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Upper montane grassland structure within six subranges of Serra do Mar, Southern Brazil[1]

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ABSTRACT - (Upper montane grassland structure within six subranges of Serra do Mar, Southern Brazil). The phytosociological structure of upper montane grasslands (high altitude grasslands) was studied in six subranges of Serra do Mar. Throughout 324 (1 m^2) plot samples, we identified 195 taxa out of 280 taxa previously found in a floristic survey. Besides the general analysis of these communities, five physiognomies (synusiae) of these grasslands were previously determined based upon the species with greater cover. *Cryptangium triquetrum* and *Croton mullerianus* had the highest phytosociological importance value among the upper montane grasslands sampled in the present study. The first species was the most important of the grassy physiognomy of all sampled subranges and the second one of the shrubby physiognomy within three subranges. *Chusquea pinifolia*, *Machaerina austrobrasiliensis*, *Deschampsia caespitosa*, *Gleichenella pectitata*, *Tibouchina dubia*, *Xyris stenophylla*, *Eryngium koehnearum* and *Eriochrysis holcoides* were also structurally important. Although considerable species richness has been observed, the dominance of one or few species in the community was common in all subranges and physiognomies. In a brief comparison with upper montane vegetation studies (mainly on rocky outcrops) carried out in Southeastern Brazil, a low sharing of species was verified. Furthermore, the scarcity of studies in the literature regarding floristic and sociological structure of upper montane grasslands hampers a deeper analysis at level of species.
Keywords: high altitude grassland, phytosociology, Sea Mountain Range

RESUMO - (Estrutura de campos altomontanos de seis serras no sul do Brasil). A estrutura fitossociológica de Campos Altomontanos foi avaliada em montanhas pertencentes a seis blocos da Serra do Mar, no Estado do Paraná: Serra Gigante, Serra do Ibitiraquire, Serra da Farinha Seca, Serra da Igreja, Serra da Prata e Serra da Pedra Branca do Araraquara. Em 324 parcelas de 1 m², foram amostrados 195 taxa, dos 280 encontrados em estudo florístico prévio. Além da análise geral dessas comunidades, foram pré-definidas cinco fisionomias vegetacionais (sinúsias) com base nas espécies com provável maior destaque na cobertura. *Cryptangium triquetrum* e *Croton mullerianus* apresentaram-se como as principais espécies dos campos altomontanos amostrados na Serra do Mar paranaense. A primeira foi a espécie mais importante em todos os trechos de fisionomia campestre, enquanto a segunda destacou-se na fisionomia subarbustiva em três serras amostradas. *Chusquea pinifolia*, *Machaerina austrobrasiliensis*, *Deschampsia caespitosa*, *Gleichenella pectitata*, *Tibouchina dubia*, *Xyris stenophylla*, *Eryngium koehnearum* e *Eriochrysis holcoides* também se destacaram em diversos trechos e fisionomias. Apesar de considerável riqueza, a dominância de uma ou poucas espécies nas comunidades avaliadas foi uma constante em todas as serras e fitofisionomias. Em uma breve comparação com estudos realizados em vegetações altomontanas, principalmente sobre afloramentos de rocha no Sudeste do Brasil, foi verificado um baixo compartilhamento de espécies com os campos altomontanos do presente estudo. A escassez de trabalhos publicados sobre a florística e a estrutura fitossociológica desses campos, dificulta análises mais aprofundadas em nível de espécie.
Palavras-chave: Campos de altitude, Campos de "alta"altitude, fitossociologia, Serra do Mar

Introduction

Standing out in a context of montane and upper montane forests, the natural landscape at the top of several mountain ranges is largely occupied by grassland vegetation. The highland regions of both Serra do Mar and Serra da Mantiqueira present about 350 km^2 of high altitude grasslands (Safford 1999a).

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Many descriptions for the various grassland formations of plateau surfaces and mountain ranges of Brazil have been reported in the literature by several authors. However, these descriptions often result in confusion, redundant and inaccurate categorization of such environments, especially for those higher level mountain ranges (*e.g.* alpine, mountaintop and steppe-like grasslands, upper montane or high elevation refuges, ecological refuges, upper montane herbaceous plant refuges, rocky grasslands (rocky outocrop vegetation), high-altitude rupestrian grasslands, the Atlantic Forest biome grasslands, altitude grasslands (campos de altitude, a generic term), upper montane grasslands (campos de "alta" altitude or "campos altomontanos", etc.) (*e.g.* Rizzini 1979, Ferri 1980, Veloso *et al*. 1991, IBGE 1992, Martinelli 1996, Safford 1999a, b, Tramujas 2000, Roderjan *et al*. 2002, Caiafa & Silva 2005, 2007, Garcia & Pirani, 2005, Ribeiro *et al*. 2007, Mocochinski & Scheer 2008, IBGE 2012, Vasconcelos 2011, Scheer *et al*. 2011a, 2013a, b, 2014, Meireles *et al*. 2014, Alves *et al*. 2014, Tinti *et al*. 2015).

The Brazilian CONAMA Resolution 10/1993 had already ascribed "campos de altitude" to the montane and upper montane levels occurring in litholic ridges from high-altitude mountains. CONAMA Resolution 423/2010, in order to link Federal Law no. 11.428/2006, regarded the term "campos de altitude" not only to upper montane environments, but also to the montane Atlantic Forest biome.

Quite often, the term "campos rupestres" (rocky outcrop vegetation or rupestrian grasslands) is used by some authors to the vegetation which predominantly occurs on very shallow soils on quartzite and sandstone rocks (among others), usually at montane and upper montane levels (Ferri 1980, Vasconcelos 2011, among others). Despite having similar physiognomy and sharing some taxa, the rock fields and "high-altitude graslands" should be treated as distinct based upon differences in geological substrates, plant species composition, climatic and phytogeographic domains (Vasconcelos 2011, Alves *et al*. 2014). However, regarding the term "montane and upper montane rupicolous/rupestrian vegetation" could also be attributed to the transitional sites with incipient substrates and/or the primary succession colonizing rock outcrops close to the upper montane grasslands of Serra do Mar (Coastal Mountain Range). As a matter of fact, both of them can be considered as upper montane vegetation refuges (Veloso *et al*. 1991), generally occurring in thin histic topsoil substrates over granitic and gneissic/migmatitic rocks, and therefore not necessarily over quartzite or sandstone rocks by leaving the physiognomy of such upper montane grasslands or even the rock grasslands uncovered. Furthermore, the term "altitude", although widely used (sometimes even by law) to determine montane and upper montane levels, is quite inaccurate since every location has a specific altitude which needs to be specified so that confusion and generalizations are avoided. Also, the terms "rupestrian" or "rupicolous" denote the neighboring or interspersed rock outcrops over topsoils or incipient substrates, which may occur on several lithologies, and for this reason the vegetation type should be added. The term "fields", adopted by IBGE (Brazilian Institute of Geography and Statistics), is more comprehensive: herbaceous and shrubby vegetation, consisting primarily of graminoids and scattered bushes. Therefore, the above terminology requires better specification. We aimed at differentiating the grasslands (CONAMA Resolution 423/2010) occurring in montane levels (commonly found in hinterland uplands) from the "high" altitude grasslands, which are predominantly Haplic and Folic Histosols that also feature "rupestrian areas" with transitional rock outcrops. To this end, we adopted in the present study the term "Upper Montane Grasslands", abiding by the parameters set for forests according to IBGE Vegetation Classification System. They can also be considered as upper montane vegetation refuges based on the concept that they dominated larger areas in the last glacial periods. Currently, along with the transition from rupestrian flora to rocky outcrops, they are different from the dominant context of forests. On the other hand, we have to point out that these ecosystems are current patterns of where they are located, arising from morphogenesis and pedogenesis processes which resulted from climate change and geomorphology up to date.

Scheer *et al*. (2011, 2013) explain the occurrence of upper montane grasslands in comparison to upper montane forests, based on the soil factor through the greater thicknesses of histic horizons in comparison to mineral ones since the characteristics of both soils are strongly related to the climate and geomorphology. High altitudes bring about lower temperatures, which favors a slower decomposition of litter, forming then such organic horizons. These conditions combined with the strong winds seem to promote herbaceous and shrubby species instead of tree species because these horizons have no structure to provide stability for the roots to sustain large trees. Moreover, grazing

by cattle and wildfires caused by human activity damage the physiognomic characteristics of some upper montane grasslands, even though many authors considered these environments as anthropic fields such as "Pampas" in Southern Brazil (Overbeck *et al*. 2007, Behling *et al*. 2009) and Campos Gerais (Safford 2001) as well as high-altitude grasslands in Southeastern Brazil. Some upper montane grasslands in the Southern and Southeastern Brazil have endured wildfires resulted from illegal agro-pasture activities of neighboring properties. As a matter of fact, only 0.5% of wildfires in the Southeastern mountains appear to be natural (Aximoff 2001), which has severely altered their floristic and pedological composition. In many upper montane grasslands of Serra do Mar, the occurrence of some specialized underground organs with the function to support grazing and fires can be only an acquired inheritance during drier past climates. It does not mean that these current mature (old growth) grasslands need fire for its maintenance.

Many areas of montane and upper montane forests have also been devastated by man-made fires, losing their ecological resilience and beginning a colonization process along with countryside-like physiognomy, which causes a disruption and distortion regarding natural grasslands.

The building processes for the formation of upper montane grasslands are complex and date back to an ancient landscape by the end of the Pleistocene-epoch, when dry-cold severe weather dominated the Southeastern region of the South American continent (Safford 1999b). According to Safford (1999a), the high number of endemic species in this formation indicates that these environments are relatively ancient and not only the result of recent anthropogenic disturbances. There is Palaeobotanical evidence that suggests that the mountain ridges of Southeastern Brazil have been uninterruptedly covered by upper montane grasslands since the end of the Pleistocene (Behling 1997a, b). A similar situation must have occurred to the regions immediately to the South, although back then some exposed mountain ridges may have been largely bare or covered only by precursor rupestrian vegetation, being colonized (or recolonized) throughout the Holocene (Scheer *et al*. 2012, 2014).

Unlike the countryside-like montane grasslands (such as "Pampas"), the difficulty of access and the adversity of environmental conditions may have safeguarded upper montane grasslands from anthropogenic degradation processes. Thus, they are rare well-preserved areas of nature in the South and Southeast of Brazil. However, their preservation has been constantly threatened by anthropogenic processes such as wildfires, biological contamination as well as disorderly tourism development (Mocochinski & Scheer 2008). While considering the high levels of endemism, the uniqueness of their ecological processes (high carbon stocks in the soil per unit area, soil retention and regulation of water flows, slope protection, etc., Scheer *et al*. 2011, 2013) as well as their restricted occurrence within a few tens of square kilometers in the State of Paraná, it is clear the importance of action plans for the conservation of such vegetation. Hence, improved basic knowledge is crucial, such as structural and floristic composition which are still scarce. By acknowledging this gap in knowledge about the biological diversity in the Southern region of Brazil, besides complementing and updating the floristic study reported by Mocochinski & Scheer (2008), we aimed at presenting the phytosociological structure of upper montane grasslands from several mountains belonging to six subranges of Serra do Mar in Paraná and their similarity. Additionally, we conducted a brief search for studies which might include similar sites in other regions of Brazil. Gathering information and knowledge about the most dominant and frequent species in these formations as well as their different vegetation types in Paraná play a key role for further research on such important environments.

Material and methods

Study areas - The six sampled subranges belong to Serra do Mar in the State of Paraná, Southern Brazil. The geographic coordinates are between latitudes 25º56'S and 25º08'S and longitudes 48º52'W and 48º30'W. The subranges are regionally known as: Serra do Ibitiraquire, Serra da Igreja, Serra da Prata, Serra Gigante, Serra da Farinha Seca (Graciosa) and Serra da Pedra Branca do Araraquara (figure 1). Such study areas were chosen based on the representativeness of this formation occurrence in Paraná and a number of outstanding differences: for instance, altitude (between 950 and 1870 m asl), extension and altitudinal ranges of the formation, geographical position, continentality, etc. (table 1).

The climate is classified as Cfb by the Köppen-Geiger system: humid subtropical climate, average temperature of the coldest month below 18 °C and above -3 °C, average temperature of the warmest month below 22 °C. Roderjan & Grodski (1998) observed absolute minimum temperature of -5 °C,

annual average of 13.4 °C and absolute maximum of 30 °C to upper montane levels, in forest environment, in Morro Anhangava in the municipality of Quatro Barras, Paraná. The rate of precipitation in Serra do Mar is well distributed throughout the year and show wide variation depending on the topography. Measurements in the coastal region surpass 2,000 mm annual precipitation and on the slopes of the subranges the values reach 3,500 mm. As for hinterland uplands, surpassing mountain ranges, annual precipitation may reach 1,500 mm (Maack 1968).

As previously mentioned, the current occurrence of upper montane grasslands over the Upper Montane Atlantic Dense Rain (Cloud) Forest is regulated by the substrate thickness relationships between (histic) organic and mineral horizons, which resulted from both climate and geomorphology. The upper montane grasslands are in predominantly Haplic and Folic Histosols as well as Histic Litholic Entisols, which either have no mineral horizons or their occurrence typically starts at a depth below 40 cm or even in places where histic horizons have a lithic contact within the depth between 20 and 40 cm. The sites where histic horizons have less thickening there are better conditions for the upper montane forest to be established (Scheer *et al*. 2013a, b), then taking place in Litholic Entisols (typically dystrophic and typically humic) (Roderjan 1994, Rocha 1999, Vaschenko *et al*. 2007) and Gleysols (Wisniewski *et al*. 2005, Scheer *et al*. 2013a), Regosols (Scheer *et al*. 2013b) as well as Cambisols (Roderjan 1994, Rocha 1999). These extremely acid soils have high organic matter content, low base saturation and high exchangeable aluminum content. In lower altitude or even isolated mountains in southern Brazil (*e.g.* Serra Gigante), the typical upper montane grasslands may occur more significantly close to the ridges, just over 1000 m asl, which does not occur in higher mountains (*e.g.* above 1300 m asl). As a matter of fact, such occurrences at lower altitudes are due to geomorphological and soil characteristics, as well as mass-elevation effect (*e.g.* lower temperatures in comparison with higher and more extensive subranges) also known as the Massenerhebung effect (Grubb 1971, Flenley 1995, Han *et al*. 2012).

As for higher subranges such as Serra do Ibitiraquire, the upper montane grasslands have a more extensive range, being proportionally higher (above 1,400 m asl), is interweaving with the occurrence of upper montane forests and rocky outcrops, by evidencing the important role of other environmental factors (table 1).

Phytosociological study - In order to study the sociological structure of the plant communities, we sampled 324 plots (1 × 1 m) in the six subranges. A different number of sample plots were set up on each subrange based upon the field area length, the number of ridges per subrange, accessibility on each subrange as well as the phytophysiognomy in the field.

Aiming to refine the approach to the structure of the communities, the samples were classified into categories, hereby treated as vegetation types or physiognomy ("synusiae"), found well preserved and in an advanced, (mature or old growth) succesion stage. This typological pre-stratification (Péllico Neto & Brena 1997) was used to obtain particular data for

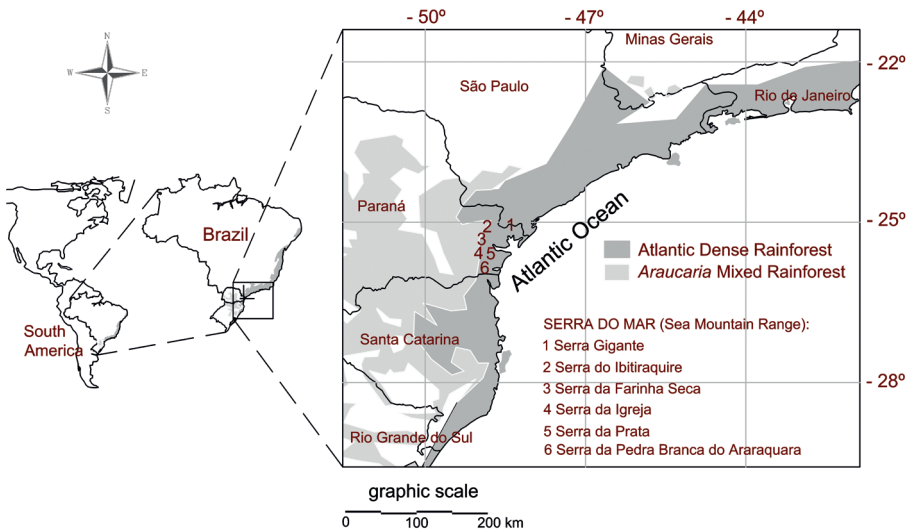

Figure 1. Location of the Subranges where the upper montane grasslands were sampled.

each vegetation physiognomy, easily characterized and recognized in the field, which enabled more accurate estimates of phytosociological descriptors. The characterization was based upon the most common species with greater cover or similar habitats, thereby visually defining the synusiae.

Five physiognomies were determined: 1. Shrubby, when the species with greater cover were visibly shrubs; 2. Grassy, when the species with greater cover were visibly graminoids; 3. *Chusquea mimosa*; 4. *Chusquea pinifolia*; 5. *Machaerina austrobrasiliensis*; when these species were visibly and clearly the most dominant ones.

All plant taxa found in the plots were registered in field records. We also recorded the maximum height and the predominant height of each species per sample plot as well as the respective percentage of the species cover (adaptation of the method reported by Braun-Blanquet 1979), based on the estimated vertical projection of the aerial parts of the plants sampled on the ground. To determine the predominant height, we took into consideration the most photosynthetically active portion of the species found within the plots sampled. To aid measurement of species cover, the plots were assembled with metric graduation measuring tapes. No attempt was made to record species density due to the difficulty to determine the number of different specimens found in the field, especially graminoids. Plant material samples were collected from each plot in order to compose the floristic list (published by Mocochinski & Scheer 2008) and also to identify the ones yet unknown by the authors. However, for some of those as yet unknown we used morpho-species

Table 1. Features of the sampled subranges of Serra do Mar (Sea Mountain Range) in Southern Brazil

Subrange	Highest ridge point (m asl)	Location (Municipalities)	Lithology (PRÓ-ATLÂNTICA, 2002)	Features	Protected Area Unit
Gigante	1069	Guaraqueçaba (PR) e Cananéia (SP)	Gneissic-migmatitic rocks (foliated granitic)	Upper montane grasslands restricted to the vicinity of ridges, occurring more significantly over 1,050 m asl. Coastal plain isolated subrange. No contact point with the plateau (hinterland upland)	APA de Guaraqueçaba e PE de Jacupiranga (SP)
do Ibitiraquire	1877	Campina Grande do Sul e Antonina (PR)	Alkali granites (Granite-Graciosa)	Approximately 790 hectares of upper montane grassland cover (Roderjan, 1999). Occurrence over 1,350 m asl. There are 13 mountains with altitude greater than 1,500 m asl	PE do Pico Paraná e Roberto Ribas Lange
da Farinha Seca	1457	Quatro Barras e Morretes (PR)	Alkali granites (Granite-Graciosa)	Upper montane grasslands occurring over 1,300 m asl. It has flat-topped ridges.	PE da Graciosa
da Igreja	1376	Morretes (PR)	Alcali granites (Alkali-granite)	Upper montane grasslands occurring over 1,250 m asl. It has flat-topped elevations	PARNA Guaricana e APA de Guaratuba
da Prata	1502	Morretes, Paranaguá e Guaratuba (PR)	Gneissic-migmatitic rocks (foliated granitic)	Upper montane grasslands occurring over 1,300 m asl. Coastal plain isolated-subrange, no contact point with the plateau	PARNA Saint Hilaire-Lange e APA de Guaratuba
da Pedra Branca do Araraquara	1222	Guaratuba (PR)	Granite-gneissic rocks	Upper montane grasslands occurring over 1,150 m asl	APA de Guaratuba

APA - Environmental Protection Area
PE – State Park
PARNA – National Park
[1] – PRÓ-ATLÂNTICA 2002
[2] – Roderjan 1999,
Source: Mocochinski & Scheer (2008)

identification, since the specific determination was not possible due to the lack of suitable source material for this purpose. The reference material was deposited in the collection of Museu Botânico Municipal in Curitiba (MBM) and duplicates were donated to the Herbarium of Universidade Federal do Paraná (UFPR-UPCB) as well as to Escola de Florestas de Curitiba (EFC). Taxa of our phytosociological survey were reviewed according to the List of Species of the Brazilian Flora 2020 (Flora of Brazil under construction 2016) as well as the Brazilian Catalogue of Plants and Fungi (Forzza *et al*. 2010).

The final graphical presentation relating to the phytosociological importance of the species in each physiognomy within the six sampled subranges was developed by AMADO 1:01 CISIA-program. The cluster analysis was performed in STATIGRAPHICS PLUS-program.

Results and Discussion

Structure of upper montane grasslands in Serra do Ibitiraquire

Serra do Ibitiraquire - Physiognomy: shrubby - We found 94 species within the 61 sampled plots and the community had an absolute plant cover of 124.7 m².100^{-1}m² (considered here the sum of the cover of all sampled species), especially *Croton mullerianus* with the highest importance percentage (table 2). Such emphasis was mainly due to the cover percentage (36.5%), more than double if compared to the second species, *Cryptangium triquetrum*. The main six species accounted for almost half the percentage of the community. Furthermore, *C. mullerianus* and *C. triquetrum* alone accounted for more than half the community relative cover.

Chusquea pinifolia stood out in the upper strata of the community with predominant height (average of 87.8 cm) and relative cover of 5.9%. *Chusquea mimosa* also stood out in the upper strata with prevailing height (average of 85 cm), however, it was found in only 20% of the sampled plots.

The species with predominant height lower than 30 cm accounted for less than 5% the community relative cover. Whereas, the species with predominant height between 30 and 60 cm accounted for 84% the relative cover, of which four out of the five most important species of such community were found in this stratum. The species with prevailing height above 60 cm accounted for 11% the relative cover, especially *C. pinifolia*, *C. mimosa* and *Machaerina austrobrasiliensis*.

Serra do Ibitiraquire - Physiognomy: grassy - 99 species (mainly graminoids) were found within the 64 sampled plots (table 3). The community had an absolute plant cover of 109 m². 100^{-1} m². *C. triquetrum* showed the highest percentage (16,4%) and relative cover of 26.5%, which represents over a quarter of the community. The difference for the other species was not as great as in the shrubby physiognomy, however, we observed that only seven species accounted for more than 50% the highest importance percentage of the community. The three main species accounted for almost 50% the community relative cover.

Cryptangium triquetrum, dominating nearly a third of the community showed a predominant height of 54.6 cm, which is higher than the other nine most important species. Thus, it characterized the physiognomy of the vegetation by creating a typical "graminoid" carpet (although Cyperaceae).

On this physiognomy, the species' prevailing height between 0 and 30 cm comprised 5% of the relative cover. The species with average hight between 30 and 60 cm comprised 47% of the relative cover. As for the species with average height greater than 60 cm comprised 48% of the relative cover.

Serra do Ibitiraquire - Physiognomy: *Chusquea pinifolia* - We found 85 species and an absolute cover of 125 m².100^{-1}m² within the 56 sampled plots with dominance of *Chusquea pinifolia* (caratuva). This species comprised more than a quarter of the importance percentage and almost half of the community relative cover (table 4). Once again *C. mullerianus* and *Cryptangium triquetrum* were among the four most important species in the sampled plot. Those, along with *Machaerina austrobrasiliensis* and *Alstroemeria amabilis* accounted for more than half the importance percentage.

This physiognomy has higher size due to the dominance of *C. pinifolia*, which showed height average of 78 cm. The gradual increase in height of such physiognomy is likely a result of the relative thickness of subsurface mineral horizons, below histosol horizons (histic) (Scheer *et al*. 2014). Another strata was observed some 50 cm afar, in which *Croton mullerianus*, *Rhynchospora exaltata* and *C. triquetrum* were dominant. We also observed the occurrence of important "graminoid" species such as *C. triquetrum*, *Deschampsia caespitosa*, *Xyris stenophylla* and *Eriochrysis holcoides* within the community.

Serra do Ibitiraquire - Physiognomy: *Chusquea mimosa* - 46 species were found in the nine sampled

Table 2. Phytosociological parameters of the shrubby physiognomy of the upper montane grasslands in Serra do Ibitiraquire (Mountain Range), n = 61. FA: absolute frequency (%); Co: absolute cover (%); FR: relative frequency (%); CoR: relative cover (%); PI: importance percentage (%); Hpre: predominant height (cm); Hmax: maximum height (cm).

	Species	FA	Co	FR	CoR	PI	Hpre	Hmax
1	*Croton mullerianus*	93.4	45.46	9.39	36.47	22.93	45.5	54.5
2	*Cryptangium triquetrum*	82.0	19.61	8.24	15.73	11.98	58.0	74.8
3	*Chusquea pinifolia*	36.1	7.36	3.62	5.90	4.76	87.8	116.2
4	*Mimosa congestifolia*	34.4	5.25	3.46	4.21	3.83	54.0	59.8
5	*Hesperozygis nitida*	31.1	4.05	3.13	3.25	3.19	36.7	45.7
6	*Machaerina austrobrasiliensis*	31.1	2.64	3.13	2.12	2.62	61.4	77.1
7	*Rhynchospora exaltata*	27.9	3.05	2.80	2.45	2.62	52.5	66.1
8	*Chusquea mimosa*	19.7	2.95	1.98	2.37	2.17	85.1	114.5
9	*Deschampsia caespitosa*	21.3	2.25	2.14	1.80	1.97	54.5	60.6
10	*Utricularia reniformis*	26.2	1.48	2.64	1.18	1.91	19.1	21.7
11	*Eryngium koehneanum*	19.7	2.13	1.98	1.71	1.84	45.1	56.3
12	*Gaylussacia brasiliensis* var *brasiliensis*	26.2	1.25	2.64	1.00	1.82	41.0	47.2
13	*Vernonanthura montevidensis*	27.9	1.02	2.80	0.82	1.81	49.2	54.2
14	*Symphyopappus cuneatus*	23.0	1.59	2.31	1.28	1.79	50.7	57.4
15	*Xyris stenophylla*	21.3	1.25	2.14	1.00	1.57	36.3	44.8
16	*Mimosa prionopus*	13.1	1.95	1.32	1.56	1.44	36.6	45.6
17	*Baccharis crispa*	21.3	0.87	2.14	0.70	1.42	48.0	54.0
18	Poaceae 5	21.3	0.72	2.14	0.58	1.36	14.6	17.6
19	*Sticherus* sp.	11.5	1.67	1.15	1.34	1.25	50.0	54.3
20	*Leandra sulfurea*	19.7	0.57	1.98	0.46	1.22	37.6	41.5
21	*Myrsine altomontana*	16.4	0.97	1.65	0.78	1.21	59.9	62.8
22	*Siphoneugena reitzii*	14.8	1.02	1.48	0.82	1.15	57.7	61.3
23	Poaceae 15	16.4	0.69	1.65	0.55	1.10	47.1	56.0
24	*Leandra* sp.	18.0	0.26	1.81	0.21	1.01	34.4	36.9
25	*Eriochrysis holcoides*	13.1	0.80	1.32	0.64	0.98	34.0	43.3
26	*Lycopodium clavatum*	11.5	0.95	1.15	0.76	0.96	28.0	35.4
27	*Gaultheria serrata* var. *organensis*	14.8	0.48	1.48	0.38	0.93	41.9	45.0
28	*Galianthe gertii*	13.1	0.66	1.32	0.53	0.92	36.5	39.3
29	*Alstroemeria amabilis*	9.8	0.69	0.99	0.55	0.77	51.5	57.7
30	*Blechnum cordatum*	9.8	0.54	0.99	0.43	0.71	43.5	47.2
31	*Dyckia reitzii*	9.8	0.52	0.99	0.42	0.70	25.8	29.8
32	*Mimosa eurystegia*	8.2	0.72	0.82	0.58	0.70	36.0	42.0
33	*Rhynchospora* sp. 1	6.6	0.84	0.66	0.67	0.66	44.8	50.3
34	*Eriocaulon ligulatum*	9.8	0.41	0.99	0.33	0.66	20.3	24.8
35	*Tibouchina hospital*	9.8	0.30	0.99	0.24	0.61	45.0	47.3
36	*Galium hypocarpium* ssp. *Indecorum*	9.8	0.28	0.99	0.22	0.61	29.7	31.7
37	*Lycopodium sp.*	8.2	0.46	0.82	0.37	0.60	27.6	35.2
38	*Myrcia hartwegiana*	8.2	0.39	0.82	0.32	0.57	54.4	60.8
39	*Tibouchina dúbia*	8.2	0.39	0.82	0.32	0.57	34.0	38.0
40	Cyperaceae 1	9.8	0.18	0.99	0.14	0.57	45.8	53.7

continue

Table 2 (continuation)

	Species	FA	Co	FR	CoR	PI	Hpre	Hmax
41	*Achyrocline satureioides*	8.2	0.23	0.82	0.18	0.50	36.2	43.2
42	Poaceae 14	8.2	0.18	0.82	0.14	0.48	39.8	40.8
43	*Dichanthelium sabulorum*	8.2	0.15	0.82	0.12	0.47	50.2	43.2
44	*Phalocallis geniculata*	8.2	0.13	0.82	0.11	0.46	62.4	68.8
45	*Baccharis angusticeps*	4.9	0.46	0.49	0.37	0.43	46.0	51.3
46	*Sticherus pruinosus*	4.9	0.33	0.49	0.26	0.38	48.7	49.3
47	*Lycopodium thyoides*	4.9	0.30	0.49	0.24	0.37	32.0	36.3
48	*Gaylussacia arassatubensis*	4.9	0.23	0.49	0.18	0.34	34.3	35.7
49	*Axonopus* sp.	4.9	0.16	0.49	0.13	0.31	15.7	21.3
50	Ericaceae 1	4.9	0.16	0.49	0.13	0.31	28.7	38.0
51	*Gaultheria serrata*	4.9	0.15	0.49	0.12	0.31	37.7	48.7
52	*Miconia* sp.	4.9	0.15	0.49	0.12	0.31	29.3	31.3
53	*Doryopteris crenulans*	4.9	0.10	0.49	0.08	0.29	22.7	23.3
54	*Trixis lessingii*	4.9	0.10	0.49	0.08	0.29	15.3	16.0
55	*Mimosa tucumensis*	3.3	0.25	0.33	0.20	0.26	40.5	49.0
56	*Ilex microdonta*	1.6	0.43	0.16	0.34	0.25	100.0	110.0
57	Poaceae 16	3.3	0.15	0.33	0.12	0.22	58.5	62.0
59	*Chascolytrum calotheca*	3.3	0.13	0.33	0.11	0.22	70.5	78.0
58	Ericaceae 2	3.3	0.13	0.33	0.11	0.22	48.0	49.5
60	*Sisyrinchium vaginatum*	3.3	0.10	0.33	0.08	0.20	45.0	45.0
61	Melastomataceae 1	3.3	0.07	0.33	0.05	0.19	32.5	35.0
62	*Sisyrinchium* sp.	3.3	0.05	0.33	0.04	0.18	41.0	45.5
63	Poaceae 13	3.3	0.03	0.33	0.03	0.18	24.0	24.0
64	*Escallonia laevis*	1.6	0.23	0.16	0.18	0.17	65.0	67.0
65	*Danthonia secundiflora*	1.6	0.16	0.16	0.13	0.15	59.0	92.0
66	*Rhynchospora* sp. 2	1.6	0.16	0.16	0.13	0.15	15.0	24.0
67	*Quesnelia imbricata*	1.6	0.13	0.16	0.11	0.13	35.0	37.0
68	*Vriesea hoehneana*	1.6	0.10	0.16	0.08	0.12	36.0	38.0
69	*Zygopetalum maculatum*	1.6	0.10	0.16	0.08	0.12	22.0	22.0
70	*Symphyopappus* sp. 1	1.6	0.08	0.16	0.07	0.12	67.0	75.0
71	*Lycopodium* sp. 2	1.6	0.07	0.16	0.05	0.11	22.0	47.0
72	*Myrciaria tenella*	1.6	0.07	0.16	0.05	0.11	83.0	83.0
73	*Stevia claussenii*	1.6	0.07	0.16	0.05	0.11	15.0	20.0
74	Gesneriaceae indet.	1.6	0.05	0.16	0.04	0.10	47.0	47.0
75	Poaceae 10	1.6	0.05	0.16	0.04	0.10	24.0	34.0
76	Poaceae 11	1.6	0.05	0.16	0.04	0.10	66.0	73.0
77	*Smilax campestris*	1.6	0.05	0.16	0.04	0.10	43.0	43.0
78	*Symphyopappus* sp. 2	1.6	0.05	0.16	0.04	0.10	60.0	60.0
79	*Symplocos corymboclados*	1.6	0.05	0.16	0.04	0.10	42.0	42.0
80	*Coccocypselum condalia*	1.6	0.03	0.16	0.03	0.10	22.0	27.0
81	*Esterhazya splendida*	1.6	0.03	0.16	0.03	0.10	50.0	61.0
82	*Gaultheria* sp. 1	1.6	0.03	0.16	0.03	0.10	68.0	68.0

continue

Table 2 (continuation)

	Species	FA	Co	FR	CoR	PI	Hpre	Hmax
83	*Graphistylis serrana*	1.6	0.03	0.16	0.03	0.10	41.0	41.0
84	*Leandra quinquedentata*	1.6	0.03	0.16	0.03	0.10	45.0	49.0
85	*Myrceugenia alpigea*	1.6	0.03	0.16	0.03	0.10	59.0	59.0
86	*Oxypetalum* sp.	1.6	0.03	0.16	0.03	0.10	72.0	76.0
87	*Tibouchina* sp. 1	1.6	0.03	0.16	0.03	0.10	38.0	38.0
88	*Weinmannia humilis*	1.6	0.03	0.16	0.03	0.10	58.0	67.0
89	*Xyris piraquarae*	1.6	0.03	0.16	0.03	0.10	74.0	74.0
90	*Baccharis nebularis*	1.6	0.02	0.16	0.01	0.09	70.0	70.0
91	*Leandra cordigera*	1.6	0.02	0.16	0.01	0.09	18.0	21.0
92	Melastomataceae indet. 2	1.6	0.02	0.16	0.01	0.09	15.0	15.0
93	*Pleopeltis hirsutissima*	1.6	0.02	0.16	0.01	0.09	34.0	34.0
94	*Tibouchina* sp. 2	1.6	0.02	0.16	0.01	0.09	17.0	17.0
	Total	995.1	124.66	100	100	100		

plots within an absolute cover of 136 $m^2.100^{-1}m^2$ (table 5). *Chusquea mimosa* comprised 25.7% of importance percentage. Shrubs and nanofanerophytes such as *Croton mullerianus*, *Siphoneugena reitzii* and *Vernonanthura montevidensis* showed significant importance in this physiognomy with the stratum right below the the main species.

Altogether, *Chusquea mimosa*, *Croton mullerianus*, *Cryptangium triquetrum*, *Siphoneugena reitzii* and *Vernonanthura montevidensis* accounted for more than half the importance percentage and also comprised more than 70% of the cover percentage.

Serra do Ibitiraquire - Physiognomy: *Machaerina austrobrasiliensis* - We found 36 species in the 10 sampled plots (table 6) and a vegetation cover of 102 $m^2.100^{-1}m^2$. *Machaerina austrobrasiliensis* accounted for more than a quarter the community dominance percentage as well as more than 40% of relative cover. *Croton mullerianus* showed high frequence. Even though *Chusquea pinifolia* was not very frequently found, it had a higher cover percentage in comparison with *Xyris stenophylla*, which had the same frequency. *Cryptangium triquetrum*, although very frequent, did not show high cover percentages. The five main species in this physiognomy comprised more than 80% of the relative cover and more than 60% of the importance percentage.

This physiognomy was observed more commonly at poor drainage sites with *Xyris stenophylla*, *Xyris piraquarae* and *Baccharis angusticeps* showing greater importance than in other vegetation physiognomy types.

Structure of upper montane grasslands in Serra da Igreja

Serra da Igreja - Physiognomy: shrubby - We found 50 species in the 27 sampled plots and a vegetation cover of 149 $m^2.100^{-1}m^2$ (table 7). *Croton mullerianus* was the most important species occurring in all plots with nearly 40% of the relative cover. *Cryptangium triquetrum* was also important in almost all plots of this physiognomy. The four main species accounted for more than half the dominance percentage of the community. Despite having low cover in the physiognomy, *Chusquea mimosa* stood out as it showed the highest portions of the vertical strata with average height of 106.4 cm in comparison to plants higher than 2 m in height.

Other shrubby species such as *Tibouchina dubia* and *Myrsine altomontana* stood out by showing the same frequency, but the first species presented vegetation cover three times greater than the second one. Furthermore, *Weinmannia humilis*, *Myrsine altomontana* and *Siphoneugena reitzii*, also dominant in this community, can grow as trees over 6 m tall in adjacent upper montane rainforests. However, in upper montane grasslands they grow as nanophanerophytes to about 1 m in height.

Serra da Igreja - Physiognomy: grassy - 33 species were detected in the 14 sampled plots within a vegetation cover of 150.5 $m^2.100^{-1}m^2$ (table 8). Similarly to the grasslands of Serra do Ibitiraquire, *Cryptangium triquetrum* was the most important species occurring in all plots and comprising more than 40% of the relative cover. *Croton mullerianus*

Table 3. Phytosociological parameters of the grassy physiognomy of the upper montane grasslands in Serra do Ibitiraquire, n = 64. FA: absolute frequency (%); Co: absolute cover (%); FR: relative frequency (%); CoR: relative cover (%); PI: importance percentual (%); Hpre: predominant height (cm); Hmax: maximum height (cm).

	Species	FA	Co	FR	CoR	PI	Hpre	Hmax
1	*Cryptangium triquetrum*	51.6	29.00	6.31	26.54	16.42	54.6	67.3
2	*Deschampsia caespitosa*	50.0	13.17	6.12	12.05	9.09	49.6	63.2
3	*Eriochrysis holcoides*	40.6	11.19	4.97	10.24	7.60	41.5	53.0
4	*Croton mullerianus*	34.4	5.92	4.21	5.42	4.81	40.0	48.6
5	*Eryngium koehneanum*	31.3	5.77	3.82	5.28	4.55	42.3	50.3
6	*Xyris stenophylla*	34.4	4.59	4.21	4.20	4.21	32.6	41.0
7	*Chusquea pinifolia*	25.0	5.58	3.06	5.10	4.08	46.4	57.3
8	*Vernonanthura montevidensis*	42.2	1.03	5.16	0.94	3.05	41.8	46.6
9	*Eryngium scirpinum*	15.6	1.89	1.91	1.73	1.82	32.7	40.7
10	*Hesperozygis nitida*	17.2	1.28	2.10	1.17	1.64	37.1	41.2
11	*Machaerina austrobrasiliensis*	10.9	2.11	1.34	1.93	1.63	68.7	75.9
12	*Nassella sellowiana*	10.9	1.78	1.34	1.63	1.48	56.0	80.9
13	*Mimosa congestifolia*	15.6	1.13	1.91	1.03	1.47	52.9	58.2
14	*Symphyopappus cuneatus*	14.1	1.30	1.72	1.19	1.45	50.8	58.3
15	*Rhynchospora exaltata*	9.4	1.89	1.15	1.73	1.44	41.5	49.0
16	*Chascolytrum calotheca*	14.1	1.25	1.72	1.14	1.43	65.3	74.3
17	*Lobelia camporum*	18.8	0.45	2.29	0.41	1.35	25.0	27.3
18	*Baccharis crispa*	18.8	0.42	2.29	0.39	1.34	39.0	42.3
19	*Mimosa prionopus*	6.3	2.05	0.76	1.87	1.32	34.5	46.0
20	*Achyrocline satureioides*	10.9	1.38	1.34	1.26	1.30	36.7	46.3
21	*Lycopodium sp.*	14.1	0.92	1.72	0.84	1.28	21.9	26.9
22	*Sisyrinchium vaginatum*	17.2	0.36	2.10	0.33	1.22	22.5	23.2
23	*Rhynchospora* sp. 1	12.5	0.98	1.53	0.90	1.22	37.1	53.6
24	Poaceae 13	15.6	0.48	1.91	0.44	1.18	20.5	22.7
25	*Galianthe gertii*	10.9	0.52	1.34	0.47	0.91	30.1	33.3
26	*Dichanthelium sabulorum*	10.9	0.48	1.34	0.44	0.89	33.3	58.0
27	*Eriocaulon ligulatum*	10.9	0.47	1.34	0.43	0.88	19.4	31.6
28	*Lycopodium thyoides*	6.3	0.94	0.76	0.86	0.81	28.5	38.5
29	*Rhynchospora* sp. 2	9.4	0.48	1.15	0.44	0.80	20.8	25.7
30	*Chusquea mimosa*	7.8	0.69	0.96	0.63	0.79	58.0	72.0
31	*Galium hypocarpium* ssp. *indecorum*	9.4	0.45	1.15	0.41	0.78	34.5	39.2
32	*Leandra* sp.	9.4	0.22	1.15	0.20	0.67	18.5	19.8
33	*Trixis lessingii*	7.8	0.34	0.96	0.31	0.64	17.2	18.8
34	*Xyris piraquarae*	4.7	0.72	0.57	0.66	0.62	38.7	47.0
35	*Lycopodium clavatum*	6.3	0.33	0.76	0.30	0.53	25.3	36.0
36	*Dyckia reitzii*	6.3	0.31	0.76	0.29	0.53	20.8	22.5
38	Poaceae 11	6.3	0.19	0.76	0.17	0.47	46.3	60.8
37	Leguminosae indet.	6.3	0.19	0.76	0.17	0.47	21.8	26.5
40	*Tibouchina hospita*	6.3	0.14	0.76	0.13	0.45	29.3	29.5
39	*Miconia* sp.	6.3	0.14	0.76	0.13	0.45	25.8	26.8
41	*Lycopodium* sp. 1	4.7	0.33	0.57	0.30	0.44	28.3	34.3

continue

Table 3 (continuation)

	Species	FA	Co	FR	CoR	PI	Hpre	Hmax
42	*Utricularia reniformis*	4.7	0.33	0.57	0.30	0.44	22.3	28.0
43	*Gaylussacia brasiliensis* var *brasiliensis*	6.3	0.11	0.76	0.10	0.43	27.0	30.8
44	*Hypochaeris catharinensis*	6.3	0.11	0.76	0.10	0.43	20.5	31.5
45	*Blechnum cordatum*	4.7	0.31	0.57	0.29	0.43	49.3	43.7
46	*Baccharis angusticeps*	4.7	0.25	0.57	0.23	0.40	36.3	41.0
47	*Sticherus* sp.	3.1	0.42	0.38	0.39	0.38	52.0	58.5
48	*Campovassouria cruciata*	4.7	0.20	0.57	0.19	0.38	37.7	40.0
49	*Alstroemeria amabilis*	4.7	0.14	0.57	0.13	0.35	32.3	37.7
50	*Esterhazya splendida*	4.7	0.11	0.57	0.10	0.34	56.0	58.7
52	*Symphyopappus* sp. 1	4.7	0.09	0.57	0.09	0.33	45.0	49.7
51	*Gaylussacia arassatubensis*	4.7	0.09	0.57	0.09	0.33	12.3	13.0
53	*Vriesea hoehneana*	1.6	0.47	0.19	0.43	0.31	30.0	41.0
55	*Stevia claussenii*	4.7	0.05	0.57	0.04	0.31	25.7	25.7
54	*Andropogon macrothrix*	4.7	0.05	0.57	0.04	0.31	16.3	16.3
56	*Escallonia laevis*	3.1	0.23	0.38	0.21	0.30	58.0	65.5
57	Cyperaceae indet. 2	3.1	0.19	0.38	0.17	0.28	20.5	23.0
58	Cyperaceae indet. 1	3.1	0.16	0.38	0.14	0.26	16.0	16.0
59	*Tibouchina dubia*	1.6	0.33	0.19	0.30	0.25	51.0	57.0
60	*Leandra quinquedentata*	3.1	0.11	0.38	0.10	0.24	35.5	36.5
61	*Galium* sp.	3.1	0.09	0.38	0.09	0.23	27.0	30.5
62	*Gaultheria serrata* var. *organensis*	3.1	0.08	0.38	0.07	0.23	37.5	41.5
63	Poaceae 10	3.1	0.08	0.38	0.07	0.23	32.5	34.0
64	Poaceae 14	3.1	0.08	0.38	0.07	0.23	18.0	29.0
65	*Tibouchina reitzii*	3.1	0.08	0.38	0.07	0.23	49.5	64.5
66	*Phalocallis geniculata*	3.1	0.06	0.38	0.06	0.22	67.0	68.0
67	Ericaceae 02	3.1	0.06	0.38	0.06	0.22	40.5	43.5
68	*Polygala campestris*	3.1	0.06	0.38	0.06	0.22	21.5	22.0
69	*Axonopus* sp.	3.1	0.03	0.38	0.03	0.21	24.0	24.0
70	*Drosera montana*	3.1	0.03	0.38	0.03	0.21	2.5	4.5
71	*Fuchsia regia* subsp. *serrae*	3.1	0.03	0.38	0.03	0.21	22.5	22.5
72	Cyperaceae 6	1.6	0.22	0.19	0.20	0.20	47.0	71.0
73	Poaceae 15	1.6	0.20	0.19	0.19	0.19	59.0	64.0
74	*Mimosa tucumensis*	1.6	0.17	0.19	0.16	0.17	23.0	31.0
75	*Myrsine altomontana*	1.6	0.17	0.19	0.16	0.17	70.0	75.0
76	*Handroanthus catarinesis*	1.6	0.14	0.19	0.13	0.16	65.0	65.0
77	*Polygala subverticillata*	1.6	0.13	0.19	0.11	0.15	26.0	30.0
78	*Oxypetalum sublanatum*	1.6	0.11	0.19	0.10	0.15	41.0	53.0
79	*Myrcia hartwegiana*	1.6	0.09	0.19	0.09	0.14	45.0	47.0
80	*Quesnelia imbricata*	1.6	0.09	0.19	0.09	0.14	38.0	38.0
81	*Weinmannia humilis*	1.6	0.08	0.19	0.07	0.13	30.0	45.0
82	Cyperaceae 2	1.6	0.06	0.19	0.06	0.12	45.0	47.0
83	*Danthonia secundiflora*	1.6	0.06	0.19	0.06	0.12	55.0	68.0

continue

Table 3 (continuation)

	Species	FA	Co	FR	CoR	PI	Hpre	Hmax
84	Lycopodiaceae indet.	1.6	0.05	0.19	0.04	0.12	1.0	1.0
85	Melastomataceae indet. 1	1.6	0.05	0.19	0.04	0.12	14.0	29.0
86	*Piptocarpha densifolia*	1.6	0.05	0.19	0.04	0.12	47.0	47.0
88	*Berberis laurina*	1.6	0.03	0.19	0.03	0.11	38.0	38.0
87	*Viola cerasifolia*	1.6	0.05	0.19	0.04	0.12	14.0	17.0
89	*Hesperozygis rhododon*	1.6	0.03	0.19	0.03	0.11	22.0	33.0
90	*Leandra sulfurea*	1.6	0.03	0.19	0.03	0.11	18.0	50.0
91	NI 4	1.6	0.03	0.19	0.03	0.11	14.0	17.0
92	Poaceae 5	1.6	0.03	0.19	0.03	0.11	38.0	71.0
93	Apocynaceae 1	1.6	0.02	0.19	0.01	0.10	43.0	43.0
94	*Baccharis nebularis*	1.6	0.02	0.19	0.01	0.10	73.0	73.0
95	*Doryopteris crenulans*	1.6	0.02	0.19	0.01	0.10	28.0	28.0
96	Melastomataceae 2	1.6	0.02	0.19	0.01	0.10	13.0	13.0
97	NI 2	1.6	0.02	0.19	0.01	0.10	26.0	26.0
98	*Scleria balansae*	1.6	0.02	0.19	0.01	0.10	13.0	18.0
99	*Holocheilus brasiliensis*	1.6	0.02	0.19	0.01	0.10	30.0	30.0
	Total	817.2	109.28	100	100	100		

Table 4. Phytosociological parameters of the *Chusquea pinifolia* physiognomy of the upper montane grasslands in Serra do Ibitiraquire, n = 56. FA: absolute frequency (%); Co: absolute cover (%); FR: relative frequency (%); CoR: relative cover (%); PI: importance percentual (%); Hpre: predominant height (cm); Hmax: maximum height (cm).

	Species	FA	Co	FR	CoR	PI	Hpre	Hmax
1	*Chusquea pinifolia*	100.0	54.07	9.62	43.26	26.44	78.4	99.4
2	*Croton mullerianus*	87.5	16.95	8.42	13.56	10.99	48.0	57.6
3	*Rhynchospora exaltata*	35.7	6.41	3.44	5.13	4.28	50.9	63.7
4	*Cryptangium triquetrum*	48.2	3.95	4.64	3.16	3.90	55.0	64.3
5	*Machaerina austrobrasiliensis*	35.7	4.82	3.44	3.86	3.65	67.2	80.1
6	*Alstroemeria amabilis*	39.3	1.71	3.78	1.37	2.58	42.6	49.6
7	*Deschampsia caespitosa*	33.9	1.30	3.26	1.04	2.15	53.6	65.9
8	*Gaylussacia brasiliensis* var. *brasiliensis*	30.4	1.55	2.92	1.24	2.08	47.7	58.0
9	*Xyris stenophylla*	26.8	1.75	2.58	1.40	1.99	35.1	42.3
10	*Baccharis crispa*	33.9	0.80	3.26	0.64	1.95	48.2	53.0
11	*Eriochrysis holcoides*	26.8	1.25	2.58	1.00	1.79	37.0	43.6
12	*Xyris piraquarae*	21.4	1.86	2.06	1.49	1.77	50.9	61.8
13	*Mimosa congestifolia*	19.6	1.66	1.89	1.33	1.61	64.0	68.6
14	*Leandra quinquedentata*	19.6	1.14	1.89	0.91	1.40	46.7	50.7
15	*Utricularia reniformis*	19.6	1.04	1.89	0.83	1.36	19.2	22.7
16	*Gaultheria serrata*	23.2	0.59	2.23	0.47	1.35	53.0	55.7
17	*Gaylussacia arassatubensis*	21.4	0.63	2.06	0.50	1.28	37.5	40.7
18	*Galium hypocarpium* ssp. *indecorum*	21.4	0.54	2.06	0.43	1.25	36.1	37.3
19	*Leandra sulfurea*	14.3	1.25	1.37	1.00	1.19	41.0	46.9
20	*Baccharis angusticeps*	12.5	1.34	1.20	1.07	1.14	58.0	59.1

continue

Table 4 (continuation)

	Species	FA	Co	FR	CoR	PI	Hpre	Hmax
21	*Hesperozygis nitida*	17.9	0.64	1.72	0.51	1.12	56.4	62.7
22	*Lycopodium thyoides*	16.1	0.86	1.55	0.69	1.12	28.2	38.2
23	*Myrsine altomontana*	16.1	0.73	1.55	0.59	1.07	76.7	82.9
24	*Sticherus* sp.	5.4	1.73	0.52	1.39	0.95	49.0	54.7
25	*Symphyopappus cuneatus*	12.5	0.80	1.20	0.64	0.92	62.1	69.0
26	*Tibouchina hospita*	14.3	0.48	1.37	0.39	0.88	42.9	47.3
27	*Rhynchospora* sp. 1	7.1	1.25	0.69	1.00	0.84	41.8	50.8
28	*Eryngium koehneanum*	10.7	0.73	1.03	0.59	0.81	39.7	53.3
29	*Scleria balansae*	12.5	0.48	1.20	0.39	0.79	34.7	43.9
30	*Vernonanthura montevidensis*	12.5	0.34	1.20	0.27	0.74	55.9	60.0
31	Melastomataceae indet. 1	12.5	0.30	1.20	0.24	0.72	23.6	24.7
32	*Mimosa tucumensis*	8.9	0.70	0.86	0.56	0.71	21.8	28.8
33	*Dyckia reitzii*	7.1	0.91	0.69	0.73	0.71	32.8	40.8
34	*Chascolytrum calotheca*	10.7	0.36	1.03	0.29	0.66	57.3	68.0
35	*Lycopodium sp.*	7.1	0.70	0.69	0.56	0.62	42.8	46.3
36	*Symplocos corymboclados*	7.1	0.63	0.69	0.50	0.59	56.0	56.8
37	*Trixis lessingii*	8.9	0.39	0.86	0.31	0.59	19.8	25.8
38	*Drimys angustifolia*	7.1	0.59	0.69	0.47	0.58	90.3	98.5
39	*Siphoneugena reitzii*	8.9	0.34	0.86	0.27	0.57	55.8	57.4
40	*Leptostelma catharinensis*	8.9	0.32	0.86	0.26	0.56	35.0	38.0
41	*Galianthe gertii*	7.1	0.46	0.69	0.37	0.53	36.8	43.3
42	*Eriocaulon ligulatum*	8.9	0.23	0.86	0.19	0.52	21.4	22.6
43	*Graphistylis serrana*	8.9	0.21	0.86	0.17	0.52	77.4	81.8
44	*Gaylussacia caratuvensis*	3.6	0.73	0.34	0.59	0.46	87.0	88.0
45	*Blechnum cordatum*	7.1	0.27	0.69	0.21	0.45	37.0	41.5
46	*Sisyrinchium vaginatum*	7.1	0.13	0.69	0.10	0.39	31.8	32.8
47	*Hypochaeris catharinensis*	5.4	0.27	0.52	0.21	0.36	18.7	39.0
48	*Dichanthelium sabulorum*	5.4	0.20	0.52	0.16	0.34	46.0	52.3
49	*Baccharis platypoda*	5.4	0.18	0.52	0.14	0.33	48.7	51.7
50	Poaceae 5	5.4	0.18	0.52	0.14	0.33	15.3	15.3
51	*Baccharis nebularis*	5.4	0.14	0.52	0.11	0.31	62.0	66.3
52	*Miconia ramboi*	5.4	0.07	0.52	0.06	0.29	34.7	35.7
53	*Weinmannia humilis*	1.8	0.50	0.17	0.40	0.29	98.0	108.0
54	*Ilex chamaedryfolia*	3.6	0.25	0.34	0.20	0.27	86.5	99.0
55	*Mimosa prionopus*	3.6	0.21	0.34	0.17	0.26	47.0	50.0
56	*Doryopteris crenulans*	3.6	0.20	0.34	0.16	0.25	31.0	44.0
57	*Achyrocline satureioides*	3.6	0.18	0.34	0.14	0.24	59.5	66.5
58	*Mimosa eurystegia*	3.6	0.18	0.34	0.14	0.24	40.5	43.0
59	*Escallonia laevis*	1.8	0.38	0.17	0.30	0.24	100.0	108.0
60	*Tibouchina dubia*	3.6	0.13	0.34	0.10	0.22	33.5	36.5
61	*Lycopodium* sp. 1	1.8	0.32	0.17	0.26	0.21	20.0	26.0
62	*Gaultheria* sp. 1	3.6	0.09	0.34	0.07	0.21	49.5	49.5

continue

Table 4 (continuation)

	Species	FA	Co	FR	CoR	PI	Hpre	Hmax
63	Ericaceae indet. 1	3.6	0.09	0.34	0.07	0.21	36.5	40.5
64	*Leandra* sp.	3.6	0.07	0.34	0.06	0.20	37.5	41.5
65	*Piptocarpha densifolia*	1.8	0.29	0.17	0.23	0.20	37.0	82.0
66	*Gaultheria serrata* var. *organensis*	3.6	0.05	0.34	0.04	0.19	63.5	63.5
67	*Phalocallis geniculata*	3.6	0.05	0.34	0.04	0.19	55.0	62.0
68	Melastomataceae indet 2	3.6	0.05	0.34	0.04	0.19	14.0	14.0
69	*Dicranopteris nervosa*	1.8	0.20	0.17	0.16	0.16	32.0	32.0
70	*Sticherus pruinosus*	1.8	0.11	0.17	0.09	0.13	34.0	37.0
71	*Polygala campestris*	1.8	0.11	0.17	0.09	0.13	29.0	29.0
72	*Lycopodium* sp. 2	1.8	0.09	0.17	0.07	0.12	40.0	58.0
73	Ericaceae indet. 2	1.8	0.07	0.17	0.06	0.11	52.0	54.0
74	Fabaceae	1.8	0.07	0.17	0.06	0.11	24.0	28.0
75	*Leandra cordigera*	1.8	0.07	0.17	0.06	0.11	15.0	22.0
76	*Andropogon macrothrix*	1.8	0.05	0.17	0.04	0.11	25.0	41.0
77	*Smilax campestris*	1.8	0.04	0.17	0.03	0.10	53.0	53.0
78	*Campovassouria cruciata*	1.8	0.04	0.17	0.03	0.10	29.0	29.0
79	*Galium sellowianum*	1.8	0.04	0.17	0.03	0.10	15.0	17.0
80	*Drosera montana*	1.8	0.04	0.17	0.03	0.10	3.0	3.0
81	*Salvia* sp.	1.8	0.02	0.17	0.01	0.09	47.0	47.0
82	*Paspalum polyphyllum*	1.8	0.02	0.17	0.01	0.09	37.0	67.0
83	*Ilex microdonta*	1.8	0.02	0.17	0.01	0.09	27.0	27.0
84	*Lobelia camporum*	1.8	0.02	0.17	0.01	0.09	22.0	22.0
85	*Galium* sp.	1.8	0.02	0.17	0.01	0.09	14.0	14.0
	Total	1039.3	125.00	100	100	100		

Table 5. Phytosociological parameters of the *Chusquea mimosa* physiognomy of the upper montane grasslands in Serra do Ibitiraquire, n = 9. FA: absolute frequency (%); Co: absolute cover (%); FR: relative frequency (%); CoR: relative cover (%); PI: importance percentual (%); Hpre: predominant height (cm); Hmax: maximum height (cm).

	Species	FA	Co	FR	CoR	PI	Hpre	Hmax
1	*Chusquea mimosa*	100.0	56.67	9.89	41.56	25.73	122.8	166.9
2	*Croton mullerianus*	66.7	23.56	6.59	17.28	11.94	58.0	72.5
3	*Cryptangium triquetrum*	44.4	9.22	4.40	6.76	5.58	64.3	76.0
4	*Siphoneugena reitzii*	44.4	5.33	4.40	3.91	4.15	76.3	88.8
5	*Vernonanthura montevidensis*	55.6	1.78	5.49	1.30	3.40	67.2	77.0
6	*Sticherus* sp.	33.3	3.56	3.30	2.61	2.95	47.0	56.0
7	*Eryngium koehneanum*	33.3	2.89	3.30	2.12	2.71	34.3	37.0
8	*Baccharis crispa*	44.4	1.33	4.40	0.98	2.69	51.8	57.5
9	*Xyris stenophylla*	22.2	3.00	2.20	2.20	2.20	35.0	46.0
10	*Pentacalia desiderabilis*	11.1	4.33	1.10	3.18	2.14	65.0	85.0
11	*Smilax campestris*	33.3	0.78	3.30	0.57	1.93	39.7	61.7
12	*Dichanthelium sabulorum*	22.2	2.11	2.20	1.55	1.87	26.0	47.0
13	*Utricularia reniformis*	22.2	1.22	2.20	0.90	1.55	21.5	25.0

continue

Table 5 (continuation)

	Species	FA	Co	FR	CoR	PI	Hpre	Hmax
14	*Leandra sulfurea*	22.2	1.11	2.20	0.81	1.51	38.0	42.5
15	*Vriesea hoehneana*	11.1	2.56	1.10	1.87	1.49	75.0	82.0
16	*Galium hypocarpium* ssp. *indecorum*	22.2	1.00	2.20	0.73	1.47	38.5	46.5
17	*Lycopodium sp.*	22.2	1.00	2.20	0.73	1.47	36.0	40.5
18	*Mimosa prionopus*	11.1	2.22	1.10	1.63	1.36	13.0	29.0
19	*Hydrocotyle quinqueloba*	22.2	0.67	2.20	0.49	1.34	37.5	39.5
20	*Phalocallis geniculata*	22.2	0.56	2.20	0.41	1.30	52.0	57.5
21	*Alstroemeria amabilis*	22.2	0.56	2.20	0.41	1.30	49.0	52.5
22	*Myrsine altomontana*	22.2	0.56	2.20	0.41	1.30	49.0	52.5
23	*Leandra* sp.	22.2	0.33	2.20	0.24	1.22	29.0	30.0
24	*Esterhazya splendida*	11.1	1.78	1.10	1.30	1.20	78.0	85.0
25	*Deschampsia caespitosa*	22.2	0.22	2.20	0.16	1.18	73.5	77.5
26	*Hesperozygis nitida*	22.2	0.22	2.20	0.16	1.18	78.5	78.5
27	*Sticherus pruinosus*	11.1	1.11	1.10	0.81	0.96	46.0	67.0
28	Poaceae 16	11.1	0.89	1.10	0.65	0.88	53.0	61.0
29	*Rhynchospora* sp. 2	11.1	0.89	1.10	0.65	0.88	28.0	28.0
30	*Symphyopappus cuneatus*	11.1	0.78	1.10	0.57	0.83	67.0	71.0
31	*Gaylussacia brasiliensis* var *brasiliensis*	11.1	0.44	1.10	0.33	0.71	40.0	45.0
32	*Machaerina austrobrasiliensis*	11.1	0.44	1.10	0.33	0.71	45.0	65.0
33	Poaceae 5	11.1	0.44	1.10	0.33	0.71	16.0	16.0
34	*Rhynchospora exaltata*	11.1	0.44	1.10	0.33	0.71	90.0	110.0
35	*Baccharis nebularis*	11.1	0.33	1.10	0.24	0.67	52.0	57.0
36	*Xyris piraquarae*	11.1	0.33	1.10	0.24	0.67	75.0	76.0
37	*Gaultheria serrata*	11.1	0.22	1.10	0.16	0.63	31.0	31.0
38	*Gaultheria* sp. 1	11.1	0.22	1.10	0.16	0.63	35.0	42.0
39	*Lycopodium clavatum*	11.1	0.22	1.10	0.16	0.63	35.0	35.0
40	*Lycopodium thyoides*	11.1	0.22	1.10	0.16	0.63	20.0	21.0
41	Poaceae 14	11.1	0.22	1.10	0.16	0.63	56.0	56.0
42	*Fuchsia regia* subsp. *serrae*	11.1	0.11	1.10	0.08	0.59	103.0	103.0
43	*Galianthe gertii*	11.1	0.11	1.10	0.08	0.59	44.0	44.0
44	Melastomataceae 1	11.1	0.11	1.10	0.08	0.59	25.0	25.0
45	*Myrciaria tenella*	11.1	0.11	1.10	0.08	0.59	44.0	44.0
46	*Tibouchina hospita*	11.1	0.11	1.10	0.08	0.59	33.0	33.0
	Total	1011.1	136.33	100	100	100		

was also found in all the plots, but showed lower cover. Only these two species along with *Tibouchina dubia* (shrubby), accounted for 50% of the importance percentage and more than 70% of the community relative cover.

The seven main species, which comprised more than 80% of the relative cover (125 $m^2.100^{-1}m^2$), showed average height between 45 and 65 cm, clearly indicating the large overlap in this portion of the community vertical stratification.

Structure of upper montane grasslands in Serra da Prata

Serra da Prata - Physiognomy: shrubby - We found 36 species in the 15 sampled plots within an absolute cover of 121 $m^2.100^{-1}m^2$ (table 9). *Croton mullerianus* displayed the highest percentage of dominance, being present in all plots and comprising almost a third of the community relative cover. *Cryptangium triquetrum*, *Machaerina austrobrasiliensis* and *Tibouchina dubia* also stood out with very close percentages of

dominance in this physiognomy. These four species accounted for almost half the dominance percentage and more than 60% of the cover percentage.

Solely six species were found in at least two thirds of the plots. Half of the detected species occurred in only one or two plots, and these species comprised just 10% of the community importance percentage.

Serra da Prata - Physiognomy: grassy - We found 30 species in the seven sampled plots within an absolute cover of 124.7 $m^2.100^{-1}m^2$ (table 10). Once again,

Table 6. Phytosociological parameters of the *Machaerina austrobrasiliensis* physiognomy of the upper montane grasslands in Serra do Ibitiraquire, n = 10. FA: absolute frequency (%); Co: absolute cover (%); FR: relative frequency (%); CoR: relative cover (%); PI: importance percentual (%); Hpre: predominant height (cm); Hmax: maximum height (cm).

	Species	FA	Co	FR	CoR	PI	Hpre	Hmax
1	*Machaerina austrobrasiliensis*	100	41.20	10.87	40.39	25.63	60.9	76.1
2	*Croton mullerianus*	90	16.50	9.78	16.18	12.98	36.8	44.8
3	*Chusquea pinifolia*	60	11.00	6.52	10.78	8.65	46.8	56.8
4	*Xyris stenophylla*	60	7.80	6.52	7.65	7.08	28.7	35.8
5	*Cryptangium triquetrum*	80	5.50	8.70	5.39	7.04	52.0	66.3
6	*Eriochrysis holcoides*	40	2.60	4.35	2.55	3.45	34.0	42.0
7	*Deschampsia caespitosa*	50	0.80	5.43	0.78	3.11	48.0	52.4
8	*Baccharis angusticeps*	30	1.50	3.26	1.47	2.37	38.0	41.0
9	*Xyris piraquarae*	30	0.80	3.26	0.78	2.02	57.0	62.7
10	*Rhynchospora exaltata*	20	1.90	2.17	1.86	2.02	36.5	51.5
11	*Galianthe gertii*	20	0.90	2.17	0.88	1.53	26.0	30.0
12	*Chusquea mimosa*	10	2.00	1.09	1.96	1.52	85.0	117.0
13	*Leandra* sp.	20	0.80	2.17	0.78	1.48	28.0	31.5
14	*Dyckia reitzii*	20	0.50	2.17	0.49	1.33	19.0	20.5
15	*Eriocaulon ligulatum*	20	0.50	2.17	0.49	1.33	26.5	28.5
16	*Gaylussacia brasiliensis var brasiliensis*	20	0.50	2.17	0.49	1.33	26.5	29.0
17	*Utricularia reniformis*	20	0.50	2.17	0.49	1.33	31.0	43.0
18	Melastomataceae indet.1	20	0.40	2.17	0.39	1.28	14.0	15.5
19	*Rhynchospora* sp. 1	20	0.40	2.17	0.39	1.28	39.0	42.5
20	*Baccharis crispa*	20	0.30	2.17	0.29	1.23	39.5	39.5
21	*Leandra cordigera*	20	0.20	2.17	0.20	1.18	18.5	18.5
22	*Leandra sulfurea*	10	1.00	1.09	0.98	1.03	49.0	58.0
23	*Symphyopappus cuneatus*	10	0.80	1.09	0.78	0.94	42.0	57.0
24	Poaceae 05	10	0.50	1.09	0.49	0.79	9.0	9.0
25	*Quesnelia imbricata*	10	0.50	1.09	0.49	0.79	40.0	44.0
26	*Gaylussacia arassatubensis*	10	0.40	1.09	0.39	0.74	20.0	23.0
27	*Mimosa congestifolia*	10	0.40	1.09	0.39	0.74	53.0	59.0
28	*Mimosa tucumensis*	10	0.40	1.09	0.39	0.74	23.0	30.0
29	*Eryngium koehneanum*	10	0.30	1.09	0.29	0.69	37.0	39.0
30	*Sticherus* sp.	10	0.30	1.09	0.29	0.69	44.0	44.0
31	*Scleria balansae*	10	0.20	1.09	0.20	0.64	10.0	12.0
32	*Tibouchina hospita*	10	0.20	1.09	0.20	0.64	17.0	23.0
33	*Galium hypocarpium* ssp. *indecorum*	10	0.10	1.09	0.10	0.59	15.0	15.0
34	*Chascolytrum calotheca*	10	0.10	1.09	0.10	0.59	55.0	55.0
35	*Sisyrinchium vaginatum*	10	0.10	1.09	0.10	0.59	40.0	40.0
36	*Trixis lessingii*	10	0.10	1.09	0.10	0.59	20.0	20.0
	Total	920	102	100	100	100		

Cryptangium triquetrum was the most important species in this physiognomy. However, *Croton mullerianus* also stood out, being present in all plots and reaching the second highest percentage of importance. We highlight the importance of species frequently found in poor drainage environments such as *Machaerina austrobrasiliensis*, *Xyris stenophylla* and *Xyris piraquarae*.

In the above strata we found shrubs and nanophanerophytes such as *Clethra uleana*, *Siphoneugena reitzii*, *Myrcia hartwegiana* and *Hesperozygis rhododon* , whereas graminoids formed a dense vegetative layer of nearly 50 cm from the ground. From the most important species, only *Machaerina austrobrasiliensis* showed predominant height (frequently above 60 cm).

Nearly two thirds of the species (19) were detected in only one or two sampled plots.

Structure of upper montane grasslands in Serra da Farinha Seca

Serra da Farinha Seca - Physiognomy: shrubby - 42 species were found in the 10 sampled plots within a vegetation cover of 134.7 $m^2.100^{-1}m^2$ (table 11). *Mimosa congestifolia* comprised the highest percentage of importance, and stood out based on its cover percentage. It accounted for nearly a quarter of the community relative cover. *Cryptangium triquetrum*, *Sticherus* sp., *Chusquea pinifolia* along with a non-identified Poaceae showed importance as well. Other shrubby species ranked only in the sixth and seventh position, namely: *Siphoneugena reitzii* and *Myrcia hartwegiana*. The seven species mentioned above comprised 54% of the importance percentage and almost 70% of the relative cover.

Chusquea pinifolia is quite important in this physiognomy based upon its frequency in the above strata and also for having all prevailing and maximum heights among the main species.

Serra da Farinha Seca - Physiognomy: grassy - 53 species were found in the 22 sampled plots within an absolute cover of 148 $m^2.100^{-1}m^2$ (2). *Cryptangium triquetrum* showed great importance in this physiognomy as it was found in all the plots, comprising 49% of the relative cover by dominating the upper strata of the community. Its average height was higher than the other eight important species, by creating a typical "graminoid"carpet.

Siphoneugena reitzii and *Tibouchina dubia* also stood out as shrubby species. However, despite their high frequency, they showed low cover values since each species accounted for solely 4% of the relative cover.

As a matter of fact, only these three species were detected in more than a third of the sampled plots. We also observed that 36, or more than two thirds of the species, showed relative cover values lower than 1%, which represents only 11% of the overall community cover.

Serra da Farinha Seca - Physiognomy: *Chusquea pinifolia* - Twenty-nine species were found in five sampled plots within an absolute cover of 134.6 $m^2.100^{-1}m^2$ (table 13). *Chusquea pinifolia* showed 30.7% of importance percentage, which represents more than half the relative cover. It was also the dominant species in the upper strata, reaching prevailing heights greater than the other species, with the exception of a non-identified Poaceae.

In the stretches where *C. pinifolia* was the most dominant, several other important shrubs were also often found occupying spaces under *Chusquea pinifolia* in the vertical strata, especially *Mimosa congestifolia*, *Siphoneugena reitzii*, *Baccharis nebularis*, *Symplocos corymboclados* and *Clethra scabra*. The latter was exclusively found in Serra da Farinha Seca. The occurrence of *Clethra uleana* is common in upper montane grasslands, while *Clethra scabra* is more common in montane forests at altitudes < 1200 m asl. However, in Serra da Farinha Seca both species share the same environment, but *C. scabra* seems to occur only in physiognomies dominated by *Chusquea pinifolia*. Falkenberg (2003) had already reported the overlapping area of occurrence of these two species in upper montane cloud forest and rupicolous vegetation in the region of Aparados da Serra Geral.

Structure of upper montane grasslands in Serra Gigante

Serra Gigante - Physiognomy: grassy - 23 species were found in the 12 sampled plots within an absolute cover of 112.4 $m^2.100^{-1}m^2$ (table 14). Even though this montane range is found to be considerably lower with small-scale grasslands in comparison to the others studied herewith, it presents a typical physiognomy of this formation, but also includes some species which were not sampled in the other upper montane grasslands. Garcia & Pirani (2005) also classified as "altitude grassland" or "high altitude grassland" the grassland vegetation in lower altitude mountain

Table 7. Phytosociological parameters of the shrubby physiognomy of the upper montane grasslands in Serra da Igreja, n = 27. FA: absolute frequency (%); Co: absolute cover (%); FR: relative frequency (%); CoR: relative cover (%); PI: importance percentual (%); Hpre: predominant height (cm); Hmax: maximum height (cm).

	Species	FA	Co	FR	CoR	PI	Hpre	Hmax
1	*Croton mullerianus*	100.0	59.19	9.57	39.63	24.60	67.6	78.1
2	*Cryptangium triquetrum*	96.3	27.78	9.22	18.60	13.91	69.7	86.1
3	*Sticherus* sp.	66.7	13.11	6.38	8.78	7.58	56.3	62.6
4	*Tibouchina dubia*	74.1	8.70	7.09	5.83	6.46	50.0	60.7
5	*Myrsine altomontana*	74.1	2.74	7.09	1.84	4.46	53.4	61.3
6	*Alstroemeria amabilis*	55.6	1.93	5.32	1.29	3.30	48.2	59.3
7	*Xyris stenophylla*	33.3	4.70	3.19	3.15	3.17	40.0	48.6
8	*Leandra cordigera*	40.7	1.93	3.90	1.29	2.60	53.1	59.5
9	Poaceae 2	33.3	2.37	3.19	1.59	2.39	58.3	68.0
10	*Blechnum cordatum*	37.0	1.26	3.55	0.84	2.19	38.0	47.7
11	*Siphoneugena reitzii*	37.0	1.15	3.55	0.77	2.16	60.2	62.6
12	*Weinmannia humilis*	22.2	2.44	2.13	1.64	1.88	82.8	85.3
13	*Galium hypocarpium* ssp. *indecorum*	25.9	1.70	2.48	1.14	1.81	38.4	44.9
14	*Chusquea mimosa*	18.5	2.48	1.77	1.66	1.72	106.4	140.2
15	*Gaylussacia brasiliensis* var *brasiliensis*	29.6	0.48	2.84	0.32	1.58	29.0	33.0
16	*Hesperozygis rhododon*	14.8	2.00	1.42	1.34	1.38	60.3	66.0
17	*Handroanthus catarinesis*	22.2	0.85	2.13	0.57	1.35	71.3	78.5
18	*Dichanthelium sabulorum*	18.5	1.22	1.77	0.82	1.30	46.0	44.8
19	Poaceae 3	22.2	0.48	2.13	0.32	1.23	42.2	47.5
20	*Vriesea platynema* var. *variegata*	7.4	2.52	0.71	1.69	1.20	61.0	63.0
21	*Eriocaulon ligulatum*	14.8	1.33	1.42	0.89	1.16	27.0	40.8
22	*Gaultheria serrata* var. *organensis*	18.5	0.74	1.77	0.50	1.13	48.4	51.8
23	*Baccharis crispa*	18.5	0.70	1.77	0.47	1.12	56.6	63.4
24	*Clethra uleana*	14.8	0.67	1.42	0.45	0.93	42.8	63.0
25	*Myrcia pulchra*	7.4	1.56	0.71	1.04	0.88	58.0	64.0
26	*Vernonanthura montevidensis*	11.1	0.59	1.06	0.40	0.73	61.3	66.7
27	*Baccharis angusticeps*	11.1	0.37	1.06	0.25	0.66	50.0	61.0
28	*Utricularia reniformis*	11.1	0.33	1.06	0.22	0.64	23.0	30.0
29	*Sticherus pruinosus*	7.4	0.56	0.71	0.37	0.54	52.5	56.0
30	*Graphistylis serrana*	7.4	0.26	0.71	0.17	0.44	47.5	53.0
31	*Smilax campestris*	7.4	0.26	0.71	0.17	0.44	52.5	55.0
32	*Myrciaria tenella*	7.4	0.19	0.71	0.12	0.42	39.5	42.0
33	Apocynaceae 1	7.4	0.15	0.71	0.10	0.40	45.0	49.0
34	*Myrcia hartwegiana*	7.4	0.11	0.71	0.07	0.39	61.0	61.0
35	*Holocheilus brasiliensis*	7.4	0.11	0.71	0.07	0.39	19.5	19.5
36	*Vriesea hoehneana*	3.7	0.56	0.35	0.37	0.36	42.0	50.0
37	*Coccocypselum condalia*	3.7	0.52	0.35	0.35	0.35	8.0	14.0
38	*Blechnum* sp. 2	3.7	0.41	0.35	0.27	0.31	73.0	85.0
39	*Drimys angustifolia*	3.7	0.11	0.35	0.07	0.21	63.0	71.0
40	Ericaceae 4	3.7	0.11	0.35	0.07	0.21	47.0	53.0

continue

Table 7 (continuation)

	Species	FA	Co	FR	CoR	PI	Hpre	Hmax
41	*Ocotea tristis*	3.7	0.11	0.35	0.07	0.21	30.0	54.0
42	*Symplocos corymboclados*	3.7	0.11	0.35	0.07	0.21	33.0	41.0
43	*Danthonia* sp.	3.7	0.07	0.35	0.05	0.20	17.0	17.0
44	*Mikania clematidifolia*	3.7	0.07	0.35	0.05	0.20	66.0	66.0
45	*Symplocos corymboclados*	3.7	0.07	0.35	0.05	0.20	41.0	60.0
46	*Ternstroemia brasiliensis*	3.7	0.07	0.35	0.05	0.20	69.0	69.0
47	*Ilex microdonta*	3.7	0.04	0.35	0.02	0.19	41.0	41.0
48	*Orthosia dusenii*	3.7	0.04	0.35	0.02	0.19	62.0	62.0
49	NI 5	3.7	0.04	0.35	0.02	0.19	30.0	30.0
50	*Verbesina glabrata*	3.7	0.04	0.35	0.02	0.19	40.0	40.0
	Total	1044.4	149.33	100	100	100		

Table 8. Phytosociological parameters of the grassy physiognomy of the upper montane grasslands in Serra da Igreja, n = 14. FA: absolute frequency (%); Co: absolute cover (%); FR: relative frequency (%); CoR: relative cover (%); PI: importance percentual (%); Hpre: predominant height (cm); Hmax: maximum height (cm).

	Species	FA	Co	FR	CoR	PI	Hpre	Hmax
1	*Cryptangium triquetrum*	100.0	62.14	10.07	41.29	25.68	64.4	75.2
2	*Croton mullerianus*	100.0	39.29	10.07	26.10	18.09	50.4	61.1
3	*Tibouchina dubia*	71.4	8.00	7.19	5.32	6.25	46.2	52.6
4	*Myrsine altomontana*	85.7	3.43	8.63	2.28	5.46	50.2	54.9
5	*Alstroemeria amabilis*	78.6	2.79	7.91	1.85	4.88	52.4	58.2
6	*Handroanthus catarinesis*	50.0	5.29	5.04	3.51	4.27	57.9	61.4
7	*Xyris stenophylla*	42.9	4.79	4.32	3.18	3.75	53.3	64.2
8	*Galium hypocarpium* ssp. *indecorum*	50.0	1.79	5.04	1.19	3.11	38.3	40.3
9	*Sticherus* sp.	35.7	3.21	3.60	2.14	2.87	55.6	58.0
10	*Leandra cordigera*	35.7	2.14	3.60	1.42	2.51	48.2	50.6
11	*Utricularia reniformis*	35.7	0.86	3.60	0.57	2.08	17.8	19.6
12	*Sticherus pruinosus*	28.6	1.14	2.88	0.76	1.82	35.3	42.0
13	*Blechnum* sp. 1	28.6	0.71	2.88	0.47	1.68	47.3	48.3
14	*Siphoneugena reitzii*	28.6	0.57	2.88	0.38	1.63	56.8	58.0
15	*Gaylussacia brasiliensis* var. *brasiliensis*	28.6	0.36	2.88	0.24	1.56	26.0	26.5
16	*Eriocaulon ligulatum*	7.1	3.57	0.72	2.37	1.55	22.0	30.0
17	*Dichanthelium sabulorum*	21.4	1.36	2.16	0.90	1.53	43.7	49.7
18	*Symplocos corymboclados*	21.4	0.43	2.16	0.28	1.22	57.7	59.7
19	*Hesperozygis rhododon*	14.3	1.43	1.44	0.95	1.19	47.5	57.5
20	*Vernonanthura montevidensis*	14.3	1.29	1.44	0.85	1.15	64.5	78.5
21	*Weinmannia humilis*	14.3	0.71	1.44	0.47	0.96	61.5	61.5
22	*Agarista niederleinii* var. *niederleinii*	14.3	0.57	1.44	0.38	0.91	73.0	78.5
23	Poaceae 2	7.1	1.43	0.72	0.95	0.83	59.0	75.0
24	*Baccharis angusticeps*	14.3	0.21	1.44	0.14	0.79	23.5	23.5
25	*Verbesina glabrata*	7.1	0.86	0.72	0.57	0.64	60.0	62.0
26	Myrtaceae indet. 1	7.1	0.71	0.72	0.47	0.60	15.0	27.0

continue

Table 8 (continuation)

	Species	FA	Co	FR	CoR	PI	Hpre	Hmax
27	*Myrcia pulchra*	7.1	0.50	0.72	0.33	0.53	76.0	79.0
28	*Chusquea mimosa*	7.1	0.29	0.72	0.19	0.45	215.0	215.0
29	*Graphistylis serrana*	7.1	0.21	0.72	0.14	0.43	39.0	54.0
30	*Baccharis crispa*	7.1	0.14	0.72	0.09	0.41	49.0	49.0
31	*Ilex microdonta*	7.1	0.14	0.72	0.09	0.41	56.0	56.0
32	*Danthonia* sp. 1	7.1	0.07	0.72	0.05	0.38	41.0	41.0
33	*Ocotea porosa*	7.1	0.07	0.72	0.05	0.38	38.0	38.0
	Total	992.9	150.50	100	100	100		

Table 9. Phytosociological parameters of the shrubby physiognomy of the upper montane grasslands in Serra da Prata, n = 15. FA: absolute frequency (%); Co: absolute cover (%); FR: relative frequency (%); CoR: relative cover (%); PI: importance percentual (%); Hpre: predominant height (cm); Hmax: maximum height (cm).

	Species	FA	Co	FR	CoR	PI	Hpre	Hmax
1	*Croton mullerianus*	100.0	36.60	9.37	30.23	19.80	53.9	62.3
2	*Cryptangium triquetrum*	93.3	13.87	8.75	11.45	10.10	56.6	68.9
3	*Machaerina austrobrasiliensis*	80.0	13.87	7.50	11.45	9.48	61.8	81.8
4	*Tibouchina dubia*	80.0	13.40	7.50	11.07	9.28	59.5	61.9
5	*Sticherus* sp.	66.7	7.53	6.25	6.22	6.24	44.7	52.0
6	*Chusquea mimosa*	66.7	5.60	6.25	4.63	5.44	68.9	96.5
7	Poaceae 1	53.3	2.87	5.00	2.37	3.68	42.3	53.0
8	*Myrcia pulchra*	40.0	4.27	3.75	3.52	3.64	70.3	79.7
9	*Gaylussacia brasiliensis* var. *brasiliensis*	53.3	1.67	5.00	1.38	3.19	38.3	40.6
10	*Myrsine altomontana*	46.7	2.20	4.38	1.82	3.10	63.7	68.0
11	*Gaultheria serrata* var. *organensis*	53.3	0.93	5.00	0.77	2.89	46.9	48.1
12	*Vriesea platynema* var. *variegata*	20.0	3.80	1.88	3.14	2.51	57.0	68.3
13	*Alstroemeria amabilis*	40.0	1.40	3.75	1.16	2.45	38.2	42.7
14	*Xyris piraquarae*	26.7	2.47	2.50	2.04	2.27	54.5	62.5
15	*Hesperozygis rhododon*	26.7	1.80	2.50	1.49	1.99	69.0	83.8
16	*Chusquea pinifolia*	20.0	1.73	1.88	1.43	1.65	58.3	75.0
17	*Vernonanthura montevidensis*	20.0	0.73	1.88	0.61	1.24	69.3	72.3
18	*Utricularia reniformis*	20.0	0.40	1.88	0.33	1.10	24.7	24.7
19	*Graphistylis serrana*	13.3	0.80	1.25	0.66	0.96	41.0	47.0
20	*Leandra quinquedentata*	13.3	0.73	1.25	0.61	0.93	56.0	61.5
21	*Blechnum cordatum*	13.3	0.47	1.25	0.39	0.82	41.0	44.0
22	*Leandra cordigera*	13.3	0.47	1.25	0.39	0.82	41.5	44.5
23	*Smilax campestris*	13.3	0.47	1.25	0.39	0.82	69.5	75.0
24	*Galium hypocarpium* ssp. *indecorum*	13.3	0.33	1.25	0.28	0.76	57.0	60.0
25	*Orthosia dusenii*	6.7	1.07	0.63	0.88	0.75	80.0	102.0
26	*Ternstroemia brasiliensis*	6.7	0.33	0.63	0.28	0.45	58.0	63.0
27	*Siphoneugena reitzii*	6.7	0.27	0.63	0.22	0.42	39.0	46.0
28	*Baccharis angusticeps*	6.7	0.20	0.63	0.17	0.40	52.0	52.0
29	*Baccharis crispa*	6.7	0.20	0.63	0.17	0.40	67.0	76.0

continue

Table 9 (continuation)

	Species	FA	Co	FR	CoR	PI	Hpre	Hmax
30	*Coccocypselum* sp.	6.7	0.13	0.63	0.11	0.37	47.0	47.0
31	*Handroanthus catarinesis*	6.7	0.13	0.63	0.11	0.37	111.0	111.0
32	*Dendrophorbium limosum*	6.7	0.07	0.63	0.06	0.34	69.0	69.0
33	*Doryopteris crenulans*	6.7	0.07	0.63	0.06	0.34	15.0	15.0
34	*Oxypetalum* sp.	6.7	0.07	0.63	0.06	0.34	38.0	38.0
35	*Rhynchospora* sp. 4	6.7	0.07	0.63	0.06	0.34	58.0	58.0
36	*Symplocos corymboclados*	6.7	0.07	0.63	0.06	0.34	31.0	33.0
	Total	1066.7	121.07	100	100	100		

Table 10. Phytosociological parameters of the grassy physiognomy of the upper montane grasslands in Serra da Prata, n = 15. FA: absolute frequency (%); Co: absolute cover (%); FR: relative frequency (%); CoR: relative cover (%); PI: importance percentual (%); Hpre: predominant height (cm); Hmax: maximum height (cm).

	Species	FA	Co	FR	CoR	PI	Hpre	Hmax
1	*Cryptangium triquetrum*	85.7	26.71	7.89	21.42	14.66	52.5	74.8
2	*Croton mullerianus*	100.0	20.14	9.21	16.15	12.68	50.0	57.6
3	*Machaerina austrobrasiliensis*	85.7	13.86	7.89	11.11	9.50	64.0	80.8
4	*Gaylussacia brasiliensis* var *brasiliensis*	85.7	8.71	7.89	6.99	7.44	33.3	36.8
5	*Xyris stenophylla*	57.1	10.71	5.26	8.59	6.93	24.8	32.3
6	*Xyris piraquarae*	42.9	12.29	3.95	9.85	6.90	52.7	77.7
7	*Sticherus* sp.	85.7	4.57	7.89	3.67	5.78	36.8	41.2
8	*Tibouchina dubia*	71.4	5.71	6.58	4.58	5.58	40.4	44.2
9	*Chusquea mimosa*	42.9	2.86	3.95	2.29	3.12	62.3	70.3
11	Poaceae 1	42.9	0.86	3.95	0.69	2.32	52.7	56.7
10	*Phalocallis geniculata*	42.9	0.86	3.95	0.69	2.32	45.7	50.7
12	*Vriesea platynema* var. *variegata*	14.3	4.00	1.32	3.21	2.26	59.0	72.0
13	*Sticherus pruinosus*	28.6	1.43	2.63	1.15	1.89	60.0	68.5
14	*Myrcia hartwegiana*	28.6	1.29	2.63	1.03	1.83	85.5	239.0
15	*Chusquea pinifolia*	28.6	1.14	2.63	0.92	1.77	52.0	57.0
16	*Alstroemeria amabilis*	28.6	0.57	2.63	0.46	1.54	60.5	61.5
17	*Clethra uleana*	14.3	2.14	1.32	1.72	1.52	95.0	102.0
18	*Myrsine altomontana*	28.6	0.43	2.63	0.34	1.49	61.0	67.0
19	*Hesperozygis rhododon*	14.3	1.57	1.32	1.26	1.29	84.0	92.0
20	*Symplocos corymboclados*	14.3	1.29	1.32	1.03	1.17	60.0	66.0
21	*Eriocaulon ligulatum*	14.3	1.14	1.32	0.92	1.12	24.0	43.0
23	*Myrcia pulchra*	14.3	0.43	1.32	0.34	0.83	60.0	64.0
22	*Gaultheria serrata* var. *organensis*	14.3	0.43	1.32	0.34	0.83	53.0	67.0
25	*Siphoneugena reitzii*	14.3	0.29	1.32	0.23	0.77	95.0	95.0
24	*Galium hypocarpium* ssp. *indecorum*	14.3	0.29	1.32	0.23	0.77	64.0	64.0
26	*Tibouchina hospita*	14.3	0.29	1.32	0.23	0.77	35.0	35.0
27	*Utricularia reniformis*	14.3	0.29	1.32	0.23	0.77	25.0	25.0
28	*Baccharis angusticeps*	14.3	0.14	1.32	0.11	0.72	55.0	55.0
29	*Dendrophorbium limosum*	14.3	0.14	1.32	0.11	0.72	35.0	35.0
30	*Leandra cordigera*	14.3	0.14	1.32	0.11	0.72	17.0	17.0
	Total	1085.7	124.71	100	100	100		

Table 11. Phytosociological parameters of the shrubby physiognomy of the upper montane grasslands in Serra da Farinha Seca, n = 10. FA: absolute frequency (%); Co: absolute cover (%); FR: relative frequency (%); CoR: relative cover (%); PI: importance percentual (%); Hpre: predominant height (cm); Hmax: maximum height (cm).

	Species	FA	Co	FR	CoR	PI	Hpre	Hmax
1	*Mimosa congestifolia*	80	32.50	6.78	24.13	15.45	69.0	80.6
2	*Cryptangium triquetrum*	80	13.20	6.78	9.80	8.29	53.8	57.8
3	Poaceae 09	70	10.20	5.93	7.57	6.75	58.0	79.1
4	*Sticherus* sp.	70	9.60	5.93	7.13	6.53	41.1	48.4
5	*Chusquea pinifolia*	70	8.80	5.93	6.53	6.23	79.0	85.1
6	*Siphoneugena reitzii*	60	9.00	5.08	6.68	5.88	65.5	70.5
7	*Myrcia hartwegiana*	40	9.70	3.39	7.20	5.30	65.3	83.8
8	*Machaerina austrobrasiliensis*	70	5.10	5.93	3.79	4.86	59.4	77.0
9	*Leandra cordigera*	70	3.70	5.93	2.75	4.34	29.9	40.4
10	*Ilex microdonta*	30	5.50	2.54	4.08	3.31	57.0	68.0
11	*Rhynchospora* sp. 1	40	4.10	3.39	3.04	3.22	52.0	59.0
12	*Myrsine altomontana*	50	1.50	4.24	1.11	2.68	52.4	47.4
13	*Tibouchina dubia*	30	2.60	2.54	1.93	2.24	34.0	35.3
14	*Clethra uleana*	30	2.20	2.54	1.63	2.09	62.3	73.7
15	*Sticherus pruinosus*	20	3.00	1.69	2.23	1.96	42.0	42.5
16	*Gaylussacia brasiliensis* var *brasiliensis*	40	0.70	3.39	0.52	1.95	50.0	53.3
17	*Galianthe gertii*	20	2.30	1.69	1.71	1.70	49.5	56.5
18	*Psidium ovale*	20	1.30	1.69	0.97	1.33	58.0	77.5
19	*Myrcia guianensis*	20	1.20	1.69	0.89	1.29	79.0	90.0
20	*Galium hypocarpium* ssp. *indecorum*	20	1.00	1.69	0.74	1.22	53.0	56.0
21	*Leandra quinquedentata*	20	0.80	1.69	0.59	1.14	55.5	52.5
22	*Persea alba*	10	1.80	0.85	1.34	1.09	110.0	133.0
23	Poaceae 7	20	0.50	1.69	0.37	1.03	45.0	54.0
24	NI 3	20	0.40	1.69	0.30	1.00	35.5	36.5
25	*Mikania clematidifolia*	10	0.60	0.85	0.45	0.65	43.0	44.0
26	*Vriesea platynema* var. *variegata*	10	0.50	0.85	0.37	0.61	40.0	44.0
27	*Graphistylis serrana*	10	0.40	0.85	0.30	0.57	53.0	44.0
28	Cyperaceae 3	10	0.30	0.85	0.22	0.54	65.0	65.0
29	Rubiaceae	10	0.30	0.85	0.22	0.54	32.0	35.0
30	*Vernonanthura montevidensis*	10	0.30	0.85	0.22	0.54	37.0	100.0
31	*Alstroemeria amabilis*	10	0.20	0.85	0.15	0.50	40.0	40.0
32	Poaceae 6	10	0.20	0.85	0.15	0.50	32.0	32.0
33	*Smilax campestris*	10	0.20	0.85	0.15	0.50	54.0	64.0
34	*Xyris piraquarae*	10	0.20	0.85	0.15	0.50	66.0	77.0
35	Apocynaceae 1	10	0.10	0.85	0.07	0.46	44.0	44.0
36	*Eryngium koehneanum*	10	0.10	0.85	0.07	0.46	40.0	40.0
37	*Podocarpus sellowii*	10	0.10	0.85	0.07	0.46	45.0	47.0
38	*Symplocos corymboclados*	10	0.10	0.85	0.07	0.46	46.0	46.0
39	*Handroanthus catarinesis*	10	0.10	0.85	0.07	0.46	62.0	62.0
40	*Tibouchina hospita*	10	0.10	0.85	0.07	0.46	39.0	39.0
41	*Utricularia reniformis*	10	0.10	0.85	0.07	0.46	28.0	28.0
42	*Verbesina glabrata*	10	0.10	0.85	0.07	0.46	76.0	76.0
	Total	1180	134.7	100	100	100		

ridges (approx. 800 m asl) in Serra do Mar State Park- Núcleo Curucutu (SP). In the sampling of Serra Gigante, *Cryptangium triquetrum* was found in all sampled plots, comprising 52% of the relative cover, which corresponds to almost one third of the importance percentage. *Paspalum polyphyllum* stood out mainly for its cover percentage as well as *Tibouchina hatschbachii* due to the species high frequency. The latter was detected exclusively in Serra Gigante, but showed importance among the community structure. *Neomarica caerulea* is another species found exclusively in Serra Gigante and showed great importance as well.

We observed that, in general, the plant community had lower heights, in which the average height of the five major species was lower than 50 cm. Altogether, these species accounted for more than 80% of the community relative cover.

Structure of upper montane grasslands in Serra da Pedra Branca do Araraquara

Serra da P.B. do Araraquara - Physiognomy: shrubby - 31 species were found in the seven sampled plots within an absolute cover of 124.9 $m^2.100^{-1}m^2$ (table 15). *Sticherus* sp. stood out as the most important species, especially for presenting high cover percentage, comprising 22% of the community. *Tibouchina dubia*, *Vernonanthura montevidensis* and *Eryngium koehneanum*, despite being the most frequent, presented lower vegetation cover when compared to *Sticherus* sp. *Coccocypselum condalia* and *Valeriana ulei* also showed high frequency, but much lower cover. Therefore, these five species were assigned to the lower strata of the community. *Machaerina austrobrasiliensis* stood out for its high cover values as well as for its predominant and maximum heights, being assigned to the upper strata.

Serra da P.B. do Araraquara - Physiognomy: grassy - 22 species were found in the five sampled plots within an absolute cover of 107.4 $m^2.100^{-1}m^2$ (table 16). *Cryptangium triquetrum* was the most important species, followed by *Eryngium koehneanum*, *Tibouchina dubia* and a non-identified Poaceae. These four species comprised more than 60% of the importance percentage and nearly 80% of the cover percentage.

Structure of upper montane grasslands in the State of Paraná, Southern Brazil

From the 280 vascular plant species surveyed by the same authors (Mocochinski & Scheer, 2008), 195 species were sampled in at least one of the 324 plots of 1 m^2, distributed in the upper montane grasslands of six mountain ranges from Southern Brazil, which were the aim of the present study.

Based upon our findings, *Cryptangium triquetrum* was the most important and frequent species in the upper montane grassland structures (approximately 14%), since it was found in all grassland physiognomies within several mountain ranges studied (figure 2).

Croton mullerianus was the second most dominant species (12%), especially in shrubby physiognomies , although it was not found neither in grassy and shrubby physiognomies of Serra da Farinha Seca and Serra da Pedra Branca do Araraquara, nor in *Chusquea pinifolia* physiognomy of Serra da Farinha Seca (figure 2).

Chusquea pinifolia was the third most important species (7%), based on its remarkable occurrence in both Serra do Ibitiraquire and Serra da Prata, by prevailing in *C. pinifolia* physiognomy.

These three main species resulted in approximately 33% of importance of the general phytosociological survey carried out in the upper montane grasslands. As for the top 10 species, which also include *Machaerina austrobrasiliensis*, *Deschampsia caespitosa*, *Gleichenella pectitata*, *Tibouchina dubia*, *Xyris stenophylla*, *Eryngium koehnearum* and *Eriochrysis holcoides* accounted for 50% of the relative importance (figure 2).

It is noteworthy that out of these 10 most important species in the upper montane grasslands in the State of Paraná, only three were cited in the List of Species related to Altitude Grasslands (campos de altitude, that include or at least should include species from montane and upper montane grasslands) of Southern Brazil by CONAMA Resolution 423/2010: *Machaerina austrobrasiliensis*, *Deschampsia caespitosa* and *Eriochrysis holcoides* are classified as indicator species of primary (mature/old growth) vegetation formations as well as medium or advanced stages of regeneration. The first one is also classified as endemic or rare. The other two species were also included in the List of Northeastern Brazil of the same Resolution, however, they should also be included in the List of the Southeastern Region. As a matter of fact, *Chusquea pinifolia*, the third main species of the present study, has not been cited in the List of the Southern Region, although it has been included in the List of both Northeastern and Southeastern Regions. *Croton mullerianus* (second main species in this survey) is not

Table 12. Phytosociological parameters of the grassy physiognomy of the upper montane grasslands in Serra da Farinha Seca, n = 22. FA: absolute frequency (%); Co: absolute cover (%); FR: relative frequency (%); CoR: relative cover (%); PI: importance percentual (%); Hpre: predominant height (cm); Hmax: maximum height (cm).

	Species	FA	Co	FR	CoR	PI	Hpre	Hmax
1	*Cryptangium triquetrum*	100.0	72.50	8.09	49.05	28.57	62.9	79.1
2	*Siphoneugena reitzii*	81.8	6.05	6.62	4.09	5.35	57.3	63.6
3	*Tibouchina dubia*	72.7	6.05	5.88	4.09	4.99	44.6	50.8
4	*Eryngium koehneanum*	63.6	4.95	5.15	3.35	4.25	44.1	50.9
5	*Baccharis nebularis*	68.2	4.09	5.51	2.77	4.14	53.1	60.2
6	*Galianthe gertii*	45.5	4.32	3.68	2.92	3.30	34.2	38.3
7	Poaceae 6	54.5	2.45	4.41	1.66	3.04	33.6	45.0
8	*Sticherus pruinosus*	50.0	2.91	4.04	1.97	3.01	45.9	49.6
9	*Sticherus* sp.	27.3	5.32	2.21	3.60	2.90	51.5	55.5
10	*Myrcia hartwegiana*	31.8	4.32	2.57	2.92	2.75	65.1	72.7
11	*Xyris dissitifolia*	50.0	2.05	4.04	1.38	2.71	43.6	47.1
12	*Vriesea platynema* var. *variegata*	22.7	4.59	1.84	3.11	2.47	39.4	53.6
13	*Utricularia reniformis*	50.0	0.91	4.04	0.62	2.33	31.9	35.4
14	*Myrsine altomontana*	45.5	1.23	3.68	0.83	2.25	48.1	54.4
15	*Leandra quinquedentata*	36.4	2.09	2.94	1.41	2.18	51.9	56.6
16	*Graphistylis serrana*	27.3	2.18	2.21	1.48	1.84	44.5	49.3
17	*Clethra uleana*	18.2	2.68	1.47	1.81	1.64	72.5	82.3
18	*Galium hypocarpium* ssp. *indecorum*	31.8	0.95	2.57	0.65	1.61	37.9	44.4
19	Poaceae 9	18.2	2.45	1.47	1.66	1.57	44.0	61.5
20	*Weinmannia humilis*	13.6	2.45	1.10	1.66	1.38	62.3	74.3
21	*Leandra cordigera*	22.7	1.36	1.84	0.92	1.38	49.2	51.8
22	Poaceae 7	22.7	0.91	1.84	0.62	1.23	37.8	52.4
23	*Mimosa congestifolia*	22.7	0.73	1.84	0.49	1.17	67.4	72.4
24	*Baccharis crispa*	18.2	1.18	1.47	0.80	1.14	45.8	51.5
25	*Chusquea pinifolia*	9.1	1.45	0.74	0.98	0.86	64.5	72.5
26	*Handroanthus catarinesis*	13.6	0.82	1.10	0.55	0.83	52.3	54.3
27	*Tibouchina hospita*	18.2	0.27	1.47	0.18	0.83	27.8	28.5
28	*Gaylussacia brasiliensis* var *brasiliensis*	18.2	0.18	1.47	0.12	0.80	31.8	32.0
29	*Machaerina austrobrasiliensis*	9.1	1.00	0.74	0.68	0.71	54.0	70.0
30	*Psidium ovale*	9.1	0.82	0.74	0.55	0.64	68.5	96.0
31	*Baccharis angusticeps*	13.6	0.27	1.10	0.18	0.64	52.0	56.7
32	*Lycopodium clavatum*	13.6	0.23	1.10	0.15	0.63	34.0	37.7
33	*Symplocos corymboclados*	9.1	0.68	0.74	0.46	0.60	71.5	74.0
34	*Xyris piraquarae*	9.1	0.59	0.74	0.40	0.57	69.0	81.5
35	*Coccocypselum* sp.	9.1	0.45	0.74	0.31	0.52	33.0	34.5
36	Apocynaceae 1	9.1	0.18	0.74	0.12	0.43	45.5	49.0
37	*Mikania clematidifolia*	9.1	0.18	0.74	0.12	0.43	48.0	51.0
38	*Alstroemeria amabilis*	9.1	0.14	0.74	0.09	0.41	43.5	46.0
39	Poaceae 8	9.1	0.14	0.74	0.09	0.41	38.5	42.0
40	*Gaultheria serrata* var. *organensis*	9.1	0.09	0.74	0.06	0.40	28.5	30.0
41	*Mikania paranensis*	9.1	0.09	0.74	0.06	0.40	49.0	50.0

continue

Table 12 (continuation)

	Species	FA	Co	FR	CoR	PI	Hpre	Hmax
42	Myrtaceae indet. 2	4.5	0.45	0.37	0.31	0.34	62.0	68.0
43	*Ocotea tristis*	4.5	0.36	0.37	0.25	0.31	77.0	83.0
44	*Austroeupatorium neglectum*	4.5	0.09	0.37	0.06	0.21	54.0	58.0
45	*Dendrophorbium limosum*	4.5	0.09	0.37	0.06	0.21	48.0	51.0
46	*Eugenia neomyrtifolia*	4.5	0.09	0.37	0.06	0.21	48.0	40.0
47	*Ilex microdonta*	4.5	0.09	0.37	0.06	0.21	46.0	49.0
48	NI 3	4.5	0.09	0.37	0.06	0.21	44.0	54.0
49	*Phalocallis geniculata*	4.5	0.05	0.37	0.03	0.20	36.0	36.0
50	*Podocarpus sellowii*	4.5	0.05	0.37	0.03	0.20	26.0	26.0
51	*Smilax campestris*	4.5	0.05	0.37	0.03	0.20	35.0	39.0
52	*Holocheilus brasiliensis*	4.5	0.05	0.37	0.03	0.20	30.0	33.0
53	*Valeriana ulei*	4.5	0.05	0.37	0.03	0.20	62.0	62.0
	Total	1236.4	147.82	100	100	100		

Table 13. Phytosociological parameters of the *Chusquea pinifolia* physiognomy of the upper montane grasslands in Serra da Farinha Seca, n = 5. FA: absolute frequency (%); Co: absolute cover (%); FR: relative frequency (%); CoR: relative cover (%); PI: importance percentual (%); Hpre: predominant height (cm); Hmax: maximum height (cm).

	Species	FA	Co	FR	CoR	PI	Hpre	Hmax
1	*Chusquea pinifolia*	100	70.80	8.77	52.60	30.69	74.2	92.0
2	*Mimosa congestifolia*	100	13.80	8.77	10.25	9.51	70.6	76.2
3	*Siphoneugena reitzii*	100	7.60	8.77	5.65	7.21	62.4	70.6
4	*Sticherus* sp.	80	6.40	7.02	4.75	5.89	41.5	47.0
5	*Baccharis nebularis*	40	6.60	3.51	4.90	4.21	57.5	63.0
6	*Machaerina austrobrasiliensis*	60	3.60	5.26	2.67	3.97	55.3	67.7
7	*Symplocos corymboclados*	60	1.80	5.26	1.34	3.30	65.3	67.7
8	*Utricularia reniformis*	60	1.00	5.26	0.74	3.00	12.3	12.3
9	*Clethra scabra*	20	5.40	1.75	4.01	2.88	85.0	93.0
10	Poaceae 8	60	0.60	5.26	0.45	2.85	20.0	20.0
11	*Dendrophorbium limosum*	40	1.40	3.51	1.04	2.27	42.0	47.5
12	*Alstroemeria amabilis*	40	1.20	3.51	0.89	2.20	37.5	39.5
13	*Smilax campestris*	40	0.80	3.51	0.59	2.05	42.5	44.5
14	*Gaultheria serrata* var. *organensis*	40	0.60	3.51	0.45	1.98	44.0	47.5
15	*Handroanthus catarinesis*	20	2.60	1.75	1.93	1.84	64.0	72.0
16	*Myrsine altomontana*	20	1.60	1.75	1.19	1.47	59.0	70.0
17	Poaceae 9	20	1.60	1.75	1.19	1.47	75.0	98.0
18	*Galium hypocarpium* ssp. *indecorum*	20	1.20	1.75	0.89	1.32	37.0	45.0
19	*Tibouchina dubia*	20	1.20	1.75	0.89	1.32	52.0	57.0
20	*Coccocypselum* sp.	20	1.00	1.75	0.74	1.25	5.0	10.0
21	Rubiaceae	20	1.00	1.75	0.74	1.25	40.0	45.0
22	*Cryptangium triquetrum*	20	0.60	1.75	0.45	1.10	61.0	61.0
23	*Leandra quinquedentata*	20	0.60	1.75	0.45	1.10	22.0	28.0
24	*Baccharis crispa*	20	0.40	1.75	0.30	1.03	39.0	42.0

continue

Table 13 (continuation)

	Species	FA	Co	FR	CoR	PI	Hpre	Hmax
25	*Ilex microdonta*	20	0.40	1.75	0.30	1.03	72.0	76.0
26	*Coccocypselum condalia*	20	0.20	1.75	0.15	0.95	18.0	18.0
27	*Myrcia hartwegiana*	20	0.20	1.75	0.15	0.95	50.0	53.0
28	*Leandra cordigera*	20	0.20	1.75	0.15	0.95	42.0	44.0
29	*Ocotea tristis*	20	0.20	1.75	0.15	0.95	59.0	59.0
	Total	1140	134.60	100	100	100		

Table 14. Phytosociological parameters of the grassy physiognomy of the upper montane grasslands in Serra Gigante, n = 12. FA: absolute frequency (%); Co: absolute cover (%); FR: relative frequency (%); CoR: relative cover (%); PI: importance percentual (%); Hpre: predominant height (cm); Hmax: maximum height (cm).

	Species	FA	Co	FR	CoR	PI	Hpre	Hmax
1	*Cryptangium triquetrum*	100.0	59.00	12.77	52.48	32.62	43.4	53.5
2	*Paspalum polyphyllum*	83.3	13.25	10.64	11.79	11.21	31.0	40.1
3	*Tibouchina hatschbachii*	91.7	8.17	11.70	7.26	9.48	38.6	49.8
4	*Neomarica caerulea*	75.0	3.83	9.57	3.41	6.49	41.6	47.8
5	*Myrcia hartwegiana*	50.0	6.42	6.38	5.71	6.05	44.7	52.2
6	*Siphoneugena reitzii*	58.3	4.00	7.45	3.56	5.50	67.6	78.4
7	*Rhynchospora exaltata*	58.3	3.75	7.45	3.34	5.39	31.3	41.0
8	*Dicranopteris nervosa*	50.0	3.75	6.38	3.34	4.86	25.0	30.0
9	Asteraceae 1	33.3	3.75	4.26	3.34	3.80	26.0	29.3
10	Poaceae 4	41.7	1.00	5.32	0.89	3.10	26.8	29.4
11	*Mikania lanuginosa*	25.0	0.58	3.19	0.52	1.86	19.0	29.3
12	*Gaylussacia brasiliensis* var *brasiliensis*	16.7	1.08	2.13	0.96	1.55	30.0	43.0
13	*Pitcairnia flammea*	8.3	1.67	1.06	1.48	1.27	38.0	43.0
14	NI 1	16.7	0.17	2.13	0.15	1.14	25.0	25.0
15	*Aechmea* sp.	8.3	0.50	1.06	0.44	0.75	32.0	32.0
16	*Bulbostylis consanguinea*	8.3	0.50	1.06	0.44	0.75	11.0	11.0
17	Asteraceae 03	8.3	0.17	1.06	0.15	0.61	20.0	20.0
18	*Coccocypselum condalia*	8.3	0.17	1.06	0.15	0.61	5.0	3.0
19	*Mandevilla atroviolacea*	8.3	0.17	1.06	0.15	0.61	70.0	90.0
20	*Piptocarpha densifolia*	8.3	0.17	1.06	0.15	0.61	34.0	34.0
21	*Utricularia reniformis*	8.3	0.17	1.06	0.15	0.61	11.0	11.0
22	Pteridophyta 2	8.3	0.08	1.06	0.07	0.57	10.0	10.0
23	*Ternstroemia brasiliensis*	8.3	0.08	1.06	0.07	0.57	56.0	56.0
	Total	783.3	112.42	100	100	100		

cited in the List. It is also noteworthy that *Criptangium triquetum*, structurally the most dominant species in this survey, is solely cited in the CONAMA Resolution to the Southeastern Region under the synonym *Lagenocarpus triquetrus*.

The four species with the highest percentage of importance on each physiognomy of each sampled subrange (table 17) showed, in most areas, approximately half the overall index for their respective communities.

In Serra do Ibitiraquire, *Croton mullerianus* stood out for being among the four main species in the five sampled physiognomies. Whereas, *Cryptangium triquetrum* was not only among the four main species in the physiognomy dominated by *Machaerina*

Table 15. Phytosociological parameters of the shrubby physiognomy of the upper montane grasslands in Serra da Pedra Branca do Araraquara, n = 7. FA: absolute frequency; Co: absolute cover; FR: relative frequency (%); CoR: relative cover (%); PI: importance percentual (%); Hpre: predominant height; Hmax: maximum height.

	Species	FA	Co	FR	CoR	PI	Hpre	Hmax
1	*Sticherus* sp.	71.4	27.86	5.81	22.31	14.06	53.2	62.0
2	*Tibouchina dubia*	85.7	14.29	6.98	11.44	9.21	54.5	66.7
3	*Vernonanthura montevidensis*	85.7	11.86	6.98	9.50	8.24	74.0	88.0
4	*Eryngium koehneanum*	85.7	9.43	6.98	7.55	7.26	62.2	70.3
5	*Machaerina austrobrasiliensis*	57.1	11.57	4.65	9.27	6.96	90.3	108.3
6	*Cryptangium triquetrum*	100.0	5.71	8.14	4.58	6.36	52.9	74.7
7	*Siphoneugena reitzii*	57.1	8.86	4.65	7.09	5.87	73.0	87.5
8	*Coccocypselum condalia*	85.7	2.86	6.98	2.29	4.63	23.3	30.7
9	*Valeriana ulei*	71.4	1.14	5.81	0.92	3.36	37.8	44.3
10	Ericaceae 1	57.1	2.57	4.65	2.06	3.36	69.5	76.5
11	*Xyris piraquarae*	42.9	3.86	3.49	3.09	3.29	51.3	61.7
12	*Chusquea mimosa*	28.6	5.14	2.33	4.12	3.22	176.5	191.5
13	*Holocheilus brasiliensis*	42.9	2.00	3.49	1.60	2.55	16.0	21.3
14	*Leandra quinquedentata*	42.9	0.71	3.49	0.57	2.03	38.3	39.0
15	Myrtaceae 3	14.3	3.14	1.16	2.52	1.84	61.0	76.0
16	*Myrsine altomontana*	28.6	1.43	2.33	1.14	1.73	73.0	87.0
17	Poaceae 12	14.3	2.86	1.16	2.29	1.73	44.0	55.0
18	*Vriesea platynema* var. *variegata*	28.6	1.00	2.33	0.80	1.56	35.5	38.0
19	*Miconia lymanii*	28.6	0.86	2.33	0.69	1.51	57.0	62.0
20	*Bulbostylis consanguinea*	14.3	2.14	1.16	1.72	1.44	30.0	55.0
21	*Agarista niederleinii* var *niederleinii*	28.6	0.29	2.33	0.23	1.28	43.0	43.0
22	*Utricularia reniformis*	28.6	0.29	2.33	0.23	1.28	10.0	10.0
23	*Blechnum cordatum*	14.3	1.57	1.16	1.26	1.21	49.0	52.0
24	*Sticherus pruinosus*	14.3	1.43	1.16	1.14	1.15	45.0	51.0
25	*Baccharis crispa*	14.3	0.57	1.16	0.46	0.81	67.0	88.0
26	*Myrcia hartwegiana*	14.3	0.43	1.16	0.34	0.75	57.0	67.0
27	*Mikania lanuginosa*	14.3	0.43	1.16	0.34	0.75	40.0	51.0
28	*Gaylussacia brasiliensis* var. *brasiliensis*	14.3	0.14	1.16	0.11	0.64	34.0	34.0
29	*Hesperozygis rhododon*	14.3	0.14	1.16	0.11	0.64	81.0	81.0
30	*Senna organensis* var. *extratropica*	14.3	0.14	1.16	0.11	0.64	52.0	52.0
31	*Smilax campestris*	14.3	0.14	1.16	0.11	0.64	59.0	59.0
	Total	1228.6	124.86	100	100	100		

Table 16. Phytosociological parameters of the grassy physiognomy of the upper montane grasslands in Serra da Pedra Branca do Araraquara, n = 5. FA: absolute frequency (%); Co: absolute cover (%); FR: relative frequency (%); CoR: relative cover (%); PI: importance percentual (%); Hpre: predominant height (cm); Hmax: maximum height (cm).

	Species	FA	Co	FR	CoR	PI	Hpre	Hmax
1	*Cryptangium triquetrum*	100	43.80	11.63	40.78	26.21	55.8	70.0
2	*Eryngium koehneanum*	100	13.80	11.63	12.85	12.24	36.6	40.6
3	*Tibouchina dubia*	100	12.60	11.63	11.73	11.68	47.2	63.8
4	Poaceae 12	80	15.00	9.30	13.97	11.63	54.3	60.0

continue

Table 16 (continuation)

	Species	FA	Co	FR	CoR	PI	Hpre	Hmax
5	*Mikania lanuginosa*	60	2.20	6.98	2.05	4.51	49.3	58.0
6	Myrtaceae 3	60	2.20	6.98	2.05	4.51	50.0	58.0
7	*Vernonanthura montevidensis*	20	6.80	2.33	6.33	4.33	74.0	112.0
8	*Coccocypselum condalia*	40	1.40	4.65	1.30	2.98	25.0	25.5
9	*Xyris piraquarae*	40	1.20	4.65	1.12	2.88	56.5	59.0
10	Cyperaceae 4	20	1.60	2.33	1.49	1.91	12.0	12.0
11	*Myrcia hartwegiana*	20	1.60	2.33	1.49	1.91	91.0	128.0
12	*Vriesea hoehneana*	20	1.60	2.33	1.49	1.91	35.0	38.0
13	Cyperaceae 5	20	0.60	2.33	0.56	1.44	50.0	52.0
14	*Hesperozygis rhododon*	20	0.60	2.33	0.56	1.44	65.0	70.0
15	*Agarista niederleinii var niederleinii*	20	0.40	2.33	0.37	1.35	44.0	44.0
16	*Baccharis crispa*	20	0.40	2.33	0.37	1.35	70.0	81.0
17	*Senna organensis* var. *extratropica*	20	0.40	2.33	0.37	1.35	53.0	75.0
18	*Valeriana ulei*	20	0.40	2.33	0.37	1.35	55.0	61.0
19	*Leandra quinquedentata*	20	0.20	2.33	0.19	1.26	61.0	61.0
20	*Miconia lymanii*	20	0.20	2.33	0.19	1.26	20.0	20.0
21	*Pimenta pseudocaryophyllus*	20	0.20	2.33	0.19	1.26	100.0	100.0
22	*Rhynchospora* sp. 3	20	0.20	2.33	0.19	1.26	13.0	13.0
	Total	860	107.4	100	100	100		

austrobrasiliensis, in which it showed the fifth highest percentage of importance. *Chusquea pinifolia* was found in three physiognomies as one of the four most important species.

In Serra da Igreja, *Cryptangium triquetrum* and *Croton mullerianus* stood out on both shrubby and grassy physiognomies. We also observed the importance of *Tibouchina dubia* on both physiognomies. In the grassy physiognomy, *Myrsine altomontana* was found as the fourth most important species, which was the only time such species was observed among the main species.

The absence of *Croton mullerianus* among the main species in Serra da Farinha Seca drew our attention, even though it does occur in the area, but it was not found in neither physiognomy of the sampled plots. In the other two sub-ranges (Serra Gigante and Serra P.B. do Araraquara), where *C. mullerianus* does not stand out in the community, the species was not even detected in the floristic survey (Mocochinski & Scheer 2008). Due to the low vegetation cover and frequency of *C. mullerianus*, *Mimosa congestifolia* species dominates the shrubby physiognomy and also stands out in areas dominated by *Chusquea pinifolia*. *Cryptangium triquetrum*, besides being the most important species in the grassy physiognomy also stood out in the shrubby physiognomy. Another important species in this Serra da Farinha Seca is *Sticherus* sp., which stood out in both shrubby and *Chusquea pinifolia* physiognomies.

We found three species in the grassy physiognomy of Serra Gigante, however, they were not important in the other subranges studied herewith. *Tibouchina hatschbachii* and *Neomarica caerulea* were detected only in Serra Gigante, whereas *Paspalum polyphyllum* was previously found in only one sampled plot of Serra do Ibitiraquire.

Cryptangium triquetrum and *Croton mullerianus* were found as the most important species in both grassy and shrubby physiognomies of Serra da Prata, in which *Machaerina austrobrasiliensis* was also important. *Gaylussacia brasiliensis* was found for the first time as one of the most important species, ranking in the fourth position of the grassy physiognomy.

Tibouchina dubia and *Eryngium koehneanum* stood out among the most important species in both grassy and shrubby physiognomies of Serra da Pedra Branca do Araraquara. While *Vernonanthura montevidensis* was found as one of the most important species only in this mountain range.

Croton mullerianus was the most important species in the shrubby physiognomy within three

out of the five subranges where such physiognomy was plot-sampled. *Cryptangium triquetrum*, despite not being the most important species in the shrubby physiognomy, was among the four most important ones within four subranges. *Tibouchina dubia* was found within three subranges among the most important species in the shrubby physiognomy. Both *Mimosa congestifolia* and *Sticherus* sp. were found among the most important species in the shrubby physiognomy within two subranges.

Cryptangium triquetrum was the most important species in the grassy physiognomy within all suveyed

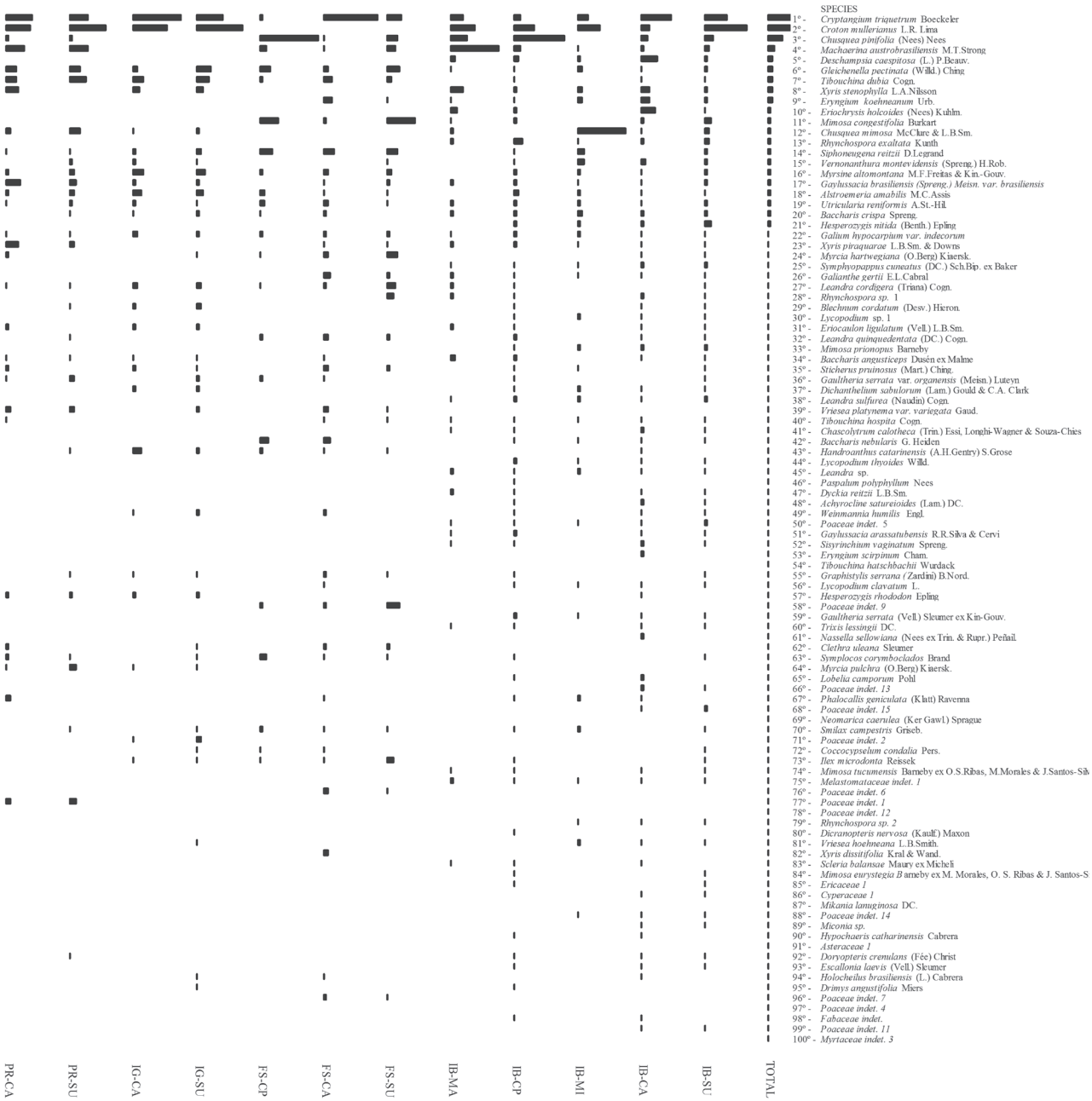

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Figure 2. Part 1. The 195 most important species in the phytosociological structure of upper montane grasslands in different physiognomies in mountains of six sub Subranges of Serra do Mar, Southern Brazil; n = 324 (1 m² plots). Subranges: FS: Farinha Seca; GI: Gigante; PB: Pedra Branca do Araraquara; IB: Ibitiraquire; IG: Igreja; PR: Prata. Physiognomies: CA: Grassy; SU: Shrubby; CP: *Chusquea pinifolia*; MA: *Machaerina austrobrasiliensis*; MI: *Chusquea mimosa*.

Figure 2 (continuation)

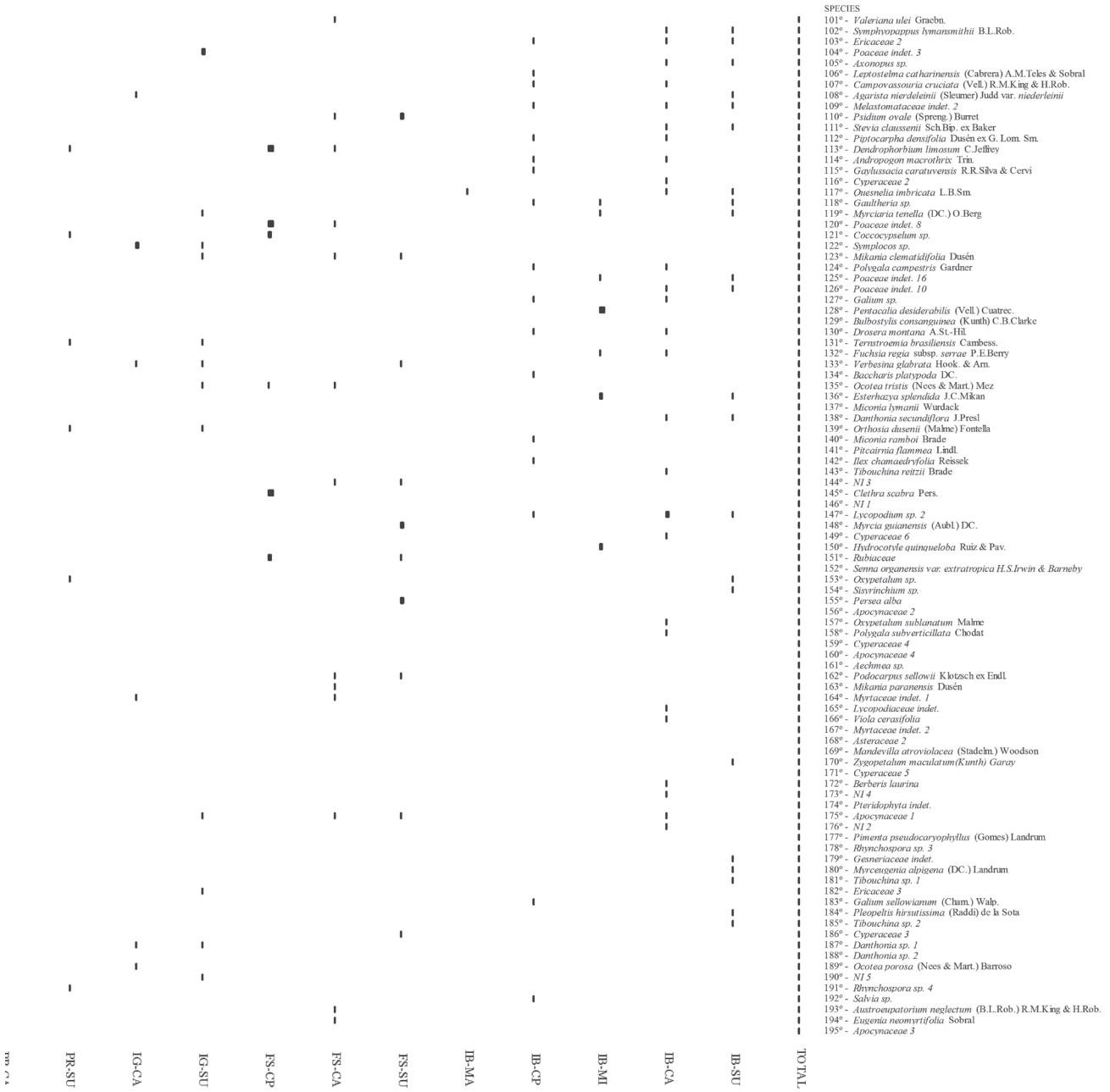

Figure 2. Part 2. The 195 most important species in the phytosociological structure of upper montane grasslands in different physiognomies in mountains of six sub Subranges of Serra do Mar, Southern Brazil; n = 324 (1 m^2 plots). Subranges: FS: Farinha Seca; GI: Gigante; PB: Pedra Branca do Araraquara; IB: Ibitiraquire; IG: Igreja; PR: Prata. Physiognomies: CA: Grassy; SU: Shrubby; CP: *Chusquea pinifolia*; MA: *Machaerina austrobrasiliensis*; MI: *Chusquea mimosa*.

subranges. *Croton mullerianus*, *Tibouchina dubia* and *Eryngium koehneanum* also stood out in this physiognomy among the most important species in at least two subranges.

The dominance of one or a few species was a constant in all the subranges as well as their phytophysiognomies. Such pattern has been fairly well-known, in which habitats subjected to extreme environmental conditions such as Restingas (beach ridge vegetation), rupestrian vegetation and upper montane grasslands, tend to be dominated by one or a few species (Scarano 2002, Caiafa & Silva 2007).

Table 17. The four most important species in each physiognomy of the sampled upper montane grassland in Southern Brazil. Legend: (*) indicates the studied subranges of Serra do Mar in the State of Paraná.

*Serra do Ibitiraquire				
Shrubby	Grassy	*C. mimosa*	*C. pinifolia*	*M.austrobrasiliensis*
Croton mullerianus	*Cryptangium triquetrum*	*Chusquea mimosa*	*Chusquea pinifolia*	*M.austrobrasiliensis*
Cryptangium triquetrum	*Deschampsia caespitosa*	*Croton mullerianus*	*Croton mullerianus*	*Croton mullerianus*
Chusquea pinifolia	*Eriochrysis holcoides*	*Cryptangium triquetrum*	*Rhynchospora exaltata*	*Chusquea pinifolia*
Mimosa congestifolia	*Croton mullerianus*	*Siphoneugena reitzii*	*Cryptangium triquetrum*	*Xyris stenophylla*

Serra da Igreja		Serra da Farinha Seca		
Shrubby	Grassy	Shrubby	Grassy	*C. pinifolia*
Croton mullerianus	*Cryptangium triquetrum*	*Mimosa congestifolia*	*Cryptangium triquetrum*	*Chusquea pinifolia*
Cryptangium triquetrum	*Croton mullerianus*	*Cryptangium triquetrum*	*Siphoneugena reitzii*	*Mimosa congestifolia*
Sticherus sp.	*Tibouchina dubia*	Poaceae indet. 9	*Tibouchina dubia*	*Siphoneugena reitzii*
Tibouchina dubia	*Myrsine altomontana*	*Sticherus* sp.	*Eryngium koehneanum*	*Sticherus* sp.

Serra Gigante	Serra da Prata		Serra da PB do Araraquara	
Grassy	Shrubby	Grassy	Shrubby	Grassy
Cryptangium triquetrum	*Croton mullerianus*	*Cryptangium triquetrum*	*Sticherus* sp.	*Cryptangium triquetrum*
Paspalum polyphyllum	*Cryptangium triquetrum*	*Croton mullerianus*	*Tibouchina dubia*	*Eryngium koehneanum*
Tibouchina hatschbachii	*M.austrobrasiliensis*	*M.austrobrasiliensis*	*Vernonanthura montevidensis*	*Tibouchina dubia*
Neomarica caerulea	*Tibouchina dubia*	*Gaylussacia brasiliensis*	*Eryngium koehneanum*	Poaceae indet. 12

Table 18 summarizes the structural parameters as well as Shannon's Diversity and Evenness indexes (H' and e) of each physiognomy in the sampled subranges.

The greatest diversity detected in the grassy physiognomy within Serra do Ibitiraquire is mainly due to the high species richness, which is likely caused by increased sampling intensity related to its greater extension and diversity of environments as well as its greater altitudinal gradient. The stretches of shrubby physiognomy within Serra da Farinha Seca and Serra da Pedra Branca do Araraquara showed relatively high values of diversity, despite their relatively lower richness. As a matter of fact, this is caused by the greater evenness in these areas, indicating a more uniform distribution of cover among different species. The grassy physiognomy in Serra da Prata also showed relatively high evenness. Conversely, the *Chusquea pinifolia* physiognomy in Serra da Farinha Seca showed low evenness values, which evidenced communities where the species of greater cover spreads over most of the relative cover. In this case, *Chusquea pinifolia* dominated 52% of the relative cover. In the grassy physiognomy of Serra Gigante, *Cryptangium triquetrum* also dominated 52% of the relative cover resulting in a lower community evenness.

For a more detailed analysis of the relationship between species richness and diversity, it would be interesting to standardize the number of plot samples in the physiognomies of each subrange. As the obtention of the diversity index based upon the species relative abundance is considered unviable, given the difficulty of differentiating individuals mainly of grass species ("graminoids"), obtaining the index from the relative cover may prove to be very useful, since this variable of estimates is not only viable, but also acceptable. Furthermore, as individuals from different species coverage may vary greatly (*e.g.* grasses that propagate by stolons may cover large areas, using a single specimen), the use of the cover is found to be interesting to assess the physiognomic heterogeneity of different communities.

We observed that there is greater similarity between grassy and shrubby physiognomies within Serra da Igreja, and secondarily, the same physiognomies within Serra da Prata (figure 3). These are medium-altitude subranges (1,320-1,450 m asl) among the sampled ones. The physiognomies of the subranges, where the sampled stretches were at lower altitudes (1,000-1,250 m asl), also formed a small group. The three physiognomies of Serra da Farinha Seca were also secondarily linked to this group, and the altitude was slightly higher (1,200-1,400 m asl). All physiognomies of Serra do Ibitiraquire (this subrange is the highest in altitude, stretches between 1,600 and 1,870 m asl) formed a large group (figure 3). These results indicate a strong relationship between the phytosociological structure of the sampled

Table 18. Parameters for each physiognomy of the sampled upper montane grassland in Southern Brazil. N: number of sampled plots, S: species richness, Co: absolute cover, spp/UA: average number of species per plot, H': Shannon-Wiener index, e: evenness indices.

Subrange	Physiognomy	N	S	Co (%)	spp/UA	H' (nats/Co)	e
Ibitiraquire	Grassy	64	99	109	8	3.00	1.5
Ibitiraquire	Shrubby	61	94	125	10	2.74	1.39
Ibitiraquire	*Chusquea pinifolia*	56	85	125	10	2.60	1.35
Farinha Seca	Grassy	22	53	148	12	2.39	1.39
Igreja	Shrubby	27	50	149	10	2.30	1.34
Ibitiraquire	*Chusquea mimosa*	9	46	136	10	2.34	1.41
Farinha Seca	Shrubby	10	42	135	12	2.77	1.71
Ibitiraquire	*Machaerina austrobrasiliensis*	10	36	102	9	2.18	1.40
Prata	Shrubby	15	36	121	11	2.48	1.59
Igreja	Grassy	14	33	151	10	2.03	1.80
PBA	Shrubby	7	31	125	12	2.69	1.80
Prata	Grassy	7	30	125	11	2.54	1.72
Farinha Seca	*Chusquea pinifolia*	5	29	134	11	0.73	0.50
Gigante	Grassy	12	23	112	8	1.81	1.33
PBA	Grassy	5	22	107	9	1.97	1.47

communities and the colonization opportunities for different populations based on the geographic location of each subrange, as well as their potential to act as a dispersal barrier (selective) for some species. In addition to the limitations imposed by geographical isolation, as the ones occurring on "inselbergs" (Porembski 2007), the altitude conditioning factors (*e.g.* temperature gradients, geomorphology/soils, formation of histic soil horizons, etc.), may also exert considerable influence on some taxa.

As we mentioned earlier, there is still scarce information about the structure and floristic composition as well as the diversity of upper montane ecosystems. Therefore, further studies and surveys are required in order to obtain a more widely applicable ecological knowledge. However, we conducted a brief analysis relating to upper montane grasslands of the present study with other vegetation studies about altitude rocky outcrops in Serra da Mantiqueira (Southeastern Brazil) (Caiafa & Silva 2007, Ribeiro *et al*. 2007, Tinti *et al*. 2015) as well as two sites of Serra do Mar (Araras & Madalena) in the State of Rio de Janeiro (Meirelles *et al*. 1999). We learned that neither of the species found in the upper montane grasslands within Serra do Mar in Paraná was found in these two areas in Rio de Janeiro. Perhaps because such species might be more adapted to grasslands than rocky outcrops. Based on studies carried out at Serra da Mantiqueira only two species were found (Caiafa & Silva 2007) to approximately two dozen species (Tinti *et al*. 2015) in common with the ones found within the subranges studied in Paraná, which in addition to the distances between them, may be related to the surrounding phytogeographic aspects. The floristic study reported by Tinti *et al*. (2015) (Serra do Brigadeiro - Mantiqueira, in the State of Minas Gerais) is in alignment with the grasslands of our study, for instance, the following taxa: *Achyrocline satureoides*, *Stevia clausseni*, *Gaultheria serrata*, "*Croton mullerianus*"(*Croton splendidus*), *Hesperozygis nitida*, *Lycopodium clavatum*, *Doryopteris crenulans* and *Galium hypocarpium*. Whereas, the phytosociological analysis by Caiafa & Silva (2007), shares only *Esterhazya splendida*, ranking in the twenty-fourth position in terms of structural importance value, in Serra da Mantiqueira (Minas Gerais) as well as the physiognomy dominated by *Chusquea mimosa* within Serra do Ibitiraquire (Serra do Mar) in Paraná.

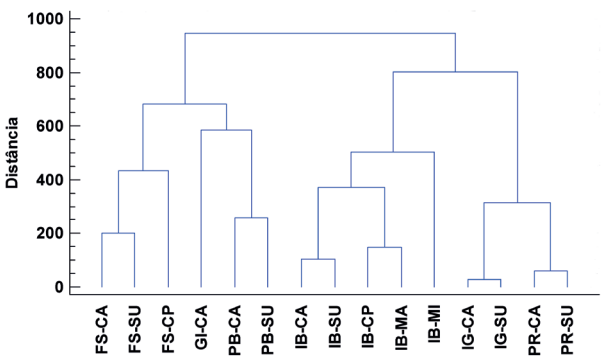

Figure 3. Clusters for upper montane grassland physiognomies in Southern Brazil using phytosociological importance values. Ward's method, City Block distances. Subranges: FS: Farinha Seca; GI: Gigante; PB: Pedra Branca do Araraquara; IB: Ibitiraquire; IG: Igreja; PR: Prata. Physiognomies: CA: Grassy; SU: Shrubby; CP: *Chusquea pinifolia*; MA: *Machaerina austrobrasiliensis*; MI: *Chusquea mimosa*.

Although the phytogeographical study by Safford (2007) has given greater emphasis to genus level, by using floristic lists for upper montane grasslands (high altitude grasslands) of subranges such as Itatiaia, Orgãos and Caparaó (Southeastern Brazil), showed considerable sharing in this taxonomic level, for example: *Cryptangium*, *Croton*, *Chusquea*, *Tibouchina*, *Hesperozygis*, *Alstroemeria*, *Esterhazya*, *Xyris*, *Mimosa*, *Gaultheria* and *Utricularia*. Based on Jaccard's index of similarity, Safford detected the following between upper montane grasslands (Southeastern areas) and Aparados da Serra Geral (Southern areas): 41.4% for genera and 9.1% for species.

Although a considerable number of common species were found in the upper montane grasslands within Serra do Mar in Paraná, the survey conducted by Falkenberg (2003) in upper montane environments within Aparados da Serra Geral in both States of Santa Catarina and Rio Grande do Sul, the author studied rupicolous vegetations adjacent to jetties and extremely steep slopes of basalt, which are quite different environments, and therefore, causing a major limiting factor for comparisons.

Currently, there have been several botanical surveys made available in the literature. Nevertheless, their updating, site specification and structural physiognomy of the habitat are needed so that other research studies may provide comparisons. Actually, there is a gap on the phytosociological structure of upper montane grasslands in Brazil. Such knowledge plays a very important role to better understand these environments.

Conclusions

The upper montane grasslands within Serra do Mar in Paraná occur in higher places of the mountains,

but they can also be found at lower altitudes, unlike what has been reported in other studies (over 1,200 m asl). Serra Gigante, for instance, where upper montane grasslands dominate mountain ridges between 1,000 and 1,070 m asl, even though they present some different species.

Cryptangium triquetrum and *Croton mullerianus* comprise the main species sampled in the upper montane grasslands of Serra do Mar in Paraná. The first species was the most important one in all the grassy stretches (subranges), while the second species stood out in the shrubby physiognomy within three sampled subranges. *Chusquea pinifolia*, *Machaerina austrobrasiliensis*, *Deschampsia caespitosa*, *Gleichenella pectitata*, *Tibouchina dubia*, *Xyris stenophylla*, *Eryngium koehnearum* and *Eriochrysis holcoides* also stood out in several stretches and physiognomies.

Phytosociological studies about grassland vegetation are quite scarce in Brazil. This situation still difficults better definitions of these environments on a continental scale, although our findings can serve as an important source of data for further ecological studies. Despite incipient, a certain similarity to genus, the comparisons among other upper montane vegetations mainly on rocky outcrops (considering the limitations of the analyzed sites) indicate that, there are likely great floristic-structural differences between the upper montane grasslands of Southern and Southeastern Brazil. In order to explain the occurrence of different physiognomies found in our study, as well as, in other surveys on upper montane ecosystems, further investigations are required, particularly regarding soils and geomorphology.

Finally, most of the species found in this study are not cited in the List of Species (the so called "indicator species") relating to Altitude Grasslands (campos de altitude montanos e altomontanos) of Southern Brazil (CONAMA Resolution 423/2010). This fact indicates that, the data about the structure of well-preserved native communities (such as the ones studied herewith) can help understanding the ecology of ecosystems as well as strategies for their protection and management.

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