Rodriguésia 73: e01712020. 2022
http://rodriguesia.jbrj.gov.br
DOI: http://dx.doi.org/10.1590/2175-7860202273051

Original Paper

Vascular epiphytes in the cloud forests of the Serra da Mantiqueira, Southeastern Region of Brazil

Samyra Gomes Furtado[1,3] *& Luiz Menini Neto*[2]

Abstract

Vascular epiphytes represent a remarkable characteristic of the tropical cloud forests. The Serra da Mantiqueira (SM) represents one of the main highland areas of Brazil harboring vegetation remnants, and highlighting the cloud forests. We present a checklist of the vascular epiphytes found in the cloud forests of the SM, discussing the data about taxonomic representativity, distribution in the phytogeographic domains, habits, threatened status in Brazil and the states comprising the SM (Espírito Santo-ES, Minas Gerais-MG, Rio de Janeiro-RJ, São Paulo-SP). Field expeditions were performed between 2012 and 2019, as well as data gathering from scientific collections and published articles. We found 678 species, representing approximately 20% and 30% of the species found in Brazil and Atlantic forest, respectively. The richest families (Orchidaceae, 288 spp.; Bromeliaceae, 112 spp.; Polypodiaceae 65 spp.) corroborated the patterns found in different scales. Forty-one species are threatened nationally (and regionally, there are 149 in ES, 55 in MG, six in RJ, 31 in SP). These numbers of richness and threatened species highlight the relevance of directing efforts toward knowledge and conservation of both cloud forest remnants and SM as a whole, under pain of losing of a large part of the floristic diversity of Atlantic forest.
Keywords: Atlantic Forest, native species, richness, threatened species.

Resumo

As epífitas vasculares representam uma característica marcante nas florestas nebulares tropicais. A Serra da Mantiqueira (SM) representa uma das principais áreas elevadas do território brasileiro, abrigando remanescentes vegetacionais, com destaque paras as florestas nebulares. Nós apresentamos uma listagem de epífitas vasculares encontradas nas florestas nebulares da SM, discutindo os dados sobre representatividade taxonômica, distribuição nos domínios fitogeográficos, hábitos, status de ameaça no Brasil e nos estados que compõem a SM (Espírito Santo-ES, Minas Gerais-MG, Rio de Janeiro-RJ, São Paulo-SP). Expedições de campo foram realizados entre 2012 e 2019, além de levantamento de dados de coleções científicas e trabalhos publicados. We found 678, representando algo em torno de 20% e 30% das espécies brasileiras e da Floresta Atlântica, respectivamente. As famílias mais ricas (Orchidaceae, 288 spp.; Bromeliaceae, 112 spp.; Polypodiaceae 65 spp.) confirmaram os padrões obtidos em diferentes escalas. Quarenta e uma espécies estão ameaçadas em nível nacional (e, regionalmente, 149 no ES, 55 em MG, seis no RJ, e 31 em SP). Os números de riqueza e de espécies ameaçadas de extinção ressaltam a relevância de direcionamento de esforços para o conhecimento e conservação tanto dos remanescentes de floresta nebular quanto da SM como um todo, sob pena de perda de grande parcela da diversidade florística da Floresta Atlântica.?
Palavras-chave: Floresta Atlântica, espécies nativas, riqueza, espécies ameaçadas.

See supplementary material at <https://doi.org/10.6084/m9.figshare.19597192>

[1] Universidade Federal de Juiz de Fora, Instituto de Ciências Biológicas, Prog. Pós-graduação em Biodiversidade e Conservação da Natureza, Juiz de Fora, MG, 36036-900, Brazil. ORCID: <https://orcid.org/0000-0002-1872-5603>

[2] Universidade Federal de Juiz de Fora, Instituto de Ciências Biológicas, Dep. Botânica. Juiz de Fora, MG, 36036-900, Brazil. ORCID: < ttps://orcid.org/0000-0001-8750-2422>

[3] Author for correspondence: furtadosg@gmail.com

Introduction

The tropical cloud forests are ecosystems which are typically found in a relatively narrow elevation zone and are characterized by persistent, frequent, or seasonal cloud cover in the vegetation level. This cover is responsible for horizontal precipitation which provides moisture for developing both the plants and the organic humid or flooded and highly organic soils, forming humus and peat. The vegetation is often composed of small trees with sclerophyll characteristics like twisted trunks and branches, dense and compact crowns, and small and rigid leaves. There is a high proportion of biomass composed of epiphytes (both lichens and vascular and avascular plants), and a decrease in lianas. These forests also present a great diversity of epiphytes, although trees, shrubs, and terricolous herbs are also very numerous, mainly if the reduced extension of the area occupied by this type of forest is considered due to the insular distribution and compared with the lowland rainforests which have high tree richness (Hamilton *et al.* 1995; Bruijnzeel *et al.* 2010). Three types of tropical cloud forests are recognized (submontane, upper montane, and subalpine) and present variations in the high canopy, the abundance of epiphytes and lianas, and in the elevation where they occur (Scatena *et al.* 2010).

It is an ecosystem which is currently threatened due to the degradation of the forests as a whole (Scatena *et al.* 2010), but also potentially under high risk from global climate changes, as they occur in high elevation and the plant species are dependent on the formation of clouds for obtaining moisture for surviving, especially during dry seasons (Still *et al.* 1999; Foster 2001; Loope & Giambeluca 2002; Ponce-Reyes *et al.* 2012; Hu & Riveros-Iregui 2016). As these areas are highly diverse and contain several endemic species, and due to the reduced and insular occurrence, changing precipitation, the formation of clouds, temperature, as well as the deforestation or decreasing in the coverage area could be disastrous for the conservation of several species (endemic or not). Furthermore, such changes will also influence the vital role that these forests play in maintaining quality freshwater due to their capacity to capture and condense the clouds and fog which are often present (Bubb *et al.* 2004; Bruijnzeel *et al.* 2010).

The presence of these forests in the Serra da Mantiqueira (SM), a mountainous chain mainly located in the Atlantic Forest along the border of the four states of the Southeastern Region of Brazil, Espírito Santo, Minas Gerais, Rio de Janeiro, and São Paulo (Várzea 1942; Machado-Filho *et al.* 1983; Gonzaga & Menini Neto 2017; Moraes *et al.* 2020; Pereira *et al.* 2021), was estimated by Pompeu *et al.* (2018) based on modeling potential distribution and remote sensor techniques using climatic, hydrometeorological and topographical variables. According to these authors, there is a predominance of these forests above 1500 m.s.m., but they are also present in lower areas of several sites of the SM (*e.g.*, Serra do Brigadeiro, Serra do Cruz, Serra do Ibitipoca, Serra Negra, personal observation). This estimation by Pompeu *et al.* (2018) was summed in the information presented by Drummond *et al.* (2005), Martinelli (2007), Stehmann & Sobral (2009), and Le Saout *et al.* (2013), thus corroborating the relevance of the SM for the Atlantic Domain biodiversity, indicating the necessity of effort for its knowledge and conservation.

As aforementioned, epiphytes are often in high abundance and richness in cloud forests (Webster 1995). This remarkable presence of epiphytes in the tropical cloud forests (Hamilton *et al.* 1995; Bruijnzeel *et al.* 2010), their ecological importance, and issues related to conservation (Benzing 1990; Zotz 2016) are responsible for several questions and highlight the necessity to better understand the diversity and distribution of this sinusya species. Thus, several recent studies have been published regarding the vascular epiphytes occurring in the SM, with part of them concentrated in the cloud forests, reinforcing its diversity (Menini Neto *et al.* 2009a; Barbosa *et al.* 2015, 2020; Alves & Menini Neto 2014; Furtado & Menini Neto 2015, 2016, 2018a,b). It is worth mentioning the checklist for the Parque Estadual do Ibitipoca in Minas Gerais state (Furtado & Menini Neto 2018a) as one of the richest published in Brazil, recording 224 species distributed in approximately 300ha of cloud forests.

There are growing efforts made in recent years to better understand the delimitation of Serra da Mantiqueira, knowledge of its floristic richness and provide subsidies for conservation (*e.g.*, Menini Neto *et al.* 2009a, b; Forzza *et al.* 2013, 2014; Pelissari & Romaniuc-Neto 2013; Rezende *et al.* 2013; Salimena *et al.* 2013; Pompeu *et al.* 2018; Antunes 2020; Gonzaga *et al.* 2020; Moraes *et al.* 2020; Moreira *et al.* 2020a, b; Pereira

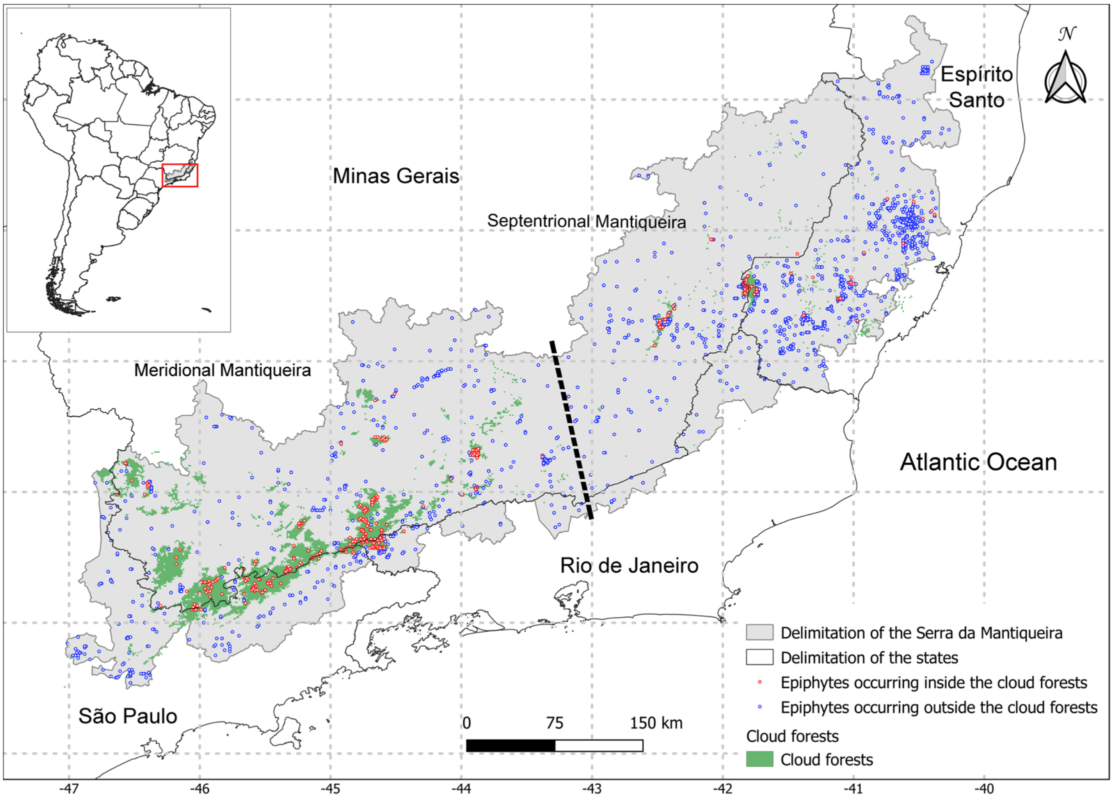

Figure 1 – Delimitation of the study area and distribution of records used in the list of vascular epiphytes of the cloud forests of the Serra da Mantiqueira, Southeast Region of Brazil. The dashed line represents the separation between the two sectors, Meridional Mantiqueira and Septentrional Mantiqueira.

et al. 2021). Thus, the present study aimed to sample and compile the vascular epiphytes in the cloud forests of this mountain chain, presenting a checklist and discussing the data about taxonomic representativity, distribution in the phytogeographic domains, habits, threat status in Brazil and the four states where the SM is located.

Material and Methods

Study area

The study area comprises the cloud forests of the Serra da Mantiqueira with its delimitation according to Pompeu *et al.* (2018) and Pereira *et al.* (2021) (Fig. 1), respectively, comprising part of the states of Espírito Santo, Minas Gerais, Rio de Janeiro, and São Paulo. Two sectors are recognized for this mountain chain, namely Septentrional Mantiqueira and Meridional Mantiqueira, defined by Machado-Filho *et al.* (1983) (see Gonzaga & Menini Neto (2017) for a more detailed panorama about this delimitation).

Dataset

The dataset was partly constructed by field expeditions performed between the years 2012 and 2019, concentrated in some of the main conservation units (CUs) with integral protection located in the Serra da Mantiqueira: Parque Estadual (PE) do Ibitipoca, PE Serra do Papagaio, PE Serra do Brigadeiro, PE Campos de Jordão, Parque Nacional (PN) do Caparaó, and PN do Itatiaia. Apart from these areas, other types of conservation units or areas outside these CUs were also sampled such as Monumento Natural Estadual da Pedra do Baú, Serra da Bandeira, Serra do Cruz, Serra Negra, Maciço Marins e Itaguaré. The specimens collected in those expeditions are deposited in the CESJ Herbarium of the Universidade Federal de Juiz de Fora (acronym according to Thiers *et al.* 2019, continuously updated).

We also gathered records of vascular epiphytes in the SpeciesLink (<http://splink.org.br/>) and SiBBr (<https://sibbr.gov.br/>) virtual data banks and also used the data published by Ramos *et al.* (2019) in first filtering of the data inside the delimitation of the SM proposed by Pereira *et al.* (2021) (Fig. 1) in order to complement this field sampling. Next, the resulting records were refined according to the probability of occurrence of cloud forests presented by Pompeu *et al.* (2018).

The data preparation steps after the filtering in the databanks were: 1) try to minimize misidentification (by using specimens identified by specialists in the families or consultation with specialists when doubts arose); 2) consulting genera and species nomenclature on the Flora do Brasil 2020 (continuously update); 3) georeferencing the specimens when the sheet labels allowed this.

The presented list is composed of native vascular epiphytes occurring in the cloud forests of the Serra da Mantiqueira and one voucher was selected for each species (or cited Ramos *et al.* (2019) as a reference in some cases where specimens were not found at the above indicated sites). We did not consider the Moraceae, often occurring as hemiepiphytes in at least part of their lifecycle, due to the difficulty to obtain information only from sheet labels, since the majority of collections are performed when the plants present arboreous habits and phorophytes are not present. We also disregarded the Clusiaceae and Marcgraviaceae, both with hemiepiphytic species, since the sheet labels did not present complete information, despite the field observation of some species. The preferred vouchers are those collected by the authors. The acronyms of the herbaria where the vouchers are deposited are according to Thiers *et al.* (2019, continuously updated). The Angiosperm families are according to APG IV (2016), while those of ferns are according to PPG I (2016).

The data regarding habits and phytogeographic domains in Brazil were obtained from the Flora do Brasil 2020 (continuously update), and threat status were obtained from Centro Nacional de Conservação da Flora (CNCFlora) (<http://www.cncflora.jbrj.gov.br>). We considered all those species indicated in the aforementioned site as 'epiphyte' or 'hemiepiphyte', including facultative epiphytes (whose habits also included 'rupicolous' and 'terricolous', beyond epiphyte). For some species without indication of epiphytic habitat in the Flora do Brasil 2020, we took into account the field observations made by the authors and considered them on the list. The data regarding threat status for each state were obtained from the respective red lists: Espírito Santo (Fraga *et al.* 2019), Minas Gerais (COPAM-MG 2008), Rio de Janeiro (Martinelli *et al.* 2018), and São Paulo (SMA-SP 2016).

Results and Discussion

The vascular epiphytes are represented in the cloud forests of the Serra da Mantiqueira by 678 species, distributed in 131 genera and 23 families (Tab. S1, available on supplementary material <https://doi.org/10.6084/m9.figshare.19597192>). This value corresponds to approximately 30% of all richness of vascular epiphytes of the Atlantic Forest (Freitas *et al.* 2016) and almost 20% of all vascular epiphytes recorded for Brazil (Flora do Brasil 2020 (continuously updated)).

The monocots stand out among the evolutionary lineages with 427 species (63%), distributed in four families, while the ferns (monilophytes) are represented by 153 species (22.5%), belonging to eight families, followed by eudicots (48 spp., 7,1%) in nine families, magnoliids (36 spp., 5.3%), only represented by Piperaceae, and lycophytes (14 spp., 2.1%), having Lycopodiaceae as an exclusive representative. The great representativeness of monocots is mainly due to Orchidaceae and Bromeliaceae, two of the richest families of vascular epiphytes. Polypodiaceae and Cactaceae stand out, respectively, among the ferns and eudicots, with both being globally well-represented in those groups (Benzing 1990; Zotz 2013, 2016).

The richest families are Orchidaceae (288 spp., 42,5%), Bromeliaceae (112 spp., 16,6%), and Polypodiaceae (65 spp., 9,6%), comprising approximately 69% of all recorded vascular epiphytes (Fig. 2). These are the three richest families in vascular epiphytes (Zotz 2013) in the Tropical Region (Gentry & Dodson 1989) and in the Atlantic Forest (Freitas *et al.* 2016), and repeat a common pattern often found in local studies in Brazil in different physiognomies (*e.g.*, Borgo & Silva 2003; Buzzato *et al.* 2008; Mania & Monteiro 2010; Bonnet *et al.* 2013; Alves & Menini Neto 2014; Barbosa *et al.* 2015; Couto *et al.* 2016; Furtado & Menini Neto 2016; Joanitti *et al.* 2017). It is worth mentioning the fact that SM concentrates 23 of the 33 families with epiphytic representatives found in the Atlantic Forest (Freitas *et al.* 2016) or approximately 1/3 of those

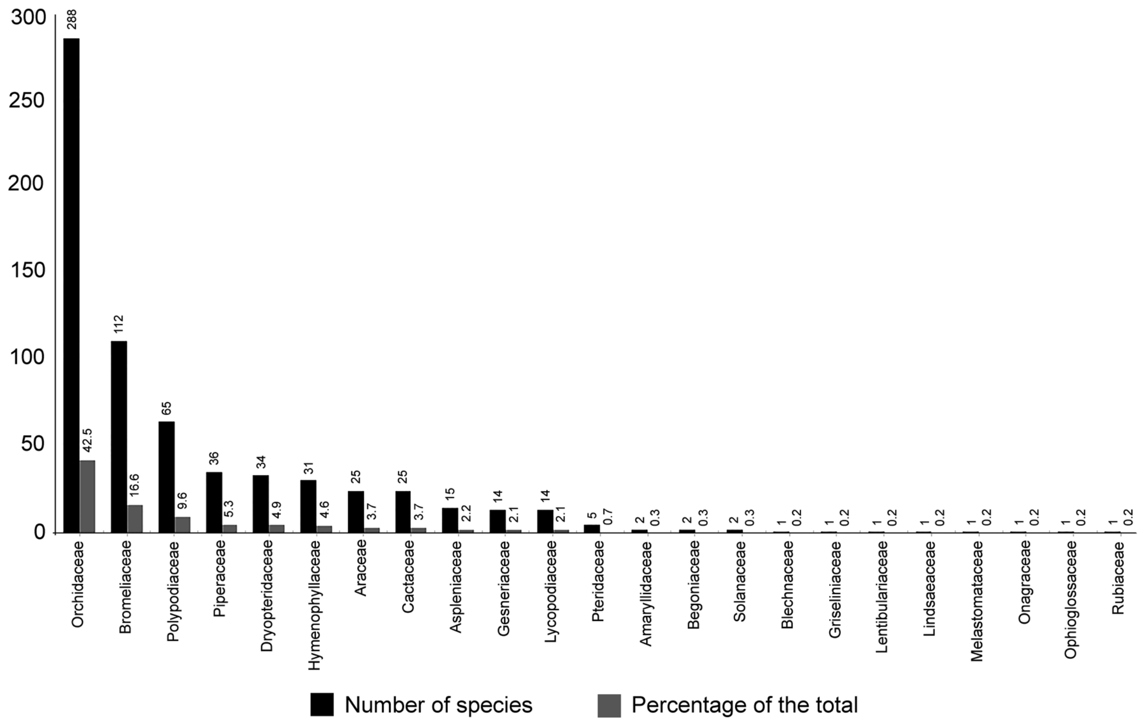

Figure 2 – Richness and percentage of the 23 families of vascular epiphytes recorded in the cloud forests of the Serra da Mantiqueira, Southeastern Region of Brazil.

that harbor species of vascular epiphytes (Zotz 2016). Furthermore, approximately half of the families (11) are represented by only one or two species, reinforcing the existence of strong uneven distribution of richness among the families, as observed by Benzing (1990) and Zotz (2016).

A total of 23 genera presented more than 10 species (representing 394 spp. or 58.3% of the total), with *Vriesea* and *Peperomia* as the richest ones (with 37 and 36 species, respectively) (Fig. 2). *Vriesea* as the richest genus is justified since it is the more diverse genus of Bromeliaceae in Brazil, with approximately 200 species (Gomes-da-Silva & Souza-Chies 2017; BFG 2018) and the Atlantic Forest is an important diversity and endemism center (Martinelli *et al.* 2008). The relevance of *Peperomia* was highlighted by Menini Neto *et al.* (2009a) and its representativeness in the cloud forests of SM is justified since it is the richest genera of vascular epiphytes if not considering Orchidaceae (Zotz 2016).

A relevant percentage (68.8%) of the species recorded is endemic to the Atlantic Forest, with 466 species. This phytogeographic domain is the richest in plant species as a whole (BFG 2018) and also the richest in vascular epiphytes in Brazil (Freitas *et al.* 2016), with high rates of endemic species. It is remarkable that the Serra da Mantiqueira only protects a high number of endemic species for this phytogeographic domain in cloud forests (meaning a small portion of the mountain chain and even smaller in the Atlantic Forest), mainly if we take into account that several species are restricted to the SM such as *Aechmea aiuruocensis* Leme (Bromeliaceae), *Anthurium leonii* E.G.Gonç. (Araceae), *Codonanthe gibbosa* Rossini & Chautems and *Nematanthus kautskyi* Chautems & Rossini (Gesneriaceae), *Hatiora herminiae* (Porto & A.Castell.) Backeb. ex Barthlott and *Schlumbergera lutea* Calvente & Zappi (Cactaceae), and *Thysanoglossa jordanensis* Porto & Brade (Orchidaceae), among others.

It is difficult to list a set of species indicative of this type of forest, however we can cite some which are often found in the cloud forests of the SM, although they are not exclusive to this physiognomy, such as: *Anthurium minarum* Sakur. & Mayo, *A. scandens* (Aubl.) Engl. (Araceae), *Asplenium auritum* Sw. (Aspleniaceae), *Billbergia distachia* (Vell.) Mez, *Vriesea bituminosa* Wawra, *V. heterostachys* (Baker) L.B.Sm. (Bromeliaceae), *Hatiora salicornioides* (Haw.) Britton & Rose, *Rhipsalis floccosa* Salm-Dyck ex Pfeiff. (Cactaceae), *Elaphoglossum vagans* (Mett.) Hieron., *Rumohra adiantiformis* (G.Forst.) Ching (Dryopteridaceae), *Nematanthus crassifolius* (Schott) Wiehler, *N. strigillosus* (Mart.) H.E.Moore (Gesneriaceae), *Griselinia ruscifolia* (Clos) Taub. (Griseliniaceae), *Hymenophyllum polyanthos* (Sw.) Sw., *Polyphlebium angustatum* (Carmich.) Ebihara & Dubuisson (Hymenophyllaceae), *Fuchsia regia* (Onagraceae), *Acianthera saundersiana* (Rchb.f.) Pridgeon & M.W.Chase, *Anathallis rubens* (Lindl.) Pridgeon & M.W.Chase, *Bulbophyllum granulosum* Barb.Rodr., *Cattleya coccinea* Lindl., *Epidendrum chlorinum* Barb. Rodr., *Gomesa ranifera* (Lindl.) M.W.Chase & N.H.Williams, *Octomeria crassifolia* Lindl., *Stelis megantha* Barb.Rodr., *S. papaquerensis* Rchb.f. (Orchidaceae), *Peperomia tetraphylla* (G.Forst.) Hook. & Arn. (Piperaceae), *Cochlidium punctatum* (Raddi) L.E.Bishop, *Lellingeria apiculata* (Kunze *ex* Klotzsch) A.R.Sm. & R.C.Moran, *Pecluma pectinatiformis* (Lindm.) M.G.Price, *Pleopeltis macrocarpa* (Bory *ex* Willd.) Kaulf., *Serpocaulon catharinae* (Langsd. & Fisch.) A.R.Sm. (Polypodiaceae), and *Dyssochroma viridiflorum* (Sims) Miers (Solanaceae) (Figs. 3-4).

Regarding the habits, 391 species are characteristic epiphytes (those listed in the site Flora do Brasil 2020 (continuously updated) only with the 'epiphyte' habit), 18 are hemiepiphyte, and the remaining species (268) are facultative epiphytes (species also presenting rupicolous and terricolous habits) (Supplementary material).

Among the threatened species (considering the CR – critically endangered, EN – endangered, and VU – vulnerable categories), 41 were cited for Brazil (Martinelli & Moraes 2013), 149 for the Espírito Santo (Fraga *et al.* 2019), 55 for Minas Gerais (COPAM 2008), six for the Rio de Janeiro (Martinelli *et al.* 2018) considering only the species endemic to this state, and 31 for São Paulo (SMA-SP 2016) (Supplementary material). At least 15 species are cited in three of the five aforementioned red lists and 46 species are considered on two lists. The great number of threatened vascular epiphytes, both globally and regionally, is a reflection of the fragility of several species of this synusia to environmental impacts like the transformation of forest areas into cropland and pastures, climatic changes, a decreasing number of pollinators (Hietz 1999; Köster *et al.* 2009; Zotz & Bader 2009; Werner *et al*. 2011; Böhnert *et al.* 2016). However, it is also related to the fact that several species are considered ornamental and have high appeal among ecotourists, tradespeople, and plant collectors, whose removal has the potential to significantly impact their populations whether on a large scale or not (Mondragón Chaparro & Ticktin 2011; Toledo-Aceves *et al.* 2014; Wraith & Pickering 2017; Delgado 2019). The red lists are characterized by being dynamic and the need for this method is clear in the indication of species which should have their threat status reviewed both regionally and globally, as highlighted in the studies of Cactaceae (Gonzaga *et al.* 2020) and Gesneriaceae (Pereira *et al.* 2021) in the SM environment.

The conservation potential of much of the biodiversity of the Atlantic Forest in a mountain chain as the SM is corroborated and reinforced in this study about the vascular epiphytes occurring in their cloud forests. Unfortunately, large extensions of the SM land have become highly modified over time from pastures for cattle, monocultures of eucalyptus and pine, and/or varied crops for food purposes (such as coffee and banana, among others), real estate speculation, mining, etc. (Hueck 1972; Joly *et al.* 1991; Mendes Júnior *et al.* 1991; Gonzaga & Menini Neto 2017). The less impacted areas or those which have been regenerating for longer are found in mountainous regions, and were generally transformed in the last century in conservation units, seeking to save at least a part of the remaining biodiversity, but several other priority areas were indicated to direct conservation and/or research efforts (Drummond *et al.* 2005; Gonzaga & Menini Neto 2017). The cloud forests are in these mountainous areas, a relatively small part of the Atlantic Forest, but have high relevance for preserving the diversity of the country, since this region is also recognized for harboring great diversity and endemism of other taxonomic/functional groups (Drummond *et al.* 2005; Martinelli 2007; Versieux & Wendt 2007; LeSaout *et al.* 2013; Stehmann & Sobral 2009; Pelissari & Romaniuc Neto 2013; Gonzaga *et al.* 2020; Pereira *et al.* 2021).

The urgent need to safeguard what remains of natural environments is evident, especially due

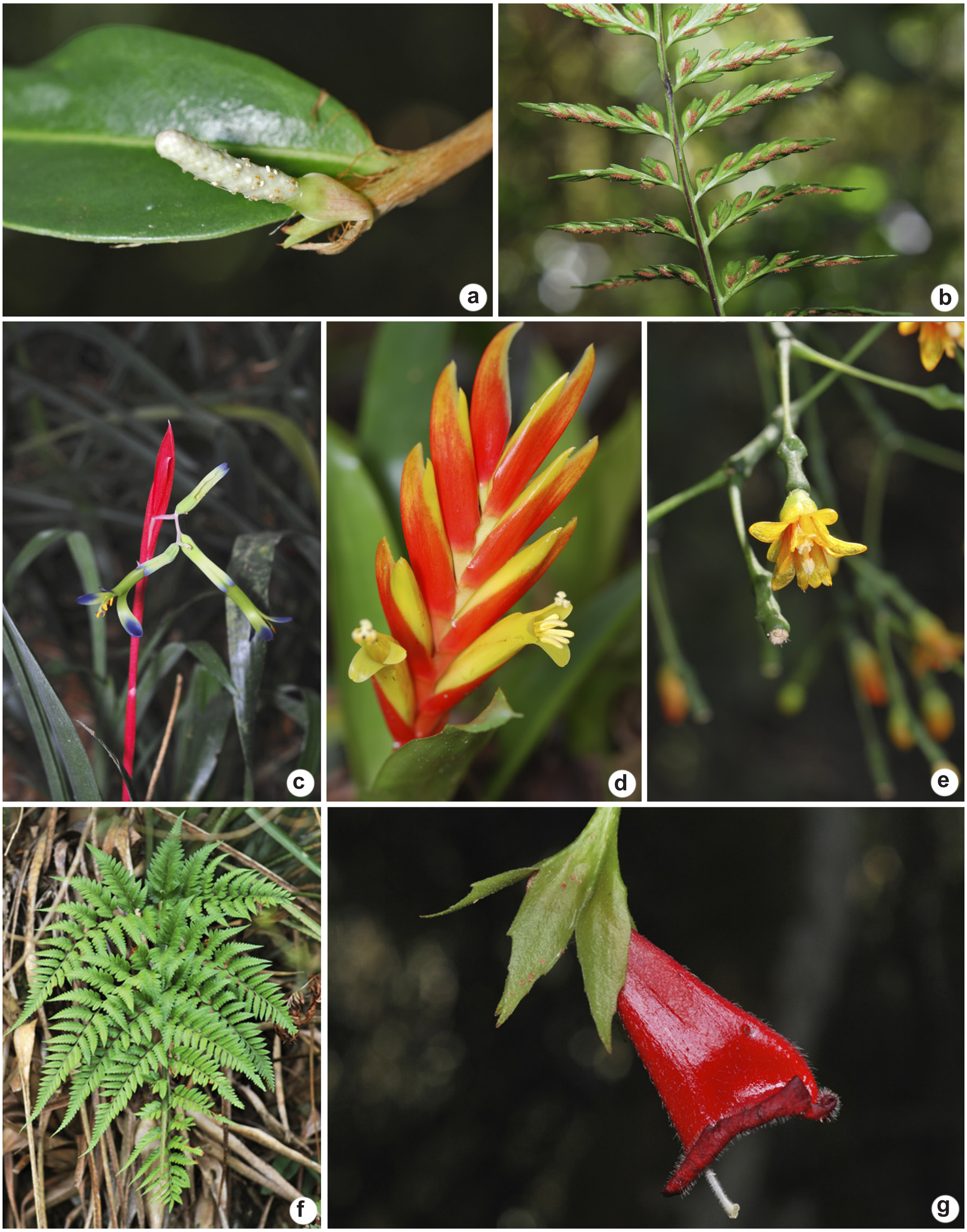

Figure 3 – a. Araceae: *Anthurium scandens* (Aubl.) Engl.; b. Aspleniaceae: *Asplenium auritum* Sw.; c-d. Bromeliaceae: c. *Billbergia distachia* (Vell.) Mez, d. *Vriesea heterostachys* (Baker) L.B.Sm.; e. Cactaceae: *Hatiora salicornioides* (Haw.) Britton & Rose; f. Dryopteridaceae: *Rumohra adiantiformis* (G.Forst.) Ching; g. Gesneriaceae: *Nematanthus crassifolius* (Schott) Wiehler (photos: L. Menini Neto).

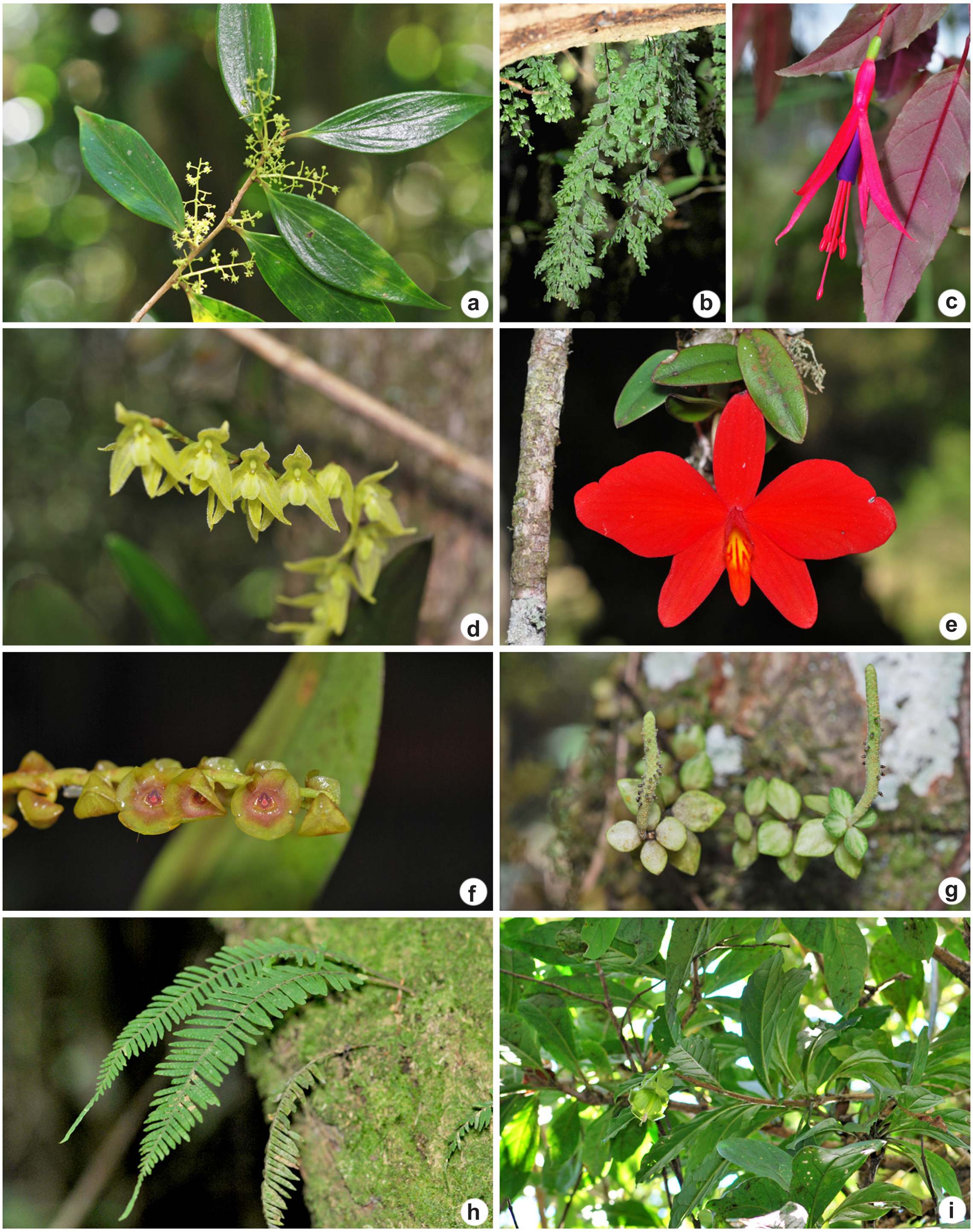

Figure 4 – a. Griseliniaceae: *Griselinia ruscifolia* (Clos) Taub.; b. Hymenophyllaceae: *Hymenophyllum polyanthos* (Sw.) Sw.; c. Onagraceae: *Fuchsia regia* (Vell.) Munz; d-f. Orchidaceae: d. *Anathallis rubens* (Lindl.) Pridgeon & M.W.Chase; e. *Cattleya coccinea* Lindl.; f. *Stelis megantha* Barb.Rodr.; g. Piperaceae: *Peperomia tetraphylla* (G.Forst.) Hook. & Arn.; h. Polypodiaceae: *Lellingeria apiculata* (Kunze ex Klotzsch) A.R.Sm. & R.C.Moran; i. Solanaceae: *Dyssochroma viridiflorum* (Sims) Miers (photos: L. Menini Neto).

to the speed at which the degradation is currently occurring, so that efforts must be made to produce knowledge and provide subsidies so that decision-makers can take into account elements to perform their functions properly.

Acknowledgements

We wish to thank the Programa de Pós-graduação em Ecologia of Universidade Federal de Juiz de Fora. This study was financed in part by the Coordenação de Aperfeiçoamento e Pessoal de Nível Superior - Brasil (CAPES), Finance Code 001. We also thank to Carlos Mariano Alvez-Valles, Dayvid Rodrigues Couto, Diego Rafael Gonzaga, Andrea Pereira Luizi-Ponzo, Talita Mota Machado, and Flávio Nunes Ramos.

References

Alves FE & Menini Neto L (2014) Vascular epiphytes in a forest fragment of Serra da Mantiqueira and floristic relationships with Atlantic high altitude areas in Minas Gerais. Brazilian Journal of Botany 37: 187-196.

Antunes K (2020) Myrtaceae Juss. da Serra da Mantiqueira, Sudeste, Brasil: distribuição, serviços ecossistêmicos e conservação. Dissertação de Mestrado. Universidade Federal de Juiz de Fora, Juiz de Fora. 242p.

APG IV (2016) An update of the Angiosperms Phylogeny Group classification for the orders and families of flowering plants: APG IV. Botanical Journal of the Linnean Society 181: 1-20.

Barbosa DEF, Basílio GA, Silva FR & Menini Neto L (2015) Vascular epiphytes in a remnant of seasonal semideciduous forest in Zona da Mata of Minas Gerais Brazil. Bioscience Journal 31: 623-633.

Barbosa DEF, Basílio GA, Furtado SG & Menini Neto L (2020) The importance of heterogeneity of habitats for the species richness of vascular epiphytes in remnants of Brazilian montane seasonal semideciduous forest. Edinburgh Journal of Botany 77: 99-118.

Benzing DH (1990) Vascular epiphytes: general biology and related biota. University Press Cambridge, Cambridge. 376p.

BFG - The Brazil Flora Group (2018) Brazilian Flora 2020: Innovation and collaboration to meet Target 1 of the Global Strategy for Plant Conservation (GSPC). Rodriguésia 69: 1513-1527.

Böhnert T, Wenzel A, Altenhövel C, Beeretz L, Tjitrosoedirdjo SS, Meijide A, Rembold K & Kreft H (2016) Effects of land-use change on vascular epiphyte diversity in Sumatra (Indonesia). Biological Conservation 202: 20-29.

Bonnet A, Caglioni E, Schmitt JL, Cadorin TJ, Gasper AL, Andrade S, Schroeder BG, Cristofolini C, Oliveira CPL, Lingner DV, Uhlmann A, Sevegnani L & Vibrans AC (2013) Epífitos vasculares da Floresta Ombrófila Densa de Santa Catarina. *In*: Vibrans AC, Bonnet A, Caglioni E, Gasper AL & Lingner DV (eds.) Inventário florístico florestal de Santa Catarina. Vol. 5. Edifurb, Blumenau. Pp. 27-71.

Borgo M & Silva SM (2003) Epífitos vasculares em fragmentos de Floresta Ombrófila Mista, Curitiba, Paraná, Brasil. Revista Brasileira de Botânica 26: 391-401.

Bruijnzeel LA, Kappelle M, Mulligan M & Scatena FN (2010) Tropical montane cloud forests: state of knowledge and sustainability perspectives in a changing world. *In*: Bruijnzeel LA, Scatena FN & Hamilton LS (eds.) Tropical Montane Cloud Forests: science for conservation and management. Cambridge University Press, Cambridge. Pp. 691-700.

Bubb P, May I, Miles L & Sayer J (2004) Cloud Forest Agenda UNEP-WCMC, Cambridge, UK. Available at <http://wwwunep-wcmcorg/resources/publications/UNEP_WCMC_bio_series/20htm>. Access on 16 October 2019.

Buzzato CR, Severo BMA & Waechter JL (2008) Composição florística e distribuição ecológica de epífitos vasculares na Floresta Nacional de Passo Fundo, Rio Grande do Sul. Iheringia, Sér. Bot. 63: 231-239.

COPAM (2008) Lista das espécies ameaçadas de extinção da flora do estado de Minas Gerais. Conselho Estadual de Política Ambiental, Minas Gerais 367: 48 pp.

Couto DR, Fontana AP, Kollmann LJC, Manhães VC, Francisco TM & Cunha GM (2016) Vascular epiphytes in seasonal semideciduous forest in the state of Espírito Santo and the similarity with other seasonal forests in Eastern Brazil. Acta Scientiarum. (Biological Science) 38, 169-177.

Delgado CN (2019) Biologia reprodutiva e distribuição espacial de *Hadrolaelia coccinea* (Lindl.) Chiron & V.P.Castro (Orchidaceae, Laeliinae) no Parque Estadual do Ibitipoca, Minas Gerais, Brasil. Dissertação de Mestrado. Universidade Federal de Juiz de Fora, Juiz de Fora. 105p.

Drummond GM, Martins CS, Machado ABM, Sebaio FA & Antonini Y (orgs.) (2005) Biodiversidade em Minas Gerais, um atlas para sua conservação. 2a ed. Fundação Biodiversitas, Belo Horizonte. 222p.

Flora do Brasil 2020 (continuously updated) Jardim Botânico do Rio de Janeiro. Available at <http://floradobrasil.jbrj.gov.br/>. Accessed on 15 May 2020

Forzza RC, Menini Neto L, Salimena FRG & Zappi D (orgs.) (2013) Flora do Parque Estadual do Ibitipoca e seu entorno. Editora UFJF, Juiz de Fora. 382p.

Forzza RC, Pifano DS, Oliveira-Filho AT, Meireles LD, Faria PL, Salimena FR, Mynssen CM & Prado J (2014) Flora vascular da Reserva Biológica da Represa do Grama, Minas Gerais, e sua relação florística com outras florestas do sudeste brasileiro. Rodriguésia 65: 275-292.

Foster R (2001) The potential negative impacts of global climate change on tropical montane cloud forests. Earth-Science Reviews 55: 73-106.

Fraga CN, Formigoni MH & Chaves FG (orgs.) (2019) Fauna e flora ameaçadas de extinção no estado do Espírito Santo. Instituto Nacional da Mata Atlântica, Santa Teresa. 432p.

Freitas L, Salino A, Menini Neto L, Almeida TE, Mortara SR, Stehmann JR, Amorim AM, Guimarães EF, Coelho MN, Zanin A & Forzza RC (2016) A comprehensive checklist of vascular epiphytes of the Atlantic Forest reveals outstanding endemic rates. PhytoKeys 58: 65-79.

Furtado SG & Menini Neto L (2015) Diversity of vascular epiphytes in two high altitude biotopes of the Brazilian Atlantic Forest. Brazilian Journal of Botany 38: 295-310.

Furtado SG & Menini Neto L (2016) Vascular epiphytic flora of a high montane environment of Brazilian Atlantic Forest: composition and floristic relationships with other ombrophilous forests. Acta Botanica Brasilica 30: 422-436.

Furtado SG & Menini Neto L (2018a) Elevational and phytophysiognomic gradients influence the epiphytic community in a cloud forest of the Atlantic phytogeographic. Plant Ecology 219: 677-690.

Furtado SG & Menini Neto L (2018b) Diversity high up: a cloud forest of the Serra da Mantiqueira as a vascular epiphyte hotspot. Rodriguésia 69: 263-279.

Gentry AH & Dodson CH (1987) Diversity and biogeography of neotropical vascular epiphytes. Annals of the Missouri Botanical Garden 74: 205-223.

Gomes-da-Silva J & Souza-Chies TT (2017) What actually is *Vriesea*? A total evidence approach in a polyphyletic genus of Tillandsioideae (Bromeliaceae, Poales). Cladistics 2017: 1-19.

Gonzaga DR & Menini Neto L (2017) Estado da conservação da Serra da Mantiqueira: ameaças, lacunas, avanços e perspectivas do conhecimento da flora. *In*: Barbosa BC, Resende LO, Prezoto F & Gonçalves EL (orgs.) Tópicos em sustentabilidade e conservação. Real Consultoria em Negócios, Juiz de Fora. 107p.

Gonzaga DR, Menini Neto L & Peixoto AL (2020). Cactaceae na Serra da Mantiqueira, Brasil. Rodriguésia 71: e02572018.

Hamilton LS, Juvik JO & Scatena FN (eds.) (1995) Tropical montane cloud forests. Springer Verlag, New York. 407p.

Hietz P (1999) Diversity and conservation of epiphytes in a changing environment. International conference on biodiversity and bioresources: conservation and utilization. Phuket, Thailand. Available at <http://www.iupac.org/symposia/proceedings/phuket97/hietz.html>. Access on 25 January 2020.

Hu J & Riveros-Iregui DA (2016) Life in the clouds: are tropical montane cloud forests responding to changes in climate. Oecologia 180: 1061-1073.

Hueck K (1972) As florestas da América do Sul. Ecologia, composição e importância econômica. Polígono, São Paulo. 466p.

Joanitti AS, Weiser VL, Cavassan O & Giles AL (2017) Vascular epiphytes in a woodland savanna forest in southeastern Brazil. The Journal of the Torrey Botanical Society 144: 439-449.

Joly CA, Leitão Filho HF & Silva SM (1991) Vegetação da Mata Atlântica. *In*: Cecchi JC & Soares MSM (coords.) Mata Atlântica/Atlantic Rain Forest. Fundação SOS Mata Atlântica, Rio de Janeiro. Pp. 95-125.

Köster N, Friederich K, Nieder J & Barthlott W (2009) Conservation of epiphyte diversity in an Andean landscape transformed by human land use. Conservation Biology 23: 911-919.

Le Saout S, Hoffmann M, Shi Y, Hughes A, Bernard C, Brooks TM, Bertzky B, Butchart SHM, Stuart SN, Badman T & Rodrigues ASL (2013) Protected areas and effective biodiversity conservation. Science 342: 803-805.

Loope LL & Giambeluca TW (2002) Vulnerability of island tropical montane cloud forests to climate change, with special reference to East Maui, Hawaii. *In*: Markham A (ed.) Potential impacts of climate change on tropical forest ecosystems. Springer, Dordrecht. Pp. 363-377.

Machado-Filho L, Ribeiro MW, Gonzalez SR, Gonzalez SR, Schemini CA, Santos Neto A, Palmeira RCB, Pires I, Teixeira W & Castro HF (1983) Folhas SF 23/24 Rio de Janeiro e Vitória. Geologia. RADAMBRASIL, Rio de Janeiro. vol. 32.

Mania LF & Monteiro R (2010) Florística e ecologia de epífitas vasculares em um fragmento de floresta de restinga, Ubatuba, SP, Brasil. Rodriguésia 61(4): 705-713.

Martinelli G (2007) Mountain biodiversity in Brazil Revista Brasileira de Botânica 30: 587-597.

Martinelli G, Vieira CM, Gonzalez M, Leitman P, Piratininga A, Costa AF & Forzza RC (2008) Bromeliaceae da Mata Atlântica brasileira: lista de espécies, distribuição e conservação. Rodriguésia 59: 209-258.

Martinelli G & Moraes AM (orgs.) (2013) Livro Vermelho da Flora do Brasil. Instituto de Pesquisas Jardim Botânico do Rio de Janeiro, Rio de Janeiro. 1100p.

Martinelli G, Martins E, Moraes M, Loyola R & Amaro R (orgs.) (2018) Livro vermelho da flora endêmica do estado do Rio de Janeiro. Instituto Estadual do Ambiente, Rio de Janeiro. 456p.

Mendes Júnior LO, Antoniazzi, Vieira MCW & Susemihl P (1991) Relatório Mantiqueira. FEDAPAM (Frente de Defesa da Mantiqueira), São Paulo. 54p.

Menini Neto L, Forzza RC & Zappi D (2009) Angiosperm epiphytes as conservation indicators in forest fragments: A case study from southeastern Minas Gerais, Brazil. Biodiversity and Conservation 18: 3785-3807.

Mondragón-Chaparro D & Ticktin T (2011) Demographic effects of harvesting bromeliads as an alternative approach to collection. Conservation Biology 25: 797-807.

Moraes AM, Milward-de-Azevedo MA, Menini Neto L, Faria APG (2020) Distribution patterns of *Passiflora* L. (Passifloraceae *s.s.*) in the Serra da Mantiqueira, Southeast Brazil. Brazilian Journal of Botany 43: 999-1012.

Moreira MM, Carrijo TT, Alves-Araújo A, Rapini A, Salino A, Firmino AD, Chagas AP, Versjane AFA, Amorim AMA, Silva AVS, Tuler AC, Peixoto AL, Soares BS, Cosenza BAP, Delgado CN, Lopes CR, Silva C, Barbosa DEF, Monteiro D, Marques D, Couto DR, Gonzaga DR, Dalcin EC, Lírio EJ, Meyer FS, Salimena FRG, Oliveira FA, Souza FS, Matos FB, Depiantti G, Antar GM, Heiden G, Dias HM, Sousa HCF, Lopes ITFV, Rollim IM, Luber J, Prado J, Nakajima JN, Lanna J, Zorzanelli JPF, Freitas J, Baumgratz JF, Pereira JBS, Oliveira JRPM, Antunes K, Sylvestre LS, Pederneiras L, Freitas L, Giacomin LL, Meireles LD, Silva LN, Pereira LC, Silva LAE, Menini Neto L, Monge M, Trovó MLO, Reginato M, Sobral MEG, Gomes M, Garbin ML, Morim MP, Soares ND, Labiak PH, Viana PL, Cardoso PH, Moraes PLR, Schwartsburd PB, Moraes, QS, Zorzanelli RF, Nichio-Amaral R, Goldenberg R, Furtado SG, Feletti T, Dutra VF, Bueno VR, Dittrich VAO & Forzza RC (2020a) A list of land plants of Parque Nacional do Caparaó, Brazil, highlights the presence of sampling gaps within this protected area. Biodiversity Data Journal 8: e59664.

Moreira MM, Carrijo TT, Alves-Araújo A, Amorim AMA, Rapini A, Silva AVS, Cosenza BAP, Lopes CR, Delgado CN, Kameyama C, Couto DR, Barbosa DEF, Monteiro D, Gonzaga DR, Dalcin EC, Guimarães EF, Lírio EJ, Matos FB, Salimena FRG, Oliveira FA, Heiden G, Lanna JM, Baumgratz JF, Pastore JFB, Oliveira JRPM, Barcelos LB, Sylvestre LS, Freitas L, Giacomin LL, Pederneiras L, Meireles LD, Lohmann LG, Pereira LC, Silva LAE, Menini Neto L, Souza MC, Trovó M, Sobral MEG, Garbin ML, Gomes M, Morim MP, Mota MCA, Labiak PH, Viana PL, Moraes PLR, Goldenberg R, Coelho RLG, Furtado SG, Silva-Neto SJ, Flores TB, Dutra VF, Bueno VR & Forzza RC (2020b) Using online databases to produce comprehensive accounts of the vascular plants from the Brazilian protected areas: The Parque Nacional do Itatiaia as a case study. Biodiversity Data Journal 8: e50837.

Pelissari G & Romaniuc-Neto S (2013) *Ficus* (Moraceae) da Serra da Mantiqueira, Brasil. Rodriguésia 64: 91-111.

Pereira LC, Chautems A, Menini Neto L (2021) Biogeography and conservation of Gesneriaceae in the Serra da Mantiqueira, Southeastern Region of Brazil. Brazilian Journal of Botany 44: 239-248.

Pompeu PV, Fontes MAL, Muliggan M, Bueno IT, Siqueira MF, Acerbi Júnior FW, Kamino LHY, Waterloo MJ & Bruijnzeel LA (2018) Assessing Atlantic cloud forest extent and protection status in southeastern Brazil. Journal for Nature Conservation 43: 146-155.

Ponce-Reyes R, Reynoso-Rosales VH, Watson JEM, Van Der Wal J, Fuller RA, Pressey RL & Possingham HP (2012) Vulnerability of cloud forest reserves in Mexico to climate change. Nature Climate Change 2: 448-452.

PPG I (2016) A community-derived classification for extant lycophytes and ferns. Journal of Systematics and Evolution 54: 563-603.

Ramos FN, Mortara SR, Monalisa-Francisco N, Elias JPC, Menini Neto L, Freitas L, Kersten R, Amorim AM, Matos FB, Nunes-Freitas AF, Alcântara S, Alexandre MHN, Almeida-Scabbia RJ, Almeida OJG, Alves FE, Alves RMO, Alvim FS, Andrade ACS, Andrade S, Aona LYS, Araújo AC, Araújo KCT, Ariati V, Assis JC, Azevedo CO, Barbosa BF, Barbosa DEF, Barbosa FR, Barros F, Basílio GA, Bataghin FA, Bered F, Bianchi JS, Blum CT, Boelter CR, Bonnet A, Brancalion PHS, Breier TB, Brion CT, Buzatto CR, Cabral A, Cadorin TJ, Caglioni E, Canêz L, Cardoso PG, Carvalho FS, Carvalho RG, Catharino ELM, Ceballos SJ, Cerezini MT, César RG, Cestari C, Chaves CJN, Citadini-Zanette V, Coelho LFM, Coffani-Nunes JV, Colares R, Colletta GD, Corrêa NM, Costa AF, Costa GM, Costa LMS, Costa NGS, Couto DR, Cristofolini C, Cruz ACR, Del Neri LA, Di Pasquo M, Dias AS, Dias LCD, Dislich R, Duarte MC, Fabricante JR, Farache FHA, Faria APG, Faxina C, Ferreira MTM, Fischer E, Fonseca CR, Fontoura T, Francisco TM, Furtado SG, Galetti M, Garbin ML, Gasper AL, Goetze M, Gomes-da-Silva J, Gonçalves MFA, Gonzaga DR, Silva ACG, Guaraldo AC, Guarino ESG, Guislon AV, Hudson LB, Jardim JG, Jungbluth P, Kaeser SS, Kessous IM, Koch NM, Kuniyoshi YS, Labiak PH, Lapate ME, Santos ACL, Leal RLB, Leite FS, Leitman P, Liboni AP, Liebsch D, Lingner DV, Lombardi JA, Lucas E, Luzzi JR, Mai P, Mania LF, Mantovani W, Maragni AG, Marques MCM, Marquez G, Martins C, Martins LN, Martins PLSS, Mazziero FFF, Melo CA, Melo MMF, Mendes AF, Mesacasa L, Morellato LPC, Moreno VS, Muller A, Murakami MMS, Cecconello E, Nardy C, Nervo MH, Neves B, Nogueira MGC, Nonato FR, Oliveira-Filho AT, Oliveira CPL, Overbeck GE, Marcusso GM, Paciencia MLB, Padilha P, Padilha PT, Pereira ACA, Pereira LC, Pereira RAS, Pincheira-Ulbrich J, Pires JSR, Pizo MA, Pôrto KC, Rattis L, Reis JRM, Reis SG, Rocha-Pessôa PC, Rocha CFD, Rocha FS, Rodrigues ARP, Rodrigues RR, Rogalski JM, Rosanelli RL, Rossado A, Rossatto DR, Rother DC, Ruiz-Miranda CR, Saiter FZ, Sampaio MB, Santana LD, Santos JS, Sartorello R, Sazima M, Schmitt JL, Schneider G, Schroeder BG, Sevegnani L, Silva Júnior VO, Silva FR, Silva MJ, Silva MPP, Silva RG, Silva SM, Singer RB, Siqueira G, Soares LE, Sousa HC, Spielmann A, Tonetti VR, Toniato MTZ, Ulguim PSB, van den Berg C, van den Berg E, Varassin IG, Silva IBV, Vibrans AC, Waechter JL, Weissenberg EW, Windisch PG, Wolowski M, Ayañez A, Yoshikawa VN, Zandoná LR, Zanella CM, Zanin EM, Zappi DC, Zipparro VB, Zorzanelli JPF & Ribeiro MC. (2019) Atlantic epiphytes: a data set of vascular and non-vascular epiphyte plants and lichens from the Atlantic Forest. Ecology 100: e02541.

Rezende MG, Elias RCL, Salimena FRG & Menini Neto L (2013) Flora vascular da Serra da Pedra Branca, Caldas, Minas Gerais e relações florísticas com áreas de altitude da Região Sudeste do Brasil. Biota Neotropica 13: 201-224.

Salimena FRG, Matozinhos CN, Abreu NL, Ribeiro JCH, Souza FS & Menini Neto L (2013) Flora fanerogâmica da Serra Negra, Minas Gerais, Brasil. Rodriguésia 64: 311-320.

Scatena FN, Bruijnzeel LA, Bubb P & Das S (2010) Chapter 1 – Setting the stage. *In*: Bruijnzeel LA, Scatena FN & Hamilton LS (eds.) Tropical Montane cloud forests – science for conservation and management International Hydrology Series Cambridge University Press, Cambridge. Pp. 3-13.

SMA-SP (2016) Resolução SMA – 57 de 5 de junho de 2016. Publica a segunda revisão da lista oficial das espécies da flora ameaçadas de extinção no Estado de São Paulo. Disponível em < https://www.infraestruturameioambiente.sp.gov.br/institutodebotanica/wp-content/uploads/sites/235/2016/06/Resolucao-SMA-057-05_2016.pdf. Accessed in 25 January 2020.

Stehmann JR & Sobral M (2009) Diagnóstico do conhecimento da diversidade botânica: fanerógamas. *In*: Drummond GM, Martins CS, Greco MB & Vieira F (orgs.) Biota Minas: diagnóstico do conhecimento sobre a biodiversidade no estado de Minas Gerais - subsídio ao Programa Biota Minas. Fundação Biodiversitas, Belo Horizonte. Pp. 355-387.

Still CJ, Foster PN & Schneider SH (1999) Simulating the effects of climate change on tropical montane cloud forests. Nature 398: 608-610.

Thiers B (2019) Index Herbariorum: A global directory of public herbaria and associated staff. New York Botanical Garden's Virtual Herbarium. Available at <http://sweetgum.nybg.org/science/ih/>. Access on 05 May 2019.

Toledo-Aceves T, Hernández-Apolinar M & Valverde T (2014) Potential impact of harvesting on the population dynamics of two epiphytic bromeliads. Acta Oecologica 50: 52-61.

Várzea A (1942) Relevo do Brasil. Revista Brasileira de Geografia 4: 97-130.

Versieux LM & Wendt T (2007) Bromeliaceae diversity and conservation in Minas Gerais state, Brazil. Biodiversity and Conservation 16: 2989-3009.

Webster GL (1995) The panorama of Neotropical Cloud Forests. *In*: Churchill SP, Balslev H, Forero E & Luteyn JL (eds.) Biodiversity and conservation of Neotropical Montane Forests (Neotropical montane forest biodiversity and conservation symposium, 1993) Proceedings... The New York Botanical Garden, New York. Pp 53-77.

Werner FA, Köster N, Kessler M & Gradstein SR (2011) Is the resilience of epiphyte assemblages to human disturbance a function of local climate? Ecotropica 17: 15-20.

Wraith J & Pickering C (2017) Tourism and recreation: a global threat to orchids. Biodiversity and Conservation 26: 3407-3420.

Zotz G (2013) The systematic distribution of vascular epiphytes–a critical update. Botanical Journal of the Linnean Society 171: 453-481.

Zotz G (2016) Plants on Plants – The biology of vascular epiphytes. Springer, Heidelberg. 282p.

Zotz G & Bader MY (2009) Epiphytic plants in a changing world-global: change effects on vascular and non-vascular epiphytes. Progress in Botany 70: 147-170.

Area Editor: Dra. Tatiana Carrijo
Received in September 10, 2020. Accepted in August 19, 2021.