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Plant diversity on granite/gneiss rock outcrop at Pedra do Pato, Serra do Brigadeiro State Park, Brazil

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Abstract: Campo de Altitude, one of the ecosystems associated with the Atlantic Forest, occurs mainly in high plateaus of Southeastern Brazil. The study area is in Serra do Brigadeiro State Park, Southeastern Brazil. We sampled six habitats (swamp field, *Vellozia* field, high mountain field, scrub slope, high altitude scrub, and cloud forest) that represent three physiognomies (grassland, scrub, and woodland). Overall, 180 species were recorded, belonging to 128 genera and 58 families. The richest families were Orchidaceae (20 species), Asteraceae (19), Melastomataceae (18), Rubiaceae (11), Myrtaceae (9) and Cyperaceae, Lauraceae, Solanaceae and Poaceae with five species each. The genera with highest number of species were: *Baccharis*, *Miconia* and *Tibouchina* with five species each; *Solanum* with four; *Paepalanthus, Myrcia, Myrciaria* and *Vellozia* with three.

Key words: mountain vegetation, campo de altitude, high altitude rocky complexes, gradient, Atlantic Forest domain

INTRODUCTION

The Atlantic Forest is known for its high plant endemism (Mori et al. 1981) and also as a center of global biodiversity (Barthlott et al. 1996). It is included among the 34 hotspots worldwide because of its high biodiversity and number of endemic species and because of habitat loss (Mittermeier et al. 2005). According to Stehmann et al. (2009) the richness of this domain is ca. 15,800 species, 48% of which are endemic. However, despite the legal protection, anthropic pressure (deforestation and overexploitation) still threatens the habitats, and consequently only a few fragments remain (11% of the original forest; Ribeiro et al. 2009).

Taking into consideration the large geographic area encompassed by the Atlantic Forest, latitudinal and altitudinal variation, as well as the presence of associated ecosystems, this domain presents considerable heterogeneity in floristic composition and habitats. This domain comprises tropical and subtropical regions with different vegetation type, both forest and non-forest types. A remarkable vegetation type associated with the Atlantic Forest is found mostly on quartzite, granite or gneiss rock outcrops. However, they are different from one another in floristic composition and structure of plant communities (Alves and Kolbek 2010). In Brazil, the ecosystem that occurs on quartzite is known as "Campo Rupestre", different from the ecosystems that occur on granite and gneiss which are known as "Campo de Altitude" and Inselberg. Campo de Altitude is high altitude grasslands above 1,700 m, although there are also similar formations in summits of lower mountains (Safford and Martinelli 2000). Inselberg usually is represented by dome-shaped outcrops abruptly rising in surrounding plains that attain different heights and can be found in a broad spectrum of sizes and various degrees of isolation (Bremer and Sander 2000).

Campo de Altitude, the object of the present study, mostly occurs in the highlands of Southeastern Brazil. Porembski (2007) pointed out that numerous mainland ecosystems such as inselbergs and mountain peaks can be considered terrestrial islands. Those isolated habitats present spatial and ecological isolation that works as a barrier against dispersion and migration. Ecological isolation can be attributed to the lack of soil and also the climate, whereas they are considered the coldest orobiome (*sensu* Walter 1984) in eastern South America, because of the high altitude and geographic exposure to southern winds and polar fronts (Safford 1999a, 1999b).

Campo de Altitude represents a small portion of the earth's surface, the total area is probably less than 350 km^2 (Safford 1999a). These areas are usually included in conservation units, mainly because they are useless for agriculture and grazing (Benites et al. 2007).

Different physiognomies are associated with rock outcrops in Campo de Altitude, forming a mosaic of synusiae with grassland, shrub, scrub and rock outcrop vegetation. Bare rocks, cliffs and rock peaks are also elements of the high altitude landscape (Safford and Martinelli 2000). This group of physionognomies shapes what we can call High Altitude Rocky Complexes (Benites et al. 2003).

The causes of Campo de Altitude formation are complex and rooted in the ancient landscape evolution, during the late Pleistocene, when the cold and dry climate was dominant in southeastern South America (Safford 1999b). The great number of endemic species indicates that they had a long term evolution and the paleobotanical evidence suggests that rock outcrops have covered the mountains tops of Southeastern Brazil since the Pleistocene (Behling and Lichte 1997; Safford 1999a).

The flora of Campo de Altitude has various origins, in which 21% of the genera are derived from temperate taxa originating outside Brazil (Safford 2007). This pattern is not exceptional for Brazil, but is found in most tropical mountains, since they possess a temperate climate (Safford 2007). According to Safford (2007), the Campo de Altitude is island of temperate climate above the tropical Atlantic Forest domain. Analysing the macroclimatic patterns, Safford (1999b) suggested that the Campo de Altitude is essentially a high latitude variant of tropical Andean *páramos*, with enhanced seasonality.

Despite this relationship with Andean highland flora, Campo de Altitude show little floristic similarity between each other. The Itatiaia mountain range, for example, presented only six species in common with Serra das Cabeças (Caiafa and Silva 2005; Ribeiro et al. 2007). Although both belong to the same large mountain range (Serra da Mantiqueira), the distance between the mountains is probably one of the factors that contributed to the low similarity (Siene et al. 2000). However, it is difficult to adequately discuss Campo de Altitude because we still have a severe lack of information about this habitat.

Considering the limited floristic data from this environment, the main objective of this article was to contribute to the knowledge of the flora of Pedra do Pato in Serra do Brigadeiro State Park, Minas Gerais State, Brazil; as well as contributing to greater information about the flora of Campo de Altitude in this area and the surrounding vegetation.

MATERIAL AND METHODS

Study area

The studied area is located in the southeast region of Brazil and is part of the Serra da Mantiqueira mountain range, with predominance of plutonic rocks (granite) and high grade metamorphics (migmatites, gneiss) (Benites et al. 2007). The Serra do Brigadeiro State Park is located in the Zona da Mata of Minas Gerais state and it is surrounded by the Atlantic Forest. The park belongs to eight municipalities: Araponga, Fervedouro, Miradouro, Ervália, Sericita, Pedra Bonita, Muriaé and Divino. The annual average rainfall is 1,300 mm and the annual average temperature is 18°C.

The terrain is rough and consists of different landforms and habitats: plateaux, steep slopes, escarpments, valleys and swamps (Schaefer et. al. 2007). The peaks in the park are all above 1,500 m, and Pedra do Pato reaches 1,980 m above sea level (20°44′35.64″ S, 042°28′03.5″ W). Due to the landscape and the altitude, it experiences much lower temperatures than the surrounding region.

Data collection

Pedra do Pato was named after its outline that resembles a duck (Figure 1). The study was carried out in six habitats (swamp field, *Vellozia* field, high mountain field, scrub slope, high altitude scrub and cloud forest) representing three physiognomies (grassland, scrub and woodland). The woodland forest was represented by cloud forest: vegetation in high altitude with a great humidity throughout the year. The samples were collected once a month during 2010 and the plants collected during the first reconnaissance expedition to the area were included in the list, but the habitats where they were collected was not specified (collecting permit: IEF number 094/10).

The fertile samples were registered in the Herbarium VIC at Universidade Federal de Viçosa (Minas Gerais, Brazil). The samples that were not in reproductive stage were no registered. The identifications were made by comparisons with exsiccates in the Herbarium VIC, by consulting specialists and literature. The classification of families and confirmation of accepted names follow the Lista de Espécies da Flora do Brasil (2014).

Comparison between areas of Campo de Altitude can be difficult due to different sampling efforts. However, we decided to compare our results to published floristic lists from 10 other sites. The published lists selected were the ones in which the studied vegetation were mentioned by the authors that was Campo de Altitude, so that to ensure that were not another type of vegetation on granite and gneiss. Thus, we compare our florist list with previously published floristic lists from Itatiaia, Serra das Cabeças (Totem Mountain), Alto Misterioso, Serra da Pedra Branca and six mountains of the Serra do Mar in Paraná.

Figure 1. View of the study area; Pedra do Pato Mountain, Serra do Brigadeiro State Park, Minas Gerais State, Brazil. Photo by Braz Cosenza.

RESULTS

A total of 180 species were sampled, belonging to 128 genera and 58 families. The richest families were Orchidaceae with 20 species (10.9% of the total), Asteraceae with 19 (10.3%), Melastomataceae with 18 (9.8%), Rubiaceae with 11 (6%), Myrtaceae with nine (4.9%), and Cyperaceae, Lauraceae, Solanaceae and Poaceae with five species each (2.7%). Altogether these represent almost 50% of the total species sampled (Table 1). A considerable number of families (31%) were only represented by a single species. The Pteridophytes were represented by three families: Anemiaceae, Lycopodiaceae and Pteridaceae. Anemiaceae was represented by only one genus, *Anemia*; Lycopodiaceae represented by *Diphasiastrum*, *Lycopodium* and *Palhinhaea*; and Pteridaceae by *Doryopteris*.

Among the angiosperms, the most representative genera were *Baccharis*, *Miconia* and *Tibouchina* with five species each; *Solanum* with four; *Paepalanthus*, *Myrcia*, *Myrciaria* and *Vellozia* with three.

The richest habitat in the present study was the *Vellozia* field, with 81 species, whereas the one with least number of species was the cloud forest with 18 species. In *Vellozia* field, the richest families were Orchidaceae (15 species) followed by Asteraceae (13 species), Cyperaceae and Eriocaulaceae (four species). *Vellozia* was the most abundant genus (Tinti et al. unpubl. data), but it was presented by three species only. In the cloud forest, we

Table 1. List of species from Pedra do Pato with their vouchers (VIC). Serra do Brigadeiro State Park, Minas Gerais, Brazil. CF: cloud forest, HAS: high altitude scrub, SS: scrub slope, VF: *Vellozia* field, SF: swamp field and HMF: high mountain field. The specific area of some species was not recorded, due to being collected during the first excursion for the reconnaissance of the area.

Family	Species	Voucher	CF	HAS	SS	VF	SF	HMF
Alstroemeriaceae	*Alstroemeria isabelleana* Herb.	38.632				X		
Amaryllidaceae	*Hippeastrum glaucescens* (Mart.) Herb.	38.218				X		
Annonaceae	*Annona* sp.	42.313						
	Xylopia sericea A.St.-Hil.	42.178			X			
Apocynaceae	*Ditassa leonii* Fontella & T.U.P.Konno	37.909					X	X
	Oxypetalum sp.	42.184						
Asteraceae	*Achyrocline satureioides* (Lam.) DC.	38.633				X	X	X
	Baccharis platypoda DC.	42.325		X		X	X	X
	Baccharis stylosa Gardner	42.333				X	X	
	Chromolaena costatipes (B.L.Rob.) R.M.King & H.Rob.	37.927				X	X	
	Eremanthus erythropappus (DC.) MacLeish	42.329		X	X			

Continued

Table 1. *Continued.*

Family	Species	Voucher	CF	HAS	SS	VF	SF	HMF
	Eupatorium sp.	42.314						
	Lepidaploa cf. *canescens* (Kunth) H.Rob.	38.635						X
	Stevia cf. *claussenii* Sch.Bip. ex Baker	38.634				X	X	
	Vernonanthura divaricata (Spreng.) H.Rob.	42.343	X		X			
Bignoniaceae	*Handroanthus albus* (Cham.) Mattos	37.922				X		
Bromeliaceae	*Dyckia weddelliana* Baker	37.915				X	X	X
	Pitcairnia cf. *carinata* Mez	37.912				X		
Campanulaceae	*Lobelia* cf. *fistulosa* Vell.	38.616		X				
Clethraceae	*Clethra scabra* Pers.	42.320	X	X	X		X	
Cunoniaceae	*Lamanonia ternata* Vell.	42.307			X			
Cyperaceae	*Bulbostylis scabra* (J.Presl & C.Presl) C.B.Clarke	37.917				X		
	Cryptangium comatum Boeckeler	42.199				X		
	Lagenocarpus rigidus Nees	42.196				X		
	Machaerina ficticia (Hemsl.) T.Koyama	42.188						
	Trilepis lhotzkiana Nees ex Arn.	37.910				X		
Elaeocarpaceae	*Sloanea hirsuta* (Schott) Planch. ex Benth.	42.195						
Ericaceae	*Gaultheria serrata* (Vell.) Sleumer ex Kin.-Gouv.	37.906						X
	Gaylussacia densa Cham.	42.194						
	Gaylussacia sp.	37.919				X		X
Eriocaulaceae	*Leiothrix flavescens* (Bong.) Ruhland	42.179				X		
	Paepalanthus macropodus Ruhland	42.166				X		
	Paepalanthus manicatus Poulsen ex Malme	42.167				X		
	Paepalanthus sp.	42.168				X		
Euphorbiaceae	*Alchornea triplinervia* (Spreng.) Müll.Arg.	42.169	X					
	Croton splendidus Mart.	42.191		X	X	X	X	X
	Sapium glandulosum (L.) Morong	42.308			X			
Fabaceae	*Crotalaria micans* Link	37.926				X	X	X
	Dalbergia foliolosa Benth.	42.339	X					
Gentianaceae	*Hockinia montana* Gardner	38.625				X	X	X
	Schultesia gracilis Mart.	42.332				X	X	X
Gesneriaceae	*Sinningia magnifica* (Otto & A.Dietr.) Wiehler	38.621					X	
	Vanhouttea leonii Chautems	38.626					X	
	Vanhouttea pendula Chautems	38.618					X	
Iridaceae	*Sisyrinchium* sp.	42.165				X		
Lamiaceae	*Hesperozygis nitida* (Benth.) Epling	37.921				X	X	X
Lauraceae	*Endlicheria paniculata* (Spreng.) J.F.Macbr.	42.321			X			
	Ocotea minarum (Nees & Mart.) Mez	42.317			X			
	Ocotea odorifera (Vell.) Rohwer	42.326			X			
	Persea americana Mill.	42.323			X			
Lentibulariaceae	*Utricularia* sp.	42.182				X		
Lycopodiaceae	*Lycopodium clavatum* L.	38.116				X	X	X
	Palhinhaea camporum (B. Øllg. & P.G. Windisch) Holub	38.115				X	X	X
Melastomataceae	*Behuria comosa* R.Tav. et al.	38.617				X		
	Huberia semiserrata DC.	37.920		X				
	Lavoisiera imbricata (Thunb.) DC.	37.908		X		X	X	X
	Marcetia taxifolia (A.St.-Hil.) DC.	42.180				X	X	X
	Miconia affinis DC.	42.311						
	Miconia sellowiana Naudin	42.322			X			
	Miconia theizans (Bonpl.) Cogn.	37.914			X			
	Tibouchina fothergillae (Schrank & Mart. ex DC.) Cogn.	37.907			X			
	Tibouchina manicata Cogn.	38.622				X	X	X
	Tibouchina sp.	38.624		X		X		
	Trembleya parviflora (D.Don) Cogn.	42.197		X			X	X
	Melastomataceae 1	38.623			X			
	Melastomataceae 2	38.108			X			
	Melastomataceae 3	42.198	X	X	X			
Meliaceae	*Cabralea canjerana* (Vell.) Mart.	42.324			X			
	Trichilia sp.	42.334			X			
Moraceae	*Sorocea bonplandii* (Baill.) W.C.Burger et al.	42.170			X			
Myrtaceae	*Calyptranthes* sp.	42.336			X			
	Marlierea affinis (O.Berg) D.Legrand	37.904			X			

Continued

Table 1. *Continued.*

Family	Species	Voucher	CF	HAS	SS	VF	SF	HMF
	Myrcia obovata (O.Berg) Nied.	37.902		X	X			
	Myrcia splendens (Sw.) DC.	38.629	X	X	X			
	Myrcia subcordata DC.	42.172		X	X			
	Myrciaria delicatula (DC.) O.Berg	38.112	X	X	X			
	Myrciaria tenella (DC.) O.Berg	37.913			X			
Nyctaginaceae	*Guapira opposita* (Vell.) Reitz	42.331			X			
Ochnaceae	*Ouratea vaccinioides* (A.St.-Hil. & Tul.) Engl.	42.183						
	Ouratea sp.	42.330						
Onagraceae	*Fuchsia* cf. *regia* (Vell.) Munz	38.111		X		X	X	X
Orchidaceae	*Acianthera prolifera* (Herb. ex Lindl.) Pridgeon & M.W.Chase	38.102				X		
	Acianthera teres (Lindl.) Borba	38.104				X		
	Bifrenaria harrisoniae (Hook.) Rchb.f.	38.103				X		
	Coppensia barbaceniae (Lindl.) Campacci	42.174				X	X	X
	Coppensia ramosa (Lindl.) Campacci	38.636				X	X	X
	Cranichis candida (Barb.Rodr.) Cogn.	38.097				X		
	Epidendrum secundum Jacq.	42.340				X		
	Govenia utriculata (Sw.) Lindl.	38.105		X	X			
	Grobya amherstiae Lindl.	38.099				X		
	Habenaria macronectar (Vell.) Hoehne	38.619				X	X	X
	Habenaria paranaensis Barb.Rodr.	38.620				X	X	X
	Hoffmannseggella cinnabarina (Batem. ex Lindl.) H.G.Jones	38.101				X		
	Prescottia montana Barb.Rodr.	42.177					X	X
	Sacoila lanceolata (Aubl.) Garay	38.100					X	X
	Zygopetalum maculatum (Kunth) Garay	42.190				X	X	X
Peraceae	*Pera glabrata* (Schott) Poepp. ex Baill.	42.341	X		X			
	Pera sp.	42.315						
Phyllanthaceae	*Phyllanthus* sp.	42.181				X	X	
Piperaceae	*Peperomia galioides* Kunth	42.338						
Poaceae	*Apochloa euprepes* (Renvoize) Zuloaga & Morrone	37.918				X	X	X
	Parodiolyra micrantha (Kunth) Davidse & Zuloaga	38.110						
	Poaceae sp.1	37.916				X		X
Polygalaceae	*Polygala stricta* A.St.-Hil. & Moq.	42.173				X		
Primulaceae	*Myrsine coriacea* (Sw.) R.Br. ex Roem. & Schult.	42.309	X		X			
	Myrsine umbellata Mart.	42.328	X	X				
Proteaceae	*Roupala montana* Aubl.	42.335	X	X	X	X	X	
Pteridaceae	*Doryopteris crenulans* (Fée) Christ	38.630				X		
Rubiaceae	*Borreria poaya* (A.St.-Hil.) DC.	37.901				X	X	X
	Declieuxia fruticosa (Willd. ex Roem. & Schult.) Kuntze	37.924				X	X	
	Galium hypocarpium (L.) Endl. ex Griseb.	38.106				X		X
	Palicourea cf. *marcgravii* A.St.-Hil.	37.923				X	X	
	Posoqueria sp.	42.306	X		X			
	Rudgea sessilis (Vell.) Müll.Arg.	38.107	X	X	X			
Rutaceae	*Zanthoxylum rhoifolium* Lam.	42.310						
Salicaceae	*Abatia americana* (Gardner) Eichler	38.109				X	X	X
Sapindaceae	*Matayba elaeagnoides* Radlk.	42.312			X			
Sapotaceae	*Chrysophyllum* sp.	42.318			X			
	Pouteria sp.	42.342			X			
Smilacaceae	*Smilax pilosa* Andreata & Leoni	42.327						X
Solanaceae	*Aureliana fasciculata* (Vell.) Sendtn.	42.337			X			
	Solanum leucodendron Sendtn.	38.627			X			
	Solanum pseudoquina A.St.-Hil.	42.186						
	Solanum sp.	42.316		X				
Velloziaceae	*Vellozia variegata* Goethart & Henrard	38.114				X	X	X
	Vellozia plicata Mart.	38.113				X	X	X
	Vellozia sp.	42.171						
Verbenaceae	*Lippia triplinervis* Gardner	42.329				X	X	X
Xyridaceae	*Xyris filifolia* L.A.Nilsson	37.925				X		

can highlight Myrtaceae (three species), Rubiaceae and Primulaceae (two species). The richest families in the scrubs were Melastomataceae (10 species), Myrtaceae (nine species) and Lauraceae, Asteracae (five species).

The flora at Pedra do Pato shared few species with the ten other mountains with which we compared the floristic list (Table 2). The site that showed the most similar floristic was Totém Mountain, part of Serra das Cabeças, which is also located in Serra do Brigadeiro State Park, and the studied area only shared two common species with Serra da Pedra Branca de Araraquara. The Serra da Pedra Branca in Minas Gerais had the richest inventory (502 species), but only 25 species were found in the area of this present study.

DISCUSSION

Despite the severe environmental conditions, rock outcrops present a great diversity of plants. Many authors that have worked with inventories in this ecosystem have registered a high number of species and have frequently discovered new species. Mocochinski and Scheer (2008), in the Serra do Mar of Paraná state, found 280 species on six mountains, paying special attention to Serra da Ibitiraquire with 224 species. Esgario et al. (2009) identified 172 species in Alto Misterioso and found 10 new species. These authors also highlighted that almost 50% of the species were restricted to the rock outcrop studied when compared with other areas. The rupicolous floras are very exclusive, present great adaptations and are restricted to specific areas. Rock outcrops close to each other can present distinct floristic compositions (Barthlott 1993).

The families that are frequently abundant and exhibit great species richness on rock outcrop vegetation in Brazil are Asteraceae and Orchidaceae (Esgario et al. 2009; Ribeiro et al. 2007; Rezende et al. 2013). However the richness of these families, as well as other families in these habitats, appears to be poorly estimated. We can attribute this to the lack of collections, as has been remarked by several other authors (Porembski 2007; Martinelli 2007; Pessanha et al. 2014). When it is possible to perform an intense field work, the number of species in those environments increases remarkably. Itacolomi State Park was considered the richest park for Asteraceae by Almeida (2008), who after an intensive field work identified 219 species of this family and described three new species.

The high richness found in Pedra do Pato can be related to the great variation of the habitats studied. Rock outcrops have varying species due to local variations in the depth and nature of the substrate, forming semi-circular to ovoidal shaped soil-islands (Meirelles et al. 1999). With greater soil depth, species adapted to higher moisture availability become dominant, with exclusion of dry-tolerant species. A great number of species (150 species) was also recorded on granite inselberg in the Nouragues Natural Reserve in French Guiana on a similar gradient (Sarthou et al. 2010) and in ironstone (127 species) in the Serra dos Carajás, Amazonia-Brazil (Nunes et al. in press). The diversity of habitats represents a variation in the resource availability and it correlates with a variation not only in the floristic composition, but also in the diversity of functional traits as a response to the different populations present on rock outcrop (de Paula et al 2015).

The floristic dissimilarity of the rock outcrops is notable when we compare our list with lists from the 10 previous studies. This highlights the difficulty of dispersion between rock outcrops due to the characteristic geographic isolation of their habitats. Sarthou et al. (2003), who studied three inselbergs in French Guiana, also found large differences in the composition of the vegetation between the areas. According to them, this difference is probably due to the low capacity of dispersal.

Rezende et al. (2015) also highlighted the diversity in Campo de Altitude and the great importance for conservation. The authors found 502 species in Serra da Pedra Branca, 46% of which belong to Campo de Altitude. The results of these authors also showed high floristic dissimilarity between the rock outcrops, when compared to ten other areas, and also presented a high number of

Table 2. Sites of rock outcrop used to compare the number of common species with Pedra do Pato (present study). S: richness, CS: common species.

Site	S	CS	Reference
Serra das Cabeças (Totem Mountain)	81	35	Caiafa and Silva 2005
Itatiaia Mountain	114	5	Ribeiro et al. 2007
Serra do Mar Paranaense	280		Mucochinski and Scheer 2008
Ibitiraquire	224	18	Mucochinski and Scheer 2008
Serra da Igreja	99	7	Mucochinski and Scheer 2008
Serra da Prata	93	5	Mucochinski and Scheer 2008
Serra da Farinha Seca	85	6	Mucochinski and Scheer 2008
Serra Gigante	80	4	Mucochinski and Scheer 2008
Serra da Pedra Branca de Araraquara	71	2	Mucochinski and Scheer 2008
Alto Misterioso	170	18	Esgario et al. 2009
Serra da Pedra Branca	502	25	Rezende et al. 2013

endemic species hosted in these environments. Alves and Kolbek (2010) also demonstrated the dissimilarity in rock outcrops and emphasized the number of endemic species in isolated outcrops (Conceição et al. 2007; Giulietti and Pirani 1988).

Large regional variations in floristic composition and in plant species richness have been demonstrated in studies of rock outcrop vegetation in different parts of the tropics (Porembski et al. 1997). In this respect, these authors emphasise the high diversity in the Brazilian Atlantic rainforest, pointing out that this diversity has not yet been analysed in detail.

The Campo de Altitude is considered relictual vegetation and presents many endemic species and microendemism that reflect the isolation of those communities (Veloso 1991; Ribeiro and Freitas 2010). Geographic barriers isolated the species on the top of the mountains and favour speciation and endemism (Benites et al. 2003). Therefore, like other vegetation on top of mountains, the Campo de Altitude are much more vulnerable to the loss of species because of climate change compared to the vegetation at lower altitudes since they are naturally restricted to small areas and specific habitats (Thuiller et al. 2005; Leão et al. 2014). According to Leão et al. (2014), the plants of Campo de Altitude associated with Atlantic Forest are the most endangered because they are restricted to small areas and exhibit high endemism. In addition, the habitat is naturally fragmented, which leads to a high vulnerability of the flora to the threat of extinction.

Pimm et al. (2010) suggested that Brazil is among the most biodiverse countries in the world but is also poorly known. In addition, the authors note that in some regions the number of endangered species in this country might increase 10–50%. Special attention must be paid to the biodiversity hotspots because 80% of species found since 1990 are from these areas. Unfortunately, these places also have exceptionally high level of habitat loss (Jappo et al. 2011). In addition, newly discovered species are already likely to be threatened by extinction when taxonomists finally describe them, because they are probably rare and endemic (Jappo et al 2011; Pimm et al. 2010).

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