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FLORISTIC COMPOSITION AND SIMILARITY OF A CAATINGA FOREST AREA, BAHIA, BRAZIL

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ABSTRACT

The present study evaluated floristic composition, similarity and the phytogeographic structuring framework of Caatinga in the Contendas do Sincorá National Forest. The climate of the region is BSwh', with annual precipitation of 500 to 700 mm and altitude between 300 and 400 m. The soil is eutrophic red-yellow ultisol. Floristic similarity was established by the unweighted pair group method with arithmetic mean. Fifty-one (51) taxa were found distributed in 20 families. The families with the largest number of genera and species were Fabaceae and Euphorbiaceae. The classification for this physiognomy was Forested Savanna-Steppe. Floristic similarity revealed a tendency of grouping between fragments of the same state and ecoregion. Despite the history of exploitation, the floristic composition was as expected for Caatinga areas. The similarity analysis revealed that the area in question does not have a similar floristic identity to the other Caatinga areas analyzed.

KEYWORDS: Chapada Diamantina Complex, Sertaneja Meridional Depression, Forested Savanna-Steppe, semi-arid, Contendas do Sincorá National Forest.

COMPOSIÇÃO E SIMILARIDADE FLORÍSTICA DE UMA ÁREA DE CAATINGA ARBÓREA, BAHIA, BRASIL

RESUMO

O presente estudo avaliou composição florística, similaridade e o enquadramento fitogeográfico da Caatinga na Floresta Nacional Contendas do Sincorá. O clima da região é BSwh', com precipitação anual de 500 a 700 mm e altitude entre 300 e 400 m. O solo é Argissolo Vermelho Amarelo Eutrófico. A similaridade florística foi estabelecida por meio do método de ligação de médias não-ponderadas. Foram encontrados 51 táxons distribuídos em 20 famílias. As famílias com maior número de gêneros e espécies foram Fabaceae e Euphorbiaceae. A classificação para esta fisionomia foi Savana-Estépica Florestada. A similaridade florística revelou uma tendência de agrupamento entre fragmentos do mesmo estado e ecorregião. Apesar do histórico de exploração, a composição florística foi a esperada para áreas de Caatinga. A análise de similaridade revelou que a área em questão não possui identidade florística semelhante às demais áreas de Caatinga analisadas.

PALAVRAS-CHAVE: Complexo da Chapada Diamantina, Depressão Sertaneja Meridional, Savana-Estépica Florestada, semiárido, Floresta Nacional Contendas do Sincorá.

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1 INTRODUCTION

Savannas have small or medium-sized trees (3 to 10 m high), generally spaced and with wide, low-spreading crowns (IBGE, 2012). According to the same publication, the term Savanna was coined by Fernández de Oviedo y Valdés, designating Venezuela's tree-lined woodlands, and later introduced by Spanish naturalists on the African continent. The Savanna-Steppe, which has several subgroups, is the name that best defines the Brazilian vegetation types of the northeastern semi-arid regions, known as Caatinga.

According to Velloso *et al.* (2002), the Caatinga is subdivided into eight ecoregions: the Campo Maior Complex, the Ibiapaba-Araripe Complex, the Sertaneja Setentrional Depression, the Borborema Plateau, the Sertaneja Meridional Depression, the São Francisco Dunes, the Chapada Diamantina Complex and the Raso da Catarina. Each ecoregion has different vegetation characteristics influenced by soil types, water availability, altitude and site relief.

The Caatinga is a unique ecosystem in the world with a significant number of rare and endemic taxa (FERRAZ *et al.*, 2013; PEREIRA JÚNIOR *et al.*, 2014; FERNANDES & QUEIROZ, 2018) and occupies approximately 10% of the Brazilian territory (GUERRA *et al.*, 2014).

Despite its uniqueness it is one of the least studied biomes in the country. According to Silva *et al.* (2015), the Amazon and the Atlantic Forest receive many researchers among the biomes present in the country considering their high riches and international interest in these areas. The Cerrado has a very high number of publications compared to those already mentioned, while the Caatinga has less than 5% of the number of publications that each of these biomes has. The Chapada Diamantina region and the South region (Mata Atlântica) in Bahia are regions which concentrate the largest number of publications, even though the Caatinga is present in more than half of the state.

The present study was motivated by the existence of this information gap regarding this important Brazilian biome, especially regarding the state of Bahia. Thus, this work aimed to perform a floristic survey, to establish the phytogeographic structuring framework and perform a floristic similarity analysis of a Caatinga tree fragment located in the Contendas do Sincorá National Forest, southwestern Bahia state.

2 MATERIALS AND METHODS

The study was carried out at the Contendas do Sincorá National Forest (Flona), situated on the BA-026 highway, km 22, in the municipality of Contendas do Sincorá, with geographic coordinates (UTM) 271468, 8460009 (headquarters), in the southwest of Bahia State (Figure 1).

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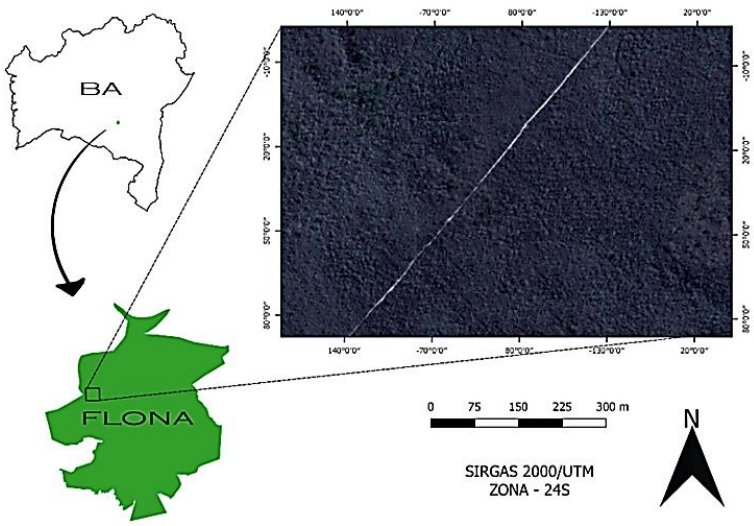

Figure 1: Location map of the study area, Contendas do Sincorá National Forest (Flona), in the municipality of Contendas do Sincorá, Bahia, Brazil. Author: Adriano Castro de Brito.

The Extrema farm was bought by a mining company aiming to extract timber for coal production. As the results were below expectations, it was sold to a second mining company that had the same objective. Once again production was considered low and the farm was ceded to IBAMA in exchange for forest replacement credits in 1997. Flona was officially created by Presidential Decree, without number, of September 21, 1999.

According to MMA (2006), the relief unit is called Peripheral and Interplanaltic Depressions. No major structural deformation was found in the area such as displacement, pushing or even fracture failures. This fact was determinant for the low water availability of its groundwater. The predominant formation in the buffer zone is sandy, which is east of the unit, with an altitude ranging from 300 m to 400 m and dominated by siliciclastic and bimodal igneous rocks.

The climate of the region is BSwh' (Köppen Classification), warm, semi-arid, with annual precipitation of 500 to 700 mm. The rainy season occurs between November and January, with an average temperature of 23°C and a relative humidity of 60 to 80% (LIMA & LIMA, 1999).

The soil is eutrophic red-yellow ultisol (MMA, 2006). Soil chemical and physical analyzes were performed at the UESB Soil Chemistry Laboratory. The collection was performed at a depth of 0 to 10 cm, disregarding the litter. The textural class found was loam. The values found were: pH (H2O) = 6.5; P = 3 mg/dm^3; K+= 0.2 c molc dm^3; Ca_2+ = 4.3 c molc dm^3; Mg_2+ 1.7 c molc dm^3 and Al_3+ 0 c molc dm^3; H+ = 1.6; Clay = 190; Sand = 410 and Silt = 410.

Flona is inserted in the Chapada Diamantina Complex ecoregion, with part of the Sertaneja Meridional Depression (VELLOSO *et al.*, 2002). The vegetation is predominantly Caatinga forest, with Cerrado and dry forest species. It is an ecotone between the Cerrado, Caatinga and Atlantic forest biomes, with difficult delimitation due to their interpenetration (LIMA & LIMA, 1999).

The floristic composition was obtained through a phytosociological survey that covered an area of 10,400 m², in addition to eventual fertile material collections. Only individuals of tree size

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with a diameter at breast height equal to or greater than 5 cm were sampled. This inclusion criterion aimed to restrict the research to individuals of arboreal size, since the objective was to analised the potential use for the caatinga area in question, in order to propose sustainable uses of the resource. Identification of the collected material was performed by consulting the specialized bibliography (Flora Brasiliensis, Flora from Bahia, Flora from Sergipe, Flora Neotropica, QUEIROZ, 2009, among others) and comparing it with specimens from the UESB herbarium in Vitória da Conquista (HUESBVC). The classification of botanical families was performed following the system APG IV (2016).

Floristic similarity relationships were performed between the study area and 19 other surveys in Caatinga (Savana-Steppe) from different states (Table 1). It is noteworthy that, for this analysis, only tree size species were used.

Table 1: List of articles used for floristic similarity assessment, with their respective locations, sampling methods and ecoregion.

Author	Location	Sampling	Ecoregion
Costa *et al.* (2015)	Tucano (BA)	Random collections	SMD and RC
Farias & Castro (2004)	Campo Maior (PI)	200 quadrant points	CMC
Ferraz *et al.* (2013)	Monumento Natural Grota do Angico (SE)	30 lots (20 x 20 m)	SMD
Guerra *et al.* (2014)	Apodi (RN)	24 lots (10 x 20 m)	SMD
Lemos & Meguro (2015)	Estação Ecológica de Aiuaba (CE)	50 lots (10 x 10 m)	IAC
Lemos & Rodal (2002)	Parque Nacional Serra da Capivara (PI)	50 lots (10 x 20 m)	CMC
Lemos & Zappi (2012)	Estação Ecológica de Aiuaba (CE)	Random collections	IAC
Lemos (2004)	Parque Nacional Serra da Capivara (PI)	Herbarium and random collections	CMC
Lima & Lima (1999)	Contendas do Sincorá (BA)	100 lots (20 x 5 m)	SMD
Oliveira *et al.* (2009)	Serra do Cariri (PB)	40 lots (50 x 4 m)	SMD
Pereira Júnior *et al.* (2012)	Monteiro (PB)	100 lots (10 x 10 m)	SMD
Pinheiro *et al.* (2010)	Mirandiba (PE)	60 lots (10 x 10 m)	SMD
Pinheiro *et al.* (2010)	Mirandiba (PE)	60 lots (10 x 10 m)	SMD
Pinheiro *et al.* (2010)	Mirandiba (PE)	60 lots (10 x 10 m)	SMD
Rodal *et al.* (2008)	Custódia e Floresta (PE)	50 lots (10 x 10 m)	SMD
Sabino *et al.* (2016)	Patos (PB)	50 lots (20 x 20 m)	SMD
Sanquetta *et al.* (2014)	Brumado (BA)	17 lots (10 x 25 m)	SMD
Santos *et al.* (2007)	Juvenília (MG)	Random collections	SMD
Santos *et al.* (2007)	Montalvânia (MG)	Random collections	SMD

In which: BA – Bahia, CE – Ceará, MG – Minas Gerais, PB – Paraíba, PE – Pernambuco, PI – Piauí, RN – Rio Grande do Norte, SE – Sergipe, CDC - Chapada Diamantina Complex, CMC - Campo Maior Complex, IAC - Ibiapaba-Araripe Complex, SMD - Sertaneja Meridional Depression and RC - Raso da Catarina.

Climate, soil type, altitude and rainfall characteristics were also evaluated (Table 2).

Table 2: List of articles used for floristic similarity assessment, with their respective soil types, climate (Köppen classification), altitude and precipitation.

Author	Group	Soil type	Climate	Altitude	Annual precipitation
Costa *et al.* (2015)	3	Pl	Aw	650 m	512.2 mm
Costa *et al.* (2015)	3	LN	Aw	650 m	512.2 mm
Farias & Castro (2004)	2	La	C1WA'4a'	95 to 120 m	1,305 mm
Ferraz *et al.* (2013)	3	N and Pl	BSh	160 m	600 mm
Guerra *et al.* (2014)	4	Ca	BSWh´	71 m	767 mm
Lemos & Meguro (2015)	2	RYU	BShw'	560 to 600 m	582 mm
Lemos & Rodal (2002)	2	RYU	BSwh'	600 m	689 mm
Lemos & Zappi (2012)	2	RYU	BShw'	560 m	474 mm
Lemos (2004)	2	RYU	BSh	500 to 600 m	687.8 mm
Lima & Lima (1999)	1	RYU	BSwh'	295 to 380 m	596 mm
Oliveira *et al.* (2009)	4	V	Bsh	407 m	500 mm
Pereira Júnior *et al.* (2012)	4	Lu	Bsh	600 m	431,8 mm
Pinheiro *et al.* (2010)	1	U	Aw	436 to 572 m	431.8 mm
Pinheiro *et al.* (2010)	3	QN	Aw	436 to 572 m	431.8 mm
Pinheiro *et al.* (2010)	3	LN	Aw	436 to 572 m	431.8 mm
Pinheiro *et al.* (2010)	4	Lu	Aw	436 to 572 m	431.8 mm
Rodal *et al.* (2008)	3	N and Pl	Aw	550 and 450 m	632 and 651 mm
Sabino *et al.* (2016)	4	Lu	Bsh	280 m	800 mm
Sanquetta *et al.* (2014)	4	Ca	BSh	457 m	640 mm
Santos *et al.* (2007)	1	U	Aw	445 m	868 mm
Santos *et al.* (2007)	1	U	Aw	495 m	910 mm

In which: U - Ultisol, RYU - Red-Yellow Ultisol, Ca - Cambisol, La - Latosol, Lu - Luvisol, N - Neosol, QN - Quartzeneic Neosols, LN - Litholic Neosol, Pl - Planossol and V – Vertisol.

The unweighted pair group method with arithmetic mean (UPGMA) and the Bray-Curtis similarity coefficient (1957) were used. Only individuals classified at species level were considered. The calculations were performed using Fitopac 2.1 software (SHEPHERD, 2010). The cut-off line for group identification was performed using the methodology proposed by Mojena (1977). Milligan & Cooper (1985) suggested the value of 1.25 for the constant "Φ".

3 RESULTS AND DISCUSSION

We sampled 51 morphospecies distributed in 20 families (Table 3). The families with the highest genera and species richness were Fabaceae and Euphorbiaceae. Several surveys conducted in Caatinga pointed out these families as being of great importance (CARDOSO *et al.*, 2009; PINHEIRO *et al.*, 2010; AMARAL *et al.*, 2012; FERREIRA *et al.*, 2013; APGAUA *et al.*, 2014; LEITÃO *et al.*, 2014; LEITE *et al.*, 2015; LEMOS & MEGURRO, 2015; SABINO *et al.*, 2016).

Table 3: Families and species sampled in Contendas do Sincorá National Forest, Contendas do Sincorá Municipality, Bahia, where: CN = **common name; VN = voucher number at the Herbarium of the State University of Southwest Bahia - Vitória da Conquista (HUESBVC).**

Familie	Species	CN	VN
Anacardiaceae	*Astronium fraxinifolium* Schott	gonçalo-alves	9299
	Astronium urundeuva (M. Allemão) Engl.	aroeira	
	Schinopsis brasiliensis Engl.	baraúna	9302
	Spondias tuberosa Arruda	umbuzeiro	9301
Annonaceae	*Annona coriacea* Mart.	araticum	
	Annona vepretorum Mart.	araticum-da-bahia	9323
Apocynaceae	*Aspidosperma pyrifolium* Mart. & Zucc.	pereiro	9300
Araliaceae	*Aralia bahiana* J. Wen		9297
	Aralia warmingiana (Marchal) J.Wen		
Arecaceae	*Syagrus coronata* (Mart.) Becc.	licuri	
Bignoniaceae	*Handroanthus selachidentatus* (A.H. Gentry) S. Grose		9309
	Tabebuia roseoalba (Ridl.) Sandwith	ipê-branco	
	Tabebuia sp.		
Boraginaceae	*Cordia americana* (L.) Gottschling & J.S.Mill.	guaiuvira	
	Cordia incognita Gottschling & J.S.Mill.	casca-fina	9305
	Cordia trichotoma (Vell.) Arráb. ex Steud.	freijó	
Burseraceae	*Commiphora leptophloeos* (Mart.) J.B. Gillett	amburana-de-cambão	9316
Cactaceae	*Quiabentia zehntneri* (Britton & Rose) Britton & Rose	quiabento	9298
Celastraceae	*Monteverdia rigida* (Mart.) Biral	pau-de-colher	
Combretaceae	*Combretum monetaria* Mart.	mofumbo	9304
	Terminalia eichleriana Alwan & Stace	pau-de-chapada	9315
Euphorbiaceae	*Cnidoscolus urens* (L.) Arthur	cansanção	9328
	Croton floribundus Spreng.	velame	9313
	Croton piptocalyx Müll. Arg.	caixeta	9325
	Jatropha mollissima (Pohl) Baill.	pinhão-bravo	9311
	Manihot carthagenensis (Jacq.) Müll.Arg.		9317
	Maprounea guianensis Aubl.	marmeleiro-do-campo	9320
	Sapium glandulosum (L.) Morong	leitteiro	9312
	Sebastiania brasiliensis Spreng.	mata-berne	9326
Fabaceae	*Chloroleucon foliolosum* (Benth.) G.P. Lewis	arapiraca	9308
	Coursetia rostrata Benth.	viuvinha	9310
	Dalbergia miscolobium Benth.	sapuvussu	
	Leucochloron limae Barneby & J.W.Grimes	couvi	9318
	Mimosa ophthalmocentra Mart. ex Benth.	jurema-embira	9324
	Mimosa tenuiflora (Willd.) Poir.	jurema-preta	9322

	Mimosa sp.1		
	Mimosa sp.2		
	Peltogyne pauciflora Benth.	coração-de-negro	9307
	Pityrocarpa moniliformis (Benth.) Luckow & R.W.Jobson	quipé	
	Pseudopiptadenia contorta (DC.) G.P.Lewis & M.P.Lima	angico-rosa	9306
	Senegalia piauhiensis (Benth.) Seigler & Ebinger	jurema-branca	9314
	Senegalia velutina (DC.) Seigler & Ebinger		9321
Malvaceae	*Ceiba boliviana* Britten & Baker f.	barriguda	
	Pseudobombax simplicifolium A. Robyns	imburuçu	9319
Myrtaceae	*Campomanesia sessiliflora* (O. Berg) Mattos	guabiroba-verde	9327
Moraceae	*Ficus* sp.		
Nyctaginaceae	*Guapira opposita* (Vell.) Reitz	maria-faceira	9303
Polygonaceae	*Coccoloba alnifolia* Casar.		
Rutaceae	*Esenbeckia febrifuga* (A. St.-Hil.) A. Juss. ex Mart.	mamoninha	9296
Sapindaceae	*Allophylus quercifolius* (Mart.) Radlk.	estraladão	
	Dilodendron bipinnatum Radlk.	maria-pobre	

Only six species were present in the study by Lima & Lima (1999) in the same area (*Astronium urundeuva*, *Jatropha molissima*, *Monteverdia rigida*, *Pseudobombax simplicifolium*, *Schinopsis brasiliensis* and *Spondias tuberosa*). This indicates a major change in Flona's floristic composition since the last survey in the area.

The survey also showed that 37% of the sampled morphospecies are exclusive to Flona when compared to the articles used in the similarity study (Table 1): *Annona coriacea*, *Aralia bahiana*, *Aralia warmingiana*, *Ceiba boliviana*, *Cnidoscolus urens*, *Coccoloba alnifolia*, *Cordia americana*, *Coursetia rostrata*, *Croton floribundus*, *Croton piptocalyx*, *Dalbergia miscolobium*, *Esenbeckia febrifuga*, *Handroanthus selachidentatus*, *Pseudopiptadenia contorta*, *Quiabentia zehntneri*, *Sapium glandulosum*, *Senegalia velutina* and *Terminalia eichleriana*.

Some species such as *Aspidosperma pyrifolium*, *Astronium urundeuva*, *Commiphora leptophloeos*, *Mimosa ophthalmocentra*, *Mimosa tenuiflora* and *Schinopsis brasiliensis* were reported as important in other studies in Caatinga (APGAUA *et al.*, 2014; FERRAZ *et al.*, 2014; SILVA *et al.*, 2014; LEITE *et al.*, 2015; SABINO *et al.*, 2016).

It is important to highlight that the presence of *A. pyrifolium* is mainly due to its adaptability to the environment. It occurs in northeastern Brazil and northern Minas Gerais, ranging from shrubbery in dry caatinga areas, to arboreal in forest caatinga. The species adapts well to locations with long drought and stony shallow soils (SILVA *et al.*, 2014) and usually occurs at altitudes below 332 m (LEITE *et al.*, 2015), constituting similar characteristics to the area of this survey.

Leite *et al.* (2015) listed *M. ophthalmocentra* and *M. tenuiflora* as pioneers, occurring in previously degraded regions and in the middle regeneration stage. The area importantly

underwent periods of vegetation exploitation before being transformed into Flona, which corroborates the information of the authors mentioned above.

According to Ferraz *et al.* (2014), the good adaptation of *A. urundeuva* to an area is an indication that early species (with greater dispersal and establishment capacity) are giving way to those with higher competitive capacity. This fact demonstrates that the area is regenerating from the impact suffered during the wood extraction for coal production.

The Burseraceae family presented only the *C. leptophloeos* species. This was also recorded by Lemos & Meguro (2015) in the state of Ceará, in a tree stratum with individuals higher than five meters. Guerra *et al.* (2014) found the species in an anthropized area in Rio Grande do Norte. According to Sanquetta *et al.* (2014), the species showed a high adaptability to both soil and water deficit in a study conducted in Brumado (BA), which is characteristic of the region.

It is worth mentioning the presence of *H. selachidentatus* and *Leucochloron limae* which were classified as "almost threatened" on the endangered species red list (MMA 2014) and *Syagrus coronata* and *S. tuberosa*, immune to cutting (State Law 13908, 2018).

The physiognomic classification that best fit the study area was Forested Savanna-Steppe (IBGE, 2012), due to its floristic composition (Table 3) and its structure. This subgroup is highlighted by *S. tuberosa*, *C. leptophloeos* and *A. pyrifolium*, as well as others of the *Mimosa* genus. Its structure is formed by two strata: one superior and sparse arboreal, and the other inferior grassy-woody, with relevant phytophysiognomic importance.

Six groups were found regarding floristic similarity (Figure 2). The cut-off line for group formation was 0.88. There was a tendency to cluster between studies in the same state. The exceptions were Farias & Castro (2004) in the municipality of Campo Maior (PI), Lima & Lima (1999) and present study in Contendas do Sincorá (BA) and Sanquetta *et al.* (2014) in Brumado (BA). The survey carried out by Farias & Castro (2004) in the municipality of Campo Maior (PI) presents very different soil type, climate, altitude and annual precipitation from the Serra da Capivara National Park (LEMOS, 2004; LEMOS & RODAL, 2002), as can be observed in Table 2. It is noteworthy that the work by Lima & Lima (1999) carried out in Contendas do Sincorá (BA) was conducted in 1990. The wood exploitation history in the area until 1997 (the year it was assigned to IBAMA) may be the explanation for the low similarity with the present study.

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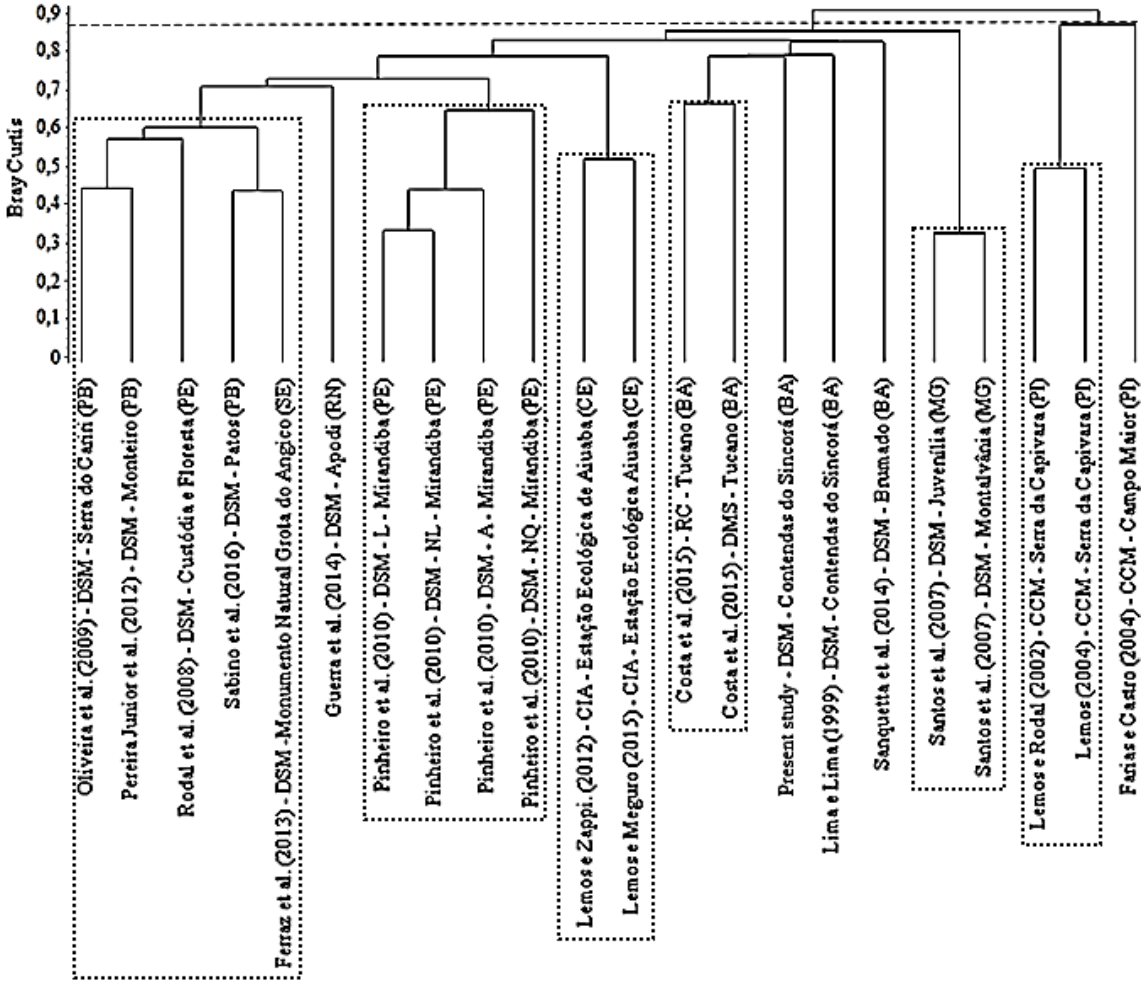

Figure 2: Floristic similarity between Caatinga forest fragments in different states, where: cut-off line for groups (---) and group delimitation (…).

It was found that five of the six created groups exclusively unite an ecoregion: the first, the second and the fifth united the experiments carried out in the Sertaneja Meridional Depression, the third in the Ibiapaba-Araripe Complex, and the sixth in the Campo Maior Complex. The fourth group brought together the Raso da Catarina and Sertaneja Meridional Depression, all in the state of Bahia. In this case, the similar altitude and precipitation found in the surveys were determinant.

The minimum distance found was 0.33 between surveys conducted in the municipalities of Juvenília and Montalvânia, Minas Gerais (SANTOS *et al.*, 2007) (Figure 2). The work carried out in Contendas do Sincorá-BA (LIMA & LIMA, 1999), did not form a group with the present study, although they were performed in the same area (Figure 1). This indicates that the area no longer had its original characteristics soon after the wood extraction for charcoal production (when the first study was carried out), since it is still in its middle regeneration stage about 20 years after the exploitation.

The cophenetic correlation was 0.85, indicating that the data provided by the dendrogram were well representative. According to Shepherd (2010), values below 0.7 indicate that the representation of the dendrogram was not satisfactory.

4 CONCLUSION

Despite the exploitation history, floristic composition was expected for Caatinga areas. Due to its floristic composition and physiognomic structure, the physiognomic classification for this physiognomy was Forested Savanna-Steppe.

The similarity analysis revealed that the Contendas do Sincorá National Forest does not have a similar floristic identity to the other Caatinga areas analyzed, including those of Bahia.

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