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Structural analysis of the vegetation on a highland granitic rock outcrop in Southeast Brazil[1]

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ABSTRACT – (Structural analysis of the vegetation on a highland granitic rock outcrop in Southeast Brazil). Granitic rock outcrops of the Brazilian southeast are either coastal or inland. The latter can often have high altitudes, such as in the summits of "Serra do Mar" and "Serra da Mantiqueira", where they are known as "Campos de Altitude". The landscape on these high altitude plateaux is often a mosaic of shrubs and treelets within a bunchgrass matrix, with sparse pteridophytes and other herbs, interspersed with variable extensions of rock outcrops. Despite the pervasiveness of rock outcrops in the Brazilian landscape, studies on the structural analysis of the vegetation on such formations are scarce. This study aimed to analyze the structure of the vegetation on a highland granitic rock outcrop in "Parque Estadual da Serra do Brigadeiro", state of Minas Gerais, Southeast Brazil (42°20' - 42°40' S and 20°20' - 21°00' W, 1,722 m of elevation). Quantitative parameters of absolute and relative frequency and dominance (cover) were estimated. The group analysis used the Jaccard similarity index. *Trilepis lhotzkiana*, *Panicum* sp. 1, and *Vellozia variegata* presented the highest relative frequencies, relative dominances and importance values. These three species, along with *Dyckia bracteata*, *Rhynchospora emaciate*, and *Tibouchina* cf. *manicata*, represented 98.3% of the relative dominance. The remaining 1.7% referred to 22 remaining species. The distinction among quadrats within formed groups by cluster analysis was due to the great number of low frequency species.

Key words - high altitude vegetation, photographic chart method, rock outcrop, "Parque Estadual da Serra do Brigadeiro", structural analysis

RESUMO – (Análise estrutural da vegetação sobre um afloramento rochoso granítico de altitude no Parque Estadual da Serra do Brigadeiro, Minas Gerais, Brasil). Os afloramentos rochosos graníticos do sudeste brasileiro ocorrem no litoral ou no interior. Neste segundo caso, incluem-se os Campos de Altitude, como aqueles encontrados nos cumes das Serras do Mar e da Mantiqueira. A fisionomia mais freqüentemente encontrada nos platôs é composta de mosaicos de arbustos e arvoretas, inseridos em uma matriz de touceiras de gramíneas, com pteridófitas e outras ervas dispostas espaçadamente, além de extensões variáveis de afloramentos rochosos. Apesar de freqüentes na paisagem brasileira, são escassos os trabalhos de análise estrutural da vegetação sobre afloramentos rochosos. O objetivo deste trabalho foi analisar a estrutura da vegetação sobre um afloramento rochoso granítico de altitude no Parque Estadual da Serra do Brigadeiro, MG (42°20' - 42°40' S e 20°20' - 21°00' W, 1.722 m de altitude). Foram estimados os parâmetros quantitativos de freqüência e dominância (cobertura), absolutas e relativas. A análise de agrupamento utilizou o índice de similaridade do Jaccard. *Trilepis lhotzchiana*, *Panicum* sp. 1 e *Vellozia variegata* apresentaram as maiores freqüências relativas, dominâncias relativas e os maiores valores de importância. Essas três espécies mais *Dyckia bracteata*, *Rhynchospora emaciata* e *Tibouchina* cf. *manicata* responderam por 98,3% da dominância relativa, os restantes 1,7% ficaram distribuídos por outras 22 espécies. A distinção das parcelas dentro dos grupos, formados na análise de agrupamento foi atribuída ao grande número de espécies de baixa freqüência.

Palavras-chave - afloramento rochoso, análise estrutural, campo de altitude, método de mapeamento fotográfico, Parque Estadual da Serra do Brigadeiro

Introduction

Rock outcrops of gneiss-granite, as well as their intermediate forms found in the Brazilian southeast, are classified as rock outcrops of coastal areas, such as the Sugar Loaf Mountain in Rio de Janeiro (RJ), and rock outcrops of highland mountainous inland areas, such as those found in "Serra do Mar" and "Serra da Mantiqueira" (Safford & Martinelli 2000).

The summits of "Serra do Mar" and "Serra da Mantiqueira" comprehend a total estimate of around 350 km^2 of "Campos de Altitude" (high altitude vegetation) (Safford 1999). In these "Campos de Altitude", different vegetation synusiae form a mosaic in which shrubs within a matrix of bunchgrasses with sparsely spread herbs and pteridophytes are the most frequent physiognomy found in the relatively extensive plateaux (Safford 1999). Variable extensions of bare rock, cliffs and rocky peaks

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are also elements of high altitude landscapes (Safford & Martinelli 2000).

Due to their convex shape (rounder geoforms) and granitic constitution, rock outcrops occurring in "Campos de Altitude" are clearly differentiated from arenite and quartzite rock outcrops found in table mountains (*e.g.* "Chapada Diamantina"), where "Campos Rupestres" are observed (Porembski *et al.* 1998).

Granitic rock outcrops show typical formation patterns, such as rock surfaces and drainage channels connecting small shallow seasonal rock pools, often showing no vascular plants. Deeper and wider rock pools, with a few centimeters of substratum, provide a water reservoir throughout the year to support a great variety of aquatic plants (Barthlott *et al*. 1993, Safford & Martinelli 2000). However, granitic outcrops of Southeast Brazil only seldomly contain such perennial pools (Safford & Martinelli 2000). Another microhabitat type, the monocotyledonous mats, is primarily formed by species tolerant to dehydration that are able to establish themselves and grow into dense tussocks directly on the bare rock (Barthlott *et al*. 1993, Safford & Martinelli 2002, Medina *et al.* 2006). Some species may grow roots into the substratum formed by the species that constitute these monocotyledonous mats (Porembski *et al*. 1998). Depending on mat size, a shrub-mat complex can be formed, which represents an intermediate phase between rock surfaces and adjacent forest formations (Ibisch *et al*. 1995). Another life form associated to monocotyledonous mats and their great water storage capacity is a group of ephemeral species known as "ephemeral and wet flush vegetation" (Barthlott *et al*. 1993, Safford & Martinelli 2000). Finally, shallow depressions also form microhabitats characterized by accumulating 5 to 12 cm of soil (humic substances) and disaggregated rock material, where grass type vegetations seem to be dominant (Safford & Martinelli 2000).

Habitat heterogeneity makes it difficult to study the plant community structure on rock outcrops. According to Escudero (1996), describing the community structure on rocky surfaces is a challenge due to the landscape complexity. Ribeiro (2002) mentioned the difficulty in establishing replicable samples, due to different topographies adjacent to one another, which may lead to different species associations as a function of the microclimatic heterogeneity.

Ecological studies on plant communities on Brazilian rock outcrops are rare (Meirelles 1996, Porembski *et al.* 1998, Safford & Martinelli 2000), particularly in altitudes higher than 1,000 m (*e.g.*, Meirelles 1996, Meirelles *et al*. 1999, Ribeiro 2002, Medina *et al*. 2006). Most such studies focused on the vegetation structure on granitic outcrops, among other issues, and emphasized the lack of studies for comparison, the difficulties in sampling the vegetation and the need of adapting phytosociological methods to sample the rupicolous vegetation. The studies by Pereira (1994), in "Serra do Cipó" – state of Minas Gerais, and by Conceição (2003), in four different sites of "Chapada Diamantina" – state of Bahia, are the only studies on plant community structure on quartzitic rock outcrops.

The main purpose of the present work was to contribute to the study of rupicolous plant communities through the structural analysis of the vegetation of a granitic rock outcrop in Southeast Brazil, at 1,722 m of elevation, *i.e.* a "Campo de Altitude" vegetation.

Material and methods

"Parque Estadual da Serra do Brigadeiro" (SBSP; 42°20' - 42°40' S and 20°20' - 21°00' W) is located in "Serra da Mantiqueira" and is entirely within "Zona da Mata", Minas Gerais State (figure 1; Engevix 1995). It is composed of granitic rocks, such as migmatites, granulites, gneisses, and the eventual quartz levels (Machado Filho *et al*. 1983). The Park displays a rough relief with scarps and rock formations with large rock outcrops. According to Koeppen's (1948) classification, the climate is mild mesothermic (CWb). The average annual precipitation is 1,300 mm and the average annual temperature is 18 °C (Engevix 1995).

The vegetation in SBSP is composed of secondary fragments of the Seasonal Semideciduous Forest (Veloso *et al*. 1991) from the Upper Montane Formation (Oliveira Filho & Fontes 2000). "Campos de Altitude" (Ferri 1980) occupy plateaux and isolated scarps in some areas above 1,600 m, presenting variable extensions of rock outcrops (Paula 1998).

"Serra das Cabeças" is one of the several ranges of mountains that compose the SBSP landscape. It encompasses three small sub-ranges, one of which is denominated "Totem Deitado", the site of the present study. The site is 1,722 m high and its summit occupies approximately 6 ha of "Campos de Altitude" type vegetation, showing synusiae of scrub vegetation, grassland and migmatite (intermediate phase between granites and gneisses) rock outcrops with major quartz veins.

For the structural analysis, 11 one-meter-wide transects, 20 meters apart, were set along the northeast/southeast direction, for the whole extent of the summit. The scrub border was the longitudinal end of the transects, which stretched up to the point where access was limited by declivity. Three transects were not analyzed, since they were totally covered by grassland with no apparent rock outcrops**.** A variable number of 1 m^2 quadrats was allocated in each transect, 5 m apart, totaling 40 m^2 of sampled area.

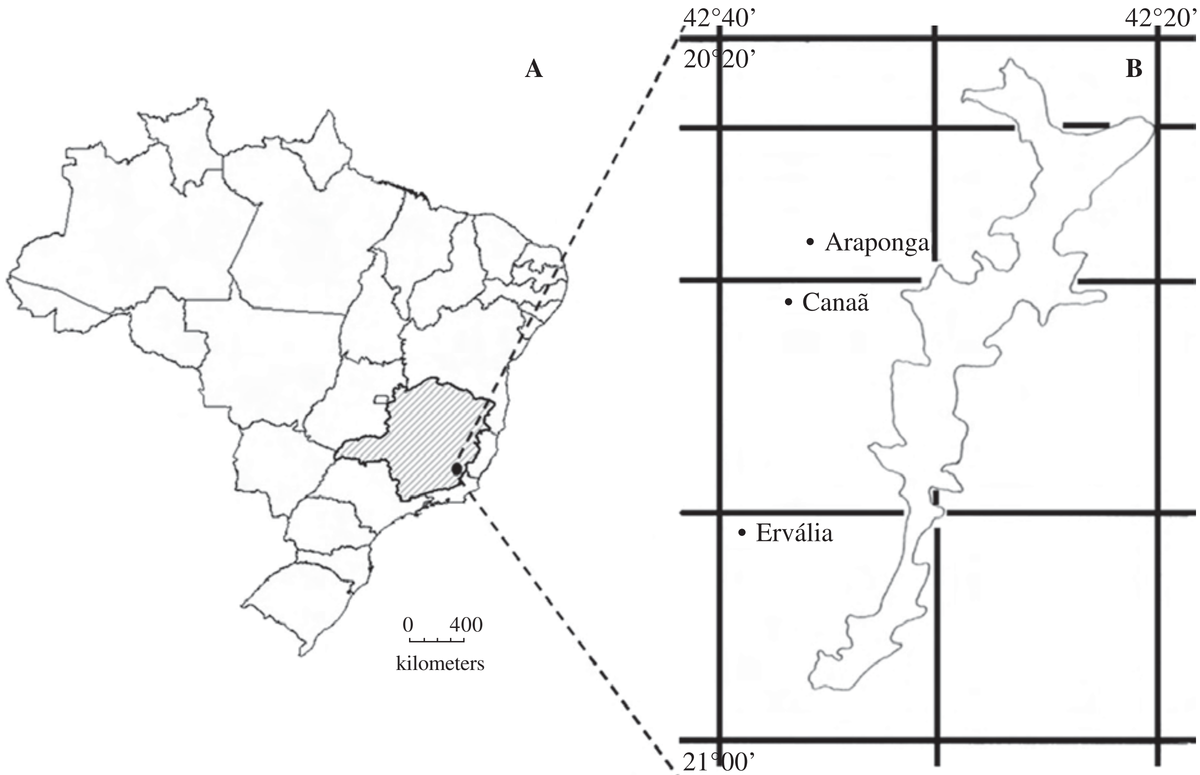

Figure 1. Map of Brazil, standing out Minas Gerais State, “Zona da Mata” area (A) and “Parque Estadual da Serra do Brigadeiro” location (B).

The quantitative parameters of frequency and dominance (cover), absolute and relative, were estimated (Müller-Dombois & Ellenberg 1974). Since the distinction of individuals for many rock outcrop plants is very difficult, as they basically grow in tussocks, species density was not determined. Thus, the Importance Value Index (Müller-Dombois & Ellenberg 1974) was modified and taken herein as the sum of the relative frequency and dominance (cover), which is a procedure adopted in many phytosociological studies in “restinga” (sandy coastal plain) vegetation, such as the ones mentioned by Almeida & Araujo (1997).

In phytosociological studies, dominance can be evaluated in several ways, depending on the purpose of the study and on the vegetation type to be analyzed. Rice (1967) and Daubenmire (1968) emphasized the ecological importance of vegetation cover to gauge plant distribution, being considered more important than density. This is based on the fact that cover represents a more accurate biomass measurement than the number of individuals. According to Müller-Dombois & Ellenberg (1974), plant cover is defined as the vertical projection of the area covered by sprouts or crowns of an individual over the ground surface, expressed as a fraction or percentage of a reference area. In the present work, it was considered to be the species cover, as well as all the green and dry (and/or senescent) parts of each individual.

We used the photograph charts method, proposed by Weaver & Clements (1938), adapted for cover estimation since originally the method was developed for mapping. Photographs (ASA 200) of each quadrat, later printed on paper, were taken with a manual photographic camera, 28 mm lens, mounted on a support 1.60 m tall, fixed on a structure representing a 1 m^2 quadrat. Photographs were taken halfway through the rainy season (January 2001) so as to avoid overlooking any geophytes, hemicryptophytes and therophytes, which may occur during the dry season. The photographs were then digitalized and the cover areas of each species measured using the QD software, developed by Prof. Elpídio Fernandes Filho, “Departamento de solos da Universidade Federal de Viçosa”, MG.

It is important to point out that the method used in the present study to estimate the species cover showed advantages and limitations. The precision in the measurement of each species cover was perceived as an advantage, since the photographs are scanned at high resolution for subsequent meticulous analysis of each species cover. Although this requires a time-consuming image analyses, it yields very precise cover values. In field conditions, the method was fast and reasonably easy to apply. A limitation of the method employed was the impossibility to assess plants shorter than 3 cm, as in the cases of *Bulbostylis scabra* and *Paepalanthus manicatus*. However, when in dense populations *B. scabra* was sampled. Meirelles (1996) pointed out the same limitation when using paper photographs of the profile of the vegetation islands to estimate the effect of vegetation seasonality on a rock outcrop in Atibaia, state of São Paulo, southeast of Brazil. In such cases, a photographed area of one square meter could be diminished to a smaller area, when the camera was positioned not so distant from the small specimen, thus increasing the photograph quality.

Cluster analysis of the quadrats was accomplished with the aid of the Fitopac 1 software (Shepherd 1995). The Jaccard's similarity coefficient was used for qualitative data (Müller-Dombois & Ellenberg 1974). The unweighed-pair-group method, using arithmetic averages (UPGMA), and the complete linkage method (Sneath & Sokal 1973) were used to interpret the floristic similarity between quadrats.

Results and discussion

Structural analysis – The structural analysis showed that 12.95 m^2 (32.37%) of the total sampled area was represented by bare rock surface. Four quadrats had 100% bare rock and 21 had from 10% to 90% of bare rock surface. In fact, the rock surface was not bare, but densely colonized by cyanobacteria. This is one of the many differences between rock outcrops of tropical Africa and those from South America. In Africa, rock surface is densely colonized by lichens, possibly due to climatic reasons not yet elucidated (Barthlott *et al*. 1993).

Twenty-eight species of vascular plants, representing 27 genera and 16 families, were sampled in the structural analysis. The results of the analyzed structural parameters are shown in table 1. We have previously found 56 species of vascular plants in a floristic survey of this rock outcrop (Caiafa & Silva 2005). Sampling then consisted of a year and a half of monthly field expeditions. Therefore, the present study found 50% of the estimated flora of the rock outcrop according to our previous study.

The species with the highest relative frequency in the sample were *Trilepis lhotzkiana* (19%), followed by *Panicum* sp. 1 (12.9%), *Vellozia variegata* (9.5%), *Tibouchina* cf. *manicata* (8.8%), *Stevia claussenii* (8.2%), and *Rhynchospora emaciata* (6.8%). *Trilepis lhotzkiana* was also the most frequent species in the sample of Meirelles *et al.* (1999), followed by two Velloziaceae species, *Nanuza plicata* and *Vellozia candida*. *Trilepis lhotzkiana* is among the most frequent species forming monocotyledonous mats on our study site (figure 2), possibly serving as substratum to other species unable to settle themselves directly on bare rock. *Vellozia variegata* also seems to play such a role, particularly when associated to *Trilepis lhotzkiana.* The only study about plant-plant interactions in "Campos de Altitude" of Brazil attributed an important nursing role to mat species, which were often Velloziaceae and Bromeliaceae species, in addition to bryophytes (Medina *et al.* 2006).

The high relative frequency of *Panicum* sp. 1, a dominant grassland species, is possibly related to the presence of flat areas with major quartz veins in the rock outcrop. These quartz veins when disaggregated originate quartzitic sand, which are establishment sites not only for *Panicum* sp. 1 but also for other grassland species. This feature deeply modifies the typical landscape of "Campos de Altitude" (Caiafa & Silva 2005), and turns it into a mosaic somewhat uncommon to the remaining of the SBSP summit (figure 3). Vegetation islands on rock outcrop in this mosaic landscape have larger area and depth and are, therefore, establishment sites also to

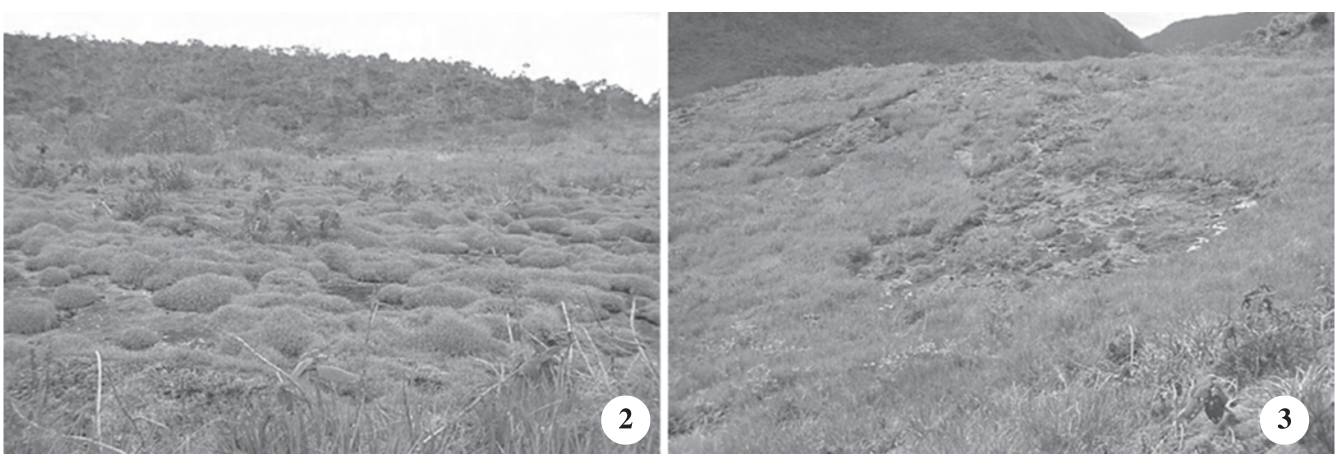

Figure 2. Cushions of *Trilepis lhotzkiana*, present in the granitic rock outcrop, in "Campo de Altitude" in the "Totem Deitado" summit, "Serra das Cabeças", "Parque Estadual da Serra do Brigadeiro", MG, Brazil**.** This 10 cm-high herb shows rosetted insertion of leaves and dense clonal growth pattern. When not massively colonized by other species, it assumes these cushion patterns. Figure 3. Mosaic of rock outcrop and grassland dominated by *Panicum* sp. 1, present in the "Totem Deitado" summit, "Serra das Cabeças", "Parque Estadual da Serra do Brigadeiro", Minas Gerais, Brazil.

Table 1. Structural parameters estimates obtained for the species sampled in "Campo de Altitude" granitic outcrop in "Totem Deitado" summit, "Serra das Cabeças", "Parque Estadual da Serra do Brigadeiro", MG, Brazil. (Ui = number of quadrats in which the species was found; FA = absolute frequency; FR = relative frequency; DoA = absolute dominance; DoR = relative dominance; VI = importance value).

Família	Espécies	U_i	FA	FR%	DoA ($36\ m^2$)	DoA $m^2\ ha^{-1}$	DoR%	VI%
CYPERACEAE	*Trilepis lhotzkiana* Nees	28	0.78	19.05	9.0242	2256.04	40.280	29.66
POACEAE	*Panicum* sp. 1	19	0.53	12.92	8.1363	2034.07	36.317	24.62
VELLOZIACEAE	*Vellozia variegata* Goethart & Henrard	14	0.39	9.52	1.6799	419.98	7.498	8.51
CYPERACEAE	*Rhynchospora emaciata* (Nees) Boeck.	10	0.28	6.80	1.2840	321.00	5.731	6.27
MELASTOMATACEAE	*Tibouchina* cf. *manicata* Cogn.	13	0.36	8.84	0.5292	132.29	2.362	5.60
ASTERACEAE	*Stevia claussenii* Sch. Bip. ex Baker	12	0.33	8.16	0.1326	33.1582	0.592	4.38
BROMELIACEAE	*Dyckia bracteata* (Witt.) Mez	3	0.08	2.04	1.3560	338.99	6.052	4.05
BROMELIACEAE	*Pitcairnia* cf. *carinata* Mez	6	0.17	4.08	0.0695	17.38	0.310	2.19
AMARYLLIDACEAE	*Hippeastrum glaucescens* (Mart.) Herb.	5	0.14	3.40	0.0339	8.48	0.151	1.78
SCHIZAEACEAE	*Anemia vilosa* Humb. & Bonpl. ex Willd.	5	0.14	3.40	0.0269	6.73	0.120	1.76
PTERIDACEAE	*Doryopteris collina* (Raddi) J. Sm.	4	0.11	2.72	0.0251	6.26	0.111	1.42
ASTERACEAE	*Baccharis stylosa* Gardner	4	0.11	2.72	0.0204	5.10	0.091	1.41
ORCHIDACEAE	*Oncidium* spp.	4	0.11	2.72	0.0082	2.04	0.036	1.38
IRIDACEAE	*Sisyrinchium* sp.	4	0.11	2.72	0.0034	0.86	0.015	1.37
ASTERACEAE	*Vernonia decumbens* Gardner	2	0.05	1.36	0.0134	3.34	0.059	0.71
GESNERIACEAE	*Siningia magnifica* Otto & Dietr.	2	0.05	1.36	0.0007	0.18	0.003	0.68
CYPERACEAE	*Rhynchospora splendens* Lindm.	1	0.03	0.68	0.0232	5.80	0.103	0.39
CYPERACEAE	*Bulbostylis scabra* (Presl.) C. B. Clarke	1	0.03	0.68	0.0087	2.16	0.038	0.36
LYCOPODIACEAE	*Huperzia pungentifolia* (Silveira) B. Øllg	1	0.03	0.68	0.0053	1.32	0.023	0.35
ASTERACEAE	*Eupatorium* sp.nov. 2	1	0.03	0.68	0.0046	1.14	0.020	0.35
XYRIDACEAE	*Xyris filifolia* L. A. Nilss.	1	0.03	0.68	0.0037	0.93	0.017	0.35
ORCHIDACEAE	*Habenaria janeirensis* Kraenzl.	1	0.03	0.68	0.0036	0.90	0.016	0.35
ORCHIDACEAE	*Zygopetalum* spp.	1	0.03	0.68	0.0034	0.86	0.015	0.35
SCROPHULARIACEAE	*Esterhazya splendida* J. G. Mikan	1	0.03	0.68	0.0029	0.72	0.013	0.35
ORCHIDACEAE	*Pleurothallis teres* Lindl.	1	0.03	0.68	0.0023	0.57	0.010	0.34
ORCHIDACEAE	*Epidendrum secundum* Jacq.	1	0.03	0.68	0.0012	0.30	0.005	0.34
CYPERACEAE	*Lagenocarpus comatus* (Boeck.) H. Pffeif.	1	0.03	0.68	0.0006	0.14	0.002	0.34
ASCLEPIADACEAE	*Ditassa leonii* Fontella & T. Konno	1	0.03	0.68	0.0005	0.12	0.002	0.34

Panicum sp. 1, since they are near the propagule source of this species.

The six species with highest relative dominance (cover) in the sample were *Trilepis lhotzkiana* (40.3%), *Panicum* sp. 1 (36.3%), *Vellozia variegata* (7.5%), *Dyckia bracteata* (6.1%), *Rhynchospora emaciata* (5.7%), and *Tibouchina* cf. *manicata* (2.4%), which altogether amounted to 98.3% of the relative dominance. The remaining 1.7% encompassed 22 other species. The pattern of a high number of species with low cover values has been found in other rock outcrops (Meirelles 1996, Conceição 2003). Indeed, Scarano (2002) argued that many such habitats peripheral to the Atlantic rain forest are oligarchic in structure, *i.e.* display a small number of dominant species and high number of locally rare species. In our case, as dominance is expressed by cover figures, the species size and the substratum occupation pattern had a great influence on this parameter.

Trilepis lhotzkiana had the highest importance value (29.7%). *Tibouchina* cf. *manicata* (5.6%) and *Stevia claussenii* (4.4%), ranked fifth and sixth respectively, due to high relative frequencies, rather than to their relative dominance, which was very low in both cases.

Cluster analysis – The dendrogram obtained by the complete linkage method was similar to the one obtained by UPGMA, *i.e.*, both formed the same groups, which is evidence of their clarity and consistency.

Five groups were formed (figure 4). All quadrats from Group 1 showed an association of *Trilepis lhotzkiana* and *Vellozia variegata*, forming monocotyledonous mats serving as substratum for the establishment of other species. Group 2 showed *Panicum* sp. 1., *Vellozia variegata* and *Trilepis lhotzkiana* in all but one quadrat (15), where T. *lhotzkiana* was absent and the linkage with the sub-group formed by the other quadrats was at cut level 0.4. This quadrat also suffered strong influence from the neighboring grassland. The same was observed, at smaller proportions, in two other quadrats (13 and 36).

Group 3 was formed by quadrats of greater floristic richness. The sub-group formed by quadrats 8 and 9

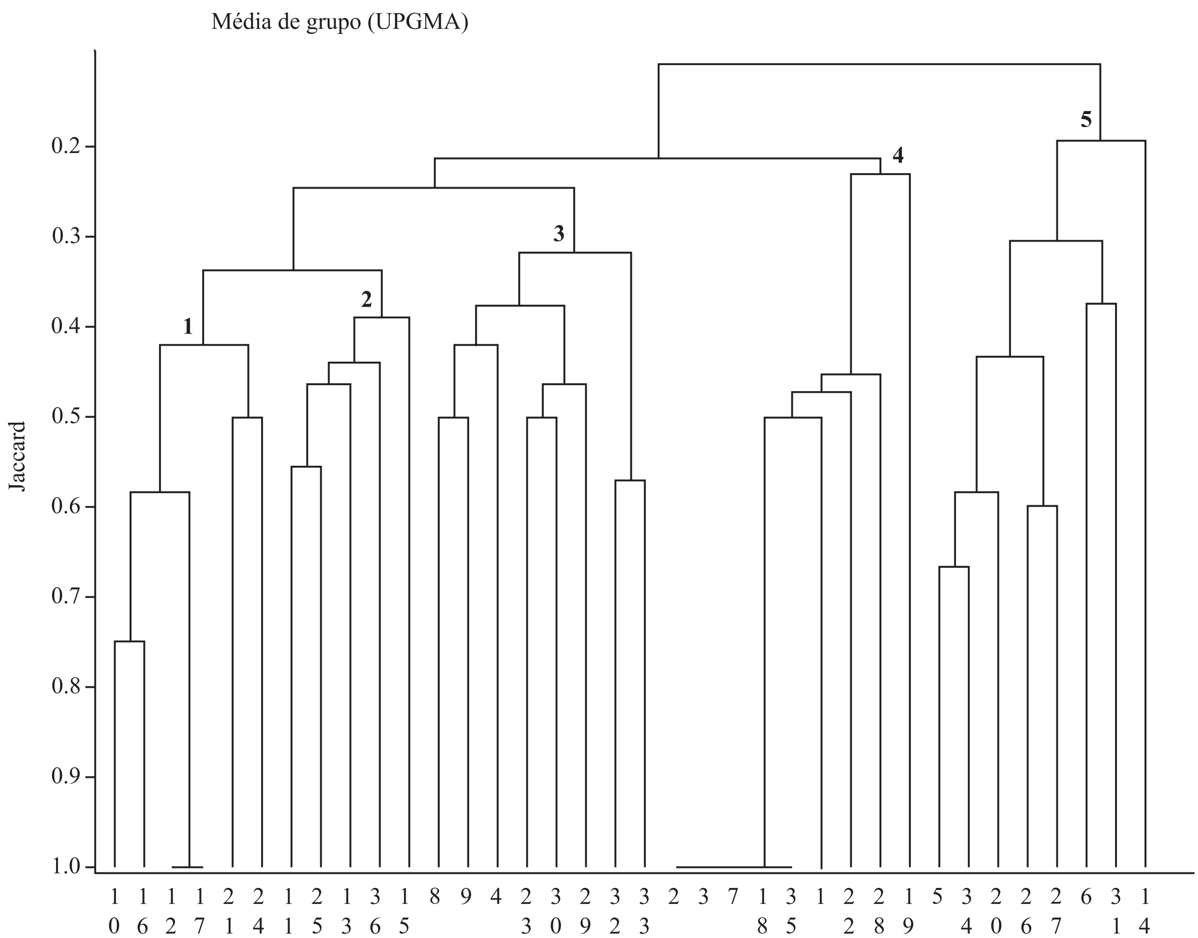

Figure 4. Dendrogram obtained by UPGMA, based in the Jaccard index, for the sampling quadrats established in the highland granitic rock outcrop, in the "Totem Deitado" summit, "Serra das Cabeças", "Parque Estadual da Serra do Brigadeiro", Minas Gerais, Brazil.

showed six species in common: *Trilepis lhotzkiana*, *Pitcairnia* cf. *carinata, Doryopteris collina, Siningia magnifica, Panicum* sp. 1, and *Anemia vilosa.* Quadrat 4 was linked to this sub-group at 40% similarity, and showed four species in common with this sub-group. The sub-group formed by quadrats 23, 30 and 29 showed *Panicum* sp. 1, *Trilepis lhotzkiana* and *Tibouchina* cf. *manicata* as common species, while all quadrats of this sub-group represented shallow depression habitats. The other quadrats of this group represented habitats formed by monocotyledonous mats. The sub-group formed by quadrats 32 and 33 had *Trilepis lhotzkiana*, *Tibouchina* cf. *manicata, Pitcairnia* cf. *carinata*, and *Stevia claussenii* in common.

The great similarity among quadrats of Group 4 was due to the almost exclusive presence of *Trilepis lhotzkiana*, a monocotyledonous mat-forming species. In this group, quadrats 2, 3, 7, 18, and 35 were exclusively composed of *T. lhotzkiana.* Quadrat 19, linked to this group at cut level 0.25, presented *T. lhotzkiana,* and also *Pleurothallis teres* and *Sizyrinchium* sp. Each of the remaining quadrats (1, 22 and 28) showed one extra species in addition to *T. lhotzkiana*: *Doryopteris collina*, *Hippeastrum glaucescens*, and *Tibouchina* cf. *manicata*, respectively. They were all growing on the mat-forming species.

Group 5 was the most different, related to the others at a similarity level of mere 10%. It had the presence of *Panicum* sp. 1 in all quadrats and the absence of *T. lhotzkiana* in almost all of them, except for quadrats 6 and 20. Quadrats 14, 26, 27, and 34 were directly influenced by the grassland, which was nearby. Five out of eight quadrats showed species sampled only once: *Xyris filifolia* (20), *Habenaria janeirensis* (26), *Epidendrum secundum* (27), *Ditassa leonii* (6), and *Rhynchospora splendens* (31).

The distinction of quadrats within groups was due to the great number of species at low frequency, a pattern also observed by Meirelles (1996) and Conceição (2003).

Trilepis lhotzkiana, Panicum sp. 1 and *Vellozia variegata* stood out as the species with higher importance values in our study site. *Trilepis lhotzkiana*, a mat species, was the dominant plant, whereupon many other species establish. Low frequency species covering restricted areas were common in these rock outcrops. The most frequent species were responsible for the between-group quadrat distinction, while the low frequency species were mainly responsible for the within-group quadrat distinction.

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