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Diversity high up: a cloud forest of the Serra da Mantiqueira as a vascular epiphyte hotspot[1]

Samyra Gomes Furtado[2,4] & *Luiz Menini Neto*[2,3]

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>.

[1] Part of Master dissertation of the first author.

[2] Universidade Federal de Juiz de Fora, Inst. Ciências Biológicas, Prog. Pós-graduação em Ecologia (PGECOL/UFJF), Campus Universitário, Bairro Martelos, Juiz de Fora, MG, Brazil.
[3] Universidade Federal de Juiz de Fora, Inst. Ciências Biológicas, Depto. Botânica, Campus Universitário, Bairro Martelos, Juiz de Fora, MG, Brazil.
[4] Author for correspondence: furtadosg@gmail.com

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).

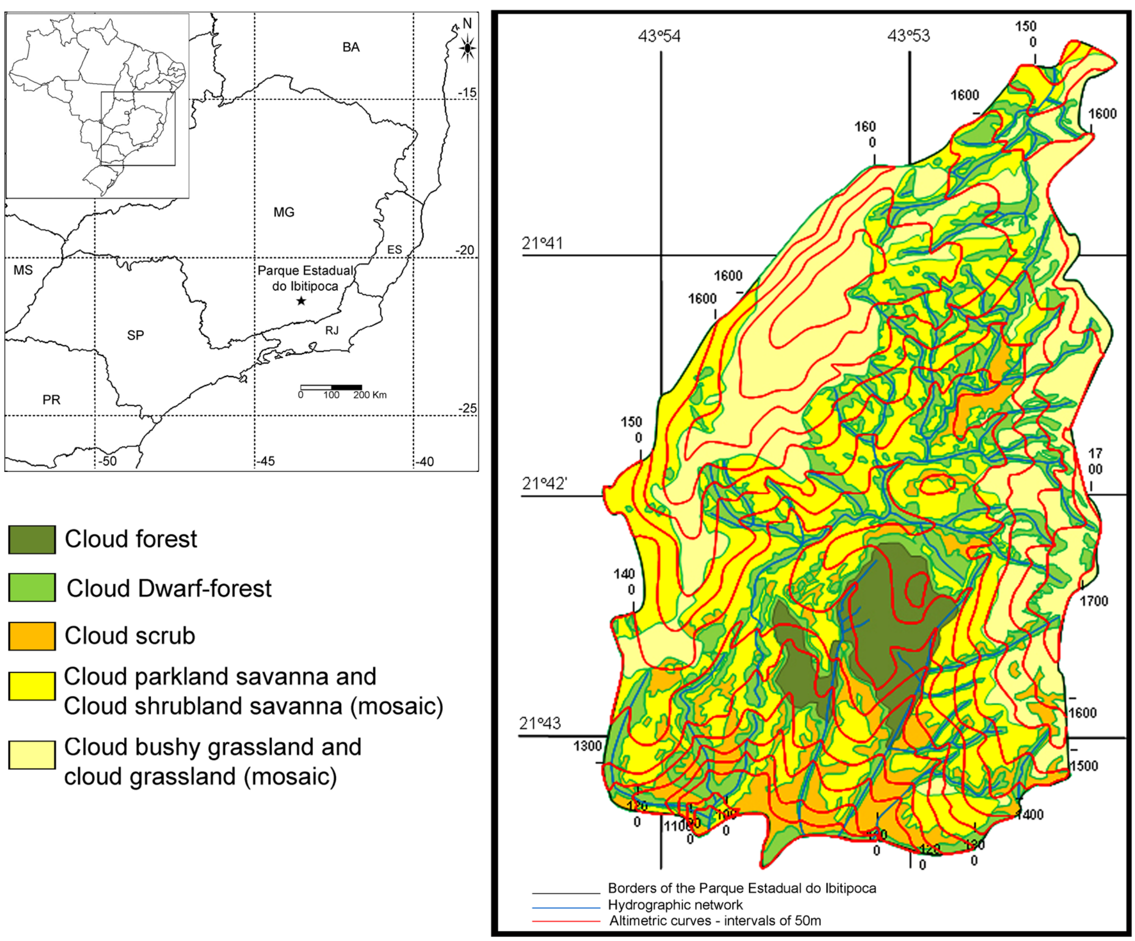

Figure 1 – Location of Parque Estadual do Ibitipoca, Minas Gerais, Brazil. Adapted from Oliveira-Filho *et al*. (2013).

The PEIB is situated in the Atlantic domain, and its vegetation harbors a mosaic of field and forest phytophysiognomies, 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>). The collected specimens were deposited at Herbarium CESJ of Universidade Federal de Juiz de Fora. Specimens deposited at the herbaria BHCB, 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

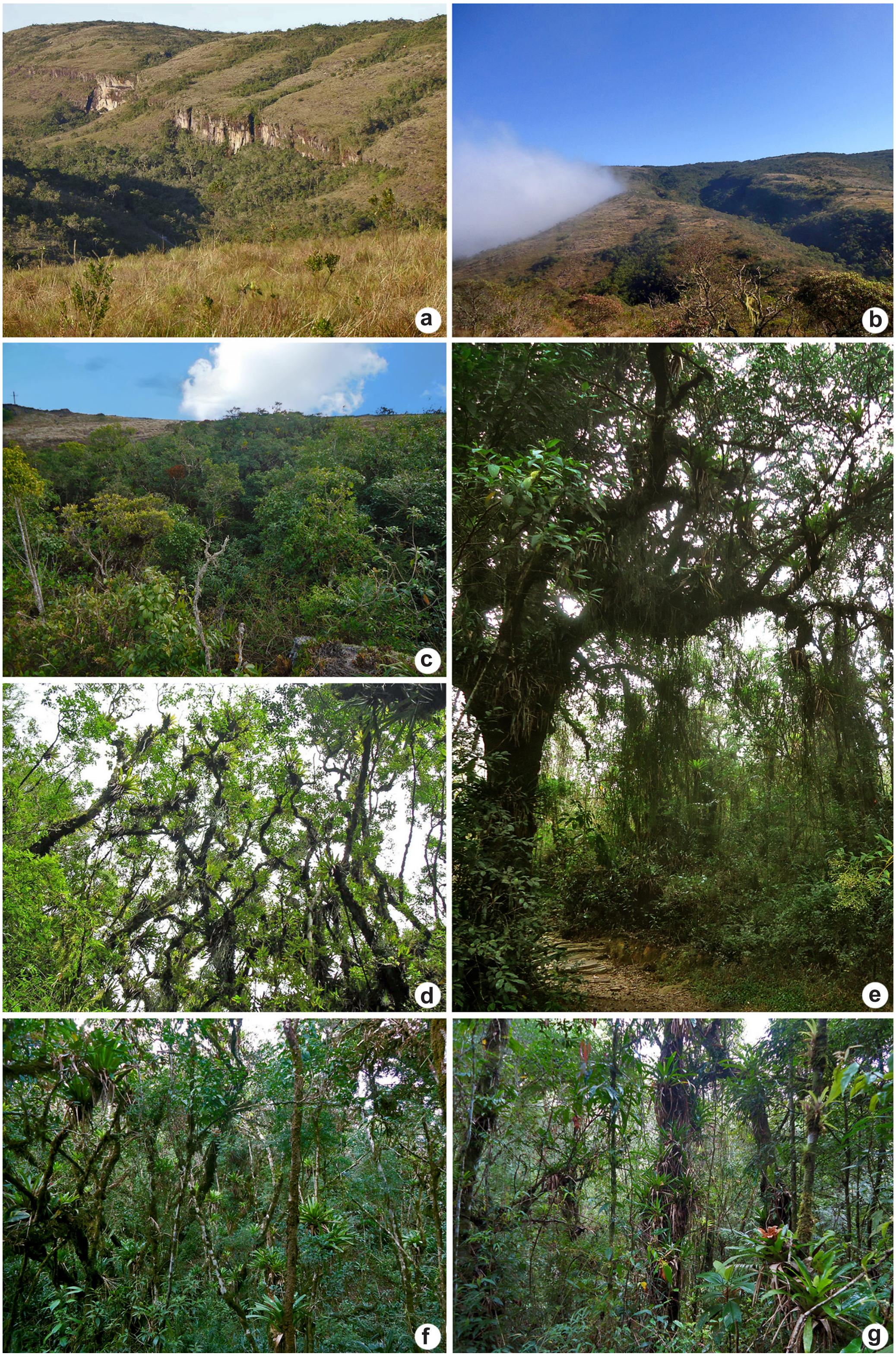

Figure 2 – Vegetation of Parque Estadual do Ibitipoca – a. patches of cloud forest interspersed with *campo rupestre*; b. detail of fog covering the forests and *campo rupestre*; c. general view of a cloud forest; d. detail of the canopy of a cloud forest. e-g. interior view of the cloud forests.

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

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

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

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

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

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

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

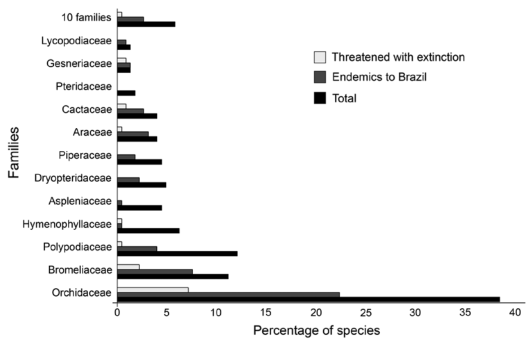

Figure 3 – Representativity of the families of vascular epiphytes and comparison with percentage of endemics and threatened with extinction in the cloud forest of Parque Estadual do Ibitipoca, Minas Gerais, Brazil.

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 Sothern Brazil.

Parque Estadual do Ibitipoca Area (ha)/ elevation (m) 1488,5 ha /1100-1784		Serra do Cruz (Minas Gerais) -/1300-1600		Serra Negra (Minas Gerais) 10000/900-1700		Parque Estadual da Serra do Papagaio (Minas Gerais) 22000/1600-1950		Parque Estadual Carlos Botelho (São Paulo) 37644/30-1000		Parque Estadual Marumbi (Paraná) 8745/~1000	
Orch	86	Orch	50	Orch	66	Orch	51	Orch	75	Orch	29
Poly	27	Poly	23	Brom	29	Poly	23	Brom	43	Brom	23
Brom	25	Brom	19	Poly	29	Brom	10	Poly	23	Poly	20
Hyme	14	Hyme	8	Pipe	10	Pipe	10	Arac	19	Hyme	12
Aspl	11	Pipe	8	Dryo	9	Aspl	5	Hyme	16	Arac	5
Dryo	11	Arac	5	Hyme	6	Hyme	4	Cact	15	Aspl	5
Pipe	10	Aspl	4	Arac	3	Lyco	4	Pipe	13	Cact	5
Arac	9	Cact	4	Gesn	3	Dryo	3	Dryo	12	Gesn	5
Other families	31	Other families	33	Other families	29	Other families	28	Other families	44	Other families	23
Total	224	Total	154	Total	184	Total	138	Total	260	Total	127
Present study		Alves & Menini Neto (2014)		Menini Neto (2009b); Souza *et al*. (2012); Salimena *et al*. (2013)		Furtado & Menini Neto (2016)		Breier (2005); Lima *et al*. (2011)		Bianchi *et al*. (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-Yánez 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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