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SHORT COMMUNICATION - Conservation of Nature

Vascular Epiphyte Diversity in a Key Atlantic Forest Remnant from Minas Gerais State, Southeastern Brazil

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Abstract

Vascular epiphytes contribute significantly to the biodiversity of tropical forests. We aimed to identify the epiphyte species occurring in the Muriqui Trail at Serra do Brigadeiro State Park (SBSP), a priority area for Atlantic forest conservation in southeastern Brazil. We selected 10 phorophytes, from which we sampled epiphytes and took light intensity measurements at three strata: up to 4 m, 4 to 8 m, and above 8 m. Phorophytes represented eight species, eight genera, and six families. We found 25 epiphytic species from 17 genera and nine families. Ferns showed highest richness, especially Polypodiaceae. We report herein important data on epiphyte diversity in eastern Minas Gerais state (Zona da Mata), including the occurrence of species rarely cited in surveys. Fomenting local conservation along with environmental education may be pivotal for counteracting anthropic pressure on SBSP.

Keywords: Epiphyte ecology, eudicots, ferns, magnoliids, monocots.

The Atlantic forest is one of the main tropical forests in the world, accounting for a large portion of all animal and plant diversity on the planet. Thereby, it is one of the priority areas for fauna and flora conservation in Brazil (Marchese, 2015). Much of the forest has been continuously removed, and currently only few remnants exist in the country (Fundação SOS Mata Atlântica & Instituto Nacional de Pesquisas Espaciais, 2020).

Epiphytes are a major component of the biodiversity of tropical forests, as they play a pivotal role in nutrient dynamics in those ecosystems (Coxson & Nadkarni, 1995; Taylor et al., 2022; Marcusso et al., 2022). They are irregularly distributed along phorophytes, showing a vertical variation in terms of species richness, number of individuals and leaf functional traits (Petter et al., 2016; Francisco et al., 2019; Mitchell et al., 2021; Dias-Pereira et al., 2022). Among the different ecosystems within the Atlantic forest domain, rainforests alone host approximately 60% of all vascular epiphytes (Ramos et al., 2019).

We aimed to identify the epiphyte species occurring on phorophytes in a major fragment of secondary montane forest from southeastern Brazil. Sampling was performed at Serra do Brigadeiro State Park, located at the Mantiqueira Mountain Range, in eastern Minas Gerais, within the Atlantic Forest phytogeographic domain. The study area is known as Muriqui trail, an interpretative trail which is frequently visited by several students from nearby institutions, as well as by residents of the local community and tourists visiting the region. The trail is located in the park central portion, ca. 200 m away from the head office, at a mean altitude of 1260 m (20º 43' 12" S and 42º 28' 47" W) (Figure 1).

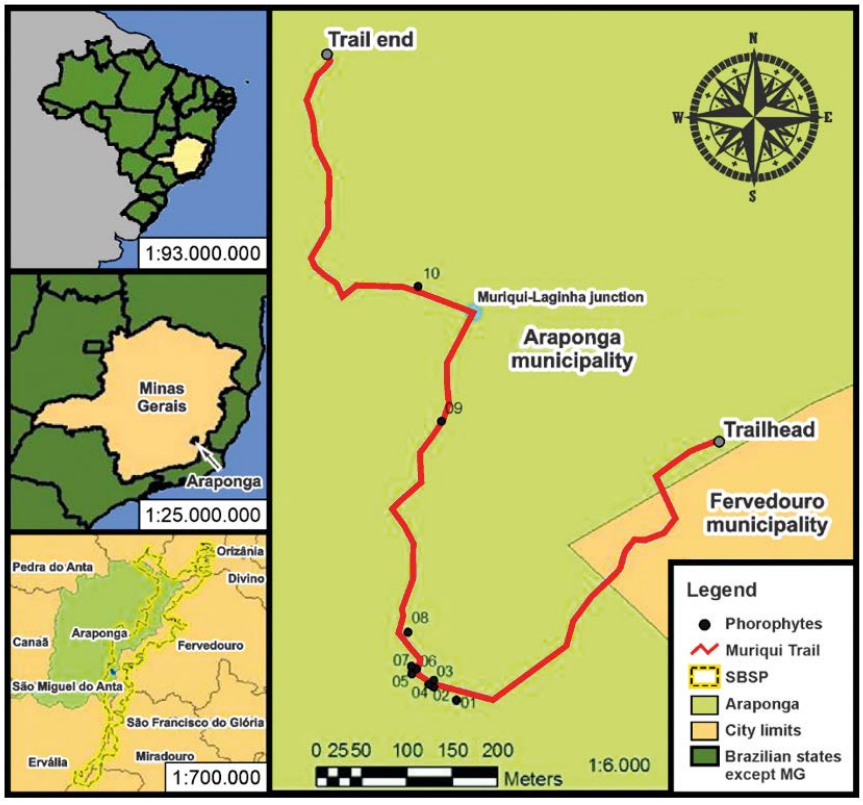

Figure 1. Map of the study area, the Muriqui trail at Serra do Brigadeiro State Park, in Araponga municipality, Minas Gerais state (MG), southeastern Brazil. Elaborated by Ricardo S. Ramos. (Adapted with permission from Dias-Pereira et al., 2022).

To sample phorophytes, we chose those that best represent the study trail in terms of number of epiphytic species occurring along vertical stratification, and that also fall into the criteria of having a minimum 10 m in height and a minimum 50 cm of circumference at breast height (CBH), which rendered a total of ten sampled phorophytes. We measured total height, CBH, bole length, and canopy depth (total phorophyte height minus bole length). Phorophytes were divided in three strata: up to 4 m, 4 to 8 m, and above 8 m. All fertile vascular epiphyte species occurring on the selected phorophytes were collected, including true, accidental and facultative epiphytes as well as hemiepiphytes, following the classification by Benzing (1990). Fertile plant material was collected on a bimonthly-basis from August 2007 through August 2008. Collections were performed by tree climbing, from soil to canopy. Vouchers of epiphyte and phorophyte species were deposited in the VIC Herbarium (acronym following Thiers, 2022, continuously updated) and were identified by consulting specialists and by comparing vouchers against specimens in the VIC Herbarium collection. We used a quantum/radiometer/photometer (model LI-185B, LI-COR Biosciences, Lincoln, USA) to determine light intensity (μmol photons m^{-2} s^{-1}) along phorophyte vertical stratification (Figure 2), following the procedure and sampling scheme described in Dias-Pereira et al. (2022).

The ten sampled phorophytes were represented by eight species, eight genera and six families (Figure 3). Phorophyte height ranged between 12 and 20 m. Minimum CBH was 53.5 cm while maximum was 179.4 cm. The only multi-trunked phorophyte was *Psychotria vellosiana* (phorophyte #10). Bole height ranged from 7 to 16 m whereas canopy depth (*i.e.*, phorophyte height minus bole height) ranged from 3 to 6 m (Table 1).

In the ten analyzed phorophytes, we found 25 vascular epiphyte species from 17 genera and nine families. Ferns were the preponderant group, with 13 species from eight genera and four families (Table 2). We also found aroids on seven phorophytes, yet we did not consider them in our study since all individuals were unfertile during collection period.

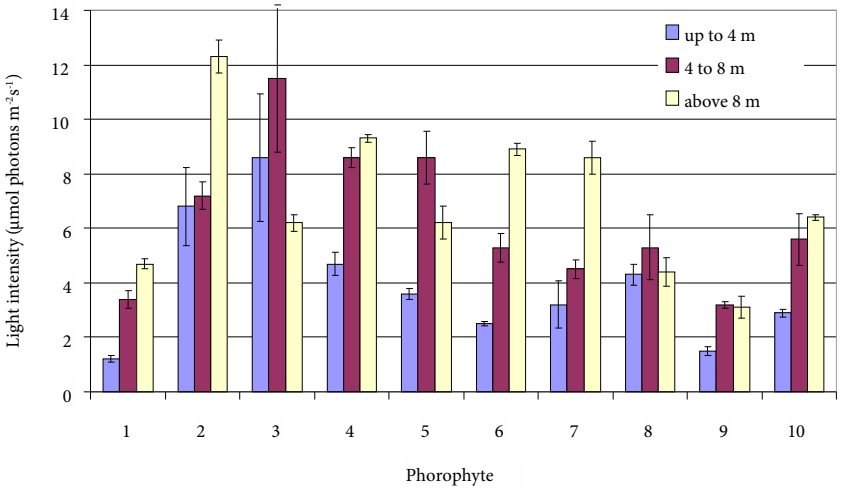

Figure 2. Light intensity at the basal (up to 4 m), median (4 to 8 m) and apical (above 8 m) strata of the studied phorophytes from an Atlantic forest fragment in southeastern Brazil. Bars represent standard error. Phorophyte numbers are as follows: #1 and #3 = *Bathysa australis* (A.St.-Hil.) K.Schum. (Rubiaceae), #2 = *Psychotria sessilis* Vell. (Rubiaceae), #4 = *Dendropanax cuneatus* (DC.) Decne & Planch. (Araliaceae), #5 and #8 = *Solanum cinnamomeum* Sendtn. (Solanaceae), #6 = *Alchornea triplinervia* (Spreng.) Müll.Arg. (Euphorbiaceae), #7 = *Sorocea bonplandii* (Baill.) W.C.Burger, Lanj. & Wess.Boer (Moraceae), #9 = *Myrcia neoclusiifolia* A.R.Lourenço & E. Lucas (Myrtaceae), and #10 = *Ps. vellosiana* Benth.

Figure 3. Sampled phorophytes in the Muriqui trail at Serra do Brigadeiro State Park, Araponga municipality (Minas Gerais state, southeastern Brazil). A. Phorophyte #1 = *Bathysa australis* (A.St.-Hil.) K.Schum. (Rubiaceae). B. Phorophyte #2 = *Psychotria sessilis* Vell. (Rubiaceae). C. Phorophyte #3 = *B. australis*. D. Phorophyte #4 = *Dendropanax cuneatus* (DC.) Decne & Planch. (Araliaceae). E. Phorophyte #5 = *Solanum cinnamomeum* Sendtn. (Solanaceae). F. Phorophyte #6 = *Alchornea triplinervia* (Spreng.) Müll.Arg. (Euphorbiaceae). G. Phorophyte #7 = *Sorocea bonplandii* (Baill.) W.C.Burger, Lanj. & Wess.Boer (Moraceae). H. Phorophyte #8 = *Sol. cinnamomeum*. I. Phorophyte #9 = *Myrcia neoclusiifolia* A.R.Lourenço & E. Lucas (Myrtaceae). J. Phorophyte #10 = *Ps. vellosiana* Benth.

Overall, environmental conditions at the canopy are more xeric than on the soil, yet this does not necessarily occur in all regions of the forest, which itself is a dynamic system (Benzing, 1990). Vertical gradients of microclimatic conditions have been shown to determine a stratified structure of epiphytic communities across different phytophisiognomies of the Atlantic rainforest (Cruz et al., 2022). In that sense, shade-tolerant species usually thrive on the inferior strata of phorophytes, where light intensity is lower (Nunes-Freitas & Rocha, 2007). In the forest remnant we studied, we found a clear vertical stratification of light intensity. However, the study area is quite shady compared with more open areas, and the mean values of light intensity we found might well be reflecting solely the diffuse radiation during the study period.

Ferns occurred on all phorophytes, showing higher diversity than magnoliids, monocots and eudicots (Tables 1 and 2). Additionally, in high altitude areas such as the one we studied, ferns are usually more species-rich than other groups, probably due to their higher tolerance to low temperatures (Moran, 1995; Furtado & Menini Neto, 2021). In regard to other plant groups, we found eudicots occurring on phorophytes #3 – *Bathysa australis* and #4 – *Dendropanax cuneatus*; magnoliids on phorophytes #1 – *B. australis*, #5 – *Solanum cinnamomeum*, #9 – *Myrcia neoclusiifolia* and #10 – *Ps. vellosiana*; and monocots on all phorophytes, represented by Orchidaceae and Bromeliaceae, especially due to the presence of *Vriesea heterostachys* on all sampled phorophytes (Tables 1 and 2).

Table 1. Phorophytes sampled for the study of epiphyte diversity in an Atlantic forest fragment from southeastern Brazil.

Phorophyte no.	*Phorophyte species* (Family)	Voucher (VIC Herbarium)	Height (m)	Bole height (m)	CBH* (cm)	Epiphyte species / (no. of species occurring on the phorophyte)
1	*Bathysa australis* (A.St.-Hil.) K.Schum. (Rubiaceae)	21,456	13	10	105	*Asplenium oligophyllum*, *Campyloneurum angustifolium*, *Campyloneurum nitidum*, *Campyloneurum repens*, *Pecluma sicca*, *Vandenboschia radicans*, *Peperomia alata*, and *Vriesea heterostachys* / (8).
2	*Psychotria sessilis* Vell. (Rubiaceae)	21,296	13	10	70	*Asplenium scandicinum*, *Campyloneurum repens*, and *Vriesea heterostachys* / (3).
3	*B. australis*	21,456	13	10	89.3	*Campyloneurum nitidum*, *Campyloneurum repens*, *Niphidium crassifolium*, *Hatiora salicornioides*, and *Vriesea heterostachys* / (5).
4	*Dendropanax cuneatus* (DC.) Decne & Planch. (Araliaceae)	21,447	20	16	179.4	*Niphidium crassifolium*, *Rumohra adiantiformis*, *Rhipsalis russellii*, *Sinningia cooperi*, *Epidendrum armeniacum*, and *Vriesea heterostachys* / (6).
5	*Solanum cinnamomeum* Sendtn. (Solanaceae)	21,458	20	16	106.7	*Niphidium crassifolium*, *Peperomia tetraphylla*, *Acianthera saundersiana*, and *Vriesea heterostachys* / (4).
6	*Alchornea triplinervia* (Spreng.) Müll.Arg. (Euphorbiaceae)	21,450	20	16	129.5	*Cochlidium punctatum*, *Pecluma recurvata*, *Pleopeltis hirsutissima*, and *Vriesea heterostachys* / (4).
7	*Sorocea bonplandii* (Baill.) W.C.Burger, Lanj. & Wess. Boer (Moraceae)	31,827	12	8	53.5	*Asplenium scandicinum*, *Vriesea heterostachys*, and *Vriesea longicaulis* / (3).
8	*Sol. cinnamomeum*	21,564	20	14	168.8	*Asplenium scandicinum*, *Pecluma recurvata*, *Pleopeltis hirsutissima*, and *Vriesea heterostachys* / (4).
9	*Myrcia neoclusiifolia* A.R.Lourenço & E.Lucas (Myrtaceae)	21,451	14	10	78.2	*Campyloneurum repens*, *Peperomia corcovadensis*, *Promenaea xanthina*, and *Vriesea heterostachys* / (4).
10	*Ps. vellosiana* Benth. (Rubiaceae) **	31,884	12	7	67.7+ 103.8	*Pleopeltis macrocarpa*, *Peperomia corcovadensis*, *Tillandsia geminiflora*, and *Vriesea heterostachys* / (4).

*CBH: circumference at breast height.

**Multi-trunk individual.

Table 2. Vascular epiphytes occurring in an Atlantic forest fragment from southeastern Brazil, in the Muriqui Trail at Serra do Brigadeiro State Park (Araponga municipality, Minas Gerais state, southeastern Brazil), with their distribution on the sampled phorophytes and values of light intensity at different phorophyte strata. Phorophyte numbers are as follows: #1 and #3 = *Bathysa australis* (A.St.-Hil.) K.Schum. (Rubiaceae), #2 = *Psychotria sessilis* Vell. (Rubiaceae), #4 = *Dendropanax cuneatus* (DC.) Decne & Planch. (Araliaceae), #5 and #8 = *Solanum cinnamomeum* Sendtn. (Solanaceae), #6 = *Alchornea triplinervia* (Spreng.) Müll.Arg. (Euphorbiaceae), #7 = *Sorocea bonplandii* (Baill.) W.C.Burger, Lanj. & Wess.Boer (Moraceae), #9 = *Myrcia neoclusiifolia* A.R.Lourenço & E. Lucas (Myrtaceae), and #10 = *Ps. vellosiana* Benth. (Adapted with permission from Dias-Pereira et al., 2022).

GROUP/Family/*Species*	Voucher (VIC Herbarium)	Occurrence*	Mean light intensity** (µmol photons $m^{-2} s^{-1}$)		
			Base	Middle	Apex
FERNS					
Aspleniaceae					
Asplenium oligophyllum Kaulf.	31,830	1	**1.157**	3.434	4.745
Asplenium scandicinum Kaulf.	31,831	2	**6.773**	7.228	12.310
		7	**3.203**	4.451	8.639
		8	4.334	**5.347**	4.353
Dryopteridaceae					
Rumohra adiantiformis (G.Forst.) Ching	21,572	4	4.718	8.570	**9.323**
Hymenophyllaceae					
Vandenboschia radicans (Sw.) Copel.	31,836	1	**1.157**	3.434	4.745
Polypodiaceae					
Campyloneurum angustifolium (Sw.) Fée	21,464	1	1.157	3.434	**4.745**
Campyloneurum nitidum (Kaulf.) C.Presl	21,465	1	1.157	**3.434**	4.745
		3	8.571	**11.547**	**6.201**
Campyloneurum repens (Aubl.) C.Presl.	31,838; 31,839	1	**1.157**	3.434	4.745
		2	**6.773**	7.228	12.310
		3	**8.571**	11.547	6.201
		9	**1.479**	3.203	**3.123**
Cochlidium punctatum (Raddi) L.E.Bishop	21,570	6	2.546	5.256	**8.919**
Niphidium crassifolium (L.) Lellinger	21,468	3	8.571	**11.547**	6.201
		4	4.718	8.570	**9.323**
		5	3.564	8.573	**6.160**
Pecluma recurvata (Kaulf.) M.G.Price	21,462; 21,463	6	2.546	**5.256**	8.919
		8	4.334	**5.347**	4.353
Pecluma sicca (Lindm.) M.G.Price	31,842	1	1.157	3.434	**4.745**
Pleopeltis hyrsutissima (Raddi) de la Sota	21,571	6	2.546	**5.256**	**8.919**
		8	4.334	5.347	**4.353**
Pleopeltis macrocarpa (Bory ex Willd.) Kaulf.	21,467	10	**2.894**	5.585	6.387
ANGIOSPERMS					
MAGNOLIIDS					
Piperaceae					
Peperomia alata Ruiz & Pav.	21,455	1	1.157	3.434	**4.745**
Peperomia corcovadensis Gardner.	21,563	9	1.479	3.203	**3.123**
		10	2.894	**5.585**	6.387
Peperomia tetraphylla (G.Forst) Hook & Arn.	21,454	5	3.564	8.573	**6.160**
MONOCOTS					
Bromeliaceae					
Tillandsia geminiflora (Brongn.)	21,565; 31,828	10	**2.894**	5.585	6.387
Vriesea heterostachys (Baker) L.B.Sm.	21,566; 21,568	1	1.157	**3.434**	4.745
		2	**6.773**	7.228	**12.310**
		3	**8.571**	**11.547**	**6.201**
		4	4.718	8.570	**9.323**
		5	**3.564**	**8.573**	6.160
		6	2.546	**5.256**	**8.919**
		7	**3.203**	**4.451**	**8.639**
		8	**4.334**	**5.347**	**4.353**
		9	1.479	**3.203**	**3.123**
		10	**2.894**	5.585	**6.387**
Vriesea longicaulis (Baker) Mez	21,567	7	3.203	**4.451**	8.639

Table 2. Continuation.

GROUP/Family/*Species*	Voucher (VIC Herbarium)	Occurrence*	Mean light intensity** (µmol photons $m^{-2} s^{-1}$)		
			Base	Middle	Apex
Orchidaceae					
Acianthera saundersiana (Rchb.f.) Pridgeon & M.W.Chase	21,452	5	3.564	8.573	**6.160**
Epidendrum armeniacum Lindl.	21,569	4	4.718	8.570	**9.323**
Promenaea xanthina (Lindl.) Lindl.	21,453	9	**1.479**	3.203	3.123
EUDICOTS					
Cactaceae					
Hatiora salicornioides (Haw.) Britton & Rose	21,449	3	8.571	**11.547**	6.201
Rhipsalis russellii Britton & Rose	21,561	4	4.718	8.570	**9.323**
Gesneriaceae					
Sinningia cooperi (Paxton) Wiehler	21,562	4	**4.718**	**8.570**	**9.323**

*Phorophyte(s) on which the epiphyte species occurred.

** Bold light intensity values are those under which each epiphyte species occurred.

We found two species that are only rarely reported in inventories: the angiosperm *Sinningia cooperi* and the fern *Cochlidium punctatum*. *Sinningia cooperi* occurred solely on phorophyte #4 – *D. cuneatus* (Tables 1 and 2), yet at all three strata. *Sinningia cooperi* commonly occurs as an epiphyte, and is considered to be widely distributed across the Mantiqueira Mountain Range (Pereira et al., 2021). *Cochlidium punctatum*, on the other hand, occurred solely on phorophyte #6 – *Alchornea triplinervia* (Tables 1 and 2). This species occurs in the Atlantic forest from the states of Bahia (northeastern Brazil) to Santa Catarina (south) (Labiak, 2022).

The Muriqui trail at Serra do Brigadeiro State Park hosts high epiphyte diversity, especially of ferns. Epiphytic ferns occurred on all sampled phorophytes, which was not seen with epiphytic eudicots and magnoliids. Reports of rare species in the study site, along with the fact that the trail composes the habitat of the northern muriqui monkey (*Brachyteles hypoxanthus*), a threatened endemic species from the native fauna, reiterate the need to protect the area. Fomenting local conservation activities along with environmental education may be pivotal for counteracting the anthropic pressure on the park, which is a key conservation unit within the Atlantic forest domain.

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