



# Diversity high up: a cloud forest of the Serra da Mantiqueira as a vascular epiphyte hotspot<sup>1</sup>

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## Abstract

The diversity of montane environments is dictated by a variety of environmental conditions. Parque Estadual do Ibitipoca is located in the Serra da Mantiqueira, between ~1,000–1,800 m, and harbors approximately 300 ha of cloud forests. The composition of vascular epiphytes was determined by analyzing data from expeditions conducted between July 2014 and July 2015, and specimens deposited at herbaria. The 224 species were distributed into 82 genera of which *Pleurothallis s.l.* was the richest (13 spp.) and 23 families of which Orchidaceae was the richest (87 spp.). This richness corresponds to approximately 9.5% of the vascular epiphytic flora of the Atlantic Forest concentrated in an area that comprises 0.00085% of this phytogeographic domain, which represents one of the largest diversities ever sampled in the Brazilian Atlantic Forest. This fact is more relevant given that 13 species are threatened at the country level and 23 at the state level.

**Key words:** Atlantic Forest, Dwarf-forest, epiphytic quotient, epiphytism, Parque Estadual do Ibitipoca.

## Resumo

A diversidade dos ambientes montanos é condicionada por inúmeras variáveis ambientais. O Parque Estadual do Ibitipoca está localizado na Serra da Mantiqueira, entre ~1.000–1.800 m, e abriga cerca de 300 ha de florestas nebulares. A composição de epífitas vasculares foi determinada pela análise dos dados de expedições, realizadas entre julho de 2014 e julho de 2015, e espécimes depositados em herbários. Foram registradas 224 espécies distribuídas em 82 gêneros dos quais *Pleurothallis s.l.* foi o mais rico (13 spp.) e 23 famílias das quais Orchidaceae foi a mais rica (87 spp.). Esta riqueza corresponde a aproximadamente 9,5% da flora de epífitas vasculares da Floresta Atlântica concentrados em uma área que compreende 0,00085% deste domínio fitogeográfico, representando uma das maiores diversidades já amostradas na Floresta Atlântica brasileira. Este fato é ainda mais relevante tendo em conta que 13 espécies estão ameaçadas a nível nacional e 23 em nível estadual.

**Palavras-chave:** Floresta Atlântica, nanofloresta, quociente epifítico, epifitismo, Parque Estadual do Ibitipoca.

## Introduction

Mountainous vegetation harbors a huge diversity of plants due to a combination of factors including isolation (the mountains are comparable to islands), climatic changes that occur in little distances due to the elevational shift, and geodiversity resulting from topographically diverse terrain and differences in substrata (Körner 2004). These factors apply to Parque Estadual do Ibitipoca, in the Serra da Mantiqueira in Minas Gerais, which harbors a remarkable plant richness despite comprising only 1,488 ha (Forzza *et al.* 2013).

Epiphytes are plants that spend part or all of their life using another plant as support and are of high ecological importance because they provide shelter and resources to animals as well as capturing and storing water (Benzing 1990; Zotz 2016). This synusia also contributes to the diversity, representing 9–10% of the known vascular species (Gentry & Dodson 1987; Zotz 2013), with a particular diversity in Neotropical rainforests (Gentry and Dodson 1987). The percentage of vascular epiphytes in the Brazilian Atlantic Forest (BAF) reaches 15% of the whole domain of

Available material also at <<https://figshare.com/s/6acf229b87cdc8b07e0e>>.

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vascular flora, of which 78% are endemic to Brazil and around 11% are threatened with extinction. These statistics reinforce the need to acquire knowledge of the biodiversity conservation and ecosystem management practices for this epiphytic group (Freitas *et al.* 2016).

Studies regarding this epiphytic synusia in Minas Gerais have been intensified (Werneck & Espírito Santo 2002; Alves *et al.* 2008; Menini Neto *et al.* 2009a; Alves & Menini Neto 2014; Barbosa *et al.* 2015; Furtado & Menini Neto 2015a, b, 2016), although they can be considered scarce if taking in account the extension of this state.

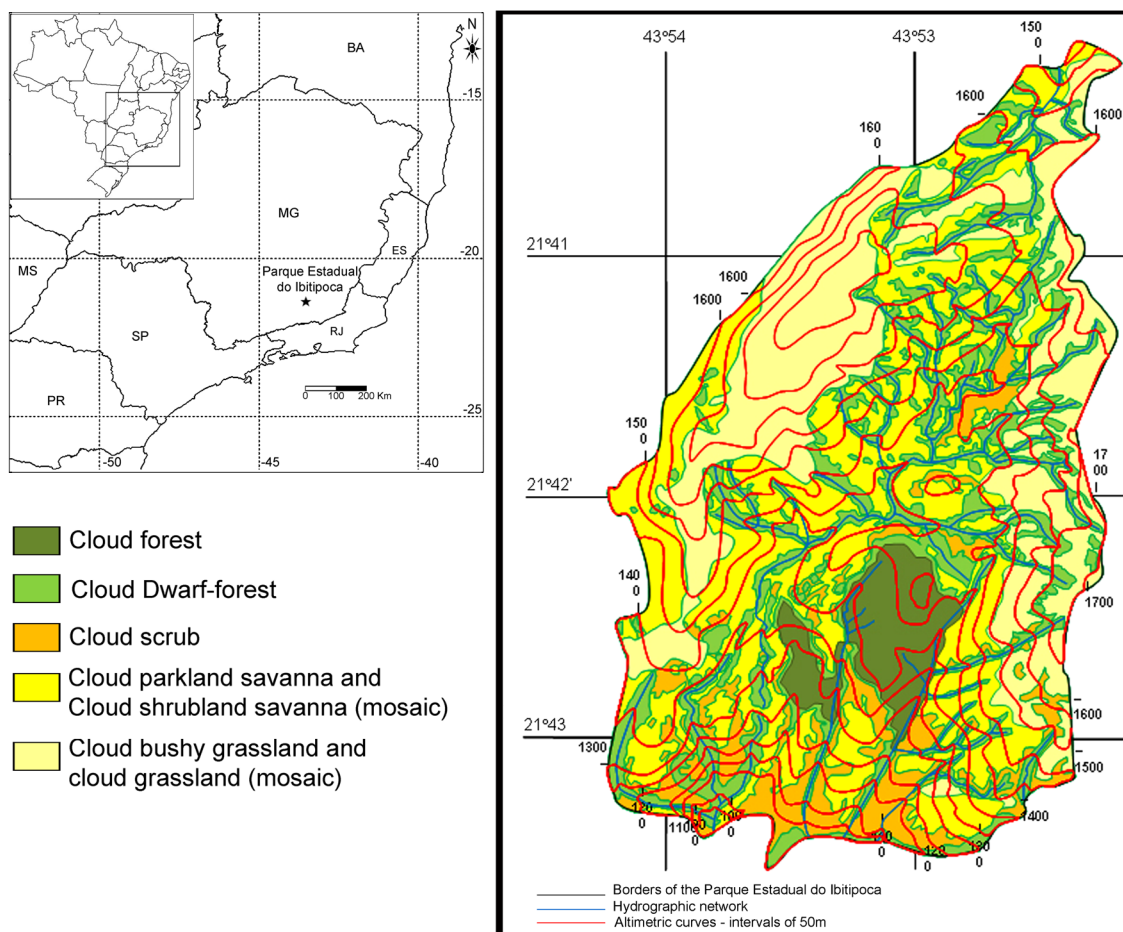
A previous checklist of epiphytic angiosperms occurring in PEIB was presented by Menini Neto *et al.* (2009a), thus the present study aimed to complement the knowledge of vascular epiphytes in PEIB (including ferns as well as new records of angiosperms), an important conservation unit

of Minas Gerais (Costa *et al.* 1998; Drummond *et al.* 2005; Forzza *et al.* 2013), contributing to the biodiversity knowledge base of the Serra da Mantiqueira and Atlantic domain.

## Material and Methods

### Study site

The Parque Estadual da Serra do Ibitipoca (PEIB) covers approximately 1,488 ha in the southeastern region of Minas Gerais, in the municipality of Lima Duarte, district of Conceição de Ibitipoca between coordinates 21°40'–21°44'S and 43°52'–43°55'W (Fig. 1). It is part of the Mantiqueira Mountains (Serra da Mantiqueira) and has an elevational range of 1,000 to 1,784 m. The climate is classified as Cwb according to the Köppen system, with dry winters and mild summers. The averages of annual precipitation and temperature are 1,532 mm and 18.9 °C, respectively (CETEC 1983).



**Figure 1** – Location of Parque Estadual do Ibitipoca, Minas Gerais, Brazil. Adapted from Oliveira-Filho *et al.* (2013).

The PEIB is situated in the Atlantic domain, and its vegetation harbors a mosaic of field and forest phytophysionomies, with the predominance of *campo rupestre*, which has a high floristic richness and several endemic species. Cloud forests are interspersed throughout the field vegetation (covering approximately 300 ha or 20% of the whole extension of PEIB), especially the so called *Mata Grande* (with a canopy of ~20 m) and the formations of dwarf-forests (with canopy of ~5 m). In this environment, the richness of vascular epiphytes is remarkable due to the moisture provided by the fog and retained by the trees (Oliveira-Filho *et al.* 2013) (Fig. 2).

The flora of PEIB is well documented with checklists of bryophytes (hornworts, liverworts, and mosses) (Luizi-Ponzo *et al.* 2013), ferns and lycophytes (Salino *et al.* 2013), and spermatophytes (angiosperms and gymnosperms) (Forzza *et al.* 2013).

#### Data collection

We conducted field trips between July 2014 and July 2015 in order to collect fertile specimens (when needed), observe and obtain photographic recordings of epiphytic species. The resulting photographs were published as a rapid color guide of The Field Museum of Chicago (<[http://fieldguides.fieldmuseum.org/sites/default/files/rapid-color-guides-dfs/712\\_brasil-epifitas\\_de\\_ibitipoca.pdf](http://fieldguides.fieldmuseum.org/sites/default/files/rapid-color-guides-dfs/712_brasil-epifitas_de_ibitipoca.pdf)>). The collected specimens were deposited at Herbarium CESJ of Universidade Federal de Juiz de Fora. Specimens deposited at the herbaria BHC, CESJ, HB, R, RB, and VIC (acronyms according to Thiers 2016) from previous collections in the PEIB spanning more than 40 years were also examined.

The evolutionary lineages of vascular plants are according to PPG (2016) for ferns and lycophytes and APG IV (2016) for angiosperms (magnoliids, monocotyledons, and eudicotyledons).

Data about endemism in Brazil were obtained in the database compiled by BFG (2015) (available at <<http://dx.doi.org/10.6084/m9.figshare.1538647>>) and Prado *et al.* (2015). The conservation status of species in Brazil is according to Martinelli & Moraes (2013), and similar data for Minas Gerais were obtained from Drummond *et al.* (2008). The distribution of the genera is according to the literature for each group.

Ecological categories are according to Benzing (1990), and we did not differentiate between primary and secondary hemiepiphytes.

#### Data analysis

We calculated the epiphytic quotient according to Hosokawa (1950), which represents the percentage of epiphytic plants identified among the vascular species that occur in the cloud forest of PEIB. One calculation set consisted of all the recorded epiphytes, and the other set excluded the accidental ones. This calculation was possible due to the existence of checklists of ferns and lycophytes (Salino *et al.* 2013) and angiosperms (Forzza *et al.* 2013) in the PEIB. A filtering of species occurring in PEIB cloud forests was conducted, through data obtained in herbarium sheets, literature [especially the published floras for the Park, cited by Forzza *et al.* (2013)] and field observation.

#### Results

A total of 224 species of vascular epiphytes were identified (of which 213 were classified at the specific level) that belonged to 82 genera and 23 families (Tab. 1), including 152 angiosperms [10 magnoliids (4.5%), 122 (54.3%) monocotyledons and 20 (8.5%) eudicotyledons], 69 (31.4%) ferns and 3 lycophytes (1.3%).

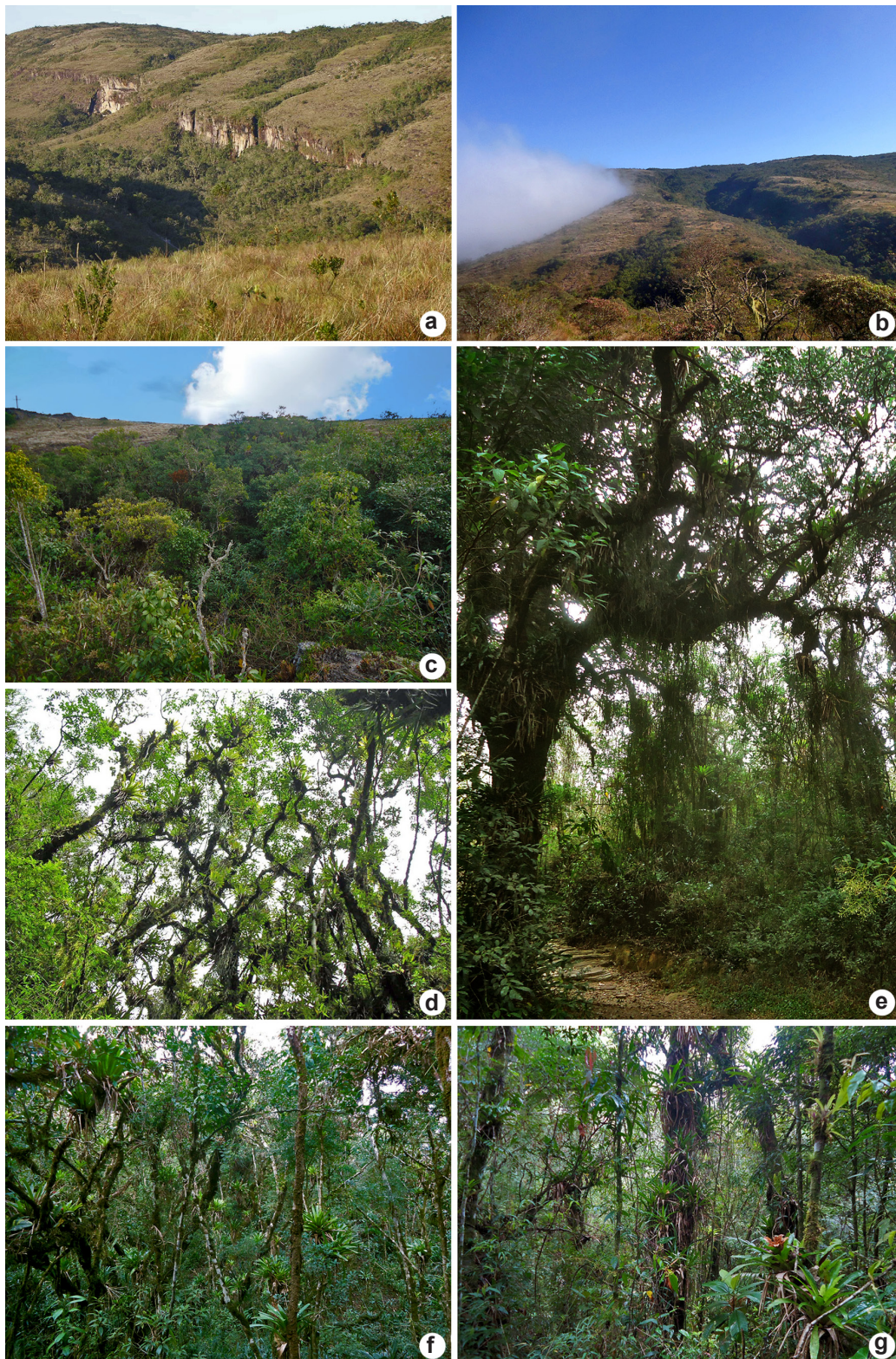
Orchidaceae was the richest family with 86 identified species (38.6% of the total), followed by Polypodiaceae with 27 species (12.1%), and Bromeliaceae with 25 (11.2%) (Fig. 3). The main families of vascular epiphytes recorded in the PEIB are compared with those in some Brazilian ombrophilous forests (Tab. 2). Regarding the genera, *Pleurothallis* R.Br. *sensu lato* is the richest with 13 species (5.9%), *Asplenium* L. with 11 species (5%), and *Peperomia* Ruiz & Pav. and *Epidendrum* L. with 10 species each.

Among the ecological categories, characteristic holoepiphytes were classified as the most prominent [127 species (57%)], followed by facultative holoepiphytes [74 (33.2%)], accidental holoepiphytes [12 (5.4%)], and hemiepiphytes [11 (4.5%)].

The values of epiphytic quotients were 30% and 28.5%, respectively, for the total and excluded accidental holoepiphytes.

#### Discussion

The region encompassing Ibitipoca State Park has been considered of “Extreme Biological Importance” (Drummond *et al.* 2005), a fact that is corroborated by the richness of vascular epiphytes. This area represents one of the highest richness levels ever recorded in areas of dense



**Figure 2** – Vegetation of Parque Estadual do Ibitipoca – a. patches of cloud forest interspersed with *campo rupestre*; b. detail of fog covering the forests and *campo rupestre*; c. general view of a cloud forest; d. detail of the canopy of a cloud forest. e-g. interior view of the cloud forests.

**Table 1** – Checklist of vascular epiphyte species recorded in cloud forests of the Parque Estadual do Ibitipoca, Minas Gerais, Brazil.

Lineages, families and species	Voucher	CS	EC
<b>Lycophytes (1/3)</b>			
Lycopodiaceae (1/3)			
<i>Phlegmariurus biformis</i> (Hook.) B.Øllg. *	<i>L.Krieger</i> (CESJ 2665)		CHL
<i>Phlegmariurus fontinaloides</i> (Spring) B.Øllg. *	<i>L.Krieger</i> (CESJ 9347)		CHL
<i>Phlegmariurus heterocarpon</i> (Fée) B.Øllg.	<i>S.G.Furtado</i> 316		CHL
<b>Ferns (35/71)</b>			
Aspleniaceae (1/10)			
<i>Asplenium auriculatum</i> Sw.	<i>S.G.Furtado</i> 308		FHL
<i>Asplenium auritum</i> Sw.	<i>R.F.Novelino et al.</i> 842		FHL
<i>Asplenium claussenii</i> Hieron.	<i>C.M.Mynssen</i> 825		FHL
<i>Asplenium feei</i> Kunze ex Fee	<i>C.M.Mynssen</i> 824		FHL
<i>Asplenium geraense</i> (C.Chr.) Sylvestre	<i>S.G.Furtado</i> 309		FHL
<i>Asplenium harpeodes</i> Kunze	<i>R.F.Novelino et al.</i> 919		FHL
<i>Asplenium oligophyllum</i> Kaulf.	<i>P.B.Pitta</i> 281		FHL
<i>Asplenium praemorsum</i> Sw.	<i>S.G.Furtado</i> 319		FHL
<i>Asplenium pseudonitidum</i> Raddi *	<i>R.C.Forzza</i> 3588		FHL
<i>Asplenium raddianum</i> Gaudich.	<i>R.C.Forzza</i> 3149		FHL
<i>Asplenium serra</i> Langsd. & Fisch.	<i>L.Krieger</i> (CESJ 8383)		FHL
Blechnaceae (1/1)			
<i>Lomaridium acutum</i> (Desv.) Gasper & V.A.O. Dittrich	<i>R.F.Novelino</i> 860		FHL
Dryopteridaceae (4/11)			
<i>Arachniodes denticulata</i> (Sw.) Ching	<i>B.R.Silva</i> 1367		AHL
<i>Elaphoglossum gayanum</i> (Fée) T.Moore	<i>S.G.Furtado</i> 314		FHL
<i>Elaphoglossum glabellum</i> J.Sm.	<i>C.M.Mynssen</i> 786		FHL
<i>Elaphoglossum lingua</i> (C.Presl) Brack. *	<i>R.F.Novelino</i> 1017		FHL
<i>Elaphoglossum lisboae</i> Rosenst. *	<i>R.F.Novelino</i> 1029		CHL
<i>Elaphoglossum luridum</i> (Fee) Christ	<i>R.F.Novelino</i> 1014		FHL
<i>Elaphoglossum pachydermum</i> (Fée) T.Moore *	<i>J.E.Z.Oliveira</i> 217		AHL
<i>Elaphoglossum strictum</i> (Raddi) T.Moore	<i>J.E.Z.Oliveira</i> 398		CHL
<i>Elaphoglossum vagans</i> (Mett.) Hieron. *	<i>R.F.Novelino</i> 1188		FHL
<i>Polybotrya speciosa</i> Schott *	<i>C.M.Mynssen</i> 828		Hem
<i>Rumohra adiantiformis</i> (G.Forst.) Ching	<i>L.Menini Neto</i> 1354		FHL
Hymenophyllaceae (4/14)			
<i>Didymoglossum hymenoides</i> (Hedw.) Desv.	<i>L.Krieger</i> (BHCB 4220)	DD MG	CHL
<i>Didymoglossum krausii</i> (Hook. & Grev.) C.Presl	<i>L.Krieger</i> (CESJ 18823)		CHL
<i>Hymenophyllum crispum</i> Kunth	<i>T.E.Almeida</i> 1171		CHL

Lineages, families and species	Voucher	CS	EC
<i>Hymenophyllum fragile</i> (Hedw.) C.V.Morton	T.E.Almeida 1186		CHL
<i>Hymenophyllum fucoides</i> (Sw.) Sw.	T.E.Almeida 1241		CHL
<i>Hymenophyllum hirsutum</i> (L.) Sw.	L.Krieger (CESJ 8375)		FHL
<i>Hymenophyllum polyanthos</i> (Sw.) Sw.	L.Krieger (CESJ 3549)		CHL
<i>Hymenophyllum pulchellum</i> Schldl. & Cham.	T.E.Almeida 1167		CHL
<i>Hymenophyllum</i> sp.	S.G.Furtado 289		CHL
<i>Polyphlebium angustatum</i> (Carmich.) Ebihara & Dubuisson	C.M.Mynssen 831		CHL
<i>Polyphlebium diaphanum</i> (Kunth) Ebihara & Dubuisson *	L.Krieger (CESJ 16218)		FHL
<i>Polyphlebium hymenophylloides</i> (Bosch) Ebihara & Dubuisson	T.E.Almeida 1181		CHL
<i>Trichomanes pilosum</i> Raddi	R.F.Novelino 870		AHL
<i>Trichomanes polypodioides</i> Raddi	C.M.Mynssen 779		CHL
Nephrolepidaceae (1/1)			
<i>Nephrolepis</i> sp.	Not collected		AHL
Polypodiaceae (12/27)			
<i>Campyloneurum angustifolium</i> (Sw.) Fee	R.C.Forzza 3152		CHL
<i>Campyloneurum nitidum</i> (Kaulf.) C.Presl	S.G.Furtado 310		FHL
<i>Campyloneurum phyllitidis</i> (L.) C.Presl	J.E.Z.Oliveira 228		CHL
<i>Cochlidium punctatum</i> (Raddi) L.E.Bishop *	L.Krieger (CESJ 11674)		CHL
<i>Cochlidium serrulatum</i> (Sw.) L.E.Bishop	S.G.Furtado 294		FHL
<i>Lellingeria apiculata</i> (Kunze ex Klotzsch) A.R.Sm. & R.C.Moran	L.Krieger (CESJ 64862)		CHL
<i>Leucotrichum</i> sp.	Not collected		CHL
<i>Melpomene flabelliformis</i> (Poir.) A.R.Sm. & R.C.Moran *	L.Krieger (CESJ 15133)		CHL
<i>Melpomene peruviana</i> (Desv.) A.R.Sm. & R.C.Moran	L.Krieger (CESJ 8380)	CR MG	FHL
<i>Melpomene pilosissima</i> (M.Martens & Galeotti) A.R.Sm. & R.C.Moran	S.G.Furtado 288		CHL
<i>Microgramma percussa</i> (Cav.) de la Sota	L.Krieger (CESJ 21276)		FHL
<i>Microgramma squamulosa</i> (Kaulf.) de la Sota	R.F.Novelino 933		FHL
<i>Moranopteris achilleifolia</i> (Kaulf.) R.Y. Hirai & J. Prado *	S.G.Furtado 287		CHL
<i>Moranopteris gradata</i> (Baker) R.Y. Hirai & J. Prado *	R.C.Forzza 4436		FHL
<i>Niphidium crassifolium</i> (L.) Lellinger	S.G.Furtado 323		FHL
<i>Pechluma pectinatiformis</i> (Lindm.) M.G.Price	C.M.Mynssen 788		CHL
<i>Pechluma recurvata</i> (Kaulf.) M.G.Price *	R.C.Forzza 3158		CHL
<i>Pechluma truncorum</i> (Lindm.) M.G.Price *	C.M.Mynssen 833		CHL
<i>Phlebodium pseudoaureum</i> (Cav.) Lellinger	R.C.Forzza 3587		FHL
<i>Pleopeltis astrolepis</i> (Liebm.) E.Fourn.	S.G.Furtado 285		CHL
<i>Pleopeltis hirsutissima</i> (Raddi) de la Sota	L.Krieger (CESJ 27419)		CHL
<i>Pleopeltis macrocarpa</i> (Bory ex Willd.) Kaulf.	R.F.Novelino 1263		CHL
<i>Pleopeltis minarum</i> (Weath.) Salino *	R.C.Forzza 3715		CHL
<i>Serpocaulon catharinae</i> (Langsd. & Fisch.) A.R.Sm. *	D.Sucre 6737		FHL

Lineages, families and species	Voucher	CS	EC
<i>Serpocaulon fraxinifolium</i> (Jacq.) A.R.Sm.	J.E.Z.Oliveira 375		Hem
<i>Serpocaulon latipes</i> (Langsd. & Fisch.) A.R.Sm. *	L.Krieger (CESJ 8378)		AHL
Polypodiaceae indet.	S.G.Furtado 292		CHL
Pteridaceae (2/4)			
<i>Radiovittaria gardneriana</i> (Fée) E.H.Crane	C.M.Mynssen 813		CHL
<i>Radiovittaria stipitata</i> (Kunze) E.H.Crane	J.E.Z.Oliveira 397		FHL
<i>Vittaria graminifolia</i> Kaulf.	S.G.Furtado 315		FHL
<i>Vittaria lineata</i> (L.) Sm.	R.F.Novelino 59		FHL
<b>Angiosperms</b>			
<b>Magnoliids (1/10)</b>			
Piperaceae (1/10)			
<i>Peperomia augescens</i> Miq. #*	F.Salimena (CESJ 27411)		AHL
<i>Peperomia corcovadensis</i> Gardn. #	D.Monteiro 625		CHL
<i>Peperomia crinicaulis</i> C.DC. #*	S.G.Furtado 291		CHL
<i>Peperomia decora</i> Dahlst. * (MG)	L.Krieger (CESJ 8541)		FHL
<i>Peperomia diaphanoides</i> Dahlst. #	S.G.Furtado 306		FHL
<i>Peperomia galioides</i> Kunth #	S.G.Furtado 303		FHL
<i>Peperomia loxensis</i> Kunth #	D.Sucre 7246		CHL
<i>Peperomia mandioccana</i> Miq. *	S.G.Furtado 302		FHL
<i>Peperomia rotundifolia</i> (L.) Kunth #	H.Magalhães (R 86560)		CHL
<i>Peperomia tetraphylla</i> (G.Forst.) Hook. & Arn.	L.Krieger (CESJ 16238)		CHL
<b>Monocotyledons (42/120)</b>			
Amaryllidaceae (1/1)			
<i>Hippeastrum aulicum</i> (Ker Gawl.) Herb. #*	P.M.Andrade (BHCB 92378)		FHL
Araceae (2/9)			
<i>Anthurium boudetii</i> Nadruz *	L.Temponi 397		FHL
<i>Anthurium comtum</i> Schott *	L.Temponi 400		FHL
<i>Anthurium leonii</i> E.G.Gonç. * (MG)	R.C.Forzza 4270	CR MG	FHL
<i>Anthurium minarum</i> Sakur. & Mayo *	L.Temponi 390		FHL
<i>Anthurium scandens</i> (Aubl.) Engl.	R.C.Forzza 2663		CHL
<i>Philodendron appendiculatum</i> Nadruz & Mayo *	R.C.Forzza 3638		Hem
<i>Philodendron bipinnatifidum</i> Schott	L.Temponi 410		Hem
<i>Philodendron minarum</i> Engl. *	R.C.Forzza 2653		Hem
<i>Philodendron propinquum</i> Schott *	L.Temponi 398		Hem
Bromeliaceae (8/25)			
<i>Aechmea bromeliifolia</i> (Rudge) Baker #	E.M.C.Leme 1474		CHL
<i>Aechmea nudicaulis</i> (L.) Griseb. *	R.Monteiro 13		CHL
<i>Billbergia alfonsojoannis</i> Reitz *	E.M.C.Leme 1475		CHL

Lineages, families and species	Voucher	CS	EC
<i>Billbergia distachia</i> (Vell.) Mez #*	S.G.Furtado 325		FHL
<i>Neoregelia ibitipocensis</i> (Leme) Leme *	R.C.Forzza 3338	CR MG	FHL
<i>Neoregelia lymaniana</i> R.Braga & Sucre *	E.M.C.Leme 1478	EN MG	FHL
<i>Neoregelia oligantha</i> L.B.Sm. * (MG)	R.F.Monteiro 38	VU BR EN MG	FHL
<i>Nidularium ferdinandocoburgii</i> Wawra *	R.C.Forzza 3182		FHL
<i>Nidularium marigoii</i> Leme *	R.C.Forzza 3232	NT BR VU MG	FHL
<i>Racinaea aerisicola</i> (Mez) M.A.Spencer & L.B.Sm. *	D.Sucre 7147		CHL
<i>Tillandsia gardneri</i> Lindl.	R.C.Forzza 3094		CHL
<i>Tillandsia geminiflora</i> Brongn.	L.Krieger (CESJ 8595)		CHL
<i>Tillandsia recurvata</i> (L.) L.	D.Sucre 7234		CHL
<i>Tillandsia streptocarpa</i> Baker #	L.Menini Neto 1349		AHL
<i>Tillandsia stricta</i> Sol.	S.G.Furtado 318		CHL
<i>Tillandsia tenuifolia</i> L.	R.C.Forzza 3137		CHL
<i>Tillandsia usneoides</i> (L.) L.	S.G.Furtado 317		CHL
<i>Vriesea bituminosa</i> Wawra *	R.F.Monteiro 28		FHL
<i>Vriesea carinata</i> Wawra *	C.C.Paula (VIC 26470)		CHL
<i>Vriesea friburgensis</i> Mez *	E.M.C.Leme 1473		FHL
<i>Vriesea guttata</i> Linden & André *	R.F.Monteiro 25		CHL
<i>Vriesea heterostachys</i> (Baker) L.B.Sm. *	G.Martinelli 15301		CHL
<i>Vriesea longicaulis</i> (Baker) Mez *	G.Martinelli 15314		FHL
<i>Vriesea penduliflora</i> L.B.Sm. *	E.M.C.Leme 1476	EN BR VU MG	FHL
<i>Wittrockia gigantea</i> (Baker) Leme *	G.Martinelli 15313		FHL
Commelinaceae (1/1)			
<i>Commelina obliqua</i> Vahl #	L.Menini Neto 1355		AHL
Orchidaceae (30/86)			
<i>Bifrenaria aureofulva</i> Lindl. #*	R.C.Forzza 88		FHL
<i>Bifrenaria harrisoniae</i> (Hook.) Rchb.f. #*	P.I.S.Braga 1938		FHL
<i>Bifrenaria stefanae</i> V.P.Castro #*	H.C.Souza (BHCB 9082)		CHL
<i>Bifrenaria vitellina</i> (Lindl.) Lindl. *	L.Menini Neto 35	EN MG	CHL
<i>Bulbophyllum micropetaliforme</i> J.E.Leite *	L.Menini Neto 152		CHL
<i>Bulbophyllum exaltatum</i> Lindl. #	D.Sucre 6839		FHL
<i>Bulbophyllum glutinosum</i> (Barb.Rodr.) Cogn. *	L.Menini Neto 125		CHL
<i>Bulbophyllum granulatum</i> Barb.Rodr. *	L.Menini Neto 107		CHL
<i>Bulbophyllum regnellii</i> Rchb.f.	L.Menini Neto 124		CHL
<i>Campylocentrum</i> cf. <i>neglectum</i> (Rchb.f. & Warm.) Cogn.	L.Menini Neto 28		CHL
<i>Campylocentrum</i> cf. <i>robustum</i> Cogn. *	L.Menini Neto 193		CHL
<i>Cattleya bicolor</i> Lindl. *	L.Menini Neto 178	NT BR VU MG	CHL

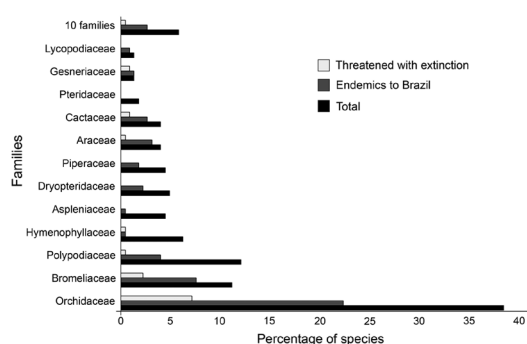


Lineages, families and species	Voucher	CS	EC
<i>Cattleya loddigesii</i> Lindl. *	Without collector (CESJ 27534)	EN MG	CHL
<i>Centroglossa macroceras</i> Rchb.f. *	R.C.Forzza 54		CHL
<i>Dichaea cogniauxiana</i> Schltr. *	L.Menini Neto 142		CHL
<i>Elleanthus brasiliensis</i> (Lindl.) Rchb.f. #	L.Menini Neto 126		FHL
<i>Encyclia patens</i> Hook. *	S.G.Furtado 299		CHL
<i>Epidendrum armeniacum</i> Lindl.	L.Menini Neto 175		CHL
<i>Epidendrum avicula</i> Lindl. #	M.C.Brügger (CESJ 24693)		CHL
<i>Epidendrum chlorinum</i> Barb.Rodr. *	L.Menini Neto 171		CHL
<i>Epidendrum cf. filicaule</i> Lindl. #	L.Menini Neto 1350		CHL
<i>Epidendrum pseudodiforme</i> Hoehne & Schltr. *	L.Menini Neto 97		CHL
<i>Epidendrum ochrochlorum</i> Barb.Rodr. *	S.G.Furtado 297	EN MG	CHL
<i>Epidendrum paranaense</i> Barb.Rodr. *	L.Menini Neto 131		FHL
<i>Epidendrum ramosum</i> Jacq. #	R.C.Forzza 16		FHL
<i>Epidendrum rigidum</i> Jacq.	L.Menini Neto 71		CHL
<i>Epidendrum secundum</i> Jacq. #	L. Menini Neto 46		FHL
<i>Eurystyles actinosophila</i> (Barb.Rodr.) Schltr. #	S.G. Furtado 326		CHL
<i>Eurystyles cogniauxii</i> (Kraenzl.) Pabst *	L.Menini Neto 77		CHL
<i>Gomesa glaziovii</i> Cogn. *	L.Menini Neto 76		FHL
<i>Gomesa gomezoides</i> (Barb.Rodr.) Pabst *	L.Menini Neto 30		CHL
<i>Gomesa recurva</i> R.Br.	L.Menini Neto 154		CHL
<i>Grobya amherstiae</i> Lindl. *	R.C.Forzza 26		CHL
<i>Hadrolaelia coccinea</i> (Lindl.) Chiron & V.P.Castro	L.Menini Neto 161	EN MG	CHL
<i>Hoffmannseggella crispata</i> (Thunb.) H.G.Jones #* (MG)	Not collected	NT BR EN MG	AHL
<i>Isabelia violacea</i> (Lindl.) van den Berg & M.W.Chase *	S.G.Furtado 282		CHL
<i>Isabelia virginalis</i> Barb.Rodr.	L.Menini Neto 47	VU BR	CHL
<i>Isochilus linearis</i> (Jacq.) R.Br	L.Menini Neto 44		CHL
<i>Lankesterella gnoma</i> (Kraenzl.) Hoehne *	L.Menini Neto 139		CHL
<i>Masdevallia infracta</i> Lindl.	L.Menini Neto 173		CHL
<i>Maxillaria brasiliensis</i> Brieger & Illg #*	L.Menini Neto 88		FHL
<i>Maxillaria gracilis</i> Lodd. #*	L.C.S.Assis 1080		FHL
<i>Maxillaria notyloglossa</i> Rchb.f.	L.Menini Neto 119		CHL
<i>Maxillaria ochroleuca</i> Lodd. ex Lindl.	L.Menini Neto 87		CHL
<i>Maxillaria picta</i> Hook. #	R.C.Forzza 92		FHL
<i>Maxillaria subulata</i> Lindl. *	L.Menini Neto 48		FHL
<i>Octomeria crassifolia</i> Lindl.	L.Menini Neto 138		CHL
<i>Octomeria diaphana</i> Lindl. *	L.Menini Neto 111		CHL
<i>Octomeria grandiflora</i> Lindl.	S.G.Furtado 300		CHL

Lineages, families and species	Voucher	CS	EC
<i>Octomeria rubrifolia</i> Barb.Rodr. *	<i>L.Menini Neto 40</i>		CHL
<i>Octomeria wawrae</i> Rchb.f. *	<i>L.Menini Neto 168</i>	EN BR	CHL
<i>Oncidium divaricatum</i> Lindl. *	<i>R.C.Forzza 2190</i>	VU BR	CHL
<i>Oncidium gravesianum</i> Rolfe *	<i>L.Menini Neto 112</i>		CHL
<i>Oncidium hookeri</i> Rolfe *	<i>L.Menini Neto 96</i>		CHL
<i>Oncidium longipes</i> Lindl.	<i>L.Menini Neto 163</i>		CHL
<i>Oncidium truncatum</i> Pabst *	<i>L.Menini Neto 95</i>	CR BR	CHL
<i>Oncidium warmingii</i> Rchb.f. #	<i>G.Martinelli 15300</i>	VU MG	AHL
<i>Pleurothallis cryptophoranthoides</i> Loefgr. *	<i>L.Menini Neto 176</i>	EN MG	CHL
<i>Pleurothallis heliconiscapa</i> Hoehne #*	<i>H.C.Sousa (BHCB 9833)</i>		CHL
<i>Pleurothallis hypnicola</i> Lindl.	<i>L.Menini Neto 134</i>		CHL
<i>Pleurothallis liparanges</i> Rchb.f. *	<i>L.Menini Neto 177</i>	CR MG	CHL
<i>Pleurothallis luteola</i> Lindl.	<i>L.Menini Neto 158</i>		CHL
<i>Pleurothallis malachantha</i> Rchb.f. *	<i>L.Menini Neto 90</i>	VU MG	CHL
<i>Pleurothallis marginalis</i> Rchb.f.	<i>L.Menini Neto 162</i>		CHL
<i>Pleurothallis quartzicola</i> (Barb.Rodr.) Cogn. *	<i>S.G.Furtado 283</i>		CHL
<i>Pleurothallis recurva</i> Lindl.	<i>L.Menini Neto 236</i>		CHL
<i>Pleurothallis rubens</i> Lindl.	<i>L.Menini Neto 31</i>		CHL
<i>Pleurothallis saundersiana</i> Rchb.f. *	<i>L.Menini Neto 37</i>		CHL
<i>Pleurothallis</i> cf. <i>saurocephala</i> Lodd. #*	Not collected		CHL
<i>Pleurothallis tricarinata</i> Poepp. & Endl.	<i>L.Menini Neto 118</i>		CHL
<i>Polystachya hoehneana</i> Kraenzl. *	<i>L.Menini Neto 91</i>	VU MG	CHL
<i>Polystachya estrellensis</i> Rchb.f. #*	<i>L.Menini Neto 1348</i>		CHL
<i>Prescottia stachyodes</i> (Sw.) Lindl. #	<i>D.R.Gonzaga 43</i>		AHL
<i>Promenaea xanthina</i> (Lindl.) Lindl. *	<i>L.Menini Neto 130</i>		CHL
<i>Prosthechea allemanoides</i> (Hoehne) W.E.Higgins *	<i>L.Menini Neto 26</i>		FHL
<i>Prosthechea calamaria</i> (Lindl.) W.E.Higgins *	<i>L.Menini Neto 180</i>		CHL
<i>Prosthechea pachysepala</i> (Klotzsch) Chiron & V.P.Castro *	<i>L.Menini Neto 36</i>		FHL
<i>Prosthechea</i> aff. <i>pachysepala</i> (Klotzsch) Chiron & V.P.Castro #	<i>D.R.Gonzaga 44</i>		CHL
<i>Scaphyglottis modesta</i> (Rchb.f.) Schltr.	<i>L.Menini Neto 52</i>		FHL
<i>Scuticaria hadwenii</i> (Lindl.) Planch. *	<i>R.C.Forzza 15</i>	EN MG	CHL
<i>Stelis aprica</i> Lindl.	<i>L.Menini Neto 127</i>		CHL
<i>Stelis intermedia</i> Poepp. & Endl.	<i>L.Menini Neto 159</i>		CHL
<i>Stelis megantha</i> Barb.Rodr. *	<i>L.Menini Neto 148</i>		CHL
<i>Stelis papaquerensis</i> Rchb.f.	<i>L.Menini Neto 157</i>		CHL
<i>Stelis</i> aff. <i>caespitosa</i> Lindl.	<i>L.Menini Neto 25</i>		CHL
<i>Thysanoglossa organensis</i> Brade *	<i>L.Menini Neto 89</i>		CHL

Lineages, families and species	Voucher	CS	EC
<b>Eudicotiledôneas (13/19)</b>			
Begoniaceae (1/2)			
<i>Begonia angulata</i> Vell. *	<i>S.G.Furtado 321</i>		FHL
<i>Begonia</i> sp.	<i>R.C.Forzza 4287</i>		FHL
Cactaceae (5/9)			
<i>Arthrocerus melanurus</i> (K.Schum.) Diers <i>et al.</i> subsp. <i>magnus</i> N.P.Taylor & Zappi #* (MG)	Not collected	EN BR CR MG	AHL
<i>Hatiora salicornioides</i> (Haw.) Britton & Rose *	<i>M.C.Brügger</i> (CESJ 21541)		FHL
<i>Lepismium cruciforme</i> (Vell.) Miq. #	<i>L.Menini Neto 1351</i>		CHL
<i>Lepismium houlettianum</i> (Lem.) Barthlott	<i>S.G.Furtado 313</i>		CHL
<i>Rhipsalis elliptica</i> G.Lindb. ex K.Schum. *	<i>R.C.Forzza 3226</i>		CHL
<i>Rhipsalis floccosa</i> Salm-Dyck ex Pfeiff.	<i>L.Krieger</i> (CESJ 8589)		CHL
<i>Rhipsalis juengeri</i> Barthlott & N.P.Taylor *	<i>L.Krieger</i> (CESJ 8594)		CHL
<i>Rhipsalis pulchra</i> Loefgr. *	<i>L.Krieger</i> (CESJ 9296)		CHL
<i>Schlumbergera opuntiioides</i> (Loefgr. & Dusén) D.R.Hunt *	<i>D.C.Zappi 258</i>	VU BR VU MG	FHL
Gesneriaceae (2/3)			
<i>Nematanthus crassifolius</i> (Schott) Wiehler *	<i>R.C.Forzza 4274</i>	VU MG	CHL
<i>Nematanthus strigillosus</i> (Mart.) H.E.Moore #*	<i>L.Krieger</i> (CESJ 13168)	NT BR	FHL
<i>Sinningia magnifica</i> (Otto & A.Dietr.) Wiehler *	<i>R.C.Forzza</i> (CESJ 27323)		FHL
Griselinaceae (1/1)			
<i>Griselinia ruscifolia</i> (Clos) Taub.	<i>S.G.Furtado 322</i>	NT BR	Hem
Lentibulariaceae (1/1)			
<i>Utricularia reniformis</i> A.St.-Hil. #*	<i>R.C.Forzza 3095</i>		CHL
Moraceae (1/1)			
<i>Ficus cf. mexiae</i> Standl. #*	Not collected		Hem
Rubiaceae (1/1)			
<i>Hillia parasitica</i> Jacq.	<i>L.Menini Neto 1353</i>		FHL
Solanaceae (1/1)			
<i>Dyssochroma viridiflorum</i> (Sims) Miers #*	<i>S.G.Furtado 301</i>		Hem
Urticaceae (1/1)			
<i>Coussapoa microcarpa</i> (Schott) Rizzini #	not collected		Hem

The number of genera and species recorded is indicated within parentheses after the lineages and families. EC: Ecological category; Hem: Hemiepiphyte; AHL: Accidental holoepiphyte; CHL: Characteristic holoepiphyte; FHL: Facultative holoepiphyte. CS: Conservation status: CR: Critically endangered; DD: Data deficient; EN: Endangered; NT: Near threatened; VU: Vulnerable. MG: Minas Gerais; BR: Brazil. In the checklist of angiosperms, the species not recorded by Menini Neto *et al.* (2009a) are marked with #. The species marked with \* are endemic to Brazil (BFG 2015; Prado *et al.* 2015).



**Figure 3** – Representativity of the families of vascular epiphytes and comparison with percentage of endemics and threatened with extinction in the cloud forest of Parque Estadual do Ibitipoca, Minas Gerais, Brazil.

ombrophilous forest in Brazil (Waechter 1992; Kersten & Kunyioshi 2006; Blum *et al.* 2011; Lima *et al.* 2011). This richness is even more remarkable when accounting for the total area of this conservation unit (1,488 ha), of which only 20% presents forest vegetation (*i.e.*, less than 300 ha are composed of this physiognomy). The richness of vascular epiphytes in the PEIB also represents approximately 9.5% of the total found in the BAF [2,256 species according to Freitas *et al.* (2016)], in a conservation unit that comprises only 0.001% of this phytogeographic domain (0.00085% if considering only the area covered by cloud forests).

Evolutionary lineages have a different configuration regarding the proportion identified in the BAF by Kersten (2010), with monocotyledons presenting a slightly smaller percentage (54.3% versus 63.5%) of that attributed to the BAF. A similar result was obtained for eudicotyledons (with 8.5% in PEIB and 14.1% in BAF). On the other hand, ferns have a higher diversity (31.4%) in the PEIB than in the BAF (16.4%).

The richest families found in the PEIB are among the richest often found in similar studies in several forest physiognomies in the Neotropical Region (Hietz & Hietz-Seifert 1995; Dittrich *et al.* 1999; Kersten & Silva 2001; Arévalo & Betancur 2004; Giongo & Waechter 2004; Kersten *et al.* 2009; Bianchi *et al.* 2012; Alves & Menini Neto 2014; Barbosa *et al.* 2015), although the order can be different in some cases.

These families (Tab. 2) are also the main families of vascular epiphytes in the BAF, despite the differences in representativity. According to

the data of Freitas *et al.* (2016), Araceae have a similar proportion in the BAF and PEIB, while Orchidaceae reaches 46.5% of all vascular epiphytes of the BAF and represents 38.6% of the total families in the PEIB. A similar result was found for Bromeliaceae, which represents 26.2% of the epiphytic species of the BAF and accounts for only 11.2% of the species in the PEIB. Thus, the reduced contribution of the last two families results in a smaller contribution of the monocotyledons to the epiphytic flora.

On the other hand, Polypodiaceae has greater representativity, with 12.1% of the vascular epiphytes of this conservation unit, a value substantially superior to the 4.3% found in the BAF (Freitas *et al.* 2016), contributing to the richness of ferns in the flora of the PEIB. The richness of this lineage was enhanced by the Hymenophyllaceae, (the fourth richest; 6.3% of total), which represents only 1.8% (in ninth position) in the BAF epiphytes, next to Aspleniaceae and Dryopteridaceae (5% each) which both have a greater relative representativity in the PEIB than in the BAF (around 1.8% each).

As reviewed by Kersten (2010), Orchidaceae is the richest family in the dense ombrophilous forest of the BAF, followed by Bromeliaceae, Araceae, Polypodiaceae, Cactaceae, Dryopteridaceae, Gesneriaceae, Hymenophyllaceae, and Piperaceae. It is apparent that although the richest families in the PEIB (Tab. 2, Fig. 2) are among the richest of this type of forest in the BAF, there is a reduced contribution of the angiosperm families Araceae, Cactaceae, and Gesneriaceae.

A comparison with some punctual studies of vascular epiphytes in ombrophilous and montane ombrophilous forests (Tab. 2) shows a consistent greater relative richness of ferns, with Polypodiaceae as the second richest in four of six sites (all areas with elevations superior to 1,000 m). Hymenophyllaceae is well represented in all sites, and Aspleniaceae and Dryopteridaceae are also among the richest families in the majority of sites. On the other hand, there are fewer Araceae species in sites of high elevation, except in the Parque Estadual Carlos Botelho, which has a wide altitudinal gradient and lower altitudes of approximately 30 m.

Thus, ferns with only marginal importance in the BAF or globally (*e.g.*, Aspleniaceae, Dryopteridaceae and Hymenophyllaceae) contribute less than 2% of the total richness in both cases (Madison 1977; Kersten 2010; Zotz 2013; Freitas *et al.* 2016) in the PEIB have a greater

**Table 2** – Comparison of species richness in families of vascular epiphytes in some checklists of rainforests in Southeastern and Southern Brazil.

Parque Estadual do Ibitipoca Area (ha)/ elevation (m) 1488,5 ha /1100-1784	Parque Estadual da Serra				Parque Estadual Carlos Botelho (São Paulo) 37644/30-1000	Parque Estadual Marumbi (Paraná) 8745/~1000
	Serra do Cruz (Minas Gerais) -/1300-1600	Serra Negra (Minas Gerais) 10000/900-1700	do Papagaio (Minas Gerais) 22000/1600-1950	Orch		
Orch	50	66	51	Orch	75	29
Poly	23	29	23	Brom	43	23
Brom	19	29	10	Poly	23	20
Hyme	8	10	10	Arac	19	12
Aspl	8	9	5	Hyme	16	5
Dryo	5	6	4	Cact	15	5
Pipe	4	3	4	Pipe	13	5
Arac	4	3	3	Dryo	12	5
Other families	33	29	28	Other families	44	23
Total	154	184	138	Total	260	127
Present study	Alves & Menini Neto (2009b); (2014)	Menini Neto (2009b); Souza <i>et al.</i> (2012); Salimena <i>et al.</i> (2013)	Furtado & Menini Neto (2016)	Breier (2005); Lima <i>et al.</i> (2011)	Bianchi <i>et al.</i> (2014)	

Families: Arac – Araceae, Aspl – Aspleniaceae, Brom – Bromeliaceae, Cact – Cactaceae, Dryo – Dryopteridaceae, Gesn – Gesneriaceae, Hyme – Hymenophyllaceae, Lyco – Lycopodiaceae, Orch – Orchidaceae, Pipe – Piperaceae, Poly – Polypodiaceae.

richness to the detriment of angiosperm families of vascular epiphytes often found among the richest. For example, Araceae, Piperaceae, and Cactaceae are the fourth, fifth and sixth richest families in the BAF, respectively; however, Cactaceae did not figure among the richest of the PEIB.

Elevation could contribute to this pattern, due to the sensitivity of some families to low temperatures. For example, Araceae has a lower percentage in the physiognomy of the mixed ombrophilous forests, which are common in the southern region of Brazil (Kersten 2010), occurring at higher latitudes (and, consequently, lower temperatures). Consistently, only one species of Araceae was observed by Furtado & Menini Neto (2016) in a mixed ombrophilous forest in the Serra da Mantiqueira ranging from 1,600 to 1,650 m of elevation. Krömer *et al.* (2005) and Cardelús *et al.* (2006) also recorded a reduction in the richness of this family correlating with the enhancement of elevation in the Andes. On the other hand, ferns have a greater richness that correlates with enhanced elevation (Moran 1995; Hietz & Hietz-Seifert 1995; Krömer *et al.* 2005; Cardelús *et al.* 2006). Further investigation in Brazilian mountainous areas will contribute to determining whether this is a consistent pattern associated with cloud forests.

The epiphytic quotient observed in the PEIB reinforces the relevance of epiphytes in the diversity of flora. This quotient is 15% in the BAF (Freitas *et al.* 2016), and this index varies from 13 to 32% (average of ~20%) in areas of Brazilian dense ombrophilous forests (Kersten 2010). Thus, the quotient percentage observed in the PEIB is higher than the average in the BAF and of the majority of areas where this value was calculated. The relevance of this value must be highlighted because it is the same as that of the Equator flora (Moller-Jorgensen & León-Yáñez 1999; Zotz 2016) and higher than the quotient for the flora of Panama (Foster & Hubbel 1990), indicating the importance of this synusia to the cloud forest in the studied area.

The majority of the 75 recorded genera (excluding those completely accidental) are tropically distributed (34 Neotropical and 17 Pantropical), and only four genera are considered Cosmopolitan. Eight genera occur exclusively in the BAF, of which six are endemic to Brazil (*Centroglossa* Barb.Rodr., *Dyssochroma* Miers, *Hatiora* Britton & Rose, *Promenaea* Lindl., *Schlumbergera* Lem., *Thysanoglossa* Porto & Brade). Six genera are found in the BAF and

Cerrado (CE), of which three are endemic to Brazil (*Grobya* Lindl., *Isabelia* Barb.Rodr., *Nematanthus* Schrad.). In addition, *Nidularium* is endemic to Brazil, occurring in Caatinga (CA) and the BAF, and *Wittrockia* Lindm. is also endemic, but occurs in CA, CE, and BAF. *Griselinia* J.R. Forst. & G. Forst present a disjunct distribution in South America and New Zealand, and *Neoregelia* L.B.Sm. is disjunct between the Andes/Amazonia (AM) and the BAF. *Scuticaria* Lindl. is found in AM, CE, BAF, and *Racinaea* M.A. Spencer & L.B.Sm. in AM and AF.

Among the 111 endemic Brazilian species (BFG 2015; Prado *et al.* 2015), four are endemic to Minas Gerais: *Anthurium leoni*, *Neoregelia oligantha*, *Hoffmannseggella crispata* (accidental), and *Peperomia decora*. Among the angiosperms, 38 represent species not recorded in the PEIB by Menini Neto *et al.* (2009a), of which only six are accidental.

Thirteen species are threatened with extinction at the country level, of which five are classified as Near Threatened, four as Vulnerable, three as Endangered, and one as Critically Endangered (Martinelli & Moraes 2013). There are 23 threatened species at the state level, of which seven are classified as Vulnerable, nine as Endangered, six as Critically Endangered, and one as Data Deficient (Drummond *et al.* 2008). Orchidaceae has the greatest number of threatened species (16 at the country or state level, or both), due in particular to the ornamental appeal of several species.

The conservation of epiphytic species represents a challenge due to habitat suppression, which threatens the biodiversity as a whole or due to the sensitivity of fragmentation and collection of ornamental species. Both the richness and the complexity of epiphyte communities in the PEIB, as well as the presence of species at different levels of risk and endemism, reinforces its importance for biodiversity, revealing that relatively small areas are also relevant to the preservation, and even consolidated conservation units must improve the strategies for maintaining the biodiversity.

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## 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.
- Alves RJV, Kolbek J & Becker J (2008) Vascular epiphyte vegetation in rocky savannas of southeastern Brazil. *Nordic Journal of Botany* 26: 101-117.
- APG IV - The Angiosperm Phylogeny Group (2016) An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV. *Botanical Journal of the Linnean Society* 181: 1-20.
- Arévalo R & Betancur J (2004) Diversidad de epífitas vasculares en cuatro bosques del sector suroriental de la Serranía de Chiribiquete, Guayana Colombiana. *Caldasia* 26: 359-380.
- 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.
- Benzing DH (1990) Vascular epiphytes: general biology and related biota. Cambridge University Press, Cambridge. 376p.
- BFG - The Brazil Flora Group (2015) Growing knowledge: an overview of seed plant diversity in Brazil. *Rodriguésia* 66: 1085-1113.
- Bianchi JS, Michelon C & Kersten RA (2012) Epífitas vasculares de uma área de ecótono entre as Florestas Ombrófilas Densa e Mista, no Parque Estadual do Marumbi, PR. *Estudos de Biologia (Ambiente e Diversidade)* 34: 37-44.
- Blum CT, Roderjan CV & Galvão F (2011) Composição florística e distribuição altitudinal de epífitas vasculares da floresta ombrófila densa na Serra da Prata, Morretes, Paraná, Brasil. *Biota Neotropica* 11: 141-159.
- Breier TB (2005) O epifitismo vascular em florestas do sudeste do Brasil. Tese de Doutorado. Universidade Estadual de Campinas, São Paulo. 139p.
- Cardelús CL, Colwell RK & Watkins JE (2006) Vascular epiphyte distribution patterns: explaining the mid-elevation richness peak. *Journal of Ecology* 94: 144-156.
- CETEC (1983) Diagnóstico ambiental do estado de Minas Gerais. Fundação Centro Tecnológico de Minas Gerais, Belo Horizonte. 158p.
- Christenhusz MJM, Zhang X-C & Schneider H (2011) A linear sequence of extant families and genera of lycophytes and ferns. *Phytotaxa* 19: 7-54
- Costa CMR, Hermann G & Martins CS (1998) Biodiversidade em Minas Gerais: um atlas para sua conservação. Fundação Biodiversitas, Belo Horizonte. 94p.
- Dittrich VAO, Kozera C & Silva SM (1999) Levantamento florístico dos epífitos vasculares do Parque Barigüi, Curitiba, Paraná, Brasil. *Iheringia, série Botânica* 52: 11-22.
- 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.
- Drummond GM, Machado ABM, Martins CS, Mendonça MP & Stehmann JR (2008) Listas vermelhas das espécies da fauna e da flora ameaçadas de extinção em Minas Gerais. 2ª ed. Fundação Biodiversitas, Belo Horizonte. CD-Rom. Available at <<http://www.biodiversitas.org.br/cdlistavermelha/default.asp>> Access on 20 June 2015.
- 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.
- Foster RB & Hubbell SP (1990) The floristic composition of the Barro Colorado Island forest. *In*: Gentry AH (ed.). *Four Neotropical rainforests*. Yale University Press, New Haven. Pp. 85-98.
- 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 (2015a) 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 (2015b) Diversity of vascular epiphytes in urban environment: a case study in a biodiversity hotspot, the Brazilian Atlantic Forest. *CES Revista* 29: 82-101.
- 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. DOI: 10.1590/0102-33062016abb0090

- Gentry AH & Dodson CH (1987) Diversity and biogeography of neotropical vascular epiphytes. *Annals of the Missouri Botanical Garden* 74: 205-223.
- Giongo C & Waechter JL (2004) Composição florística e estrutura comunitária de epífitos em uma floresta de galeria na Depressão Central do Rio Grande do Sul. *Revista Brasileira de Botânica* 27: 563-572.
- Hietz P & Hietz-Seifert U (1995) Composition and ecology of vascular epiphyte communities along an altitudinal gradient in Central Veracruz, Mexico. *Journal of Vegetation Science* 6: 487-498.
- Hosokawa T (1950) Epiphyte-quotient. *Botanical Magazine of Tokyo* 63: 18-19.
- Kersten RA (2010) Epífitas vasculares - histórico, participação taxonômica e aspectos relevantes com ênfase na Mata Atlântica. *Hoehnea* 37: 9-38.
- Kersten RA & Kuniyoshi YS (2006) Epífitos vasculares na Bacia do Alto Iguaçu, Paraná, Brasil -composição florística. *Estudos de Biologia* 28: 55-71.
- Kersten RA, Kuniyoshi YS & Roderjan CV (2009) Epífitas vasculares em duas formações ribeirinhas adjacentes na bacia do rio Iguaçu - Terceiro Planalto Paranaense. *Iheringia, Série Botânica* 64: 33-43.
- Kersten RA & Silva SM (2001) Composição florística e distribuição espacial de epífitas vasculares em floresta da planície litorânea da Ilha do Mel, Paraná, Brasil. *Revista Brasileira de Botânica* 24: 213-226.
- Körner C (2004) Mountain biodiversity, its causes and function. *Ambio* 13: 11-17. Available at <<http://www.ncbi.nlm.nih.gov/pubmed/15575177>>. Access on 15 September 2015.
- Krömer T, Kessler M, Gradstein R & Acebey A (2005) Diversity patterns of vascular epiphytes along an elevational gradient in the Andes. *Journal of Biogeography* 32: 1799-1809.
- Lima RAF, Dittrich VAO, Souza VC, Salino A, Breier TB & Aguiar OT (2011) Flora vascular do Parque Estadual Carlos Botelho, São Paulo, Brasil. *Biota Neotropica* 11: 173-214.
- Luizi-Ponzo AP, Siviero TS, Amorim ET, Henriques DK, Rocha LM, Gomes HCS, Paiva LA, Rodrigues RS, Silva IC, Silva AGD, Ribeiro GC, Gomes CQ & Campeão AS (2013) Briófitas do Parque Estadual do Ibitipoca no Herbário Prof. Leopoldo Krieger. *In: Forzza RC, Menini Neto L, Salimena FRG & Zappi D (orgs.) Flora do Parque Estadual do Ibitipoca e seu entorno*. Editora UFJF, Juiz de Fora. Pp. 95-122.
- Madison M (1977) Vascular epiphytes: their systematic occurrence and salient features. *Selbyana* 2: 1-13.
- Martinelli G & Moraes MA (orgs.) (2013) Livro vermelho da flora do Brasil. Jardim Botânico do Rio de Janeiro, Andrea Jakobsson, Rio de Janeiro. 1100p.
- Menini Neto L, Forzza RC & Zappi D (2009a) Angiosperm epiphytes as conservation indicators in forest fragments: A case study from southeastern Minas Gerais, Brazil. *Biodiversity and Conservation* 18: 3785-3807.
- Menini Neto L, Matozinhos CN, Abreu NL, Valente ASM, Antunes K, Souza FS, Viana PL & Salimena FRG (2009b) Flora vascular não-arbórea de uma floresta de grota na Serra da Mantiqueira, Zona da Mata de Minas Gerais, Brasil. *Biota Neotropica* 9: 149-161.
- Moller-Jorgensen P & León-Yáñez S (1999) Catalogue of the vascular plants of Ecuador. Missouri Botanical Garden Press, St. Louis. 1181p.
- Moran RC (1995) The importance of mountains to pteridophytes, with emphasis on Neotropical montane forests. *In: Churchill SP, Balslev H, Forero E & Luteyn JL (eds.) Biodiversity and conservation of Neotropical montane forests (Proceedings of a symposium, New York Botanical Garden, 21-26 June 1993)*. New York Botanical Garden, New York. Pp. 359-363.
- Oliveira-Filho AT, Fontes MAL, Viana PL, Valente ASM, Salimena FRG & Ferreira FM (2013) O mosaico de fitofisionomias do Parque Estadual do Ibitipoca. *In: Forzza RC, Menini Neto L, Salimena FRG & Zappi D (orgs.) Flora do Parque Estadual do Ibitipoca e seu entorno*. Editora UFJF, Juiz de Fora. Pp. 53-93.
- PPG I (2016) A community-derived classification for extant lycophytes and ferns. *Journal of Systematics and Evolution* 54: 563-603.
- Prado J, Sylvestre LS, Labiak PH, Windisch PG, Salino A, Barros ICL, Hirai RY, Almeida TE, Santiago ACP, Kieling-Rubio MA, Pereira AFN, Øllgaard B, Ramos CGV, Mickel JT, Dittrich VAO, Mynssen CM, Schwartsburd PB, Condack JPS, Pereira JBS & Matos FB (2015) Diversity of ferns and lycophytes in Brazil. *Rodriguésia* 66: 1073-1083.
- Salimena FRG, Matozinhos CN, Abreu NL, Ribeiro JH, Souza FS & Menini Neto L (2013) Flora fanerogâmica da Serra Negra, Minas Gerais, Brasil. *Rodriguésia* 64: 311-320.
- Salino A, Almeida TE, Mynssen CM, Condack JPS & Sylvestre LS (2013) Pteridófitas do Parque Estadual do Ibitipoca. *In: Forzza RC, Menini Neto L, Salimena FRG & Zappi D (orgs.) Flora do Parque Estadual do Ibitipoca e seu entorno*. Editora UFJF, Juiz de Fora. Pp. 123-152.
- Souza FS, Salino A, Viana PL & Salimena FRG (2012) Pteridófitas da Serra Negra, Minas Gerais, Brasil. *Acta Botanica Brasilica* 26: 378-390.
- Thiers B [continuously updated]. Index herbariorum: a global directory of public herbaria and associated staff. The New York Botanical Garden. Available at <<http://sweetgum.nybg.org/science/ih/>>. Access on 20 June 2016.
- Waechter JL (1992) O epifitismo vascular na planície costeira do Rio Grande do Sul. Tese de Doutorado.



- Universidade Federal de São Carlos, São Carlos. 163p.
- Werneck M & Espírito-Santo MM (2002) Species diversity and abundance of vascular epiphytes on *Vellozia piresiana* in Brazil. *Biotropica* 34: 51-57.
- 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, Cham. 282p.

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