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Original Paper

Vascular epiphytes of the Serra do Relógio: the surprising richness of the seasonal forests in the mountains of Minas Gerais, Southeastern Brazil

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Abstract

Studies conducted on vascular epiphytes in Minas Gerais have revealed high richness in the seasonal semi-deciduous forests (SSF) in comparison with those of other Brazilian states. This study aimed to present a vascular epiphyte checklist of the Serra do Relógio (SR) in the Atlantic Forest of Minas Gerais, in order to analyze the similarity between two areas in different altitudes, as well as to discuss the high richness recorded for this synusia in the SSFs of this state. The survey was performed in two conservation units (CUs) apart from each other approximately 6 km and with elevations varying between ~500 and 1,434 m. The data were obtained from published articles and fieldwork performed between the years 2016 and 2019. We recorded 158 species distributed in 76 genera and 22 families. This richness is greater than those found in some ombrophilous forests, which was an unexpected result due to the high moisture of this phytophysionomy. Although approximately 66% of the species found in the SR are anemochoric and the compared CUs are geographically close, the similarity was only 22%, suggesting that the difference in altitude between the areas and the history of use can impose filters that influence the floristic composition of each one area. These results highlight the importance of preserving the forest remnants in Brazil and creating and maintain CUs to protect them.

Key words: altitude, Atlantic Forest, conservation units, Serra da Mantiqueira, Zona da Mata.

Resumo

Os estudos sobre epífitas vasculares realizados em Minas Gerais vêm revelando uma elevada riqueza nas Florestas Estacionais Semideciduais (FES), quando comparadas àquelas de outros estados brasileiros. O presente estudo teve como objetivos apresentar uma listagem das epífitas vasculares da Serra do Relógio, na Floresta Atlântica de Minas Gerais, analisar a similaridade entre duas áreas localizadas em diferentes altitudes, além de discutir sobre a elevada riqueza registrada para esta sinúsia nas FES do estado. A pesquisa foi conduzida em duas Unidades de Conservação (UC) que distam cerca de 6 km entre si e possuem altitudes variando entre ~500 e 1.434 m. Os dados foram obtidos de estudos publicados e expedições realizadas entre os anos de 2016 e 2019. Nós registramos 158 espécies pertencentes a 76 gêneros e 22 famílias. A riqueza observada no presente estudo é maior do que aquela encontrada em pesquisas realizadas em florestas ombrófilas, fato considerado inesperado devido à elevada umidade desta fitofisionomia. Embora ~66% das espécies da SR tenham suas sementes dispersas pelo vento e as UC's sejam geograficamente muito próximas, a similaridade encontrada foi de apenas ~22%, sugerindo que a diferença de altitude entre as áreas e o histórico de uso podem estabelecer filtros que influenciam na composição florística de cada uma delas. Nossos resultados ressaltam a importância da conservação dos remanescentes florestais no Brasil e da criação e manutenção de UC's para protegê-los.

Palavras-chave: altitude, Floresta Atlântica, unidades de conservação, Serra da Mantiqueira, Zona da Mata.

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Introduction

Epiphytes are plants which spend their whole life, or part of it, without contact with the soil, normally using trees as support without parasitizing them (Benzing 1990; Zotz 2016). They play an important role in ecosystems, providing food, water, and shelter, and are even compared to small ecosystems (Rommel & Baights 1999; Zanin & Tusset 2007; Seidl *et al*. 2020). Epiphytes also contribute to maintaining nutrients and local air moisture (Benzing 1998; Hargis *et al*. 2019), and this characteristic can be highly relevant in the dry period in forests such as seasonal semi-deciduous forests (SSF) (Mestre *et al*. 2001). About 9% of all vascular plants in the world are epiphytes (Zotz 2013), while this proportion is approximately 15% in the Atlantic Forest (Freitas *et al*. 2016), and this number can be up to 50% of the total in smaller scales (Kelly *et al*. 1994).

Studies on vascular epiphytes in Minas Gerais have intensified in the last decade and have been performed in several types of vegetations such as urban green areas (Alvim *et al*. 2020; Kaeser *et al*. 2020), urban forests (Furtado & Menini Neto 2015a; Santana *et al*. 2017; Martins *et al*. 2020), *Cerrado sensu stricto* (Menini Neto *et al*. 2019), ombrophilous forests (Alves & Menini Neto 2014; Furtado & Menini Neto 2015b, 2016, 2018a,b) and seasonal semi-deciduous forests (Barbosa *et al*. 2015, 2019; Basílio *et al*. 2015). It is worth mentioning that the last vegetation type presented higher richness of vascular epiphytes in the Atlantic Forest (Zona da Mata) of Minas Gerais than in any other Brazilian states in the same type of phytophysionomy (Barbosa *et al.* 2015, 2019).

The Atlantic Forest in Minas Gerais originally covered 41% of the state territory, but is currently reduced to approximately 4% of its original area (Drummond *et al*. 2008) and is mainly represented by secondary forest fragments (Campanili & Schaffer 2010). The SSF is the forest physiognomy which covers the largest extension in this state and was the most affected vegetation due to deforestation for cattle, crops, and urban expansion (Stehmann & Sobral 2009). It is recognized that it shelters high richness and endemism, however it is still undersampled, representing a knowledge gap in Brazil and is considered a priority for conducting floristic inventories (Giulietti *et al*. 2009; Stehmann *et al*. 2009; Werneck *et al*. 2011). Such knowledge is even lower if taking into consideration the herb stratum or epiphytic plants (Stehmann & Sobral 2009), with an understudied epiphytic flora even in larger and well-studied SSF remnants in Minas Gerais (Lombardi & Gonçalves 2000; Messias *et al*. 2017).

In addition to the several phytophysiognomies, the Atlantic Forest has remarkable topographic heterogeneity from sea level to near 3,000 m. These conditions allow a great variety of habitats and complex biodiversity, which puts it as a global hotspot of biodiversity (Myers *et al*. 2000; Oliveira-Filho & Fontes 2000; Guedes *et al*. 2020). Both on global and regional scales the mountains are recognized as world centers of diversity, showing a high number of threatened and endemic species, representing refuges for several organisms (Körner 2004; Barthlott *et al*. 2005; Antonelli *et al.* 2018). Among the Brazilian mountain chains, is worth mentioning the Serra da Mantiqueira, an important montane complex, essential to the conservation and maintenance of the biodiversity of the Southeastern Region of Brazil (Drummond *et al*. 2005; Martinelli 2007; Guedes *et al*. 2020).

The Serra do Relógio (SR) gathers one of the most relevant forest remnants of Zona da Mata of Minas Gerais and is part of the Southeastern Corridor of the Atlantic Forest in Serra da Mantiqueira. It is considered a very important area for the conservation of the flora in this state (Drummond *et al*. 2005). It is a mountain chain with relevant environmental service for the society, provided by the existence of several water springs responsible for supplying about 31,000 people from the municipalities of Descoberto and São João Nepomuceno (Menini Neto *et al*. 2004), and the possibility of connecting forest fragments of this region (Barbosa *et al*. 2021). The main phytophysiognomy of this area is montane seasonal semi-deciduous forest (IBGE 2012), although there are also wetlands, cloud forests, and *campos de altitude* (high altitude grasslands) at elevations above 1,000 m (Pereira Filho & Sartori 2013). Much of the SR is inserted in private properties, some of which have been transformed into Conservation Units (CUs), such as the Reserva Particular do Patrimônio Natural (RPPN), the Alto da Boa Vista (RPPNABV), RPPN Jurerê, RPPN Sítio Sannyasim, and the Parque Natural Municipal of Serra do Relógio, in addition to the Reserva Biológica da Represa

do Grama (RBRG), the first biological reserve of Minas Gerais.

Although the Serra do Relógio is recognized as important for biodiversity conservation and has floristic studies about families (Menini Neto *et al*. 2004; Almeida *et al.* 2005; Lobão *et al.* 2006; Matozinhos & Konno 2008; Pereira *et al*. 2021) and general flora of the RBRG (Forzza *et al*. 2014), no one specific study about epiphytic flora was performed to date.

Considering the importance of this synusia for maintaining biodiversity in tropical forests and the relevance of the researched area, the present study aimed to present a vascular epiphyte checklist of the SR, analyzing the composition of the community and the similarity between the RPPNABV and RBRG (areas close to each other but at different elevations), and to discuss the high richness recorded for vascular epiphytes in SSFs of Minas Gerais, as well as the importance of preserving forest remnants in Brazil.

Material and Methods

Study area

The SR is located in the municipalities of Astolfo Dutra, Guarani, and Descoberto, and this study was performed in the portion located in the municipality of Descoberto, mainly in the RBRG (21º25'S, 42º56'W) and RPPNABV CUs (21º22'S, 42º56'W) (Figs. 1-2), which have extensions of 263.8 ha and 138.26 ha, respectively, totaling a montane SSF area of 402.06 ha. The relief is wavy to mountainous and the elevations lie between ~500 and 1,440 m. The RBRG is located between ~500 and 700 m, while the RPPNABV is located between ~820 and 1,440 m. The climate is Cwb according to the Köppen classification, with two well-defined seasons; one warm and humid (October to April), and another with mild temperatures and dry (May to September). The mean annual temperature is 22.3 °C and the mean precipitation is 1,550 mm, with the occurrence of orographic rainfalls, due to the relief

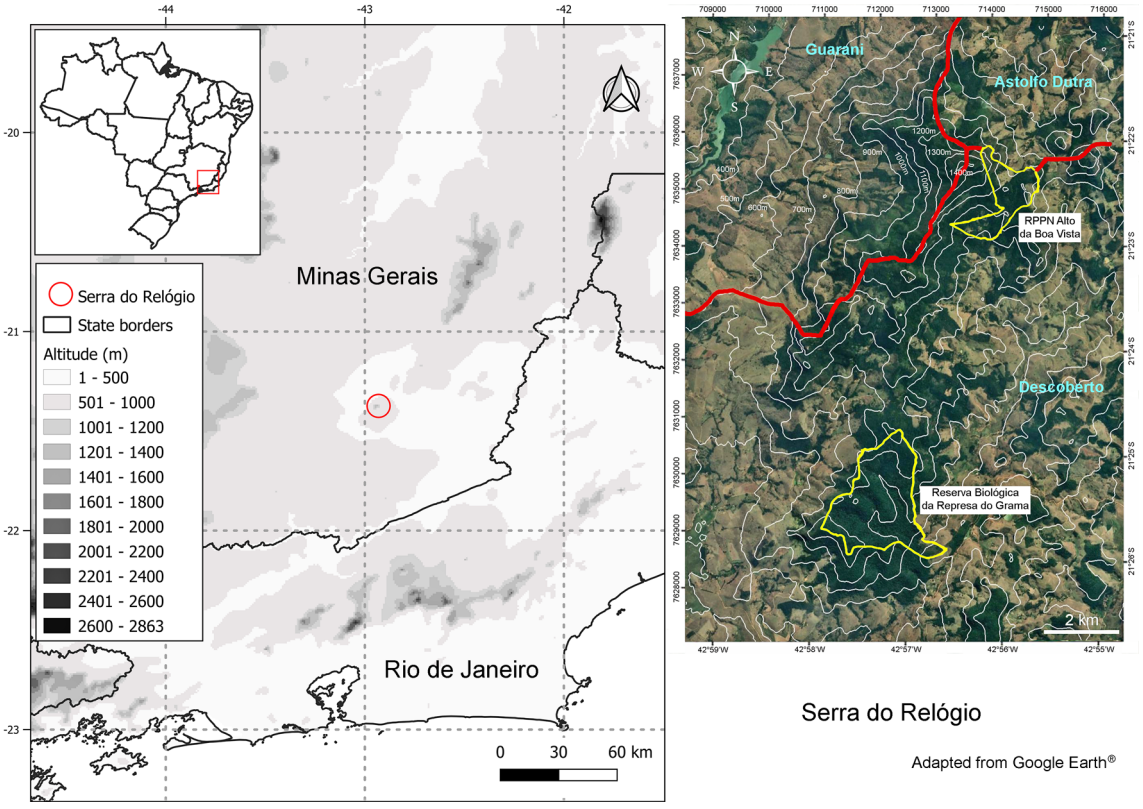

Figure 1 – Location of the study area. Left highlighting the Serra do Relógio (red circle), Zona da Mata, Minas Gerais, Southeastern Brazil. Right, aerial view of the Serra do Relógio and the Conservation Units (delimited in yellow) within its coverage area. In red the delimitation of the municipalities (whose names are shown in blue). RPPN: *Reserva Particular do Patrimônio Natural* (Private Natural Heritage Reserve).

responsible for the ascendence of moist coastal air masses (Pereira Filho & Sartori 2013).

The two forest fragments are ~6 km apart but are somehow connected through an ecological corridor between the CUs, interspersed with crop and cattle pasture areas. Furthermore, both localities were used for coffee crops and wood extraction, and therefore present several seral stages, from reforested areas in the initial succession stage to areas with mature forests, with several large trees, mainly associated with places which are difficult to access (Pereira Filho & Sartori 2013; Forzza *et al*. 2014).

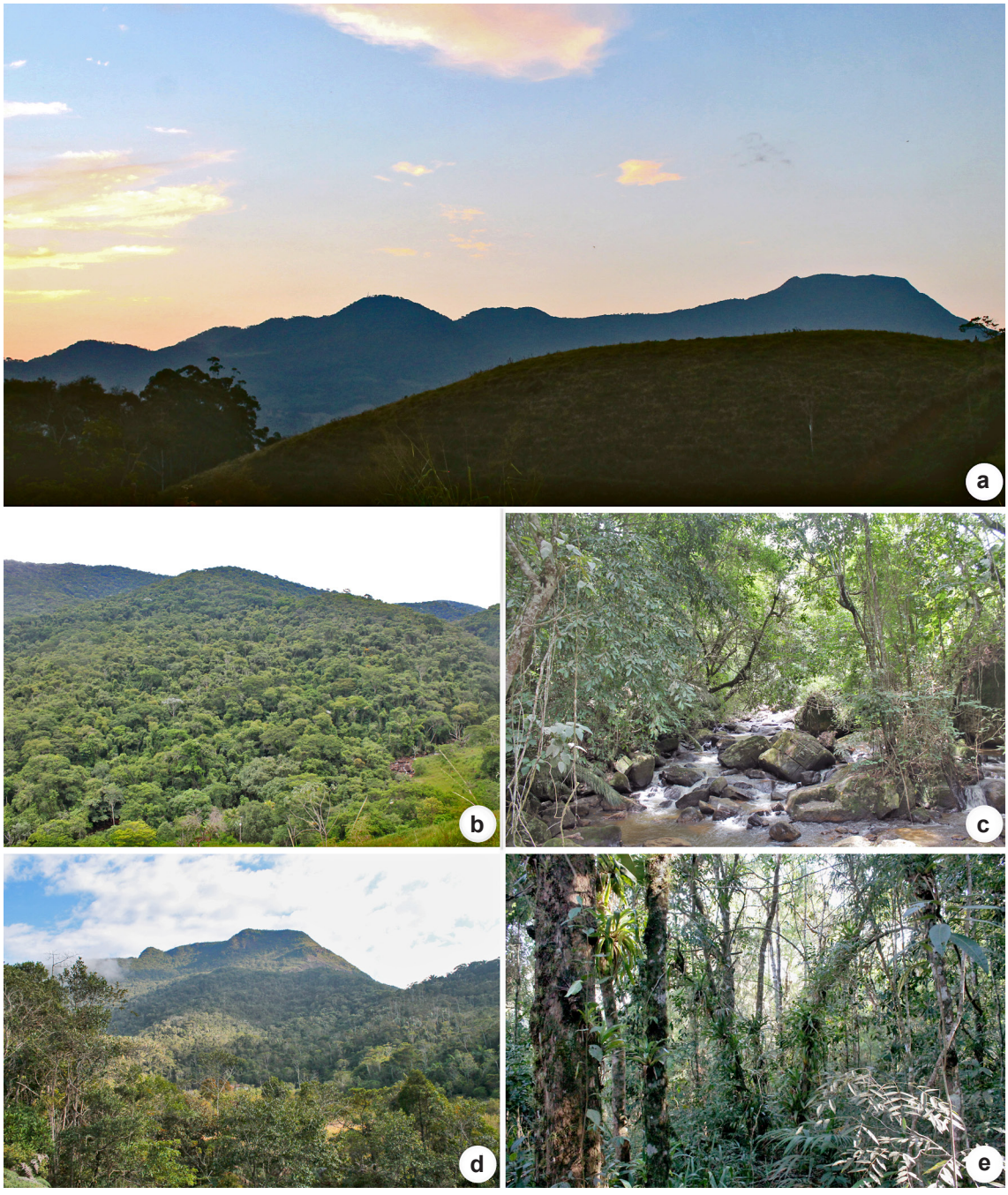

Figure 2 – a. General view of the Serra do Relógio, Zona da Mata, Minas Gerais, Southeastern Brazil; b-c. Reserva Biológica da Represa do Grama; d-e. RPPN Alto da Boa Vista. (Photos: D.E.F. Barbosa).

Data collection

Data regarding species of the RBRG were obtained from published studies performed between 1999 and 2004 (Menini Neto *et al*. 2009; Forzza *et al*. 2014). The data for the RPPNABV was obtained from the management plan of the CU (Pereira Filho & Sartori 2013) and from collections performed by the authors of this study between July 2016 and January 2018, totaling 19 expeditions. We used the method presented by Filgueiras *et al*. (1994), aiming to cover the largest possible area. Fertile specimens were photographed (Figs. 3-4), collected (when necessary), herborized, and deposited in the CESJ Herbarium of the Universidade Federal de Juiz de Fora (acronym according to Thiers, continuously updated). An additional search was performed in the virtual databases (<http://reflora.jbrj.gov.br/>, <https://www.gbif.org/>, <http://www.jbrj.gov.br/jabot/>, <http://splink.cria.org.br/>) to seek additional records from both areas.

The species were identified with the support of specialists in the families and consultation with the literature. The spelling of the species names and authors were verified in 'The International Plants Names Index' (<https://www.ipni.org>). The evolutionary lineages of the plants are according to PPG I (2016) for ferns and lycophytes, and to the APG IV (2016) for the angiosperms.

The conservation status of the species was obtained from the Red Book of Brazilian Flora (Martinelli & Moraes 2013) and Drummond *et al.* (2008) for Brazil and Minas Gerais state, respectively. The species were classified into dispersal syndromes and ecological categories according to Benzing (1990), but we did not distinguish between primary and secondary hemiepiphytes.

Similarity analysis

Although the two fragments are composed of montane SSF and are connected, both are located in different elevations, which can influence the temperature and humidity of each area (Ding *et al*. 2016). Thus, we performed a similarity analysis to compare both areas taking into account that epiphytes are sensitive to microclimatic variations (Padilha *et al*. 2017; Barbosa *et al*. 2019).

A matrix of the presence (1) and absence (0) of the species was constructed. We used 147 species of vascular epiphytes, since those unidentified or without an accurate location information obtained in the herbarium sheets were excluded (*Epidendrum ramosum* Jacq., *Maxillaria parviflora* (Poepp. & Endl.) Garay and *Scaphyglottis reflexa* Lindl.). The similarity analysis was performed using UPGMA (Unweighted Pair Group Method with Arithmetic Mean) and the Jaccard Index in the PAST v.4.03 free access software program (Hammer *et al*. 2001).

Results and Discussion

We recorded 158 species in the Serra do Relógio (SR), distributed in 76 genera and 22 families (Tab. S1, available on supplementary material <https://doi.org/10.6084/m9.figshare.19750303.v1>). Eighty-six species were recorded in the RBRG, which has an area almost twice as large (263.8 ha) compared to the RPPNABV (138.26 ha), which houses 100 species. The altitude can justify these results, whereas that richest areas in vascular epiphytes have been recorded in elevations between 1,000 and 2,000 m in several studies (Madison 1977; Gentry & Dodson 1987; Benzing 1990; Küper *et al*. 2004; Krömer *et al*. 2005; Blum *et al.* 2011; Bonnet *et al*. 2011; Ding *et al*. 2016; Furtado & Menini Neto 2018a; Barbosa *et al*. 2019), thus favoring a richer epiphytic flora in the RPPNABV.

Ferns were represented by 45 species (approximately 28%), 21 genera, and 8 families, with the richest being Polypodiaceae (27 spp.), Aspleniaceae (seven spp.), and Hymenophyllaceae (four spp.) (Tab. S1, available on supplementary material <https://doi.org/10.6084/m9.figshare.19750303.v1>). The richest genus was *Asplenium* L. (Aspleniaceae) (seven spp.), followed by *Campyloneurum* C.Presl (Polypodiaceae) (six spp.), *Pleopeltis* Humb. (Polypodiaceae (five spp.), and *Pecluma* M.G.Price (Polypodiaceae) (four spp.). Lycophytes were represented by three species (approximately 2%), two genera and two families (Lycopodiaceae and Selaginellaceae).

Angiosperms were represented by 110 species (approximately 70%), distributed in 52 genera and 12 families. Orchidaceae (39 spp.) was the richest family, followed by Bromeliaceae (29 spp.), Araceae (15 spp.), and Piperaceae (eight spp.) (Tab. S1, available on supplementary material <https://doi.org/10.6084/m9.figshare.19750303.v1>). The richest genera were *Peperomia* Ruiz & Pav. (Piperaceae) and *Vriesea* Lindl. (Bromeliaceae) (eight spp. each), followed by *Philodendron* Schott (Araceae) (seven spp.) and *Epidendrum* L. (Orchidaceae), and *Billbergia* Thunb. (Bromeliaceae) (six spp. each).

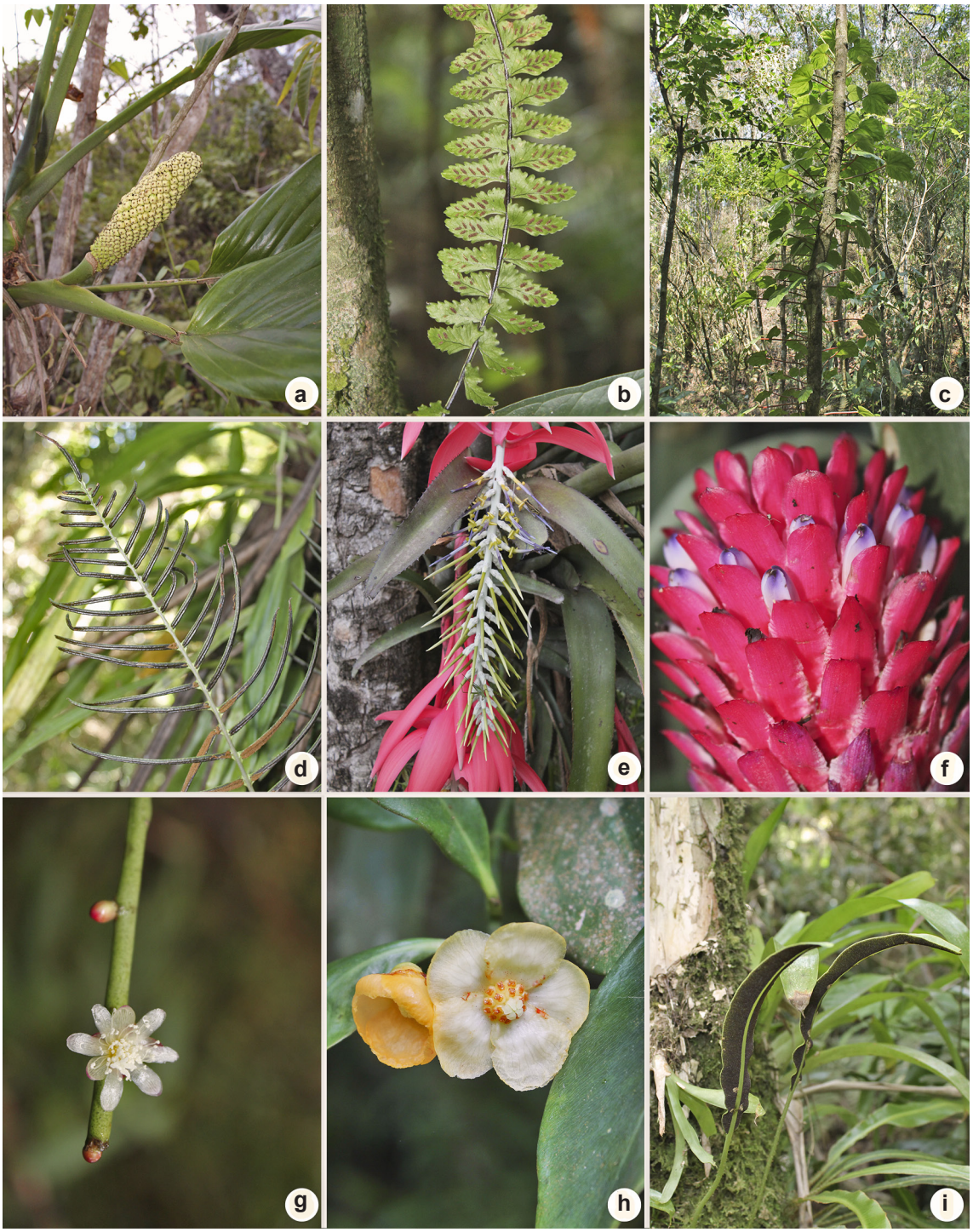

Figure 3 – a-i. Some species of vascular epiphytes recorded in the Serra do Relógio, Zona da Mata, Minas Gerais, Southeastern Brazil – a. Araceae: *Monstera adansonii*; b. Aspleniaceae: *Asplenium mourai*; c. Begoniaceae: *Begonia convolvulacea*; d. Blechnaceae: *Lomaridium plumieri*; e. Bromeliaceae: *Billbergia porteana*; f. Bromeliaceae: *Quesnelia arvensis*; g. Cactaceae: *Rhipsalis floccosa*; h. Clusiaceae: *Clusia* sp.; i. Dryopteridaceae: *Elaphoglossum glaziovii*.

The richest families are according to the patterns found in the Neotropical Region (NR) (Mendieta-Leiva *et al*. 2020) and the Atlantic Forest (AF) (Ramos *et al*. 2019), in which Orchidaceae and Bromeliaceae are the richest. Polypodiaceae is the third richest family and often occupy such rank in small scales, although Araceae, the third in AF and NR, is the fourth richest family in the SR (Hietz & Hietz-Seifert 1995; Wolf & Alejandro 2003; Obermüller *et al*. 2012; Marcusso & Monteiro 2016; Furtado & Menini Neto 2018a; Araújo *et al*. 2019; Barbosa *et al*. 2019), which was corroborated in the present study. These four families together represent 70% of the recorded species in the SR.

The richest genera of ferns (*Asplenium*, *Campyloneurum*, *Pleopeltis*, and *Pecluma*) are according to the literature (Kersten & Silva 2001; Buzatto *et al*. 2008; Perleberg *et al*. 2013; Ramos *et al*. 2019). It is worth mentioning the presence of *Elaphoglossum* Schott *ex* J.Sm., *Hymenophyllum* J. Sm., and *Phlegmariurus* (Herter) Holub, all well-represented in ombrophilous forests and underrepresented in species in seasonal forests (BFG 2018). However, the first two genera were recorded by Barbosa *et al*. (2019) in a floristic survey performed in SSF fragments located above 1,200 m, suggesting that the presence of these genera/species in SSF above 1,000 m is more common than previously thought.

The main genera trend for angiosperms was also confirmed with the predominance of *Peperomia*, *Vriesea*, and *Epidendrum*, with the presence of *Billbergia* being less common in this ranking (Bianchi *et al*. 2012; Perleberg *et al*. 2013; Alves & Menini Neto 2014; Barbosa *et al*. 2015; Padilha *et al*. 2015). *Philodendron* Schott is noteworthy in this group because it is one of the richest genera in the AF (Ramos *et al*. 2019), although not commonly cited among the richest genera in studies performed in the Southeastern Region of Brazil (Breier 2005; Bataghin *et al*. 2010; Alves & Menini Neto 2014; Couto *et al*. 2016; Marcusso & Monteiro 2016; Furtado & Menini Neto 2018a; Barbosa *et al*. 2019). On the other hand, some genera of Pleurothallidinae are often found in ombrophilous forests (Luer 1986; Furtado & Menini Neto 2016, 2018a) and well-represented in SSF of Minas Gerais state (Barbosa *et al*. 2015, 2019), but is represented by only five species in the SR.

Studies performed in ombrophilous forests have recorded the highest richness in Brazil (Schütz-Gatti 2000; Blum *et al*. 2011; Furtado & Menini Neto 2018a), which is an expected result due to the high moisture of this phytophysiognomy, which in turn favors epiphyte establishment (Gentry & Dodson 1987; Kersten 2010). However, the richness found in the SR is unexpectedly higher than those found in studies performed in ombrophilous forest and ecotones with other vegetation types (mixed ombrophilous forest or seasonal semi-deciduous forest) which are considered to be very rich areas in epiphytes (Kersten 2010; Kersten & Waechter 2011) (Tab. S2, available on supplementary material <https://doi.org/10.6084/m9.figshare.19750303.v1>).

Some characteristics could be related to the high recorded richness in the SR. The sampling period in the RBRG (four years) was much longer than in other studies about vascular epiphytes (see Barbosa *et al*. 2019), representing a great sampling effort and an eventual influence on the richness. On the other hand, this study was not entirely focused on epiphytic plants, which could have resulted in the undersampling of this synusia (Lima *et al*. 2011; Messias *et al*. 2017). The sampling time in the RPPNABV was similar to that of other studies (19 months). Thus, in this case, it seems that the sampling effort was not a determining reason for the species richness, as observed by Barbosa *et al*. (2015, 2019).

Both areas have a heterogeneous relief, water springs, and streams, which according to Drummond *et al*. (2005), are factors responsible for the high floristic richness in Minas Gerais and may be applicable in this case. Together with the aforementioned elements, the size of the fragments can also contribute, taking into account that larger areas are potentially more suitable to hold more species, also diminishing the influence of the border effect which is directly related to the species richness of this synusia (Debinski & Holt 2000; Bataghin *et al.* 2008). Furthermore, although the forests of Minas Gerais are profoundly fragmented, they may be a little more preserved in comparison with the SSF in other states. Therefore, more studies in undersampled regions are necessary to fulfill the knowledge gaps and enable a better understanding about the epiphytic flora and the conservation status of the forest remnants of this state, considering that epiphytes are good indicators in these cases (Triana-Moreno *et al*. 2003; Bataghin *et al*. 2010).

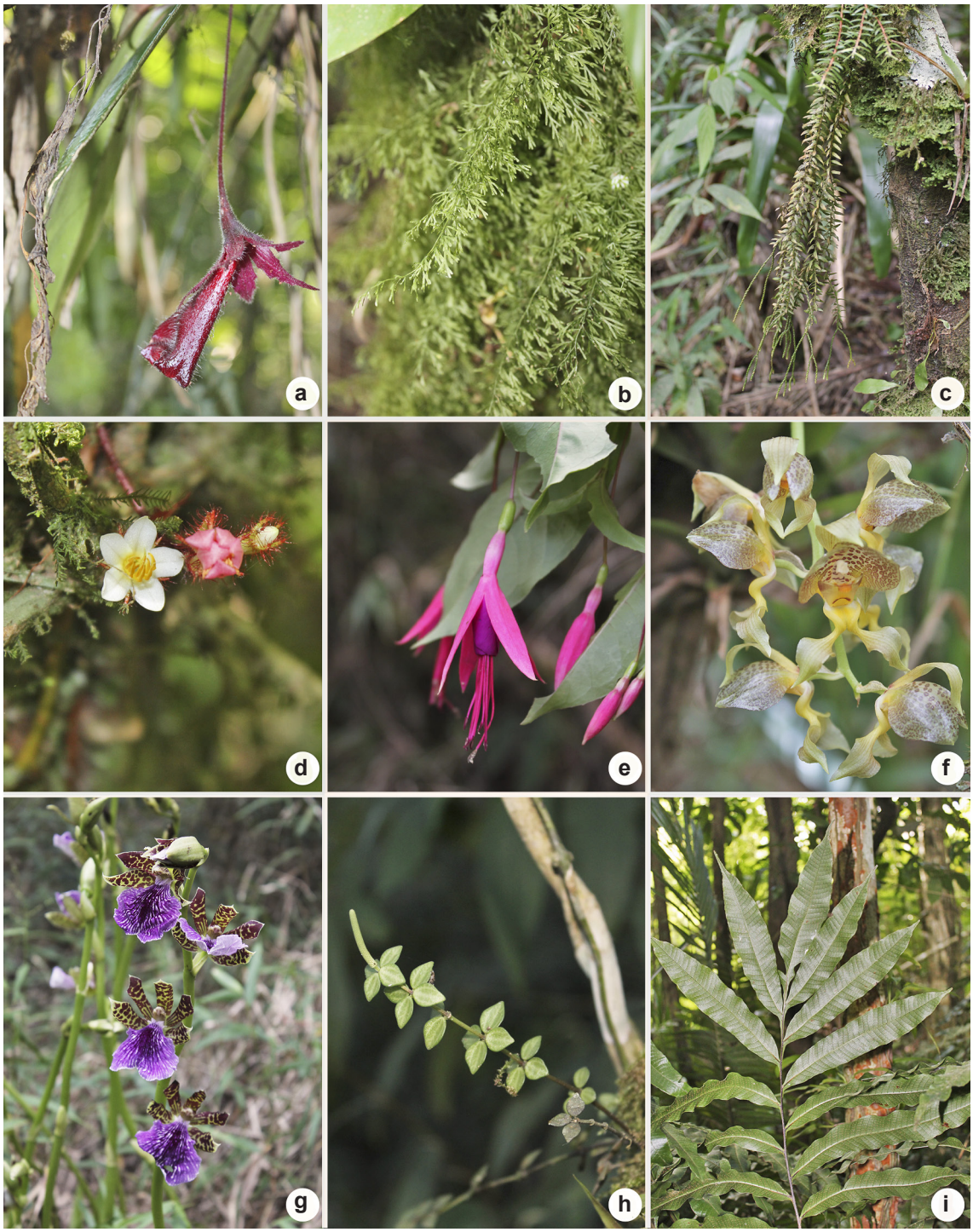

Figure 4 – a-i. Some species of vascular epiphytes recorded in the Serra do Relógio, Zona da Mata, Minas Gerais, Southeastern Brazil – a. Gesneriaceae: *Nematanthus crassifolius*; b. Hymenophyllaceae: *Polyphlebium angustatum*; c. Lycopodiaceae: *Phlegmariurus biformis*; d. Melastomataceae: *Pleiochiton blepharodes*; e. Onagraceae: *Fuchsia regia*; f. Orchidaceae: *Grobya amherstiae*; g. Orchidaceae: *Zygopetalum mosenianum*; h. Piperaceae: *Peperomia tetraphylla*; i. Polypodiaceae: *Campyloneurum decurrens*.

Eight species found in the SR are noteworthy because they are threatened with extinction on different scales (Drummond *et al*. 2008; Martinelli & Moraes 2013). *Asplenium mourai*, *Billbergia tweedieana*, *Nematanthus crassifolius*, and *Nidularium longiflorum* are considered vulnerable (VU) in Minas Gerais, while *Quesnelia augustocoburgii* and *Epidendrum ochrochlorum* are endangered (EN) and *Zygopetalum mosenianum* is critically endangered (CR) in this state. *Vriesea penduliflora* is considered VU in Minas Gerais and EN in Brazil.

Regarding the ecological categories, we found 118 characteristic holoepiphytes (75%), 18 facultative holoepiphytes (11%), 20 hemiepiphytes (13%), and only two accidental epiphytes (1%). In relation to dispersion syndromes, we found 104 anemochoric species (66%) and 54 zoochoric species (34%) concerning the dispersal syndrome. The high number of Orchidaceae and fern species justifies the predominance of characteristic holoepiphytes, as also found in other studies (Kersten & Silva 2001; Bataghin *et al*. 2010; Barbosa *et al*. 2015; Furtado & Menini Neto 2016; Mai *et al*. 2019). The facultative holoepiphytes are mainly represented by Bromeliaceae, Begoniaceae, and Cactaceae species, while as expected Araceae is responsible for the majority of the hemiepiphytes (Blum *et al*. 2011; Barbosa *et al*. 2019). The record of only two accidental epiphytes probably reinforces that such studied fragments must present a good conservation condition, once is expected that anthropized areas present a high number of species of this category (Barthlott *et al*. 2001; Furtado & Menini Neto 2015a; Santana *et al*. 2017; Alvim *et al*. 2020).

Anemochory as the main dispersal syndrome is an expected pattern (Benzing 1990; Geraldino *et al*. 2010; Barbosa *et al*. 2015), considering the distribution of the plants on phorophytes (Madison 1977) and is influenced in the present study by the high number of orchids, ferns, and bromeliads of the genera *Tillandsia* and *Vriesea*.

The similarity analysis revealed that only 22% (or 32 species) are shared between both studied areas. Also studying epiphytes, Küper *et al*. (2004) found a low similarity between close sites (~30 km) in the Andes. A similar result was also found by Alves & Menini Neto (2014) in three areas of the Serra da Mantiqueira, with distances varying from ~14 and 22 km. The sites compared in both studies present similar altitudes and phytophysiognomies, which is different from the present study because both CUs are closer (~6 km) and are connected by an ecological corridor, and are also composed of the same phytophysiognomy. Thus, we could expect greater sharing of species. However, the low recorded similarity suggests that the difference of elevations between the areas imposes environmental filters which influence the epiphytic community composition. For example, to some extent areas located at higher altitudes can provide milder temperatures and higher humidity due to the presence of clouds and orographic rainfalls, influencing the formation of more peculiar flora (Hietz & Hietz -Seifert 1995; Ding *et al*. 2016). Morelli *et al*. (2020) recorded significant differences in the composition of trees in a mountain, showing that habitat heterogeneity of montane areas is conducive to species turnover.

Thus, in addition to watercourses, the RPPNABV is above 1,000 m a.s.l. and is influenced by orographic rainfalls, and can therefore offer favorable conditions for species demanding a moister environment (Bonnet *et al*. 2010; Marcusso & Monteiro 2016), as the species occurring in the rainforest, such as *Asplenium mourai*, *Cirrhaea dependens*, *Cochlidium punctatum*, *Elaphoglossum glaziovii*, *Epidendrum chlorinum*, *Hymenophyllum caudiculatum*, *Lellingeria apiculata*, *Melpomene pilosissima*, *Moranopteris achilleifolia*, *Phlegmariurus biformis*, *P. fontinaloides*, *Vriesea bituminosa*, *V. longicaulis*, and *V. penduliflora*. (BFG 2018) and are not present in the RBRG, which has lower elevations between ~500 and 700 m a.s.l.

However, other typical species from ombrophilous forests were recorded in the RBRG, such as *Anthurium comtum*, *A. solitarium*, *Philodendron appendiculatum*, and *P. curvilobum* aroids, and *Asplenium mucronatum*, *Campyloneurum atlanticum*, and *C. herbaceum* ferns. In this case, their occurrence is associated with the watercourses of this fragment which according to Bonnet *et al*. (2010) and Barbosa *et al*. (2015), can attenuate the typical seasonality of the SSFs. It is worth mentioning that the majority of species were observed along these watercourses and were represented by only a few specimens. On the other hand, the specimens in the RPPNABV were widely distributed and more numerous, and such association was not evident. In other words, different features are exerting similar influences, but with distinct intensities.

The characteristics of each fragment can be responsible for both the exclusivity of some species

and some families. For example, while Blechnaceae, Clusiaceae, Dryopteridaceae, Lomariopsidaceae, Lycopodiaceae, Nephrolepidaceae, Onagraceae and Sellaginelaceae were exclusively recorded in the RPPNABV, Cyclanthaceae, Dennstaedtiaceae and Marcgraviaceae only presented epiphytic species in the RBRG (Fig. 5).

Considering that the majority of species in the SR are anemochoric, we would expect a more expressive sharing of species of this group between the CUs. However, this is not a guarantee that such species can colonize other sites. Features such as moisture, temperature, the phorophyte bark, and the presence of mycorrhizal fungi (important for some species), can be determinant for the colonization success of a site. Furthermore, these seeds may not even be able to break through the local barrier and reach neighboring fragments in very moist environments because they can get soaked in these conditions and are unable to float (Cascante-Marín *et al*. 2009; Einzmann & Zotz 2017; Victoriano-Romero *et al*. 2017). Thus, several species of the RPPNABV may be retained in this fragment, thus justifying the low number of shared anemochoric species between the areas. There was a total of 18 species (from 32) shared between both CUs which are anemochoric (Tab. S1, available on supplementary material <https://doi.org/10.6084/m9.figshare.19750303.v1>), but all can be considered generalists (as well as the zoochoric) with wide distribution in distinct phytophysiognomies of the Atlantic Forest and other phytogeographic domains or countries, as well as adapted to several environmental conditions (BFG 2018).

Even in recognizing the importance of the

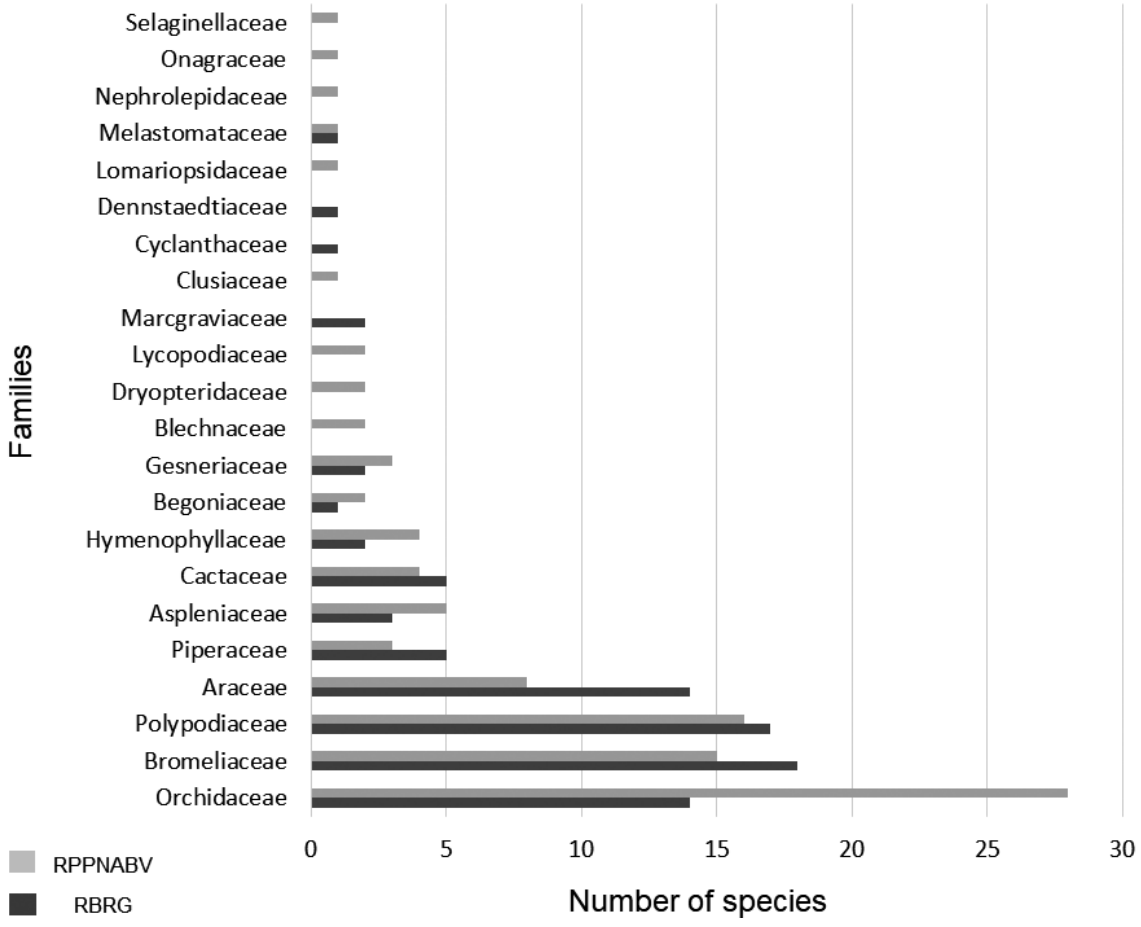

Figure 5 – Number of species and families of vascular epiphytes recorded at Reserva Biológica da Represa do Grama (RBRG) and Reserva Particular do Patrimônio Natural Alto da Boa Vista (RPPNABV) in the Serra do Relógio, Zona da Mata, Minas Gerais, Southeastern Brazil.

aforementioned environmental elements, some anthropogenic factors also deserve attention such as the historical use of each fragment, which can contribute to low floristic similarity between very close sites located at similar altitudes, as shown by Barbosa *et al*. (unpublished data). Both CUs were used in the past for coffee crops and selective logging, which directly affect the epiphytes and result in a local loss of species (Barthlott *et al*. 2001). In this context, the RBRG may have been more intensely exploited due to the lower elevations and have less steep relief, thus facilitating access to withdraw resources, and resulting in poorer epiphytic flora in comparison with RPPNABV.

It is further worth mentioning that several new species were found in this region in the last two decades (Sommer & Ferrucci 2004; Lobão *et al.* 2006; Sobral & Couto 2006; Fraga & Aymard 2007; Sobral *et al.* 2012), with new distribution records (Menini Neto *et al*. 2004; Almeida *et al.* 2005; Matozinhos & Konno 2008; Versieux & Wendt 2006), and rare species for Minas Gerais state (Forzza *et al*. 2014), also harboring *Besleria brevicalyx* G.E.Ferreira & Chautems (Gesneriaceae) (Ferreira *et al*. 2016), endemic to the SR. Considering that 80% of the Atlantic Forest remnants have less than 50 ha (Ribeiro *et al*. 2009), fragments having this extension can be considered rare and deserve attention. Therefore, our results corroborate the high importance of this region for preserving the biodiversity of Minas Gerais, according to the proposal of Drummond *et al*. (2005). However, despite the RBRG having its flora well-known (Forzza *et al*. 2014), this is not true for the other fragments of the region, and further studies are necessary (Barbosa *et al*. 2021).

The present study provided an increase in the knowledge of vascular epiphytes in Minas Gerais and confirmed the trend of the high richness of this sinusya in the SSF of this state, as observed in other studies. However, we recommend that more surveys be carried out in other areas outside the Zona da Mata of Minas Gerais in order to confirm this trend of richness on a wider scale or whether existing factors in small scales are preponderant. Furthermore, considering the current fragmentation degree of the Atlantic Forest, the importance of conserving the remaining remnants in Brazil is evident to maintain the species and the ecosystem services. Therefore, the creation of both public and private CUs should be encouraged.

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