Vascular epiphytic flora of a high montane environment of Brazilian Atlantic Forest: composition and floristic relationships with other ombrophilous forests

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ABSTRACT
Only a few studies regarding vascular epiphytes have been conducted in mixed ombrophilous forests (MOF) in Serra da Mantiqueira, a mountainous environment in the Brazilian Atlantic Forest, where the relationships of epiphytic flora with other physiognomies are unknown. This study aimed to survey the epiphytes of a MOF remnant located in Serra da Mantiqueira, and to analyze the floristic relationships with ombrophilous forests of the Southern and Southeastern regions of Brazil. The checklist was compared with 51 other areas composed of ombrophilous forests and/or ecotones with other physiognomies using UPGMA (with Sørensen index), and canonical correspondence analysis (CCA). We recorded 138 species, and Orchidaceae and Polypodiaceae were the richest families (51 and 23 species, respectively). The UPGMA showed the importance of physiognomy and elevation in the floristic relationships, and CCA reinforced the influence of elevation, in addition to the shortest distance to the ocean and minimum annual temperature; however, in this analysis, the physiognomies showed little influence on the relationships. The epiphytic flora of MOF of Southern and Southeastern regions of Brazil has different relationships compared with the data available for shrubs and trees, suggesting a greater importance of phorophytic species than geographical distance and, to some extent, environmental variables.

Keywords: biodiversity, conservation, endangered species, environmental variables, epiphytism, mixed ombrophilous forest, Serra da Mantiqueira, similarity

Introduction
Brazilian Atlantic Forest exhibits high diversity, harbouring approximately 16000 plant species, totalling about 46% of the country flora, of which approximately 7500 are endemic (Stehmann et al. 2009; Forzza et al. 2012). These numbers, together with intense anthropogenic degradation, earned it the status of the world hotspot of biodiversity (Mittermeier et al. 2004). However, there are great gaps in knowledge about the native flora, especially in places of difficult access, such as the mountainous environments (Martinelli 2007; Rapini et al. 2009), as well as for some functional groups, such as epiphytes (Kersten 2010).

Mountainous regions are environments with high indices of richness and endemism, in addition to representing islands of vegetation with important forest remnants (Martinelli 2007), maintained due to the barrier represented by the relief, which avoids direct anthropogenic action.

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The Serra da Mantiqueira covers the borders of Minas Gerais, São Paulo, Rio de Janeiro, and Espírito Santo states, forming together with the Serra do Mar a mountainous range consisting primarily of Atlantic Forest (Rizzini 1997). It is considered a priority for conservation and study due to its biotic and abiotic features (Drummond et al. 2005; Lino et al. 2007; Saout et al. 2013).

Serra do Papagaio is one of the natural areas that must be highlighted in the Serra da Mantiqueira in Minas Gerais. It is protected by a state park (Parque Estadual da Serra do Papagaio [PESP]), composed of approximately 23000 ha, and is geographically connected with the Parque Nacional do Itatiaia, representing a continuous montane environment. Despite the importance of this region, only a few floristic/ecologic studies have been conducted to date (Scolforo et al. 2008; Pereira et al. 2013; Santiago 2013; Furtado & Menini Neto 2015a; Santana 2016).

The PESP harbours one of the rare fragments of mixed ombrophilous forest (MOF) (or araucaria forest) of Minas Gerais (Ab’Saber 2003; Backes 2009), interspersed with “campo de altitude” and dense ombrophilous forest (DOF). This is the only protected MOF fragment by a conservation unity of integral protection in Minas Gerais (Furtado & Menini Neto 2015a). It is one of the most threatened forest ecosystems of the country. It is estimated that only about 3% of the original cover of this phytosohny remains, including exploited and regeneration areas (Bauermann & Behling 2009). This forest formation reaches the highest elevation in the Serra da Mantiqueira (Backes 2009), and, in PESP, this elevation can reach 2000 m a.s.l. (SG Furtado & I. Menini Neto unpivl. res.).

Several studies were carried out in Neotropical Region showing the astonishing diversity of vascular epiphytes (e.g., Gentry & Dodson 1987; Catchpole 2004; Benavides et al. 2005; Blum et al. 2011; Alves & Menini Neto 2014; Leitman et al. 2014), as well as the importance of elevation gradient on this diversity, especially in the Andes and Central America (e.g., Krümer et al. 2005; Cardelús et al. 2006; Watkins Jr. et al. 2006; Furtado & Menini Neto 2016). However, despite the increasing number of studies on flora and ecology of epiphytes, especially in recent years, there is still a shortage, when considering their ecological importance in the tropical forests (Nadkarni 1984; Nieder et al. 2000). Although Brazil has a considerable richness of epiphytes, mainly due to the forest physiognomies of the BAF (Freitas et al. 2016; Menini Neto et al. 2016), studies of the epiphytic synusia only have been intensive during the past 30 years, mainly concentrating in the Southern Region of the country (Kersten 2010). In order to contribute to the reduction of knowledge gaps regarding this functional group in the Atlantic Forest, the goals of this study were: 1) to evaluate the richness and composition of the vascular epiphytes in the physiognomy of MOF and in the ecotone with DOF in the PESP; 2) to analyse the floristic relationships, and respective influence of environmental variables, between areas of the Southeastern and Southern regions of Brazil with similar vegetation; 3) to test whether the pattern of floristic relationships of trees and shrubs found in MOF of Serra da Mantiqueira and those of Southern Region is corroborated by epiphytic flora.

Materials and methods

Study area

The PESP is located in the southern region of Minas Gerais in Serra da Mantiqueira (Fig. 1), comprising 22917 ha, between the municipalities of Aiuruoca, Alagoa, Baependi, Itamonte, and Pouso Alto (22.1420S, 44.7328W). The elevations are mainly above 1800 m a.s.l., and the climate is classified as Cwb (according to the Köppen classification), a temperate, highland, tropical climate with dry winters (Silva et al. 2008).

The park harbours important remnants of Atlantic Forest, composed of a mosaic of high montane DOF, high montane MOF, and “campo de altitude” (which is a vegetation predominantly composed of open fields with grasses, sometimes with rocky outcrops, also named by Safford (1999) as “Brazilian páramos”). In the studied area, the MOF occurs mainly as fragments of alluvial forest, predominantly on humic and histic cambisols, at elevations ranging from 1600-1700 m a.s.l., along the Santo Agostinho brook (Silva et al. 2008). It forms continuous vegetation that is composed of three strata: a canopy of Araucaria angustifolia (Bertol.) Kuntze (Araucariaceae) (about 30 m high); a second stratum composed predominantly of Podocarpus lambertii Klotzsch ex Endl. (Podocarpaceae) (10-15 m high); and a third stratum (up to approximately 8–10 m high) composed of shrubs and treelets of the families Lauraceae, Myrtaceae, Primulaceae, and Winteraceae, among others. This physiognomy exhibits transition areas, with the DOF at 1900-2000 m a.s.l., with few individuals of A. angustifolia and near complete absence of P. lambertii. Podocarpus lambertii also occurs in patches interspersed within the “campo de altitude”, adjacent to the alluvial forest (Furtado & Menini Neto 2015a).

Floristic survey

The floristic survey was conducted through monthly expeditions between April 2012 and September 2013 using the walking method (“método de caminhamento”) (Filgueiras et al. 1994) in order to cover the largest possible area of MOF and transition with DOF in each expedition. The fertile specimens were collected, herborised, and deposited in the Herbarium CESJ (acronym according to Thiers [2015]). The plants were photographed in the field and published as a rapid colour guide (Furtado & Menini Neto 2013). The species were classified according to their relationships with...
phorophytes (Benzing 1990) and identified according to the specialised bibliography, consultation with the herbarium material collection, and specialists.

Evolutionary lineages are according to the APG IV (2016) for angiosperms (eudicotyledons, magnoliids, and monocotyledons) and Christenhusz et al. (2011) for the ferns (lycophytes and monilophytes). Orchidaceae genera *Maxillaria*, *Oncidium*, and *Pleurothallis* were considered in a broad sense due to the lack of consensus regarding their delimitations and due to several recent proposals of segregation in several smaller genera.

**Multivariate analyses**

The composition of vascular epiphytes of the PESP was compared to areas with available lists of vascular epiphytes and some areas with extensive vascular flora surveys that discriminated each life form. We used 52 areas of MOF or DOF, and, in some cases, ecotones with other physiognomies occurring in Southern and Southeastern regions of Brazil, in addition to areas of the Serra da Mantiqueira with elevations similar to the PESP (Tab. S1 in supplementary material). The data were obtained from published studies and the database of herbaria collections available at the site Specieslink of “Centro de Referência em Informação Ambiental” (CRIA) (http://www.splink.org.br). All unidentified species were excluded, resulting in a matrix of presence (1) and absence (0), with 910 species.

The similarity between the aforementioned areas was evaluated through cluster analysis using the unweighted pair-group method with arithmetic mean (UPGMA) and similarity index of Sørensen. The cophenetic coefficient was calculated to test the fit between the matrix and resulting dendrogram. A Mantel test was conducted to evaluate the correlation between the geographic distance and calculated similarity among the areas. These analyses were conducted using the software PAST v. 3.01 (Hammer et al. 2001).

In order to evaluate the correlation among the environmental variables and composition of vascular epiphytes, a canonical correspondence analysis (CCA) was conducted (ter Braak 1986; Palmer 1993). Previous analyses were performed with a set of 19 climatic variables (annual mean temperature, mean monthly temperature range, isothermality, temperature seasonality, max temperature...
of warmest month, min temperature of coldest month, temperature annual range, mean temperature of wettest quarter, mean temperature of driest quarter, mean temperature of warmest quarter, mean temperature of coldest quarter, annual precipitation, precipitation of wettest month, precipitation of driest month, precipitation seasonality, precipitation of wettest quarter, precipitation of driest quarter, precipitation of warmest quarter, precipitation of coldest quarter). The variables were presented by Hijmans et al. (2005), and are available in the site WorldClim (www.worldclim.org). These variables were complemented with other considered important to the epiphytic flora (Benzing 1990): minimal and maximal elevations and minimal and maximal annual means of temperature obtained in the respective articles, and the shortest distance to the Atlantic Ocean, which was calculated for each area using the software DIVA-GIS v. 7.5 (Hijmans et al. 2001), which is used to represent a seasonality gradient.

After this preliminary analysis, the redundant variables, with high values of inflation, were discarded (ter Braak 1986). Three variables resulted as the most representative and correlated with the two first ordination axes: shortest distance to the ocean, elevation, and minimal annual temperature. The permutation test of Monte Carlo was conducted a posteriori in order to evaluate the significance of the canonical correlations at a significance level of 95% (p < 0.05) (ter Braak 1986; Palmer 1993). These analyses were conducted with the software CANOCO v. 4.5 (ter Braak & Smilauer 2002).

**Results**

**Floristic survey**

We recorded 25 families, 66 genera, and 138 species in the studied area. The ferns were represented by 43 species (31.16% of total) and the angiosperms by 95 species (68.84%). Orchidaceae was the richest family (51 species, 37%), followed by Polypodiaceae (23 species, 17%), Bromeliaceae, and Piperaceae (10 species, 7% each). Pleurothallis s.l. was the richest genus with 11 species, followed by Peperomia, with 10 species (Tab. 1). The majority of species occurred in the MOF (122 species), of which 62 were exclusive, and 60 were shared with the ecotone with the DOF, with 16 being exclusive to the ecotone.

The richest evolutionary lineages were the monocotyledons (63 species) and the monilophytes (39 species), being Orchidaceae and Polypodiaceae the richest families, respectively. Characteristic holoepiphytes were the most well represented ecological category (107 species), but the number of accidental holoepiphytes families and species, 10 (40% of total) and 19 (14% of total), respectively,

**Table 1.** List of vascular epiphytes recorded in the Parque Estadual da Serra do Papagaio, Minas Gerais, Brazil.

| Families and species | EC | Habitat | Voucher |
|----------------------|----|---------|---------|
| **Ferns**            |    |         |         |
| Licophytes           |    |         |         |
| Lycopodiaceae (1/4)  |    |         |         |
| *Phlegmariurus acerosus* (Sw.) B.Øllg. | CHL | F | Furtado 74 |
| *Phlegmariurus biforis* (Hook.) B.Øllg. | CHL | F | Furtado 75 |
| *Phlegmariurus fontinaloides* (Spring) B.Øllg. | CHL | F/B | Furtado 114 |
| *Phlegmariurus quadrifariatus* (Bory) B.Øllg. | CHL | F | Furtado 66 |
| **Monilophytes**     |    |         |         |
| *Anemia phyllitidis* (L.) Sw. | AHL | F | Furtado 88 |
| **Aspleniacae (1/5)** |    |         |         |
| *Asplenium aff. inaequilaterale* Wild. | AHL | F | Furtado 221 |
| *Asplenium auriculatum* Sw. | CHL | F/B | Furtado 46 |
| *Asplenium auritum* Sw. | CHL | F/B | Furtado 37 |
| *Asplenium incurvatum* Fee | CHL | F/B | Furtado 93 |
| *Asplenium serra* Langsd. & Fisch. | CHL | E | Souza 960 |
| **Dryopteridaceae (2/3)** |    |         |         |
| *Elaphoglossum gayanum* (Fée) T.Moore | CHL | F/B | Furtado 183 |
| *Elaphoglossum vagans* (Mett.) Hieron. | FHL | F/B | Furtado 129 |
| *Rumohra adiantiformis* (G.Forst.) Ching | CHL | F/B | Furtado 113 |
| **Hymenophylaceae (3/4)** |    |         |         |
| *Hymenophyllum polyanthus* (Sw.) Sw. | CHL | F/B | Furtado 64 |
| *Polypeblgium angustatum* (Carmich.) Ebihara & Dubuisson | CHL | F | Furtado 97 |
| *Trichomanes anadromum* Rosenst | CHL | F | Furtado 276 |
| *Trichomanes polyiodoides* Raddi | CHL | F | Furtado 90 |
| **Ophioglossaceae (1/1)** |    |         |         |
| *Ophioglossum palmatum* L. | CHL | E | Furtado 267 |
Table 1. Cont.

| Families and species | EC    | Habitat | Voucher   |
|----------------------|-------|---------|-----------|
| **Polypodiaceae (12/23)** |       |         |           |
| Campyloneurum aglaolepis (Alston) de la Sota | CHL   | F       | Furtado 94 |
| Campyloneurum angustifolium (Sw.) Fée | CHL   | F/B     | Menini Neto 965 |
| Campyloneurum mitidum (Kaulf.) C.Presl | CHL   | F       | Furtado 236 |
| Campyloneurum sp. | CHL   | F/B     | Furtado 216 |
| Ceradenia albidula (Baker) L.E.Bishop | CHL   | E       | Furtado 132 |
| Cecidium punctatum (Raddi) L.E.Bishop | CHL   | F/B     | Furtado 137 |
| Leucatrichum sp. | CHL   | E       | Furtado 198 |
| Leucatrichum pinnatum (Kunze ex Klotzsch) A.R.Sm. & R.C.Moran | CHL   | F/B     | Furtado 110 |
| Melpomene flabelliformis (Poir.) A.R.Sm. & R.C.Moran | CHL   | F/B     | Furtado 127 |
| Microgramma percussa (Cav.) de la Sota | CHL   | F       | Salimena 2836 |
| Microgramma squamulosa (Kaulf.) de la Sota | CHL   | F/B     | Furtado 8 |
| Micropolypodium achilleifolium Labiak & F.R.Matos | CHL   | F       | Furtado 150 |
| Pechuma pedinatiformis (Lindlm.) M.G.Price | CHL   | F/B     | Souza 955 |
| Pechuma sp. | CHL   | F       | Furtado 7 |
| Peplontis hirsutissima (Raddi) de la Sota | CHL   | F/B     | Furtado 32 |
| Peplontis macrocarpa (Bory ex Willd.) Kaulf. | CHL   | F/B     | Furtado 9 |
| Peplontis pleopeltidis (Fée) de la Sota | CHL   | F/B     | Furtado 116 |
| Serpocalon cathariniae (Langsd. & Fisch.) A.R.Sm. | CHL   | F/B     | Furtado 50 |
| Zygodiplodia longisepala (C.Chr.) L.E.Bishop | CHL   | F       | Souza 1006 |
| Polypodiaceae indet. | CHL   | F       | Furtado 45 |
| **Pteridaceae (1/2)** |       |         |           |
| Vittaria graminifolia Kaulf. | CHL   | F/B     | Souza 979 |
| Vittaria lineata (L.) SM | CHL   | F/B     | Furtado 136 |
| **Angiosperms** |       |         |           |
| **Magnoliids** |       |         |           |
| Peperomia campinasana C.DC. | CHL   | F       | Furtado 73 |
| Peperomia catherinae Miq. | CHL   | F       | Furtado 106 |
| Peperomia cf. glabella (Sw.) A.Dietr. | CHL   | F       | Furtado 202 |
| Peperomia hilariana Miq. | FHL   | F/B     | Menini Neto 814 |
| Peperomia hispida (Sw.) A. Dietr. | CHL   | F       | Furtado 72 |
| Peperomia mandioccana Miq. | CHL   | F/B     | Furtado 99 |
| Peperomia subtermifolia Yunck. | CHL   | F/B     | Furtado 98 |
| Peperomia tetraphylla (G.Forst.) Hook. & Arn. | CHL   | F/B     | Furtado 195 |
| Peperomia trimera Miq. | CHL   | F/B     | Menini Neto 841 |
| Peperomia trimeroidea Dahlst. | CHL   | F/B     | Furtado 172 |
| **Monocotyledons** |       |         |           |
| **Araceae (1/1)** |       |         |           |
| Philadenron sp. | HEM   | E       | Nardy 2 |
| **Bromeliaceae (5/10)** – Rafaela C. Forzza (RB) |       |         |           |
| Aechmea aiurucensis Leme | FHL   | E       | Furtado 259 |
| Aechmea distichantha Lern. | FHL   | E       | Furtado 234 |
| Billbergia distachia (Veil.) Mez | CHL   | F/B     | Furtado 91 |
| Tillandsia mariposae Leme | FHL   | F/B     | Furtado 228 |
| Tillandsia recurvata (L.) L. | CHL   | F       | Furtado 222 |
| Tillandsia stricta Sol. | CHL   | F/B     | Furtado 100 |
| Tillandsia tenella L. | CHL   | F       | Furtado 67 |
| Vriesea bituminosa Wawra | FHL   | F/B     | Furtado 250 |
| Vriesea gigantea Gaudich. | FHL   | F/B     | Furtado 146 |
| Vriesea sceptrum Mez | FHL   | F/B     | Menini Neto 792 |
Table 1. Cont.

| Families and species | EC  | Habitat | Voucher |
|----------------------|-----|---------|---------|
| Orchidaceae (18/51) – Luiz Menini Neto, Samyra G. Furtado, Camila Nardy (CESJ) |     |         |         |
| Bifrenaria stefanae V.P.Castro | CHL  | F/E     | Furtado 124 |
| Bulbophyllum granulosum Barb.Rodr. | CHL  | F       | Furtado 207 |
| Bulbophyllum regnellii Rchb.f. | CHL  | F       | Furtado 242 |
| Capanemia adelaidiae Brade | CHL  | E       | Furtado 53 |
| Cryptophananthus jordanensis Brade | CHL  | E       | Furtado 274 |
| Dryadella liliputiana (Cogn.) Luer | CHL  | F/E     | Furtado 141 |
| Encyclia patemi Hook. | CHL  | F       | Furtado 275 |
| Episendrum chlorinum Barb.Rodr. | CHL  | F/E     | Furtado 214 |
| Episendrum mantiqueirianum Porto & Brade | CHL  | F/E     | Furtado 85 |
| Gomesa gomezoides (Barb.Rodr.) Pabst | CHL  | F/E     | Furtado 210 |
| Grobya amherstiae Lindl. | CHL  | E       | Furtado 255 |
| Hadrolaelia coccinea (Lindl.) Chiron & V.P.Castro | CHL  | F/E     | Furtado 79 |
| Hadrolaelia mantiqueirae (Fowlie) Furtado | CHL  | F/E     | Furtado 80 |
| Hadrolaelia pygmaea (Pabst) Chiron & V.P.Castro | CHL  | F       | Furtado 208 |
| Hapalorchis lineatus (Lindl.) Schltr. | AHI  | E       | Furtado 252 |
| Hapalorchis mixanthus (Barb.Rodr.) Hoehne | AHI  | F/E     | Furtado 69 |
| Lankesterella gnoma (Kraenzl.) Hoehne | CHL  | F/E     | Furtado 169 |
| Loefgrenianthus blanche-ami (Loefgr.) Hoehne | CHL  | F/E     | Furtado 176 |
| Maxillaria neuwiedii Rchb.f. | CHL  | F       | Menini Neto 1108 |
| Maxillaria nottyglossa Rchb.f. | CHL  | E       | Furtado 243 |
| Maxillaria parananaensis Barb.Rodr. | CHL  | F       | Furtado 36 |
| Maxillaria picta Hook. | CHL  | F/E     | Furtado 213 |
| Octomeria crassifolia Lindl. | CHL  | F/E     | Furtado 174 |
| Octomeria geraensis Barb.Rodr. | CHL  | F/E     | Furtado 35 |
| Octomeria ochroleuca Barb.Rodr. | CHL  | F       | Furtado 277 |
| Octomeria wanneri Rchb.f. | CHL  | F       | Furtado 25 |
| Octomeria sp1 | CHL  | F       | Furtado 92 |
| Octomeria sp2 | CHL  | F       | Furtado 167 |
| Octomeria sp3 | CHL  | F       | Furtado 168 |
| Oncidium cogniauxianum Schltr. | CHL  | F       | Furtado 203 |
| Oncidium divaricatum Lindl. | CHL  | F       | Furtado 220 |
| Oncidium forbesi Hook. | CHL  | E       | Menini Neto 776 |
| Oncidium gardneri Lindl. | CHL  | F/E     | Furtado 215 |
| Oncidium hookeri Rolfe | CHL  | F/E     | Furtado 241 |
| Oncidium longicorns Mutel | CHL  | F/E     | Furtado 162 |
| Phymatidium mellobarretti Hoehne & Williams | CHL  | F/E     | Furtado 26 |
| Pleurothallis adenocharla Loefgr. | CHL  | E       | Furtado 119 |
| Pleurothallis bocainensis Porto & Brade | CHL  | F/E     | Furtado 68 |
| Pleurothallis cf. corticicola Schltr. ex Hoehne | CHL  | F       | Furtado 251 |
| Pleurothallis grobyi Bateman ex Lindl. | CHL  | F/E     | Furtado 117 |
| Pleurothallis lineatella Cogn. | CHL  | F       | Furtado 163 |
| Pleurothallis pleurothallioides (Cogn.) Handro | CHL  | F       | Furtado 1 |
| Pleurothallis pterophora Cogn. | CHL  | E       | Furtado 226 |
| Pleurothallis radialis Porto & Brade | CHL  | E       | Furtado 253 |
| Pleurothallis rostellata Barb.Rodr. | CHL  | F       | Furtado 161 |
| Pleurothallis rubens Lindl. | CHL  | F/E     | Furtado 87 |
| Pleurothallis uniflora Lindl. | CHL  | F       | Menini Neto 1068 |
| Stelis intermedia Poepp. & Endl. | CHL  | F       | Menini Neto 1059 |
| Stelis papaquereensis Rchb.f. | CHL  | F/E     | Furtado 186 |
| Stelis sp1 | CHL  | F/E     | Furtado 196 |
| Stelis sp2 | CHL  | F       | Furtado 273 |

Eudicotyledons

Araliaceae (1/1)

| Families and species | EC  | Habitat | Voucher |
|----------------------|-----|---------|---------|
| Hydrocotyle cf. bonariensis Lam. | AHI  | F       | Furtado 22 |
Numbers between parentheses after the families names represent the number of genera and species, respectively. Names after families represent the specialists that collaborate in the taxa identification. EC: Ecological categories – HEM: hemiepiphyte; AHL: accidental holoepiphyte; CHL: characteristic holoepiphyte; FHL facultative holoepiphyte. Habitat – F: Mixed Ombrophilous Forest; E: ecotone.

Two main clusters were formed (1 and 2). The first (1) is composed mainly of DOF and shows a division in two other groups, with areas of Serra do Mar and Serra da Mantiqueira at elevations ranging from 500-2879 m a.s.l. in a group (▲) and areas of Southern and Southeastern regions at elevations ranging from 0-1000 m a.s.l. in the other group (Δ). Cluster 2 grouped together the MOF but shows a segregation of the southern areas at elevations ranging from 340-1200 m a.s.l. (●) from those of Serra da Mantiqueira (including the PESP) at elevations ranging from 1000-2010 m a.s.l. (○).

Despite the existence of a branch composed only of MOF areas, the similarity can be considered low among

Multivariate analyses

The cluster analysis resulted in the dendrogram presented in the Fig. 2, which obtained a cophenetic coefficient of 0.86, showing little distortion between the matrix and graphic. The Mantel test resulted in a positive correlation between the geographic distance and similarity matrix (r = 0.55, p = 0.0001).

Table 1. Cont.

| Families and species | EC     | Habitat | Voucher   |
|----------------------|--------|---------|-----------|
| **Asteraceae** (2/6) |        |         |           |
| Ageratum fastigiatum (Gardner) R.M.King & H.Rob. | AHL    | F       | Furtado 247 |
| Baccharis crispa Spreng. | AHL    | F       | Furtado 237 |
| Asteraceae sp1        | AHL    | F       | Furtado 268 |
| Asteraceae sp2        | AHL    | F       | Furtado 269 |
| Asteraceae sp3        | AHL    | F       | Furtado 270 |
| Asteraceae sp4        | AHL    | F       | Furtado 271 |
| **Cactaceae** (1/2)  |        |         |           |
| Rhipsalis floccosa Salm-Dyck ex Pfeiff. | CHL    | F/E    | Furtado 107 |
| Rhipsalis pulchra Loefgr. | CHL    | F/E    | Furtado 139 |
| **Caryophyllaceae** (1/1) | | | |
| Arenaria lanuginosa (Michx.) Rohrb. | AHL    | F       | Furtado 23 |
| **Ericaceae** (1/1)  |        |         |           |
| Agarista oleifolia (Cham.) G.Don | AHL    | F       | Santiago 604 |
| **Gesneriaceae** (2/3) |        |         |           |
| Nematanthus fornsi (Vell.) Chautema | FHL    | E       | Furtado 160 |
| Sinningia cooperi (Paston) Wiehler | CHL    | F       | Furtado 49 |
| Sinningia douglassi (Lindl.) Chautema | CHL    | F       | Furtado 164 |
| **Melastomataceae** (3/3) |        |         |           |
| Leandra carassana (DC.) Cogn. | AHL    | F       | Furtado 248 |
| Miconia hyemalis A.St-Hil. & Naudin | AHL    | F       | Furtado 246 |
| Pleischiton blepharodes (DC.) Reginato et al. | CHL    | F       | Furtado 201 |
| **Onagraceae** (1/1) |        |         |           |
| Fuchsia regia (Vell.) Munz | FHL    | F       | Furtado 165 |
| **Plantaginaceae** (1/1) | | | |
| Plantago sp. | AHL    | F       | Furtado 272 |
| **Poaceae** (1/1)   |        |         |           |
| Chusquea sp. | AHL    | F/E    | Furtado 254 |
| Polygalaecae (1/1)  |        |         |           |
| Polygala lancifolia A.St.-Hil. & Moq. | AHL    | F       | Furtado 65 |
| **Ranunculaceae** (1/1) |        |         |           |
| Anemone sellowii Pritz. | AHL    | F       | Furtado 89 |
| **Solonaceae** (1/1) |        |         |           |
| Dysoschroma viridiflorum (Sims) Miers | HEM    | F/E    | Furtado 244 |

must be highlighted, with Asteraceae being the richest family with six species. Also, Melastomataceae must be noted, exhibiting one characteristic holoepiphyte and two accidental holoepiphytes species (Tab. 2).
The number of species of each family or evolutionary lineage is between parentheses after their names. CHL – characteristic holoepiphytes; FHL – facultative holoepiphytes; AHL – accidental holoepiphytes; HEM – hemiepiphytes. N – number of species, % – percentage of species of each family distributed in the ecological categories.

* Families with species typically terricolous and represented in this study only by accidental holoepiphytes.

The two aforementioned subsets (around 0.25). Even the subset composed only of the remnants of MOF in the Serra da Mantiqueira exhibited low similarity and shared only 11 species (Fig. 3).

The results of the CCA, highlighted in the Tab. 3, showed eigenvalues higher than 0.3, which is considered high according to Felfili et al. (2011), representing a strong gradient in both axes. The values of species-environment correlations also are considered high (0.985 and 0.947 for axes 1 and 2, respectively). The Monte Carlo test showed a significant correlation between the distribution of species and the environmental variables used in the analysis (p < 0.05) (Tab. 3). The variables elevation and minimum annual temperature showed higher correlations with axis 1, while the shortest distance to the ocean was more correlated with axis 2 (Tab. 4).

The ordination diagram (Fig. 4) did not show a clear group among the areas with same physiognomy, as presented in the dendrogram (Fig. 2), especially regarding the MOF; only a tendency of grouping among them was observed. However, the area surveyed in the present study, ‘mgpesp’, was closely related to at least one of the MOF areas in the Serra da Mantiqueira, ‘sppecj’ (Parque Estadual de Campos do Jordão, in São Paulo state), and both were more correlated with the areas of DOF at high elevations than those of MOF occurring in the Southern Region of Brazil (Fig. 4).
Figure 2. Dendrogram (Sørensen similarity index) obtained in the similarity analysis with 53 localities of the Southeastern and Southern regions of Brazil based on a binary matrix of 910 species of vascular epiphytes. Cophenetic coefficient = 0.86. Numbers in the branches are explained in the text. DOF: dense ombrophilous forest; MOF: mixed ombrophilous forest; CR: ‘campo rupestre’; CA: ‘campo de altitude’; SSF: seasonal semi-deciduous forest; RES: ‘restinga’ (coastal vegetation); MAN: Mangrove. ● areas composed by mixed ombrophilous forest from Planalto Meridional (Southern Region), ○ areas composed by mixed ombrophilous forest from Serra da Mantiqueira (Southeastern Region), ▲ areas composed by dense ombrophilous forest from Serra do Mar or Serra da Mantiqueira (Southeastern Region), Δ areas composed by dense ombrophilous forest from Serra do Mar (Southern Region).
Figure 3. Venn diagram with the superposition of vascular epiphytic species of areas with mixed ombrophilous forest (MOF) of Serra da Mantiqueira: Parque Estadual da Serra do Papagaio; Serra da Pedra Branca; and Parque Estadual de Campos do Jordão. SI: Similarity index of Sørensen.

Figure 4. Bi-plot diagram results of the canonical correspondence analysis showing the relationships of 53 areas of the Southeastern and Southern regions of Brazil based on a binary matrix of 910 species of vascular epiphytes and the main environmental variables. The diagram shows the ordination of the first two axes. ● areas composed by mixed ombrophilous forest from Planalto Meridional (Southern Region), ○ areas composed by mixed ombrophilous forest from Serra da Mantiqueira (Southeastern Region), ▲ areas composed by dense ombrophilous forest from Serra do Mar or Serra da Mantiqueira (Southeastern Region), Δ areas composed by dense ombrophilous forest from Serra do Mar (Southern Region).
Araceae and Piperaceae are the five richest families in regions as well as the most important environmental variables. Of Southeastern and Southern regions. Plants, and the Brazilian Atlantic Forest is one of the centres of Orchidaceae and the largest among the epiphytic Neotropical region. Pleurothallis are prominent in the Atlantic domain as well as in the ecotone Philodendron represented only by the present study, this fact is corroborated, since Araceae is considerably decreases, according to Kersten (2010). In being the fourth richest, and the Araceae contribution the richest. However, the Piperaceae contribution increases, between MOF and DOF.

**Table 4.** Correlations of the environmental variables with the two first axes of canonical ordination of vascular epiphytes of 53 areas of Southeastern and Southern regions.

| Environmental variables         | Axis 1  | Axis 2  |
|--------------------------------|---------|---------|
| Shortest distance to the ocean  | 0.2431  | 0.9098  |
| Elevation                      | 0.9626  | -0.1219 |
| Minimum annual temperature     | -0.3739 | -0.0116 |

*All canonical axes.*

**Discussion**

**Floristic survey**

The species richness of each evolutionary lineage is similar to that observed in the Atlantic Forest (Kersten 2010; Freitas et al. 2016), although the proportion of representation of each is different. We found a lower percentage of monocotyledons (approximately 46% in the PESP versus approximately 64% for the Atlantic Forest) and a higher percentage of moniliphytes (approximately 29% in the PESP versus approximately 16% for the Atlantic Forest). This lower representation of monocotyledons is due to the reduced number of species of Bromeliaceae (10 species) and Araceae (only one species). The moniliphytes exhibited a larger contribution to the species composition, as the group is recognisably rich in the MOF, especially due to the Polypodiaceae, according to Kersten (2010).

Despite Orchidaceae, Polypodiaceae, Bromeliaceae, Araceae and Piperaceae are the five richest families in epiphytes in Atlantic domain (Kersten 2010; Freitas et al. 2016) and Neotropical region (Gentry & Dodson 1987) as well as at the global level (Zotz 2013), the contribution of each family in this study was different. When considering the physiognomy of MOF only, the first three families also are the richest. However, the Piperaceae contribution increases, being the fourth richest, and the Araceae contribution considerably decreases, according to Kersten (2010). In the present study, this fact is corroborated, since Araceae is represented only by Philodendron sp., found in the ecotone between MOF and DOF.

The two richest genera (Pleurothallis s.l. and Peperomia) are prominent in the Atlantic domain as well as in the Neotropical region. Pleurothallis s.l. is one of the richest genera of Orchidaceae and the largest among the epiphytic plants, and the Brazilian Atlantic Forest is one of the centres of diversity especially in areas of high elevations (Pridgeon 1982; Luer 1986; Gentry & Dodson 1987), such as the PESP. Peperomia is one of the largest genera of Piperaceae and exhibits high richness in the Brazilian Atlantic Forest (Menini Neto et al. 2016), especially in the ombrophilous forest (Carvalho-Silva 2008), and it is the richest genus among epiphytes if the large genera of Orchidaceae are excluded (Zotz 2013), justifying the number of species.

The richness of vascular epiphytes of the PESP is higher than that of other studied areas in the MOF of the Southern Region (e.g., Cervi & Dombrowski 1985; Cervi et al. 1988; Dittrich et al. 1999; Kersten & Silva 2002; Borgo & Silva 2003; Kersten 2006: Kersten et al. 2009) and in the MOF of Parque Estadual de Campos do Jordão (located at the Serra da Mantiqueira) (Mania 2013), even if we consider only the richness found in the araucaria forests of the PESP (122 species). The PESP exhibits higher richness than that found in several studies conducted in seasonal semi-deciduous forest (Aguiar et al. 1981; Dislich & Mantovani 1998; Borgo et al. 2002; Rogalski & Zanin 2003; Giongo & Waechter 2004). This contradicts the data gathered by Kersten (2010), who found this physiognomy richer compared to the MOF of Southern Region of Brazil, although this author suggests that status of conservation of the MOF could be the responsible for this result. Thus, the degree of conservation of the PESP must be responsible, in part, for these results, although other features, such as elevation, could influence observed richness (Furtado & Menini Neto 2015a), once a richness peak for epiphytes in altitudinal gradients is common among 1000-2000 m (Madison 1977; Gentry e Dodson 1987; Benzing 1990; Krömer et al. 2005; Cardelús et al. 2006).

Two other aspects can also influence the richness and must be addressed. The lower latitude of PESP compared with other areas composed by MOF, also can be important due to the influence of latitude on the temperature, which is a relevant feature regarding the epiphyte richness (Benzing...
Montane environment itself is another possible influence on the richness found in the present study. Such environment is often found to be a refuge to species and, consequently, shows remarkable richness and endemism if compared with lowland vegetation (Körner 2004; Martinelli 2007).

On the other hand, the ecotone between the MOF and DOF exhibited lower richness (76 species) when compared to the study conducted by Kersten (2006) in a similar environment of transition, in which 143 species were recorded. The same situation occurs when comparing the PESP with areas of DOF, which are typically richer (Breier 2005; Petean 2009; Bonnet et al. 2013a, b). However, in some cases, the PESP exhibits a higher richness (Hertel 1950; Petean 2002). Such result must be related to the absence of Podocarpus lambertii in the ecotone area. This tree species represents an important phorophyte in the PESP, harbouring 89 of the epiphyte species or 75% of the total recorded in this study (Furtado & Menini Neto 2015a).

Results confirm that characteristic holoepiphyte is the most common ecological category, corroborating similar studies conducted in MOF (Dittrich et al. 1999; Heftel & Faustioni 2004; Buzatto et al. 2008; Bonnet et al. 2011). However, accidental holoepiphytes, as the second-most representative category, is unusual (Bonnet et al. 2011) and must be noted. In the PESP, the majority of accidental holoepiphytes was found in some parts of the forest that suffered from fire in the year 2011 that had their entire or almost entire epiphytic communities destroyed.

Anthropogenic disturbances (as fire) are often responsible to alter the community composition, opening space to the establishment of opportunistic and/or ruderal species that tolerate the new disturbed environment (Hobbs et al. 1992) and occupy the earliest stages of succession (Monaco et al. 2002). Thus, such disturbances can be related with the establishment of accidental holoepiphytes in the studied site, consequently enhancing their proportion in comparison with characteristic holoepiphytes. Some weed/ruderal species were already recorded as accidental holoepiphytes in disturbed environments (e.g., Ageratum conyzoides, Drymaria cordata, Erechtites valerianaefolius, Plantago major, Setaria palmifolia) (Holzner & Numata 1982). Species of these genera were also found as accidental holoepiphytes in the present study (Ageratum and Plantago) and in some other studies dealing with vascular epiphytes in disturbed environment (for example, Bhatt et al. 2015; Furtado & Menini Neto 2015b). It is necessary to conduct more accurate studies in addition to better sampling of this ecological category of epiphytes, which is neglected in several studies regarding epiphyte synusia, and deserves more attention as pointed out by Zott (2013). Moreover, Benzing (1990) emphasised that environments with high moisture facilitate the occurrence of accidental species, which can explain, in part, the representativeness of this category in the present study.

**Multivariate analyses**

Importance of vegetation formation and elevation in the composition and distribution of vascular epiphytes showed in the dendrogram is similar to the pattern found for angiosperm epiphytes by Menini Neto et al. (2009) although these authors used fewer areas than the present study. In the graphic, there is a tendency of grouping the areas that share DOF but segregation of the MOF of Southern and Southeastern regions.

The scatter plot of the CCA reinforced the influence of elevation but added the shortest distance to the ocean and the minimum annual temperature as important in calculation of the relationships. The set of variables of this study were also showed to be relevant in studies dealing with biogeography and floristic relationships of angiosperm epiphytes in Atlantic Forest (Menini Neto et al. 2009; 2016; Leitman et al. 2015).

Variables such moisture, light availability, temperature, and seasonality have direct influence in the distribution of epiphytes in the environment (Benzing 1990). Thus, complex variables that are composed by the first ones, for instance in a wide scale, elevation, latitude, continentality and, in a narrow scale, distance from water bodies, stratification on the phorophyte, and relief, also interfere on the epiphyte community.

Low temperature and frost are pointed as limiting to the richness of vascular epiphytes in different scales (Gentry & Dodson 1987; Krömer et al. 2005; Blum et al. 2011; Hsu et al. 2014), which is corroborated in this study, once we found that minimum annual temperature is one of the important variables regarding the obtained floristic relationships. Elevation is directly related with temperature, atmospheric pressure and cloud cover and indirectly related with moisture, sun hours, wind, geology and seasonality (Körner 2004), that is, adds both positive and negative variables to the development of epiphytes, inclusive showing a variation depending upon the epiphytic group. For instance, Orchidaceae and monilophytes present a relative enhancement in the richness following the elevation, reaching a diversity peak in higher altitudes than found in other groups (Moran 1995; Krömer et al. 2005).

Positive correlation between geographic distance and Sørensen similarity index is due to the grouping in a cluster of distant areas composed by MOF (since the areas of Planalto Meridional, in the Southern Region, grouped together with those present in the Serra da Mantiqueira, in the Southeastern Region of Brazil). This cluster, albeit with a reduced similarity index, contradicts the rare studies that deal with the floristic relationships of the MOF. For instance, studies concerning the flora of shrubs and trees showed great dissimilarities between the areas of MOF of the Southern and Southeastern regions of Brazil (Jarenkow & Budke 2009; Ribeiro 2011).
During the Middle and Upper Holocene (between 4,320 and 1,000 years before the present) the typical tree species of MOF expanded, especially due to the enhancement of moisture, forming forests along the rivers (Bauermann & Behling 2009). Therefore, the MOF of Serra da Mantiqueira took refuge in patches and became isolated from the southern forests, forming islands among the ‘campo de altitude’, likely due to the dynamic between the field and forest (Behling & Pillar 2007). This isolation, although sufficient for some recognition of distinct floristic sets, as the case of shrubs and trees, seems too weak for homogenisation of the vascular epiphytic flora of MOF with other surrounding physiognomies.

Regarding the environmental variables, the study of Oliveira-Filho et al. (2013) also stressed the shortest distance to the ocean, elevation, and variation in the temperature throughout the year, among others, as important in determining the relationships among the forest physiognomies of the Southern Region of Brazil based on flora of trees.

It is possible that the composition of typical tree species in the MOF and, consequently, the probability of being the main phorophytes contribute to higher frequency and sharing of several epiphytic species, explaining the similarity between the areas of the Southern and Southeastern regions, despite the distance between them. Therefore, species like A. angustifolia and P. lambertii, which are dominant trees in the studied area (Santana 2016), often emphasised among the species of the prominent importance value index in phytosociological studies conducted on MOF of the Southern and Southeastern regions (Geraldi et al. 2005; Seger et al. 2005; Ribeiro et al. 2007; Araujo et al. 2010; Silva et al. 2012; Souza et al. 2012), can possibly be a determinant for the occurrence of epiphytic species shared by areas with this physiognomy, regardless of geographic distance or environmental variables.

Wilberger et al. (2009) and Furtado & Menini Neto (2015a) evaluated the vascular epiphytes on A. angustifolia and P. lambertii, respectively, showing their importance as support for the epiphytic synusia. However, the lack of studies that correlated the occurrence of epiphytes and respective phorophytes in the MOF, regardless of species, impede deeper conclusions about this subject.

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References

Ab’saber AN. 2003. Os domínios de natureza no Brasil: potencialidades paisagísticas. São Paulo, Ateliè Editorial.

Aguiar LW, Citadini-Zanette V, Martau L, Backes A. 1981. Composição florística de epífitos vasculares numa área localizada nos municípios de Montenegro e Triunfo, Rio Grande do Sul, Brasil. Iheringia, Série Botânica 28: 55-93.

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

APG IV – The Angiosperm Phylogeny Group. 2016. An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG III. Botanical Journal of the Linnean Society 181: 1-20.

Araujo MM, Chami L, Longhi SJ, Avila AL, Brena DA. 2010. Análise de agrupamento em remanescente de Floresta Ombrófila Mista. Ciência Florestal 20: 1-18.

Backes A. 2009. Distribuição geográfica atual da Floresta com Araucária: condicionamento climático. In: Fonseca CR, Souza AF, Leal-Zanchet AM, Dutra T, Backes A, Ganado G. (eds.) Floresta com Araucária: Ecologia, conservação e desenvolvimento sustentável. Ribeirão Preto, Holos Editora. p. 137-148.

Bauermann SG, Behling H. 2009. Dinâmica paleovegetacional da Floresta com Araucária a partir do final do Pleistoceno: o que mostra a palinologia. In: Fonseca CR, Souza AF, Leal-Zanchet AM, Dutra T, Backes A, Ganado G. (eds.) Floresta com Araucária: Ecologia, conservação e desenvolvimento sustentável. Ribeirão Preto, Holos Editora. p. 35-38.

Behling H, Pillar VS. 2007. Late Quaternary vegetation, biodiversity and fire dynamics on the southern Brazilian highland and their implication for conservation and management of modern Araucaria forest and grassland ecosystems. Philosophical transactions of the Royal Society of London, Biological Sciences 362: 243-251.

Benavides AM, Duque AJ, Duivenvoorden JF, Vasco GA, Callejas R. 2005. A first quantitative census of vascular epiphytes in rain forests of Colombian Amazonia. Biodiversity and Conservation 14: 739-758.

Benzing DH. 1990. Vascular epiphytes. New York, Cambridge University Press.

Bhatt A, Gairola S, Govender Y, Bainjath H, Ramdhani S. 2015. Epiphyte diversity on host trees in an urban environment, eThekwini Municipal Area, South Africa. New Zealand Journal of Botany 53: 24-37.

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.

Bonnet A, Curcio GR, Lavoranti OJ, Galvão F. 2011. Flora epífita vascular em três unidades vegetacionais do rio Tibagi, Paraná, Brasil. Rodriguésia 62: 491-498.

Bonnet A, Caglioni E, Schmitt JL, et al. 2013a. Capítulo 1 - Epífitos vasculares da Floresta Ombrófila Densa de Santa Catarina. In: Vibrans AC, Bonnet A, Caglioni E, Gasper AL, Lingner DV. (eds.) Inventário Florístico Florestal de Santa Catarina. Vol. 5. Blumenau, Edifurb. p. 27-71.

Bonnet A, Caglioni E, Schmitt JL, et al. 2013b. Capítulo 2 – Descrições das unidades amostrais dos epífitos vasculares. In: Vibrans AC, Bonnet A, Caglioni E, Gasper AL, Lingner DV. (eds.) Inventário Florístico Florestal de Santa Catarina Vol. 5. Blumenau, Edifurb. p. 72-335.

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

Borgo M, Pentean M, Silva SM. 2002. Epífitos vasculares em um remanescente de floresta estacional semidecidual, município de Fênix, PR, Brasil. Acta Biológica Leopoldina 24: 121-130.

Breier TB. 2005. O epífitismo vascular em florestas do Sudeste do Brasil. Doctorate Thesis, Universidade Estadual de Campinas, Campinas.

Buzaotto CR, Severo BMA, Waechter JL. 2008. Composição florística e distribuição ecológica de epífitos vasculares na Floresta Nacional de Passo Fundo, Rio Grande do Sul. Iheringia, série Botânica 63: 231-239.
Cardelús CL, Colwell RK, Watkins Jr. JE. 2006. Vascular epiphyte distribution patterns: explaining the mid-elevation peak richness. Journal of Ecology 94: 144-156.

Carvalho-Silva M. 2008. Peperomia Ruiz & Pav. no Brasil: morfologia e taxonomia do subgênero Rhynchosporum (Miq.) Dahlst. PhD Thesis, Escola Nacional de Botânica Tropical, Brazil.

Catchpole D. 2004. The ecology of vascular epiphytes on a Ficus L. host (Moraceae) in a Peruvian cloud forest. PhD Thesis, University of Tasmania, Australia.

Cervi AC, Dombrowski LTD. 1985. Bromeliaceae de um capão de floresta primária do Centro Politécnico de Curitiba (Paraná, Brasil). Fontequeria 9: 9-11.

Cervi AC, Acra LA, Rodrigues L, Train S, Ivanchechen SL, Moreira ALOR. 1988. Contribuição ao conhecimento das epífitas (exclusive Bromeliaceae) de uma floresta de araucária do primeiro planalto paranaense. Insula 18: 75-82.

Christenhusz MJM, Zhang XC, Schneider H. 2011. A linear sequence of extant families and genera of lycophytes and ferns. Phytotaxa 19: 7-54.

Dislich R, Mantovani W. 1998. A flora de epífitas vasculares a reserva da Cidade Universitária “Armando de Salles Oliveira” (São Paulo, Brasil). Boletim de Botânica da Universidade de São Paulo 17: 1-83.

Ditrich VAO, Kocea C, Silva SM. 1999. Levantamento florístico de epífitas vasculares no Parque Barigüi, Paraná, Brasil. Iheringia, série Botânica 52: 11-22.

Drummond GM, Martins CS, Machado ABM, Sebaio FA, Antonini Y. 2005. Biodiversidade em Minas Gerais, um atlas para sua conservação. 2nd. edn. Belo Horizonte, Fundação Biodiversitas.

Felfili JM, Roitman I, Medeiros MM, Sanchez M. 2011. Procedimentos e métodos de amostragem de vegetação. In: Felfili JM, Eisenlohr PV, Menini Neto L. (eds.) Fitossociologia no Parque Estadual da Serra do Papagaio, Minas Gerais. Ribeirão Preto, Holos. p. 86-121.

Figueras TS, Nogueira PE, Brochado AL, Guala GF. 1994. Caminhamento: um método expedito para levantamentos florísticos qualitativos. Cadernos de Geociências 12: 39-43.

Forzza RC, Baumgratz JFA, Bicudo CEM, Melo MMRF, Andrade LA, Meira Neto JAA. (eds.) Biodiversidade em Minas Gerais, um atlas para sua conservação. 2nd. edn. Belo Horizonte, Fundação Biodiversitas. 2004. Mountain biodiversity in Brazil. Revista Brasileira de Biologia 26: 11-19.

Forzza RC, Baumgratz JFA, Bicudo CEM, Melo MMRF, Andrade LA, Meira Neto JAA. (eds.) Biodiversidade em Minas Gerais, um atlas para sua conservação. 2nd. edn. Belo Horizonte, Fundação Biodiversitas.

Hertel RJG. 1950. Contribuição à ecologia de flora epífita da serra do mar (vertente oeste) do Paraná. Arquivos do Museu Paranaense 8: 3-63.

Hijmans RJ, Cameron SE, Parra JL, Jones PG, Jarvis A. 2005. Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology 25: 1965-1978.

Hijmans RJ, Guarino L, Cruz M, Rojas E. 2001. Computer tools for spatial analysis of plant genetic resources data: I. DIVA-GIS. Plant Genetic Resources Newsletter 127: 15-19.

Holzner W, Numata M. 1982. Biology and ecology of weeds. The Hague, Dr. W. Junk Publishers.

Hsu RCC, Wolf JH, Tamis WL. 2014. Regional and elevational patterns in vascular epiphyte richness on an East Asian island. Biotropica 46: 549-555.

Jarenkov JA, Budke JC. 2009. Padrões florísticos e análise estrutural de remanescentes de floresta com Araucária no Brasil. In: Fonseca CR, Souza AF, Leal-Zanchet AM, Dutra TL, Backes A, Ganade G. (eds.) Floresta com Araucária: ecologia, conservação e desenvolvimento sustentável. Ribeirão Preto, Holos. p. 35-38.

Kersten RA. 2006. Epífitos vasculares – história, participação taxonômica e aspectos relevantes com ênfase na Mata Atlântica. Hoehnea 37: 9-38.

Kersten RA, Kuniyoshi YS, Roderjan CV. 2009. Comunidade epifita em duas formações florestais do Rio São Jerônimo, Bacia do Rio Iguaçu, municípios de Guarapuava e Pinhão, Paraná. Iheringia, série Botânica 64: 33-43.

Kersten RA, Silva SM. 2002. Florística e estrutura do componente epífito vascular em Floresta Ombrófila Mista Aluvial do rio Barigüí, Paraná, Brasil. Revista Brasileira de Botânica 25: 259-267.

Körner C. 2004. Mountain biodiversity, its causes and function. Ambio 33: 13-17.

Krömer T, Kessler M, Gradstein SR, Abeeey K. 2005. Diversity patterns of vascular epiphytes along an elevational gradient in the Andes. Journal of Biogeography 32: 1799-1809.

Leitman P, Amorim A, Menin Neto L, Forzza RC. 2014. Epiphytic angiosperms in a mountain forest in southern Bahia, Brazil. Biota Neotropica 14: 1-12.

Leitman P, Amorim A, Sansevero JBB, Forzza RC. 2015. Floristic patterns of epiphytes in the Brazilian Atlantic Forest, a biodiversity hotspot. Botanical Journal of the Linnean Society 179: 587-601.

Lino CF, Albuquerque JL, Dias H. 2007. Cadernos da Reserva da Biosfera da Mata Atlântica n° 32 – Mosaicos de unidade de conservação no corredor da Serra do Mar. São Paulo. São Paulo, Conselho Nacional da Reserva da Biosfera da Mata Atlântica.

Luer CA. 1986. Icones Pleurothallidinarum III. Systematics of Pleurothallis (Orchidaceae). Monographs in Systematic Botany from the Missouri Botanical Garden, 20. St. Louis, MGB Press.

Madison V. 1977. Vascular epiphytes: their systematic occurrence and salient features. Selbyana 2: 1-13.

Mania F. 2013. Composição florística de comunidades epífitas vasculares em Unidades de Conservação no Estado de São Paulo. PhD Thesis, Universidade Estadual Paulista Júlio de Mesquita Filho, Brazil.

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

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

Menini Neto L, Furtado SG, Zappi DC, Oliveira-Filho AT, Forzza RC. 2016. Biogeography of epiphytic Angiosperms in the Brazilian Atlantic Forest, a world biodiversity hotspot. Brazilian Journal of Botany 39: 261-273.

Mittermeier RA, Gil PR, Hoffmann M, et al. 2004. Hotspots revisited: earth’s biologically richest and most endangered terrestrial ecoregions. Washington, Ceme.

Monaco TJ, Weller SC, Ashton FM. 2002. Weed science: principles & practices. New York, John Wiley & Sons, Inc.

Moran RC. 1995. The importance of mountains to pteridophytes, with emphasis on Neotropical Montane Forests. In: Churchill SP, Balsev H, Forero E, Luteyn JL. (eds.) Biodiversity and conservation of
Neotropical Montane Forests. New York, The New York Botanical Garden, p. 359-363.

Nadkarni N. 1984. Epiphyte biomass and nutrient capital of a neotropical elfin forest. Biotropica 16: 249-256.

Nieder J, Engwald S, Klawun M, Barthlott W. 2000. Spatial distribution of vascular epiphytes (including hemiepiphytes) in a Lowland Amazon Rain Forest (Surumoni Crane Plot) of Southern Venezuela. Biotropica 32: 385-396.

Oliveira-Filho AT, Budke JC, Jarenkow JA, Eisenlohr PV, Neves DRM. 2013. Delving into the variations in tree species composition and richness across South American tropical Atlantic and Pampean forests. Journal of Plant Ecology 6: 1-23.

Palmer MW. 1993. Putting things in even better order: the advantages of canonical correspondence analysis. Ecology 74: 2215-2230.

Pereira LC, Chautems A, Mello RM, Menini Neto L. 2013. Gesneriaceae no Parque Estadual da Serra do Papagaio, Minas Gerais, Brasil. Boletim de Botânica da Universidade de São Paulo 31: 1-12.

Petean MP. 2009. O componente epífita vascular em Floresta Ombrófila Mista localizada no município de Pinhais, Paraná – Brasil. Floresta 35: 291-302.

Silva AC, Higuchi P, Aguiar MD, Negrini M, Fert Neto J, Hess AF. 2012. Relações florísticas e fitossociológica de uma Floresta Ombrófila Mista montana secundária em Lages, Santa Catarina. Ciência Florestal 22: 193-206.

Silva LVC, Viana PL, Mota NFO. 2008. Plano de Manejo do Parque Estadual da Serra do Papagaio, Minas Gerais, Brasil. Belo Horizonte, Instituto Estadual de Florestas.

Souza FS, Salino A, Viana PL, Salimena FRG. 2012. Pteridófitas da Serra Negra, Minas Gerais, Brasil. Acta Botanica Brasiliaca 26: 378-390.

Stehmann JR, Forzza RC, Salino A, Sobral M, Costa DP, Kamino LH. 2009. Diversidade taxonômica na Floresta Atlântica. In: Stehmann JR, Forzza RC, Salino A, Sobral M, Costa DP, Kamino LH. (eds.) Plantas da Floresta Atlântica. Rio de Janeiro, Instituto de Pesquisas Jardim Botânico do Rio de Janeiro, p. 3-12.

ter Braak, CJE. 1986. Canonical correspondence analysis: a new eigenvector technique for multivariate direct gradient analysis. Ecology 67: 1167-1179.

ter Braak CJE, Smilauer P. 2002. CANOCO reference manual and CanoDraw for Windows user’s guide: software for canonical community ordination (version 4.5). Itaca, Microcomputer Power.

Thiers B. 2015. Index Herbariorum: A global directory of public herbaria and associated staff. New York Botanical Garden’s Virtual Herbarium. <http://sweetgum.nybg.org/ih/> 2 Feb. 2015.

Watkins Jr. JE, Cardelús C, Colwell RK, Moran RC. 2006. Species richness and distribution of ferns along an elevational gradient in Costa Rica. American Journal of Botany 93: 73-83.

Wilberger TP, Boeni BO, Azambuja CP, et al. 2009. Epífitos vasculares associados à Araucaria angustifolia. In: Fonseca CR, Souza AF, Leal- Zanchet AM, Dutra T, Backes A, Ganado G. (eds.) Floresta com Araucária: Ecologia, conservação e desenvolvimento sustentável. Ribeirão Preto, Holos Editora. p. 137-147.

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