Diversity of Vascular Epiphytes in Urban Green Areas of Juiz de Fora, Minas Gerais, Brazil

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Abstract
This study aimed to characterize the floristic composition and community structure of vascular epiphytes in 13 green areas of Juiz de Fora, in the State of Minas Gerais, Brazil. The calculated parameters were relative and absolute frequencies, Shannon diversity ($H'$) and Pielou evenness ($J$) indices. 56 species belonging to 22 families were recorded, with the richest species being Bromeliaceae (eight spp.), Tillandsia tricholepis, T. recurvata, Microgramma squamulosa, and Rhipsalis lindbergiana were dominant (comprising 79.5% of relative frequency). Most species were accidental epiphytes (25 spp.), probably due to an effect of the disturbed environment. The richest and most diverse area was the Parque Halfeld (26 species and $H' = 2.2$), which is also the oldest sampled area. There was a higher concentration of epiphytes in the tree crowns, possibly representing a response to anthropic actions. The results highlighted the importance of thorough studies to achieve a better understanding of this ecologically relevant synusia in such disturbed environments.

Keywords: Atlantic forest, Serra da Mantiqueira, urban vegetation, Zona da Mata.

1. Introduction
Currently, the urban environment is highly modified by anthropic actions, however, it has been previously composed of natural vegetation and may represent vegetation refuges (green areas) in most cities (Silva et al., 2013). Thus, these green areas can contribute to biodiversity conservation, even acting as small ecological corridors (Gomes & Soares, 2003). In some cases, these green areas are composed by remnants of the original vegetation (Freitas et al., 2015); on the other hand, these areas have been frequently reduced their soil extension with the plants being confined inside small pots and surrounded by an impermeable area which does not allow their expansions and consequent growth of such environments.

The use of afforested areas is an expressive feature of contemporary life, offering several opportunities for recreation, and allowing human beings to come into contact with the natural environment (Biondi, 2015). Thus, according to Gomes & Soares (2003), an effecuation of these areas by the public power is necessary through afforestation and g pieces of equipment for children, and then contributing to enhance the environmental quality of the cities as well as the Quality of Life (QoL) of the inhabitants.

Organisms living in tree crowns reveal distinct dynamics from those which are cultivated in the pots (or beds), thereby in some way, establishing complex communities (Elias et al., 2006). Although the canopy represents a complex structure of the forest (Lowman & Rinker, 2004), it is often not frequent in urban green areas (parks, squares, etc.), since the trees have grown in isolation (in beds) and have possibly presented distinct dynamics in comparison with the forest.

Epiphytes often occur in the canopy and do not establish contact with the soil (except for hemiepiphytes) (Benzing, 1990; Zotz, 2016). They are plants that grow upon other plants (phorophytes) but are not parasitic, meaning they do not nutritionally depend on the phorophyte (Gentry & Dodson, 1987). The urban environment is relatively poor in epiphytes, but several species are highly abundant and play some ecological role (Lapo & Magenta, 2014), although sometimes unknown. Several studies demonstrated the importance of epiphytes to evaluate the environmental quality of the cities and their surroundings (e.g., Graciano et al., 2003; Alves et al., 2008; Bermudez et al., 2009), nevertheless, not much is known about this group of plants when compared with its wide range, and even less, when related to the urban environment (Fabricante et al., 2006; Krömer et al., 2014; Furtado & Menini, 2015).

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According to Gomes & Soares (2003), the literature often highlights the neglect and lack of interest of public organs and even of the population to know the importance of the vegetation in the urban environment, however, it is very important to know and value its ecological services, and not only seen as a decorative element of the cities. Epiphytes are known by their important ecological functions (Benzing, 1990; Gotsch et al., 2016; Zotz, 2016), which are probably not different in the urban environment, where they certainly represent a relevant part of the vegetation, and which is still lacking in studies.

Thus, this study is seeking to contribute to the knowledge of the little-studied epiphytic synusia in the urban environment. The present study aimed to characterize the floristic composition and structure of vascular epiphytes in green areas of the municipality of Juiz de Fora, Zona da Mata of the State of Minas Gerais, Brazil.

2. Material and methods

2.1. Study area

This study was performed between 2014 and 2017 in 13 urban green areas (squares) located in the central region of the municipality of Juiz de Fora, Zona da Mata of the State of Minas Gerais, Northern Mantiqueira (Rocha et al., 2003), in the Southeastern Region of Brazil. The extension of the sample areas comprised approximately eight ha (Table 1, Figure 1).

The vegetation of the region is mainly composed of a montane seasonal semi-deciduous forest (IBGE, 2012). The climate is subtropical ocean highland climate (Cwb) (according to the Köppen classification), mesothermal, characterized by rainy and warm summers and cold and dry winters; mean annual precipitation of 1536mm and mean temperature of 18.9 °C; and an altitude of from 700 to 900m (CESAMA, 2010).

2.2. Sampling

The epiphytes were sampled in trees and/or arborescent plants (e.g., Araceae, Asparagaceae, Pandanaceae, Strelitziaceae, etc.) in the 13 studied squares. The presence and identification of the epiphytes were observed through binoculars and/or photographs. The plants (epiphytes and phorophytes) were identified in the field when possible and by an analysis of photographs and comparison with specimens deposited in herbaria available in the site of the Virtual Herbarium REFLORA (JBRJ, 2019). The species of vascular epiphytes were classified in the ecological categories of Hemiepiphyte (HEM); Accidental Epiphyte (AE) and Characteristic Holoepiphyte (CHL), according to Benzing (1990).

Phorophytes were divided into three strata: A) basal half of the trunk; B) upper half of the trunk; C) tree crown. The division into strata aimed to evaluate the distribution of the epiphytes along the phorophytes and eventual correlation with the maintenance of the trees and/or collection made.
by the inhabitants. Phorophytes which did not present stem ramification (such as the aforementioned arborescent plants) were identified and recorded, but a stratification was not evaluated.

2.3. Statistical analyses

A linear regression was performed to evaluate the correlation between the total number of trees and extension with the richness of epiphytes found in the green areas. The phytosociological parameters calculated were relative and absolute frequencies, the Shannon diversity index ($H'$) and the Pielou evenness index ($J$). The $H'$ values were compared using the Hutcheson $t$-test. The richness of vascular epiphytes on exotic and native phorophytes was compared by the $t$-test. The analyses were performed in Microsoft Office Excel 2019 and Past v. 3 software programs.

3. Results and discussion

Thus, 1129 trees/arborescent plants were analyzed, of which 827 were phorophytes, with the presence of at least one vascular epiphyte, representing approximately 73% of the total sample. 56 species of vascular epiphytes could be found and were distributed across 22 families (Table 2).

Bromeliaceae was the richest family (presenting eight species), followed by Araceae, Orchidaceae, and Polypodiaceae (six spp. each) and Cactaceae (three), comprising 29 species or approximately 52% of the total recorded richness. These families are among the richest one regarding vascular epiphyte species (Benzing, 1990; Zotz, 2016), which also constitutes a pattern found in the Neotropical Region (Gentry & Dodson, 1987) and the Atlantic Forest (Kersten, 2010; Freitas et al., 2016), in which the studied area is inserted, however, it could be noted that the rank may be different depending on the evaluated vegetation physiognomy. It is worth mentioning that this is a common pattern which is also found in other urban areas, and it was possible to notice that the representativity of the tree families could be twice represented even in disturbed urban environments (Dislich & Mantovani, 1998; Hefler & Faustioni, 2004; Fabricante et al., 2006; Alves et al., 2014; Lapo & Magenta, 2014). Commelinaceae, Moraceae, Poaceae, and Solanaceae presented two species each, while the remaining families only presented one species each (totaling 19 species).

This result showed that the green areas of the city of Juiz de Fora presented a relevant epiphyte flora when compared with similar studies performed in other urban areas (Hefler & Faustioni, 2004; Fabricante et al., 2006; Alves et al., 2014; Lapo & Magenta, 2014; Becker et al., 2015), and also similar to the results of Furtado & Menini (2015) regarding cultivated trees and remnants of semi-deciduous seasonal forest in the campus of the Universidade Federal de Juiz de Fora (UFJF).
Table 2. Families and species of vascular epiphytes recorded in the green areas of the municipality of Juiz de Fora, in the State of Minas Gerais, Brazil and respective ecological categories and phytosociological parameters.

| Species                          | Fam (Families) | EC (Ecological Categories) | AF  | RF  | TO  | 1 (43) | 2 (49) | 3 (18) | 4 (42) | 5 (31) | 6 (140) | 7 (222) | 8 (29) | 9 (15) | 10 (101) | 11 (26) | 12 (58) |
|----------------------------------|----------------|-----------------------------|-----|-----|-----|--------|--------|--------|--------|--------|---------|---------|--------|--------|-----------|--------|--------|
| Tillandsia tricholepis Baker     | Brom           | CHL                         | 77.87 | 30.78 | 644 | 17 | 49 | 10 | 33 | 28 | 40 | 122 | 194 | 10 | 75 | 18 | 48 |
| Tillandsia recurvata (L.) L.     | Brom           | CHL                         | 62.52 | 24.71 | 517 | 36 | 17 | 13 | 7 | 18 | 27 | 119 | 177 | 3 | 2 | 73 | 8 | 17 |
| Microgramma squamulosa (Kaulf.) de la Sota | Polyphylly   | CHL                         | 42.32 | 16.73 | 350 | 26 | 12 | 14 | 15 | 18 | 47 | 107 | 24 | 8 | 33 | 4 | 28 |
| Rhipsalis lindbergiana K.Schum.  | Cact           | CHL                         | 18.50 | 7.31 | 153 | 28 | - | 3 | - | 1 | 8 | - | 81 | 8 | 2 | 16 | - | 6 |
| Pleopeltis astroplepis (Liebm.) E.Fourn.  | Polyphylly   | CHL                         | 8.22 | 3.25 | 68 | - | - | - | 1 | 3 | 1 | 25 | 12 | - | - | 22 | 2 | 2 |
| Billbergia horrida Regal         | Brom           | CHL                         | 7.38 | 2.92 | 61 | - | - | - | - | - | - | 58 | - | - | - | 3 | - |
| Microgramma vaccinifolia (Langsd. & Fisch.) Copel | Polyphylly   | CHL                         | 6.29 | 2.49 | 52 | - | - | - | 1 | 1 | 1 | 3 | 43 | - | 1 | - | - | 2 |
| Ficus microcarpa L.              | Mor            | Hem                         | 6.05 | 2.39 | 50 | 2 | - | - | 4 | 4 | 2 | 21 | 13 | - | - | - | 4 | - |
| Epiphyllum phyllanthus (L.) Hawc. | Cact           | CHL                         | 2.42 | 0.96 | 30 | 1 | - | - | 1 | 5 | - | 22 | 1 | - | - | - | - |
| Ficus cf. citrifolia Mill.       | Mor            | Hem                         | 3.02 | 1.20 | 25 | 1 | - | - | - | - | 3 | 13 | 1 | - | 3 | - | 2 |
| Philodendron bipinnatifidum Schott ex Endl. | Arac           | Hem                         | 2.42 | 0.96 | 20 | - | - | - | 1 | 8 | 4 | - | - | 1 | - | 5 |
| Syngonium podophyllum Schott     | Arac           | Hem                         | 1.93 | 0.76 | 16 | 3 | - | 4 | - | - | 1 | 8 | - | - | - | - | - |
| Pleopeltis hirsutissima (Raddi) de la Sota | Polyphylly   | CHL                         | 1.57 | 0.62 | 13 | 4 | - | 1 | 1 | 2 | - | - | 1 | 4 | 1 | - | 1 |
| Epipremnum pinnatum (L.) Engl.   | Arac           | Hem                         | 0.85 | 0.33 | 7 | - | - | - | - | - | 7 | - | - | - | - | - |
| Monstera deliciosa Liebm.        | Arac           | Hem                         | 0.73 | 0.29 | 6 | - | - | - | - | - | - | - | - | 6 | - | - |
| Tillandsia stricta Sol. ex Ker Gawl | Brom           | CHL                         | 0.73 | 0.29 | 6 | - | - | - | - | - | - | - | - | - | - | - |
| Catarseum cernuum (Lindl.) Rchb.f. | Orch           | CHL                         | 0.60 | 0.24 | 5 | - | - | - | 1 | 2 | - | 1 | 1 | - | - | - | - |
| Hylocereus undatus (Hawc.) Britton & Rose | Cact           | CHL                         | 0.60 | 0.24 | 5 | - | - | - | - | - | 5 | - | - | - | - | - |
| Pleopeltis pleopeltifolia (Raddi) Alston | Polyphylly   | CHL                         | 0.60 | 0.24 | 5 | - | - | - | 2 | - | - | 1 | - | - | 2 | - |
| Dendrobium nobile Lindl.         | Orch           | CHL                         | 0.48 | 0.19 | 4 | - | - | - | 4 | - | - | - | - | - | - | - |
| Polystachya estrellensis Rchb. f. | Orch           | CHL                         | 0.48 | 0.19 | 4 | - | - | - | 4 | - | - | - | - | - | - |
| Portea petropolitana (Wawra) Mez | Brom           | CHL                         | 0.48 | 0.19 | 4 | - | - | - | 4 | - | - | - | - | - | - |
| Talinum paniculatum (Jacq.) Gaertn. | Port           | AE                          | 0.48 | 0.19 | 4 | - | - | - | 1 | - | - | 3 | - | - | - |
| Tradescantia zebrina Heynh. ex Bosse | Comm           | AE                          | 0.48 | 0.19 | 4 | 2 | - | - | - | - | - | - | - |
| Unidentified Eudicot 1           | -              | AE                          | 0.48 | 0.19 | 4 | - | - | - | - | - | 4 | - | - | - |
| Schefflera arboricola (Hayata) Merr. | Api            | AE                          | 0.36 | 0.14 | 3 | - | - | - | 1 | - | - | 1 | - | - | - |
| Tillandsia cf. polystachia (L.) L. | Brom           | AE                          | 0.36 | 0.14 | 3 | - | - | - | 1 | - | - | 2 | - | - | - |
| Callisia repens (Jacq.) L.       | Comm           | AE                          | 0.36 | 0.14 | 3 | - | - | - | - | - | - | - | - | 3 | - | - |
| Epipremnum aureum (Linden & André) | G.S.Bunting   | -              | 0.24 | 0.10 | 2 | - | - | - | - | - | - | - | 2 | - | - | - |
| Philodendron sp.                 | Arac           | Hem                         | 0.24 | 0.10 | 2 | 2 | - | - | - | - | - | 1 | 1 | - | - | - | - |

Fam (Families): Api = Apiaceae; Arac = Araceae; Aspar = Asparagaceae; Aster = Asteraeaceae; Balsam = Balsaminaceae; Brom = Bromeliaceae; Cact = Cactaceae; Comm = Commelinaceae; Crass = Crassulaceae; Cucur = Cucurbitaceae; Eupho = Euphorbiaceae; Hypox = Hypoxidaceae; Malv = Malvaceae; Mor = Moraceae; Orch = Orchidaceae; Phyll = Phyllanthaceae; Poac = Poaceae; Polyp = Polypodiaceae; Port = Portulacaceae; Rut = Rutaceae; Solan = Solanaceae; Tunte = Turneaceae. EC (Ecological Categories): AE = Absolute Epiphyte; CHL = Characteristic Holoepiphyte; Hem = Hemiepiphyte. Frequencies: AF = Absolute Frequency; RF = Relative Frequency; TO = Total Occurrences in the squares. Squares: (1) Armando Toschi Ministirinho; (2) Menelick de Carvalho; (3) Pedro Marques; (4) Jairas de Lery; (5) Presidente Antônio Carlos Agassiz; (7) Presidente Garrastazu Médici; (8) Parque Haéd; (9) Largo do Riachuelo; (10) Mahatma Gandhi; (11) Prefeito Olavo Costa; (12) Praça da República; (13) Igreja Catedral. Between parentheses are presented the number of phophytes in each square.
Table 2. Continued...

| Species | Fam | EC | AF | RF | TO |
|---------|-----|----|----|----|----|
| **Solanum americanum Mill.** | Solan | AE | 0.24 | 0.10 | 2 |
| **Poaceae indeterminada** | Poac | AE | 0.24 | 0.10 | 2 |
| **Aechmea nudicaulis** (L.) Griseb. | Brom | CHL | 0.12 | 0.05 | 1 |
| **Alchornea triplinervia** (Spreng.) Müll.Arg. | Euph | AE | 0.12 | 0.05 | 1 |
| **Asparagus densiflorus** (Kunth) Jessop | Aspar | AE | 0.12 | 0.05 | 1 |
| **Asteraceae indeterminada** | Aster | AE | 0.12 | 0.05 | 1 |
| **Cattleya loddigesii Lindl.** | Orch | CHL | 0.12 | 0.05 | 1 |
| **Cycloponon argyrophilus** Barb.Rodr. | Orch | AE | 0.12 | 0.05 | 1 |
| **Cucurbitaceae indeterminada** | Cucur | AE | 0.12 | 0.05 | 1 |
| **Hypoxis decumbens** L. | Hypox | AE | 0.12 | 0.05 | 1 |
| **Impatiens walleriana** Hook.f. | Balsam | AE | 0.12 | 0.05 | 1 |
| **Kalanchoe de laegeiis** Eckl. & Zeyh. | Crass | AE | 0.12 | 0.05 | 1 |
| **Malvaceae indeterminada** | Malv | AE | 0.12 | 0.05 | 1 |
| **Murraya paniculata** (L.) Jack | Rut | AE | 0.12 | 0.05 | 1 |
| **Oncidium baueri** Lindl. | Orch | CHL | 0.12 | 0.05 | 1 |
| **Phlebodium pseudoaureum** (Cav.) Lellinger | Polyp | AE | 0.12 | 0.05 | 1 |
| **Phyllanthus sp.** | Phyll | AE | 0.12 | 0.05 | 1 |
| **Setaria parviflora** (Poir.) Kerguele | Poac | AE | 0.12 | 0.05 | 1 |
| **Solanum cf. paniculatum** L. | Solan | AE | 0.12 | 0.05 | 1 |
| **Tillandsia usneoides** (L.) L. | Brom | CHL | 0.12 | 0.05 | 1 |
| **Turnera subulata** Sm. | Tultne | AE | 0.12 | 0.05 | 1 |
| **Unidentified Eudicot 2** | - | AE | 0.12 | 0.05 | 1 |
| **Unidentified Eudicot 3** | - | AE | 0.12 | 0.05 | 1 |
| **Unidentified Eudicot 4** | - | AE | 0.12 | 0.05 | 1 |
| **Unidentified Eudicot 5** | - | AE | 0.12 | 0.05 | 1 |
| **Unidentified Eudicot 6** | - | AE | 0.12 | 0.05 | 1 |

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Fabricante et al. (2006) stated that the reduced number of species found in urban areas could be due to the disturbed environment, and this characteristic was quite different from the original habitat of these species.

Remarkably, both Araceae and Orchidaceae (two of the richest families found in Atlantic Forest (Kersten, 2010; Freitas et al., 2016)) were not represented by widely distributed species among the five richest families, while both Moraceae species could be found in several places in the studied area, in this case highlighting *Ficus microcarpa* L., an exotic species found in seven of 13 sampled squares (Table 2). This species is a hemiepiphyte originated from Asia and Oceania (Siqueira, 2006), and subsequently introduced as ornamental and is now considered as an invasive species in several areas of the Americas (Instituto Hórus de Desenvolvimento e Conservação Ambiental, 2016). This species has become more common in Brazil since the introduction of pollinating insects has also been detected (Farache et al., 2009), and thus has facilitated its dispersal due to the fleshy syconium and drupe-like fruits with fleshy and nutritious exocarp which are dispersed by mammals and ants (Kauffmann et al., 1991).

The richest green area was the Parque Halfeld, with 26 species (Table 3). The linear regression showed that both extension of the squares (*r*-0.74, *p*-0.003) and the total number of trees (*r*-0.89, *p*-0.001) had a positive correlation with the richness of vascular epiphytes occurring in the surveyed squares.

Only two species were shared by all 13 areas (*T. recurvata* and *M. squamulosa*), respectively, in other words, the second and third species in the frequency ranking. *Billbergia horrida* was a species that stands out for its high occurrence in one of the green areas studied (Parque Halfeld) and was also recorded within tens of meters away in the Catedral area (Figure 1), however, this species was not found in other areas. Even though it was noted that this species occurs frequently in cultivated trees and fragments of semideciduous secondary forest associated with the Botanical Garden of the UFFJ, near the central region of this municipality (Marques, 2016; Santana et al., 2017).

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Table 3. Values of Shannon (*H')* diversity and Pielou (*J*) evenness calculated for the studied squares.

| Squares | S | *H'* | *J* | Hutcheson *t*-test |
|---------|---|------|-----|--------------------|
| ATM     | 10 (2) | 1.63 | 0.78 | MC, PM, PH |
| MC      | 8 (2)  | 1.18 | 0.66 | JL, PAC, MP, PGM, PH, LR, Cat |
| PM      | 6 (1)  | 1.36 | 0.84 | PAC, MP, PH, OC, Cat |
| JL      | 14 (2) | 1.6  | 0.67 | PH, OC |
| PAC     | 12 (1) | 1.68 | 0.73 | PH, MG |
| MP      | 12 (2) | 1.7  | 0.74 | PH, OC |
| PGM     | 19 (5) | 1.5  | 0.68 | PH |
| PH      | 24 (1) | 2.2  | 0.7  | All squares |
| LR      | 10 (1) | 1.61 | 0.77 | MC, PH |
| MG      | 11 (4) | 1.2  | 0.74 | PAC, PH |
| OC      | 16 (7) | 1.5  | 0.68 | PM, PH, JL, MP |
| PR      | 15 (4) | 1.4  | 0.74 | PH |
| Cat     | 11 (1) | 1.5  | 0.65 | MC, PM, PH |

*S = richness of vascular epiphytes found in the square; *H'* = diversity index of Shannon; *J* = evenness index of Pielou; Hutcheson *t*-test = present the results of comparison between pairs of squares and those with significant difference; ATM = Armando Toschi Ministrinhiro; MC = Menelick de Carvalho; PM = Pedro Marques; JL = Jarbas de Lery; PAC = Presidente Antônio Carlos; MP = Mariano Procópio; PGM = Presidente Garrastazu Médici; PH = Parque Halfeld; LR = Largo do Riachuelo; MG = Mahatma Gandhi; OC = Prefeito Olavo Costa; PR = República; Cat = Igreja Catedral.

The most species (46.4%) are accidental species (26 spp.), followed by characteristic holoepiphytes (35.7%, 20 spp.) and 10 species of hemiepiphytes (17.9%) (Table 2). The accidental epiphytes do not have morphophysiological adaptions for the epiphytic lifeform, although they occasionally attain maturity without rooting in the soil (Benzing, 1990). According to the studies performed by Furtado & Menini (2015) and Santana et al. (2017) also in urban areas of Juiz de Fora, accidental epiphytes also presented high richness and the authors pointed out that a disturbed environment would be responsible for this result (a possibility also suggested by Barthlott et al. (2001), Bataghin et al. (2008) and Dettke et al. (2008)), so it could be noted that the present study corroborated these data. Additionally, palm leaf sheath provides a moist environment which accumulates organic matter (Benzing, 1990; Santos & Jardim, 2017) and represents a site for the establishment of several species of ferns, true epiphytic or not (Benzing, 1990). Similarly, we could associate the high occurrence of palm trees found in the squares studied in Juiz de Fora with the number of AE species being higher than CHL, since several AE (although not necessarily ferns) were observed in the same condition highlighted by Benzing (1990). However, further discussion is not possible due to the scarcity of systematic data on accidental epiphytes (Hoeber et al., 2019).

The most common epiphytic species (totaling 79.5% of the relative frequency) were: *T. tricholepis* (Absolute Frequency (AF) of 77.87%, in 644 phorophytes), *T. recurvata* (AF of 62.52% in 517 phorophytes), *M. squamulosa* (AF of 42.32% in 350 phorophytes) and *R. lindbergiana* (AF of 18.5% in...
in the prevalence of accidental epiphytes). This dominance is also found in studies about the urban flora evaluating other lifeforms (Kramer & Krupek, 2012; Santos et al., 2012; Freitas et al., 2015; Monalisa-Francisco & Ramos, 2019). This reflects the fact that the presence of plants in the cities is usually composed of one or a few dominant species (Pauleit et al., 2002), probably related to the availability of tree and shrub seedlings for planting, which must be tolerant to the stressing environment, as which probably occurs with epiphytes. Besides that, once the richness and composition of epiphytes are also influenced by phorophytes (Burns & Zotz, 2010), the low richness of trees must influence the occurrence of epiphytes.

By the same reasoning, it must apply to the diversity and evenness values for each square, which are presented in Table 3, also including the results of the Hutcheson $t$-test used to compare the Shannon diversity indices. The diversity of the Parque Halfeld ($H' = 2.2$) was the highest and most different than other areas. Parque Halfeld presents taller trees, an almost continuous canopy and is the oldest square in the municipality of Juiz de Fora, dating from the mid-nineteenth century. It is also the only area presenting watercourses, thus creating a microclimate for the epiphytes. Due to the establishment period of the plants and the presence of moisture, both characteristics could be related to the composition and structure of the communities of vascular epiphytes (Benzing, 1990; Zotz, 2016), and such observed features probably justify this diversity.

Table 4 presents the phorophyte species which have more than 10 individuals (520 or 62.9% of the total sampled phorophytes). Among the 22 species, 14 were exotic and only eight were identified as native Brazilian flora (although not necessarily from the Atlantic domain) (BFG, 2018). This proportion of exotic species is greater if taking into account the number of specimens, with 361 individuals of exotic species and 159 individuals of native species. The exotic phorophytes also presented greater richness of vascular epiphytes (43, of which 15 are accidental epiphytes), while the native phorophytes presented a richness of 35 epiphytes (of which 14 are accidental epiphytes). However, there was no significant difference between these values according to $t$-test ($t=1.14$, $p=0.26$). The high occurrence of exotic phorophytes is apparently not detrimental to the establishment of vascular epiphytes in an urban environment, highlighting the possibility of using such species as substrate by the epiphytic community in the green areas. On the other hand, the use of exotic plants can be very harmful in a broad context, as some species like *Ligustrum lucidum*, *Spathodea campanulata*, and *Terminalia catappa* are among the invasive species of Brazilian flora (Instituto Hórus de Desenvolvimento e Conservação Ambiental, 2016), although they are commonly used in urban aforestation and often found in nurseries of the municipality (Oliveira et al., 2014).
There is significant richness and diversity of vascular epiphytes in the stratum C (the crown), which presented 55 species (H’=2.00), followed by stratum B (upper half of the trunk) where 20 species were recorded (H’=1.65), and stratum A (lower half of the trunk) with only 16 species (H’=1.52). The Hutcheson t-test showed the difference between the values of C and the other two strata (A and C, \(p<0.001\); B and C, \(p<0.001\)), but not between A and B (\(p=0.12\)). Although the center of the tree crown is commonly the richest region in phorophytes (Benzing, 1990), in this study the greater richness and diversity of epiphytes in the tree crown must be exacerbated by anthropogenic influence (once C was almost three times and more than three times richer than B and A, respectively). Some common actions are often observed and must be responsible for this result such as ornamentation in holidays (for example, Christmas) and maintenance performed by the municipality’s employees, in addition to the collection of some specimens, which not reach the tree crown (personal observation). According to Dislich & Mantovani (1998), several epiphytes, such as Bromeliaceae and Orchidaceae, are highly ornamental and easily removed from the trees, resulting in interference in the composition and structure of the community of vascular epiphytes in the urban environment.

### 4. Conclusions

In general, the vascular epiphyte species found in the urban environment (mainly the dominant species) present a wide ecological spectrum, so they can even establish in strongly disturbed environments. It is interesting to notice that even introduced trees species can sustain an epiphytic community and potentially enhance the ecological functions of a green area, providing shelter, water and food to the fauna, besides, to help to control the environmental temperature and moisture,
the same way when they are found in the forests. On the other hand, the reduced offer of different substrata (since there is also dominance between the cultivated trees) can negatively influence the richness and/or diversity of epiphytes in the urban environment, although further studies are necessary to delve into this issue.

The present study also highlighted the importance of surveying the flora of the cities, expanding the knowledge of urban flora in a time when anthropogenic changes are accentuated in global cities. In this sense, a better understanding of the urban vegetation from the academic and government to population standpoints is imperious, as they ultimately enjoy the benefits of the urban areas; however, without understanding that these species are also responsible for maintenance and even the establishment of these important areas for the environment of the cities.

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