphorbiaceae	LD
Manihot glaziovii Muell. Arg.	Euphorbiaceae	LD
Sapium glandulosum (L.) Morong	Euphorbiaceae	LD
Mimosa tenuiflora (Willd.) Poir.	Fabaceae	LD
Mimosa ophthalmocentra Mart. ex Benth.	Fabaceae	LD
Piptadenia stipulacea (Benth.) Ducke	Fabaceae	LD
Pseudobombax marginatum (A.St.-Hil.) A. Robyns	Malvaceae	LD
Commiphora leptophloeos (Mart.) J.B. Gillett	Anacardiaceae	SD
Myracrodruon urundeuva Allemão	Anacardiaceae	SD
Spondias tuberosa Arruda	Anacardiaceae	SD
Aspidosperma pyrifolium Mart.	Apocynaceae	SD
Tabebuia aurea (Silva Manso) Benth. & Hook.f. ex S.Moore	Bignoniaceae	SD
Anadenanthera colubrina (Vell.) Brenan	Fabaceae	SD
Bauhinia cheilantha (Bong.) Steud.	Fabaceae	SD
Libidibia ferrea (Mart. ex Tul.) L.P.Queiroz	Fabaceae	SD
Poincianella pyramidalis (Tul.) L.P.Queiroz	Fabaceae	SD

E evergreen species, *FD* facultative deciduous species, *LD* long deciduous species (4–6 month without leafs), *SD* short deciduous species (2–3 months without leafs)

et al. 2001; Gotelli and Ellison 2010). The differences between groups were evaluated using PERMANOVA with 999 permutations (Gotelli and Ellison 2010).

Results

The soft traits measured did not formed groups based on deciduousness. First, the cluster analysis showed a different pattern (Fig. 3). Then, on Principal Component Analysis (PCA) the deciduousness factor was not able to form any visual group (Fig. 4). On the end of the analysis, with PERMANOVA test, no significant difference emerged among the pre-established groups (Table 3).

Otherwise, three groups were identified by cluster analysis based on Euclidean distance, with a cutoff point of 2,2. The cophenetic coefficient was 0.6699, indicating a good fit between the graphic representation of distances and their original matrix. This allowed us to make inferences by means of visual evaluation as shown in Fig. 3. The three groups were: (1) low WBD; (2) low SLA and hight LT; and (3) high WBD (Table 4). Using PERMANOVA, there was a statistically significant difference among the three groups formed (Table 5).

In detail, after normalization and standardization of the data, the species with highest values of SLA and LA, and lowest of LT was *Anadenanthera colubrina*. The lowest WBD was found in *Jatropha molissima*. However, the highest WBD was observed in *Libidibia ferrea*. Finally, *Cynophalla fleuxosa* showed the lowest SLA values (Table 4).

PCA served to indicate which factors were most important in the ordination of the data points on the axes—this had a central role in answering the principal question of this work, both WBD and SLA were the predominant attributes in the identification of PFTs in the semiarid region of Brazil (Fig. 5). The results indicate that WBD on axis 1 explains 40.8 % of the variation and on axis 2 the most important attribute was SLA (0.671), explaining 37.4 % of the variation (Tables 6, 7).

Discussion

The first group is composed by deciduous trees, one short and the others are long deciduous. The most remarkable point about this group is the low WBD. Studies on a global scale observed that the density of wood is negatively related to precipitation (Chave et al. 2009). Plants with lower density wood are more susceptible to implosion or rupture of xylem vessels, since they are more vulnerable to cavitation (Hacke and Sperry 2001; Chave et al. 2009). However, conductive tissues of low cost with woods of low density (Hacke and Sperry 2001), which allow rapid growth due to their lower cost of development per dry matter (Swenson and Enquist 2007; Chave et al. 2009). This is a typical example of compensation: in order to benefit of a higher water transport rate, these species lose the ability to maintain their xylem ducts. WBD and capacity to store water in stems are inversely proportional characteristics, allowing plants with low WBD to accumulate a large volume of water in the stems, so that this reserve could be utilized for the production of new leaves, flowers, and fruits, even in the dry season (Borchert et al. 2002). Flowering or producing new leaves even in the dry season could prevent attack by herbivores, which are much more active during the rainy season (Lima and Rodal 2010). This could also represent a strategy to maximize the photosynthetic activity during the short rainy season (Chapotin et al. 2006), when the leaves expand rapidly as the first rains begin.

Table 2 Original raw data of leaf traits (SLA, LA, LT) and wood trait (WBD)

Species	WBD (g cm^3)	LA (mm^2)	SLA (m^2 kg^{-1})	LT (mm)
Anadenanthera colubrina (Vell.) Brenan	0.7944 ± (0.0319)	163582.36 ± (55586.56)	45.7424 ± (18.1532)	0.6510 ± (0.0952)
Aspidosperma pyrifolium Mart.	0.7210 ± (0.3056)	24042.34 ± (4206.676)	10.6922 ± (1.0902)	3.3813 ± (0.6830)
Bauhinia cheilantha (Bong.) Steud.	0.7896 ± (0.0258)	25769.37 ± (4907.415)	17.3397 ± (3.4164)	2.1660 ± (0.0793)
Commiphora leptophloeos (Mart.) J.B. Gillett	0.3804 ± (0.1683)	18360.08 ± (6399.67)	6.7085 ± (1.0603)	1.2040 ± (0.2083)
Croton blanchetianus Baill.	0.6770 ± (0.0562)	35461.69 ± (15379.96)	9.7493 ± (1.1312)	3.0960 ± (0.6884)
Cynophalla flexuosa (L.) J.Presl	0.6879 ± (0.2269)	84509.74 ± (26857.71)	5.7943 ± (1.0156)	3.9544 ± (0.6377)
Jatropha mollissima (Pohl) Baill.	0.2900 ± (0.0690)	39684.10 ± (8418.057)	15.2566 ± (3.0710)	3.5700 ± (0.4263)
Libidibia ferrea (Mart. ex Tul.) L.P.Queiroz	0.8040 ± (0.0649)	18078.75 ± (3825.276)	11.1247 ± (3.3172)	1.6089 ± (0.4487)
Manihot glaziovii Muell. Arg.	0.3781 ± (0.0724)	13040.33 ± (9159.64)	21.7833 ± (5.4039)	0.9890 ± (0.0942)
Mimosa tenuiflora (Willd.) Poir.	0.7348 ± (0.0308)	25290.44 ± (16796.92)	16.2562 ± (2.3719)	1.3811 ± (0.1662)
Mimosa ophthalmocentra Mart. ex Benth.	0.7418 ± (0.0653)	13875.31 ± (5552.684)	20.0704 ± (4.6660)	1.1310 ± (0.2920)
Myracrodruon urundeuva Allemão	0.7181 ± (0.0652)	20231.44 ± (5050.997)	11.0845 ± (0.8387)	1.0900 ± (0.0580)
Piptadenia stipulacea (Benth.) Ducke	0.7365 ± (0.1091)	51022.56 ± (25340.73)	22.9040 ± (3.0025)	1.1867 ± (0.1342)
Poincianella pyramidalis (Tul.) L.P.Queiroz	0.6566 ± (0.1173)	106417.43 ± (55621.32)	14.6972 ± (3.1921)	1.4600 ± (0.2134)
Pseudobombax marginatum (A.St.-Hil.) A. Robyns	0.5543 ± (0.2704)	13358.67 ± (3110.132)	12.9306 ± (1.8858)	2.0088 ± (0.3864)
Sapium glandulosum (L.) Morong	0.3656 ± (0.0734)	44399.11 ± (19840.66)	18.4557 ± (3.8064)	1.4357 ± (0.6045)
Schinopsis brasiliensis Engl.	0.7161 ± (0.0670)	16624.78 ± (5165.818)	10.9815 ± (1.7597)	1.2411 ± (0.1203)
Sideroxylon obtusifolium (Roem. & Schult.) T.D.Penn.	0.7555 ± (0.0708)	151530.87 ± (49166.55)	6.7085 ± (1.2593)	1.2040 ± (0.0896)
Spondias tuberosa Arruda	0.6068 ± (0.0636)	4151.05 ± (1837.716)	30.3151 ± (4.8988)	1.7075 ± (0.6915)
Tabebuia aurea (Silva Manso) Benth. & Hook.f. ex S.Moore	0.5229 ± (0.0653)	4151.05 ± (8127.666)	6.9805 ± (0.5603)	3.7163 ± (0.2666)
Ziziphus joazeiro Mart.	0.6723 ± (0.0426)	31125.29 ± (5722.751)	13.3593 ± (1.9726)	2.4389 ± (0.4668)

Values in parenthesis are standard deviation. The species are shown on alphabetical order

WBD wood basic density, *LA* leaf area, *SLA* specific leaf area, *LT* leaf thickness

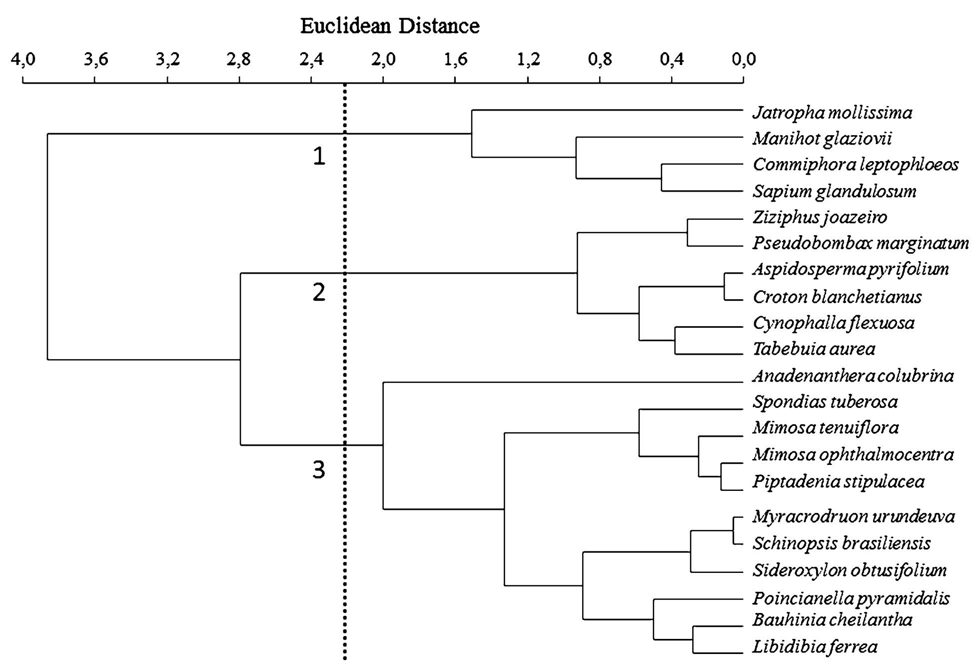

Fig. 3 Cluster analysis with Euclidian distance using the Ward method. The cutoff value (4.9) is show on the *dotted line*. The cophenetic correlation coefficient was 0.6711

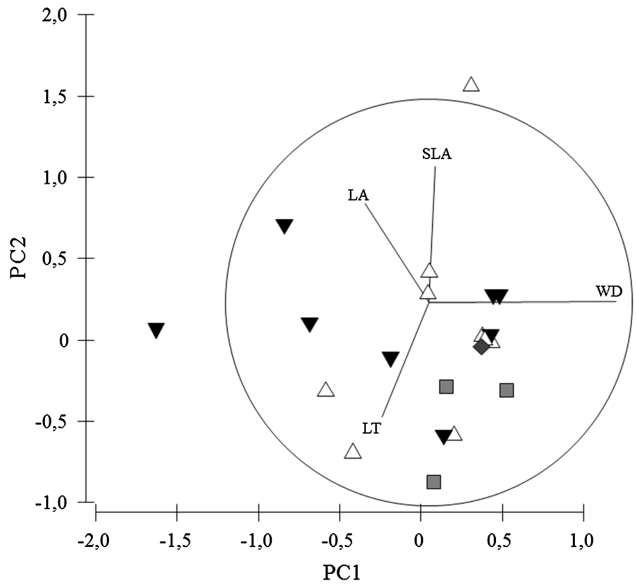

Fig. 4 Principal component analysis (PCA) of the groups according to deciduousness. *WBD* wood basic density, *LA* leaf area, *SLA* specific leaf area, *LT* leaf thickness. *Upside white triangle* short deciduous, *Downside black triangle* long deciduous, *gray square* evergreen, *black diamond* facultative deciduous

Table 3 PERMANOVA results between the groups previously made by deciduousness

Groups (*deciduousness*)	*t*	*P* (perm)	Unique perms
SD, LD	0.84185	0.591	983
SD, E	1.0441	0.378	214
SD, FD	0.4756	0.784	10
LD, E	1.345	0.166	164
LD, FD	0.70929	0.785	9
E, FD	0.80041	0.741	4

P (perm) significance, *Perm* permutations

Also, the fist group is mainly formed by Euphorbiaceae, more specifically the subfamilies Euphorbioideae and Crotonoideae which characteristically have latex (Lucena and Alves 2010). That latex is a result of chemical deposition that occurs during heartwood formation helping to prevent attacks from predators and pathogens (Mennega 2005). The chemical defense is an alternative strategy against predators and xylophagous insects (Farrel et al. 1991).

On the other hand, the high WBD is the main factor in the third group. Plants that have high WBD show a low growth rate and mortality, since there is a greater carbon density, considering that these plants are long-lived and grow very tall and, therefore, tend to invest in strong stems to support the plant as a whole, besides resisting environmental risks (Chave et al. 2009). Moreover, dense woods are also more resistant to embolism and implosion or rupture of xylem vessels. Thus, these species are less vulnerable to cavitation of xylem vessels (Hacke and Sperry 2001). However, a high WBD can be a response of high stress environment, xylophagous insects and lower soil fertility (Chave et al. 2006).

The Fabaceae and Anacardiaceae families are present only on the third group. Fabaceae species listed on this study are all early secondary, besides *Mimosa tenuiflora* and *Poincianella pyramidalis* (Carvalho et al. 2011). *M. tenuiflora*, besides the high WBD, is considered a relatively short living species (Azevêdo et al. 2012). Their high wood density may be for physical defense rather than for long lifespan (Cornelissen et al. 2003). Anacardiaceae species *Myracrodruon urundeuva* and *Schinopsis brasiliensis* are considered endangered species by Brasilian Government (MMA 2008). *Spondias tuberosa* is endemic from caatinga (Giulietti et al. 2002). High WBD provides protection against stress environment and predation, but these species are overexploited, being used by coal and timber industries, and by the local population as medicinal plants and for fence building (Albuquerque et al. 2005).

The main attributes of the second group were high LT and low SLA. Leaves of species with greater leaf longevity are thicker than those of deciduous species, as they have a thick cuticle with a coriaceous texture and low SLA (Cornelissen et al. 2003). Low SLA values are also related to low soil fertility (Cornelissen et al. 2003), because plants with low SLA leaves are typically distributed in areas with dystrophic soils (Wright et al. 2004). Despite of our predictions based on literature (Wright et al. 2004; Kattge et al. 2011), there is no relation between SLA and deciduousness.

Also, it seems likely that SLA may not distinguish species of different phenologies co-ocurring in savannas (Nelson et al. 2002). Souza (2012), working in the Cerrado, found no difference in the mean lifespan or SLA of evergreen and deciduous species, instead both leaf habit groups had a wide range of lifespan and SLA values.

These three groups formed are found in an environment of extreme water seasonality (Albuquerque et al. 2012) and in soil with low concentrations of N and P (Menezes et al. 2012). Also water availability is a critical factor for the survival of various species native in areas of high temperatures and light intensity, which results in a high evaporative demand and consequent soil dessication (Trovão et al. 2007). Albeit no link between SLA and deciduousness has been found, this study represents an

Table 4 Normalized data of species with taxonomic classification and the comparisons between previous grouping (Deciduousness) and post-hoc group (Cluster)

Order	Family	Species	WBD	LA	SLA	LT	Cluster	Deciduousness
Malpighiales	Euphorbiaceae	*Jatropha mollissima* (Pohl) Baill.	0	2.217	1.355	1.978	1	LD
		Manihot glaziovii Muell. Arg.	0.474	1.905	1.644	0.916	1	LD
		Sapium glandulosum (L.) Morong	0.437	1.121	1.502	1.147	1	LD
Sapindales	Burseraceae	*Commiphora leptophloeos* (Mart.) J.B. Gillett	0.484	0.958	0.895	1.031	1	SD
Bombacoideae	Malvaceae	*Pseudobombax marginatum* (A.St.-Hil.) A. Robyns	1.126	1.341	1.241	1.406	2	LD
Capparales	Capparaceae	*Cynophalla flexuosa* (L.) J.Presl	1.525	1.118	0.838	2.098	2	E
Gentianales	Apocynaceae	*Aspidosperma pyrifolium* Mart.	1.601	1.102	1.124	1.916	2	SD
Lamiales	Bignoniaceae	*Tabebuia aurea* (Silva Manso) Benth. & Hook.f. ex S.Moore	1.029	1.3	0.912	2.024	2	SD
Malpighiales	Euphorbiaceae	*Croton blanchetianus* Baill.	1.499	1.065	1.072	1.82	2	LD
Rhamnales	Rhamnaceae	*Ziziphus joazeiro* Mart.	1.473	1.141	1.262	1.58	2	E
Fabales	Fabaceae	*Anadenanthera colubrina* (Vell.) Brenan	1.777	2.293	2.458	0.72	3	SD
		Bauhinia cheilantha (Bong.) Steud.	1.767	1.387	1.452	1.471	3	SD
		Libidibia ferrea (Mart. ex Tul.) L.P.Queiroz	1.799	1.449	1.147	1.229	3	SD
		Mimosa tenuiflora (Willd.) Poir.	1.625	1.071	1.402	1.12	3	LD
		Mimosa ophthalmocentra Mart. ex Benth.	1.65	1.195	1.572	0.993	3	LD
		Piptadenia stipulacea (Benth.) Ducke	1.65	1.062	1.69	1.022	3	LD
		Poincianella pyramidalis (Tul.) L.P.Queiroz	1.446	1.737	1.328	1.159	3	SD
Sapindales	Anacardiaceae	*Myracrodruon urundeuva* Allemão	1.596	1.182	1.145	0.971	3	SD
		Schinopsis brasiliensis Engl.	1.601	1.2	1.139	1.05	3	FD
		Spondias tuberosa Arruda	1.299	1.256	1.969	1.274	3	SD
Sapindales	Sapotaceae	*Sideroxylon obtusifolium* (Roem. & Schult.) T.D.Penn.	1.688	0.958	0.895	1.031	3	E

WBD wood basic density, *LA* leaf area, *SLA* specific leaf area, *LT* leaf thickness

Table 5 PERMANOVA results between the groups formed by Ward's method

Groups (*Post hoc*)	*t*	*P* (perm)	Unique perms
1, 2	3.0911	0.004	209
1, 3	3.2326	0.003	707
2, 3	3.016	0.002	954

P (perm) significance, *Perm* permutations

additional evidence that perhaps the severity of caatinga environments limits leaf longevity, meaning that differences between evergreen and deciduous species are less important.

This was a pioneer study in this area, serving with a good indication for areas with marked seasonality as the caatinga. The attributes of the plant species studied formed groups that reflect different survival strategies of plants in semiarid ecosystems, indicating possible PFT. Among the attributes measured, the most important in the formation of these clusters was WBD, accounting for 40.8 % of the variation in the data.

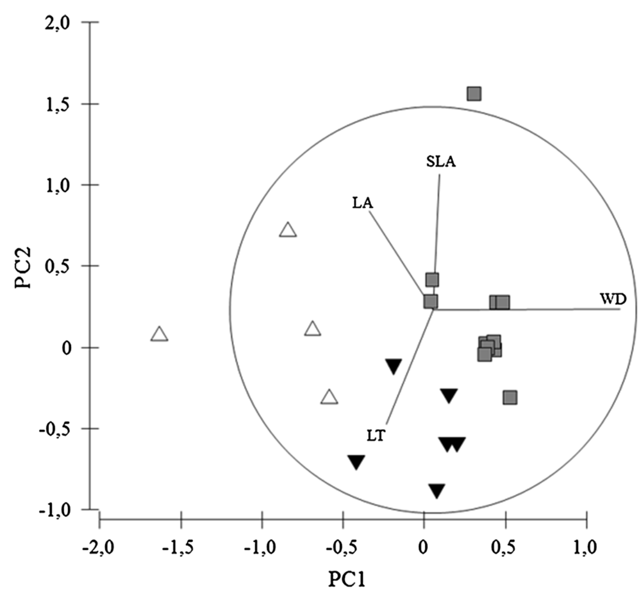

Fig. 5 Principal component analysis (PCA) of the groups according to trait values. *WBD* wood basic density, *LA* leaf area, *SLA* specific leaf area, *LT* leaf thickness. *Upside white triangle* group 1, *Downside black triangle* group 2, *Gray square* group 3

Table 6 Principal component analysis (PCA) eigenvalues results

PC	Eigenvalues	% Variation	Cum. % Variation
1	0.304	40.8*	40.8
2	0.279	37.4*	78.2
3	0.12	16.1	94.4
4	4.21E−02	5.6	100

* Eigenvalues that explains most of data variation

Table 7 Eigenvectors values per axis of PCA

Variable	PC1	PC2	PC3	PC4
WBD	0.921[a]	0.002	−0.364	−0.141
LA	−0.313	0.484	−0.559	−0.596
SLA	0.03	0.671[a]	−0.197	0.714
LT	−0.231	−0.562	−0.718	0.339

[a] Variable that best explained the variation on the axis

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