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INSELBERGS AS A SOURCE OF β DIVERSITY IN A VEGETATION MATRIX IN COQUEIRAL, MINAS GERAIS, BRAZIL

INSELBERG COMO FONTE DE DIVERSIDADE β EM UMA MATRIZ VEGETACIONAL, NO MUNICÍPIO DE COQUEIRAL - MG

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ABSTRACT

This study aimed to answer the following question: Does habitat heterogeneity affect the tree community? To answer that question, we evaluated the influence of the species composition and structure of the tree community of inselbergs on the tree community of the matrix where the inselberg is located. The correlations between environmental and vegetation gradients were analyzed by canonical correspondence analysis of a species composition matrix constructed from abundance data of 40 plots sampled in two areas, one composed of seasonal semideciduous forest (SSF) and another with riparian forests, a vegetation corridor, and inselbergs. A similarity dendrogram of the four areas was calculated using the Dice-Sorensen index and UPGMA linkage method. The species indicator analysis was used to evaluate which species were characteristic of each area sampled. The eigenvalues of the first two axes were high indicating high species turnover. The correlations between environmental variables and plots indicated the formation of three groups: the first one formed by the SSF patch plots with high clay content; the second group formed by the vegetation corridor and inselberg plots, which did not separate as sharply as the first group, with a small separation in organic matter content; and the third group, formed by the riparian forest plots, which are located in areas of highest soil fertility, with high content of calcium, sum of bases and base saturation. The results showed high species turnover among areas, indicating that even though the areas are geographically close, the occurrence of inselbergs increased habitat heterogeneity, directly affecting the variation in species composition and community structure among areas.
Keywords: conservation; species replacement; forest patches.

RESUMO

O presente trabalho objetivou responder a seguinte pergunta: A heterogeneidade ambiental influencia a comunidade arbórea? Para isso avaliou-se a interferência da composição e estrutura da comunidade arbórea

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localizada em *inselberg* sobre a comunidade arbórea da matriz na qual o *inselberg* está inserido. Para isso fez-se uma CCA (análise de correspondência canônica) sobre uma matriz de abundância das espécies de 40 parcelas amostradas em dois fragmentos, um de Floresta Estacional Semidecidual (FES) e outro constituído por mata ciliar, corredor e *inselbergs*. Foi construído um dendrograma de similaridade para as quatro áreas utilizando o índice de Dice-Sorensen e o método de ligação UPGMA. A análise de espécies indicadoras foi usada para avaliar quais espécies foram características de cada área amostrada. Os autovalores dos dois primeiros eixos foram altos, evidenciando uma forte substituição das espécies. As correlações entre variáveis ambientais e parcelas indicaram a formação de três grupos: o primeiro formado pelas parcelas do fragmento FES, com alto teor de argila; o segundo grupo formado pelas parcelas do corredor e dos *inselbergs*, que não se separaram tão nitidamente como o primeiro grupo, apresentando uma pequena separação quanto ao teor de matéria orgânica; e o terceiro grupo, formado pelas parcelas da mata ciliar, com alto teor de magnésio, cálcio, soma de bases e saturação de bases, sendo solos de maior fertilidade. Os resultados evidenciaram alta substituição de espécies
entre as áreas, indicando que, apesar de ser bem próximas, a presença do *inselberg* aumentou a heterogeneidade ambiental, o que afeta diretamente a variação, tanto na composição de espécies quanto na estrutura entre as áreas.
Palavras-chave: conservação; substituição de espécies; fragmentos florestais.

INTRODUCTION

The conservation of biodiversity represents a great challenge due to the high level of anthropogenic disturbances of natural ecosystems (VIANA and PINHEIRO, 1998). There is an increasing trend to focus conservation efforts on ecotone areas, marginal ecosystems, and "fragments", i.e., sub-units inserted in or associated with large biogeographical units. Stressing the need for specific conservation policies in areas with rocky outcrops, regardless of biome or vegetation type in which they are inserted (SCARANO, 2007). However, studies on plant communities in these environments are rare (POREMBSKI et al., 1998) and the vegetation on these outcrops is still quite unknown (SCARANO, 2007).

Inselbergs are monolithic mountains or groups of mountains that appear abruptly amidst the landscape, consisting mainly of granitic or gneissic rocks (POREMBSKI et al., 1998; POREMBSKI and BARTHLOTT, 2000). They naturally present unequal and spatially distributed resources (POREMBSKI and BARTHLOTT, 2000) which determine the heterogeneity (relative abundance of rocks and vegetation), structural complexity (shape and composition of rocks), and quality (abundance of rocks and vegetation resources) (MICHAEL et al., 2010) of the habitats. Moreover, the complexity of gradients, mainly soil depth and water availability, determine vegetation structure (GROGER and HUBER, 2007). The soils are shallow and characteristically nutrient-poor and vary according to the rock with which they are associated (BENITES et al., 2007).

The vegetation of inselbergs is characterized as "a mosaic of marginal habitats" where a great number of taxa find adequate niches in an extremely condensed space (GRÖGER and HUBER, 2007). Although inselbergs present an apparently monotonous vegetation, they have a wide diversity of pedoenvironments in addition to an associated vegetation mosaic determined in great extent by the local relief and micro-environmental aspects (BENITES et al., 2007). These characteristics make inselbergs a center of diversity for plants well adapted to extreme conditions, particularly water shortage and low nutrient availability (POREMBSKI, 2007).

Inselbergs increase habitat heterogeneity. Some studies relate hatital variation to changes in species composition of communities, indicating that a greater variety of habitats and environmental conditions promote greater variation in species composition (MCINTYRE et al., 2001; BUCKLEY and JETZ, 2008; JANKOWSKI et al., 2009), which increases beta diversity. Because beta diversity reflects the dissimilarities in species composition between two or more areas, it reflects the differences in species composition at the landscape or habitat scale (WHITTAKER et al., 2001).

Although a significant number of inselbergs is located in conservation units (MMA 2002), management plans which take into account the particularities of those environments are still lacking. Moreover, inselbergs have been broadly disregarded from the biological standpoint (POREMBSKI, 2007). As a consequence of their adverse and unfavorable conditions, the vegetation of inselbergs is clearly influenced by its surroundings. The extent of the island character depends on the type of vegetation and floristic differentiation between the inselberg and its surrounding matrix (POREMBSKI, 2007), because there are strong relationships between inselbergs and the neighboring vegetation (SCARANO, 2007). Thus, phytosociology studies allow better knowledge of the composition and structure of the plant community, contributing towards better understanding of biogeographical patterns (FINA and MONTEIRO, 2009).

Most inselbergs studied have a small-sized vegetation, mostly composed of herbaceous and shrub species (FRANÇA et al., 1997; POREMBSKI and BARTHLOTT, 2000; CAIAFA and SILVA, 2007; RIBEIRO et al., 2007). Thus, studies in inselbergs with arboreal vegetation in the south of Minas Gerais state, Brazil are of fundamental importance for conservation efforts.

Thus, this study aimed to answer the following question: Does habitat heterogeneity affect the tree community? This hypothesis was tested by assessing: (i) the influence of the species composition of the tree community of an inselberg on the tree community of the matrix where the inselberg is located; (ii) the influence of the tree community structure of the inselberg on the tree community of the matrix where the inselberg is located. The evaluation of the influence of habitat heterogeneity on tree community enables the development of more effective conservation policies.

MATERIAL AND METHODS

Study area

The sample patches were located in the municipality of Coqueiral, Minas Gerais state, Brazil (21°09’19’’ S and 45°28’17’’ W; 810–840 m altitude; Fig. 1). The climate is Cwb or mesothermal according to the Köppen classification, with mild summers and dry winters. The average annual rainfall is 1,493 mm and the average annual temperature is 19.3 °C (VILELA and RAMALHO, 1979). The first area is a 7.5 ha patch characterized as Seasonal Semideciduous Forest. In this area, 20 20 x 20 m plots, distant 20 m apart, were established in three transects parallel to the longest axis of the fragment. The second area is a mosaic composed of riparian forest, granitic-gneissic inselberg, and a vegetation corridor which accompanies the interior of the draining line over the inselberg linking the riparian forest to the inselberg. The inselberg plots were established in areas of litter deposition in rock crevices with shallow soils. Twenty plots, distant 20 m apart, were also established in this area: six in the riparian forest, nine in the vegetation corridor, and five in the inselberg. Inselberg plots only were 20 x 20 m, due to the more homogeneous, small-sized environment, whereas in other microenvironments plots were 10 x 40 m to maximize the greatest sampling intensity in the direction of least variation within each sampling unit, and consequently to sample the variation occurring in these environments. In each plot, all woody individuals with cbh (circumference at breast height) ≥ 15.7 cm were sampled, plant height was recorded, and the species were identified. All botanical material collected was stored in the ESAL herbarium at the Universidade Federal de Lavras. For soil characterization, a 500 g surface soil sample (0–20 cm depth) was collected in each plot. Each composite sample was obtained by mixing and homogenizing five subsamples randomly collected in each plot. The chemical and textural analyses of the samples were done in the Soil Analysis Laboratory at the Universidade Federal de

FIGURE 1: Forest patches in Coqueiral, Minas Gerais, Brazil.
FIGURA 1: Fragmentos localizados no município de Coqueiral - MG.

Lavras, following the EMBRAPA protocol (1997). The soil variables determined were: pH; contents of potassium, phosphorus-Mehlic, remaining-phosphorus, Calcium, Magnesium, Aluminum and Hydrogen Aluminum; sum of bases, base saturation; organic matter; aluminum saturation; effective cation exchange capacity and cation-holding capacity of the soil and contents of sand, silt, and clay.

Data analysis

To describe tree community structure, the classical quantitative descriptors were calculated per species: absolute and relative density, absolute and relative dominance, absolute and relative frequency, and importance value index (IVI) (MUELLER-DOMBOIS and ELLENBERG, 1974), in addition to the Shannon diversity index (*H*') and Pielou's equitability index (*J*) (BROWER and ZAR, 1984).

Tree density and basal area per plot were compared using analysis of variance (Anova) to test for differences in structure parameters among the microenvironments associated with the Tukey's test after testing for normality of the data using the D'Agostino test (ZAR, 1996). A species accumulation curve for the specific richness observed (Mao Tau) in each area was calculated after 500 randomizations using EstimateS 9.0 (COLWELL, 2013).

The correlations between environmental and vegetation gradients were analyzed by canonical correspondence analysis (CCA) (TER BRAAK, 1987) using PC-ORD for Windows version 4.14 software (MCCUNE and MEFFORD, 1999). A species composition matrix was constructed from abundance data per plot. According to the recommendations by TER BRAAK (1995), abundance values (a) were ln (a+1) transformed to compensate for the deviations caused by outliers.

The environmental variable matrix included one categorical variable that was used to define the four microenvironments and seventeen quantitative edaphic variables. Nevertheless, after a preliminary CCA was calculated, 12 quantitative variables were weakly correlated or redundant and excluded from the final analysis. Thus, the final CCA was calculated with the categorical variable and the six most representative variables that strongly correlated with the ordination axis: calcium (Ca), aluminum (Al), sum of bases (SB), base saturation (V), organic matter (MO), and clay. The Monte Carlo permutation test was done (TER BRAAK, 1988) to test the significance of the model.

A similarity dendrogram of the four areas was calculated using the Dice-Sorensen index and UPGMA linkage method. We also calculated the cophenetic correlation coefficient, which measures the level of cophenetic correlation between the original similarity matrix and the calculated matrix. Values equal to or higher than 0.7 are considered satisfactory as representative of the original matrix (SHEPHERD, 2006). The similarity dendrogram and cophenetic correlation coefficient were calculated using Past software.

The species indicator analysis (DUFRÊNE and LEGENDRE, 1997) was used to evaluate which species were characteristic of each area sampled. The indicator value (ValInd) was compared with the results of 1,000 data randomizations using the Monte Carlo test. The calculations were done using PC-ORD for Windows version 4.14 software (MCCUNE and MEFFORD, 1999).

RESULTS

In the Seasonal Semideciduous Forest (SSF) patch 887 individuals distributed into 144 species were sampled. In the second fragment, consisting of three areas, 159 species were found: 82 in the riparian forest, 101 in the vegetation corridor, and 64 in the inselbergs, totaling 1,265 individuals, 286 sampled in the riparian forest, 601 in the corridor, and 378 in the inselbergs (Table 1). The basal area presented no statistical difference among the areas ($F_{0.05\ (1),\ 3.36} = 0.7877$; $p = 0.5114$), but there were significant differences in density ($F_{0.05\ (1),\ 3.36} = 97,3281$; $p < 0.0001$). The riparian forest differed from the corridor ($q = 4.7201$; $p < 0.05$), inselberg ($q = 6.0048$; $p<0.01$) and of the SSF ($q = 11.4942$; $p < 0.01$). The SSF differed from the corridor ($q = 19.5272$; $p < 0.01$) and from the inselberg ($q = 0.179727$; $p < 0.01$). Only the corridor and inselberg did not differ as to density ($q = 2.0589$; $p > 0.05$). Comparisons were made using the mean values. These results show that community structure differed among the microenvironments, indicating that inselberg and vegetation corridor communities had a higher number of individuals of smaller CBH than riparian forest and SSF.

The species accumulation curve showed that, for the same number of individuals, the inselberg had the lowest species richness, followed by the vegetation corridor, riparian forest,

TABLE 1: Density (ind/ha), basal area (m^2/ha), diversity - H' (nats/individual) and equability (J) in four microenvironments in the municipality of Coqueiral, Minas Gerais state, Brazil.

TABELA 1: Densidade (ind/ha), Área basal (m^2/ha), diversidade - H' (nats/indivíduo) e equabilidade (J) em quatro microambientes no município de Coqueiral - MG.

Area	Density (ind/ha)	Basal area (m^2/ha)	H'(nats/individual)	J
Riparian Forest	1191.67A	28.6A	3.88	0.88
Corridor	1669.44B	29.62A	4.03	0.87
Inselberg	1890.00B	22.22A	3.61	0.87
SSF Patch	1108.75C	29.33A	4.31	0.87

Where in: Parameters followed by the same letter in the column are not statistically different

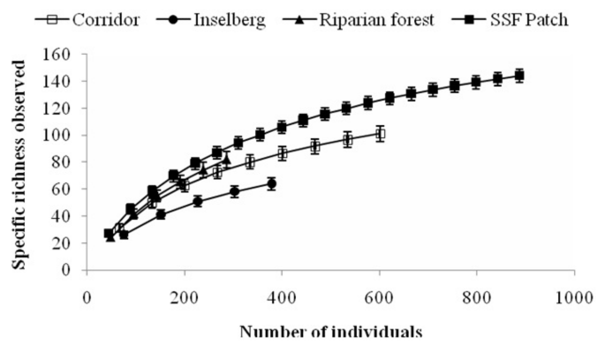

FIGURE 2: Species accumulation curve after 500 randomizations of the number of individuals sampled in four microenvrionments in the municipality of Coqueiral, Minas Gerais state, Brazil.

FIGURA 2: Curva de acumulação de espécies obtida de 500 randomizações do número de indivíduos amostrados em quatro microambientes no município de Coqueiral - MG.

and SSF (Fig. 2).

The most important species in the SSF patch were *Aspidosperma olivaceum* Müll.Arg., *Copaifera langsdorffii* Desf., *Aspidosperma australe* Müll.Arg., *Ocotea odorifera* (Vell.) Rohwer, *Tachigali rugosa* (Mart. ex Benth.) Zarucchi & Pipoly, *Amaioua intermedia* Mart. ex Schult. & Schult.f., *Mouriri glazioviana* Cogn., *Copaifera trapezifolia* Hayne, *Duguetia lanceolata* A.St.-Hil., and *Xylopia brasiliensis* Spreng. In the riparian forest, the most important species were *Platycyamus regnellii* Benth., *Croton floribundus* Spreng., *Bathysa australis* (A.St.-Hil.) Benth. & Hook.f., *Cariniana legalis* (Mart.) Kuntze, and *Copaifera langsdorffii*; in the vegetation corridor *Callisthene major* Mart., *Copaifera langsdorffii*, *Tapirira obtusa* (Benth.) J.D.Mitch., *Faramea nigrescens* Mart., and *Casearia arborea* (Rich.) Urb. were the most important species, whereas in the inselbergs, *Copaifera langsdorffii*, *Terminalia glabrescens* Mart., *Maytenus robusta* Reissek, *Platypodium elegans* Vogel, and *Myrciaria floribunda* (H.West ex Willd.) O.Berg were the most important species. Therefore, only *C. langsdorffii* was among the most important species in the four areas (Table 2).

The number of indicator species ranged among the areas: 17 in the riparian forest, 18 in the inselberg, 12 in the corridor, and nine in the SSF, which represents 20.73%, 28.12%, 11.88%, and 6.25% of the total number of species in each area, respectively.

The species with highest indicator values in the riparian forest were *Bauhinia longifolia* (Bong.) D.Dietr, *Croton floribundus*, *Machaerium hirtum* (Vell.) Stellfeld, *Celtis brasiliensis* (Gardn.) Planch., and *Senna macranthera* (Collad.) H.S.Irwin & Barneby. In the vegetation corridor, the species with highest indicator values were *Callisthene major*, *Faramea nigrescens*, *Siphoneugena densiflora* O.Berg, *Casearia arborea*, and *Myrsine umbellata* Mart., whereas the species *Maytenus robusta*, *Luehea divaricata* Mart., *Myrciaria floribunda*, *Eugenia cerasiflora* Miq., and *Zanthoxylum rhoifolium* Lam. were most indicative of inselbergs, and *Ocotea odorifera*, *Mouriri glazioviana*, *Duguetia lanceolata*, and *Aspidosperma olivaceum* were most indicative of the SSF patch (Table 3).

The eigenvalues of the first two axes were 0.465 and 0.369, respectively, and indicates high species turnover between the extremes of axis 1, which represents a soil quality gradient. Conversely, plots in axis 2 were separated by clay content. The

TABLE 2: Species of greatest importance value (IV) in the Riparian Forest, Inselberg, Vegetation Corridor, and Seasonal Semideciduous Forest Patch (SSF) in Coqueiral, Minas Gerais state, Brazil.

TABELA 2: Espécies de maior valor de importância (VI) da Mata ciliar, *Inselberg*, Corredor e Fragmento de Floresta Estacional Semidecidual (FES).

Environment/species	IV	Environment/species	IV
Riparian Forest		Corridor	
Platycyamus regnellii Benth.	27.61	*Callisthene major* Mart.	23.33
Croton floribundus Spreng.	23.07	*Copaifera langsdorffii* Desf.	17.17
Bathysa australis (A.St.-Hil.) Benth. & Hook.f.	13.96	*Tapirira obtusa* (Benth.) J.D.Mitch.	15.59
Cariniana legalis (Mart.) Kuntze	13.58	*Faramea nigrescens* Mart.	12.43
Copaifera langsdorffii Desf.	11.47	*Casearia arborea* (Rich.) Urb.	9.48
Inga vera Willd.	11.31	*Byrsonima laxiflora* Griseb.	8.95
Metrodorea stipularis Mart.	8.93	*Myrsine umbellata* Mart.	7.30
Eugenia acutata Miq.	8.33	*Siphoneugena densiflora* O.Berg	7.23
Eugenia florida DC.	7.07	*Protium spruceanum* (Benth.) Engl.	6.99
Cecropia pachystachya Trécul	6.94	*Terminalia glabrescens* Mart.	6.69
Environment/species	IV	Environment/species	IV
Inselberg		Seasonal Semideciduous forest	
Copaifera langsdorffii Desf.	24.03	*Aspidosperma olivaceum* Müll.Arg.	18.12
Terminalia glabrescens Mart.	20.42	*Copaifera langsdorffii* Desf.	16.40
Maytenus robusta Reissek	17.75	*Aspidosperma australe* Müll.Arg.	11.96
Platypodium elegans Vogel	16.66	*Ocotea odorifera* (Vell.) Rohwer	11.09
Myrciaria floribunda (H.West ex Willd.) O.Berg	15.71	*Tachigali rugosa* (Mart. ex Benth.) Zarucchi & Pipoly	10.98
Metrodorea stipularis Mart.	10.60	*Amaioua intermedia* Mart. ex Schult. & Schult.f.	10.49
Eugenia cerasiflora Miq.	10.34	*Mouriri glazioviana* Cogn.	9.01
Luehea divaricata Mart.	9.68	*Copaifera trapezifolia* Hayne	7.84
Eugenia acutata Miq.	9.38	*Duguetia lanceolata* A.St.-Hil.	7.74
Ixora brevifolia Benth.	9.37	*Xylopia brasiliensis* Spreng.	7.05

correlation values between environmental variables and species was high (94% and 90%) and the Monte Carlo permutation test revealed a significant correlation between species abundance and environmental variables ($p< 0.005$). The proportion of the total variance explained by the first two axes was 12.2%, indicating that was a high level of ´noise`, or remaining variance that was not explained by the environmental variables investigated. The correlations between environmental variables and plots indicated the formation of three groups (Fig. 3): the first one formed by the SSF patch plots with high clay content; the second group formed by the vegetation corridor and inselberg plots, which were not separated clearly, with a slight separation by organic matter content; and the third group, formed by the riparian forest plots, which are located in areas of highest soil fertility, with high content of calcium, sum of bases and base saturation.

Similarly to the CCA, the dendrogram showed a sharp distinction among the areas. The riparian forest was very dissimilar from the other areas (approximately 63% dissimilarity), followed by the group composed of the SSF plots, and the vegetation corridor and inselberg plots, which did not separate clearly, showing that the inselbergs are more similar to the SSF patch than the riparian forest, even though they are geographically closer to the latter, indicating high beta diversity (Fig. 4). The cophenetic correlation coefficient was 0.73, indicating good reliability (low distortion) in the generation of the dendrogram from the raw data.

The differentiation between areas can also be observed by shared and exclusive species to each group. Only 12 species occurred in the four areas: *Albizia polycephala* (Benth.) Killip, *Casearia decandra* Jacq., *Casearia obliqua* Spreng., *Casearia sylvestris* Sw, *Copaifera langsdorffii*, *Cordiera concolor* (Cham.) Kuntze, *Eugenia acutata* Miq., *Machaerium nyctitans* (Vell.) Benth., *Maytenus robusta*, *Myrcia splendens* (Sw.) DC., *Myrciaria floribunda*, and *Vochysia magnifica* Warm. In addition, a great number of species occurred in a single area: 58 in the SSF, seven in the inselberg,

TABLE 3: Indicator species of the riparian forest, inselberg, vegetation Corridor, and Seasonal Semideciduous Forest patch (SSF) in Coqueiral, Minas Gerais state, Brazil. VI - Indicator Value; p - significance.

TABELA 3: Espécies indicadoras da Mata ciliar, *Inselberg*, Corredor e Fragmento de Floresta Estacional Semidecidual (FES). VI - valor de indicação; p - significância.

Environment/species	IV	p	Environment/species	IV	p
Riparian forest			Inselberg		
Bauhinia longifolia (Bong.) D.Dietr	66.7	0.0002	*Maytenus robusta* Reissek	86.9	0.0002
Croton floribundus Spreng.	59.3	0.0052	*Luehea divaricata* Mart.	80	0.0002
Machaerium hirtum (Vell.) Stellfeld	50	0.0022	*Myrciaria floribunda* (H.West ex Willd.) O.Berg	77.4	0.0002
Celtis brasiliensis (Gardn.) Planch.	50	0.0036	*Eugenia cerasiflora* Miq.	76.7	0.0002
Senna macranthera (Collad.) H.S.Irwin & Barneby	50	0.0036	*Zanthoxylum rhoifolium* Lam.	72.7	0.0004
Cariniana legalis (Mart.) Kuntze	50	0.0042	*Terminalia glabrescens* Mart.	52.9	0.0078
Guapira hirsuta (Choisy) Lundell	50	0.0042	*Luehea grandiflora* Mart. & Zucc.	48.7	0.0046
Inga vera Willd.	48.8	0.0052	*Cordiera concolor* (Cham.) Kuntze	47.5	0.0206
Cupania zanthoxyloides Cambess.	44.2	0.0138	*Zanthoxylum fagara* (L.) Sarg.	47	0.0026
Bathysa australis (A.St.-Hil.) Benth. & Hook.f.	42.9	0.0362	*Ixora brevifolia* Benth.	47	0.0084
Cabralea canjerana (Vell.) Mart.	41.7	0.0148	*Platypodium elegans* Vogel	47	0.01
Endlicheria paniculata (Spreng.) J.F.Macbr.	40.9	0.012	*Eriotheca candolleana* (K.Schum.) A.Robyns	45.5	0.0068
Rollinia sylvatica (A.St.-Hil.) Mart.	38.5	0.0128	*Vitex polygama* Cham.	43.2	0.0104
Platycyamus regnellii Benth.	36.8	0.0156	*Casearia sylvestris* Sw.	43	0.0312
Galipea jasminiflora (A.St.-Hil.) Engl.	33.8	0.0198	*Myrciaria tenella* (DC.) O.Berg	38.9	0.0328
Maclura tinctoria (L.) D.Don ex Steud.	33.3	0.0328	*Casearia decandra* Jacq.	37.3	0.0476
Ceiba speciosa (A.St.-Hil.) Ravenna	33.3	0.0336	*Handroanthus serratifolius* (Vahl) S.O.Grose	36	0.035
			Cedrela fissilis Vell.	31.3	0.0362
Environment/species	IV	p	Environment/species	IV	p
Corridor			SSF Patch		
Callisthene major Mart.	63.2	0.0006	*Ocotea odorifera* (Vell.) Rohwer	72.7	0.0002
Faramea nigrescens Mart.	61.7	0,0026	*Mouriri glazioviana* Cogn.	57.9	0.0042
Siphoneugena densiflora O.Berg	59.8	0,001	*Duguetia lanceolata* A.St.-Hil.	56.3	0.0026
Casearia arborea (Rich.) Urb.	56.7	0,0068	*Aspidosperma olivaceum* Müll.Arg.	55.2	0.007
Myrsine umbellata Mart.	54.6	0.0048	*Jacaranda macrantha* Cham.	55	0.0032
Tapirira obtusa (Benth.) J.D.Mitch.	51.4	0.0208	*Tapirira guianensis* Aubl.	55	0.0034
Dalbergia nigra (Vell.) Allemão ex Benth.	44.4	0.0084	*Xylopia brasiliensis* Spreng.	55	0.0048
Vismia brasiliensis Choisy	44.4	0.0104	*Tachigali rugosa* (Mart. ex Benth.) Zarucchi & Pipoly	47.2	0.0114
Protium spruceanum (Benth.) Engl.	42.9	0.0274	*Calyptranthes clusiifolia* O.Berg	46	0.0158
Eugenia sonderiana O.Berg	33.3	0.0268			
Euplassa legalis (Vell.) I.M.Johnst.	33.3	0.0302			
Dalbergia villosa (Benth.) Benth.	29	0.0486			

15 in the vegetation corridor, and 21 in the riparian forest, which represents 46.54% of the species total, stressing the difference in floristic composition among the environments.

DISCUSSION

The higher biomass allocation in number of individuals at the expense of basal area in inselbergs may be related to the higher light levels (BERTANI et al., 2001), the harsh environmental conditions, shallow soils, poor nutrient availability, and low water-holding capacity (GRÖGER and HUBER, 2007). In addition, despite the high recruitment in inselbergs, mortality caused by abiotic factors is also high (FENNER, 1987).The low diversity in outcrops compared to other forest types was also report by Cao and Zhang (1997), who compared rain forests, montane forests, limestone outcrop forests in China. According to the authors, the low diversity of outcrops is due to the harsh environmental conditions, because outcrops are dry habitats with shallow soils, few species are adapted to these environments. In our study, the vegetation corridor had higher species richness than the inselberg, and this result is probably due to the fact that the former connects the riparian forest to the inselberg and thus has species from both formations. However,

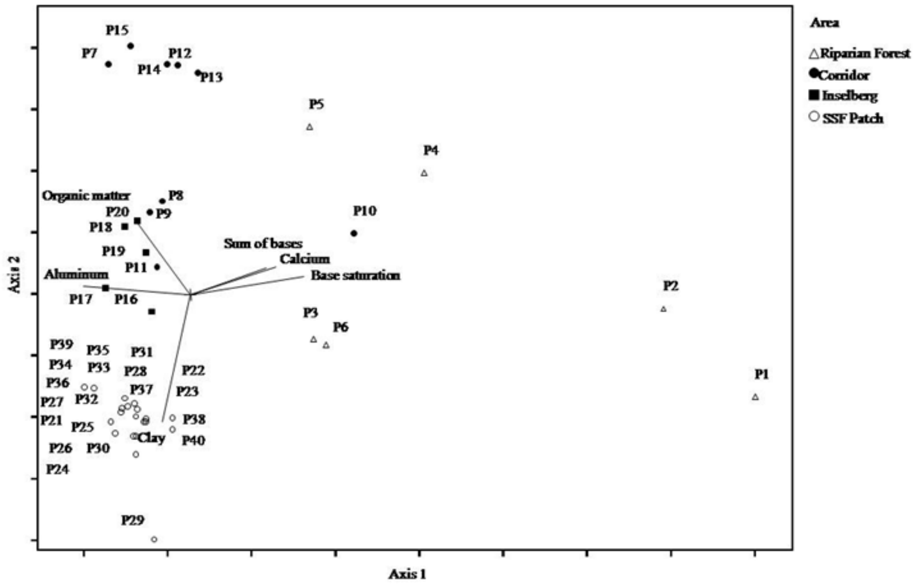

FIGURE 3: Canonical correspondence analysis ordination diagram based on species density distributions of 40 plots (1–6: riparian forest; 7–15: vegetation corridor; 16–20: inselberg; 21–40: Seasonal Semideciduous Forest) in the municipality of Coqueiral, Minas Gerais, Brazil. The edaphic variables are represented by vectors.

FIGURA3: Diagrama de ordenação de 40 parcelas: (1-6) mata ciliar; (7-15) corredor; (16-20) *inselberg*; (21-40) Fragmento de Floresta Estacional Semidecidual, no município de Coqueiral, pela análise de correspondência canônica, baseada na distribuição da densidade das espécies. As variáveis edáficas estão representadas por vetores.

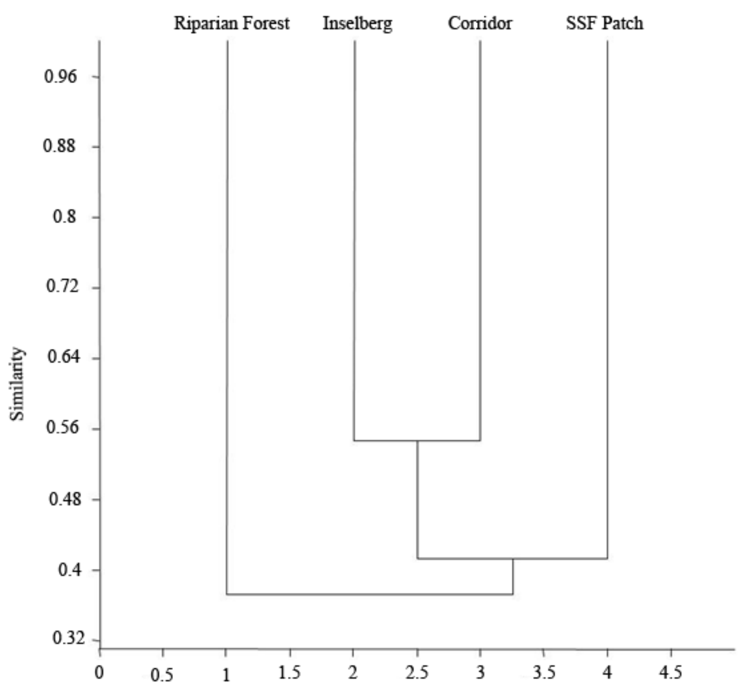

FIGURE 4: Florisitic similarity dendrogram of four microenvironments sampled in the municipality of Coqueiral, Minas Gerais, Brazil.

FIGURA 4: Dendrograma de similaridade florística de quatro microambientes amostrados no município de Coqueiral - MG.

the high equability observed in all environments demonstrates the lack of ecological dominance, indicating that the species are evenly represented in each studied area (KANIESKI et al., 2010).

Environmental heterogeneity results in high species turnover, which increases β diversity, (POREMBSKI, 2007). Habitat heterogeneity is the factor most widely associated with the determination of beta diversity (MORENO and HALFFTER, 2001), because beta diversity results from the species responses to variations between sites and, thus can be understood as the degree of habitat specialization of (SHMIDA and WILSON, 1985; JANKOWSKI et al., 2009; MELO et al. 2009). *Copaifera langsdorffii* was the only species with a high importance value in all areas, showing that adaptation varies even in geographically close areas, because plant species differ in their nutrient requirements and microclimate (DENSLOW, 1980). *Copaifera langsdorffii* is distributed throughout the Brazilian territory in open areas and forest formations with well drained soils (FREITAS and OLIVEIRA, 2002; FAGUNDES et al., 2007; VEIGA JUNIOR and PINTO, 2002). The species *Terminalia glabrescens*, which had the second IV in the inselberg is associated with well drained soils (FAGUNDES et al., 2007).

Some species were among the most important in each environment and also had the highest indicator values such as: *Ocotea adorifera* (SSF plots); *Croton floribundus* (riparian forest); *Callisthene major*, *Casearia arborea*, and *Faramea nigrescens* (vegetation corridor); and *Maytenus robusta* and *Myrciaria floribunda* (inselberg). *Ocotea odorifera* is listed as endangered in IBAMA Red List (IBAMA, 1992) and is among the most important tree species in ombrophilous forests (NEGRELLI and LEUCHTENBERG, 2001). In addition, *C. major* is more often found in well-drained environments (CARVALHO et al., 2005; IMAÑA-ENCINAS et al., 2007). Conversely, *M. robusta* is a heliophyle occurring in more open vegetation (LORENZI, 1998), which explains its higher indicator values in the inselberg.

Several studies have shown that the vegetation mosaic of forest patches is related to the physicochemical characteristics of soil (OLIVEIRA FILHO et al., 1994; RODRIGUES et al., 2007; CAMARGOS et al., 2008), including a few studies on rocky outcrops (CONCEIÇÃO et al., 2007; GRÖGER and HUBER 2007). Groger and Huber (2007) found that soil depth gradients and water availability were the main factors determining the floristic composition on a rocky outcrop in the Guayana Escudo. Conceição et al. (2007) compared four areas in Chapada Diamantina, Brazil and found that the structure and floristic composition were related to soil characteristics rather than the distance between the sites, indicating that the variation in soil characteristics affected the plant community studied.

The value for axis 1 can be considered high (TER BRAAK, 1987; FELFILI and REZENDE, 2003) and the low variance explained by the first two axes is a common feature of vegetation data, which does not affect the significance of the species-environment relationships (TER BRAAK, 1987). Clay, which correlated mostly with SSF plots, is responsible for the adsorption of both cations and anions and holding bases and water, causing the soils to be wet, muddy, and more compressed (RIZZINI, 1997). However, calcium and base saturation, which correlated mostly with riparian forest plots, are indicative of low acidity (CAMARGOS et al., 2008).

The greatest dissimilarity of the riparian forest to the vegetation corridor, inselberg, and semideciduous forest patch was probably due to the stronger floristic links of riparian forests with wetter forests especially regarding high soil moisture content (OLIVEIRA FILHO and RATTER, 2009). These results also indicate that even communities situated in close areas can be floristically and structurally different (FERREIRA JUNIOR et al., 2008).

CONCLUSION

The harsh environmental conditions in the inselberg, which are conditioned by the shallow soils, affect its species richness and community structure. Inselbergs had the lowest species richness and a greater number of individuals of smaller diameter, resulting in greater differences in species composition and community structure between the inselberg and the surrounding matrix and consequently higher β diversity. The results showed high species turnover among areas, indicating that even though the areas are geographically close, the occurrence of inselbergs directly affects the variation in species composition and community structure among areas.

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