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ORIGINAL ARTICLE - Conservation of Nature

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 (26 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 effectuation 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

Table 1. Studied green areas in the municipality of Juiz de Fora, Minas Gerais, Brazil.

Green areas (squares)	Extension	TNT	NF	Coordinates
Armando Toschi Ministrinho (ATM)	0.38 ha	62	43	21°45’11”S, 43°21’30”W 21°45’11”S
Dr. Menelick de Carvalho (MC)	0.29 ha	59	49	21°45’28”S, 43°21’11”W 21°45’28”S
Pedro Marques (PM)	0.32 ha	27	18	21°45’30”S, 43°21’21”W 21°45’30”S
Jarbas de Lery (JL)	0.59 ha	116	42	21°46’17”S, 43°21’06”W 21°46’17”S
Pres. Antônio Carlos (PAC)	0.74 ha	33	31	21°45’42”S, 43°20’37”W 21°45’42”S
Mariano Procópio (MP)	0.4 ha	80	53	21°44’48”S, 43°21’17”W 21°44’48”S
Pres. Garrastazu Médici (PGM)	1.23 ha	158	140	21°46’37”S, 43°20’36”W 21°46’37”S
Parque Halfeld (PH)	1.3 ha	265	222	21°45’39”S, 43°21’02”W 21°45’39”S
Largo do Riachuelo (LR)	0.65 ha	55	29	21°45’23”S, 43°21’02”W 21°45’23”S
Mahatma Gandhi (MG)	0.1 ha0.	75	15	21°45’02”S, 43°21’29”W
Prefeito Olavo Costa (OC)	0.7 ha	109	101	21°44’25”S, 43°21’04”W
República (PR)	0.4 ha	53	26	21°45’56”S, 43°20’14”W
Igreja Catedral (Cat)	1 ha	83	58	21°45’50”S, 43°20’59”W

TNT = Total number of trees/arborescent plants sampled in the green areas; NF = Number of sampled phorophytes in the green areas.

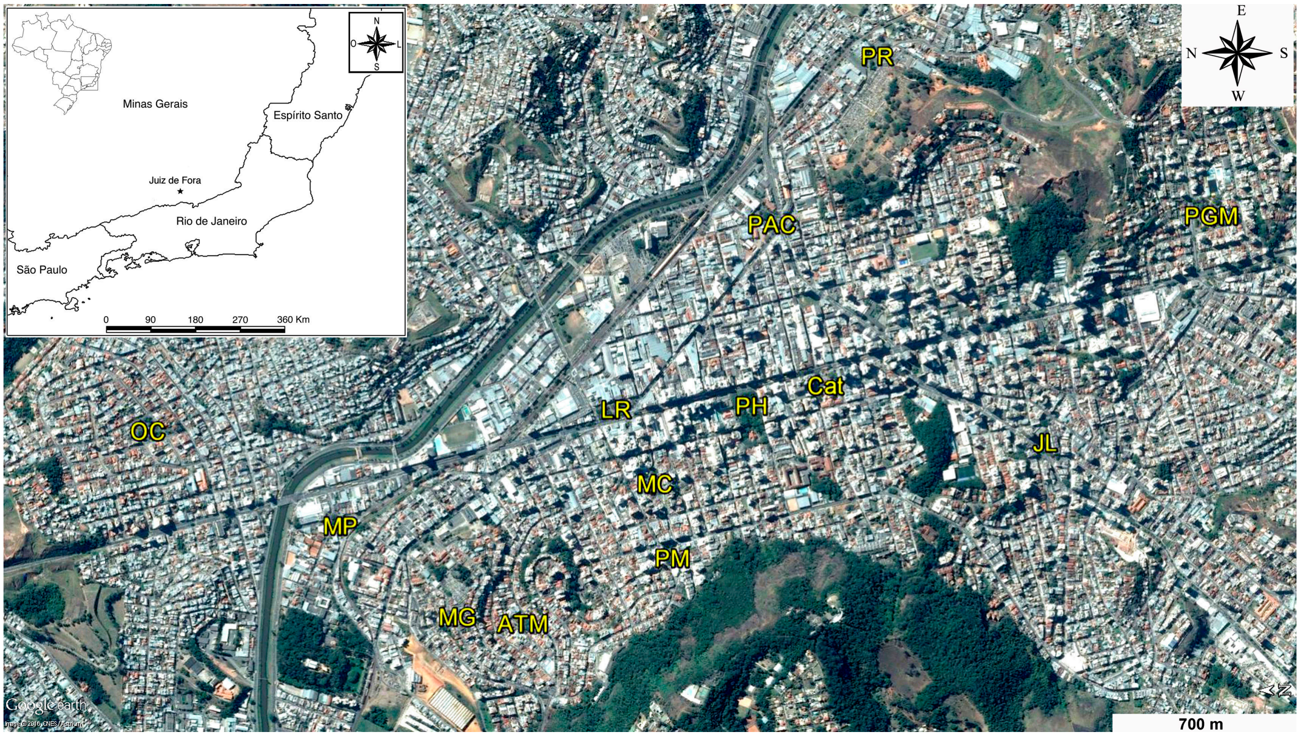

Figure 1. Location of the studied green areas. OC = Prefeito Olavo Costa; MP = Mariano Procópio; MG = Mahatma Gandhi; ATM = Armando Toschi Ministrinho; LR = Largo do Riachuelo; MC = Menelick de Carvalho; PM = Pedro Marques; PH = Parque Halfeld; PAC = Presidente Antônio Carlos; Cat = Catedral; PR = República; JL = Jarbas de Lery; PGM = Presidente Garrastazu Médici.

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	EC	Frequencies total			Occurrences of epiphytes in the phorophytes of each square												
			AF	RF	TO	1 (43)	2 (49)	3 (18)	4 (42)	5 (31)	6 (53)	7 (140)	8 (222)	9 (29)	10 (15)	11 (101)	12 (26)	13 (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	17	8	27	119	177	3	2	73	8	17
Microgramma squamulosa (Kaulf) de la Sota	Polyp	CHL	42.32	16.73	350	26	12	14	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 astrolepis (Liebm.) E.Fourn.	Polyp	CHL	8.22	3.25	68	-	-	-	1	3	1	25	12	-	-	22	2	2
Billbergia horrida Regel	Brom	CHL	7.38	2.92	61	-	-	-	-	-	-	-	58	-	-	-	-	3
Microgramma vaccinifolia (Langsd. & Fisch.) Copel	Polyp	CHL	6.29	2.49	52	-	-	-	1	1	1	3	43	-	1	-	-	2
Ficus microcarpa L.f.	Mor	Hem	6.05	2.39	50	-	2	-	-	4	4	2	21	13	-	-	-	4
Epiphyllum phyllanthus (L.) Haw.	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	2	13	1	-	3	-	2
Philodendron bippinatifidum Schott ex Endl.	Arac	Hem	2.42	0.96	20	-	-	1	-	-	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	Polyp	CHL	1.57	0.62	13	4	-	-	1	2	-	-	-	1	-	4	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	-	-	-	-	-	-	-	6	-	-	-	-	-
Catasetum cernuum (Lindl.) Rchb.f.	Orch	CHL	0.60	0.24	5	-	-	-	1	2	-	1	1	-	-	-	-	-
Hylocereus undatus (Haw.) Britton & Rose	Cact	CHL	0.60	0.24	5	-	-	-	-	-	-	-	5	-	-	-	-	-
Pleopeltis pleopeltifolia (Raddi) Alston	Polyp	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	-	-	-	-	-	-	-	2	-	-	-	-
Unidentified Eudicot 1	-	AE	0.48	0.19	4	-	-	-	-	-	4	-	-	-	-	-	-	-
Schefflera arboricola (Hayata) Merr.	Api	AE	0.36	0.14	3	-	-	-	-	1	-	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	Arac	Hem	0.24	0.10	2	-	-	-	-	-	-	-	2	-	-	-	-	-
Philodendron sp.	Arac	Hem	0.24	0.10	2	-	-	-	-	-	-	1	1	-	-	-	-	-

Fam (Families): Api = Apiaceae; Arac = Araceae; Aspar = Asparagaceae; Aster = Asteraceae; 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; Turne = Turneraceae. **EC (Ecological Categories):** AE = Accidental Epiphyte; CHL = Characteristic Holoepiphyte; Hem = Hemiepiphyte. **Frequencies:** AF = Absolute Frequency; RF = Relative Frequency; TO = Total Occurrences in the squares. **Squares:** (1) Armando Toschi Ministrinho; (2) Menelick de Carvalho; (3) Pedro Marques; (4) Jarbas de Lery; (5) Presidente Antônio Carlos; (6) Agassis; (7) Presidente Garrastazu Médici; (8) Parque Halfeld; (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 phorophytes in each square.

Table 2. Continued...

Species	Fam	EC	Frequencies total			Occurrences of epiphytes in the phorophytes of each square												
			AF	RF	TO	1 (43)	2 (49)	3 (18)	4 (42)	5 (31)	6 (53)	7 (140)	8 (222)	9 (29)	10 (15)	11 (101)	12 (26)	13 (58)
Solanum americanum Mill.	Solan	AE	0.24	0.10	2	-	-	-	-	-	-	-	-	-	-	1	1	-
Poaceae indeterminada	Poac	AE	0.24	0.10	2	-	-	-	-	-	-	2	-	-	-	-	-	-
Aechmea nudicaulis (L.) Griseb.	Brom	CHL	0.12	0.05	1	1	-	-	-	-	-	-	-	-	-	-	-	-
Alchornea triplinervia (Spreng.) Müll.Arg.	Eupho	AE	0.12	0.05	1	-	-	-	-	-	-	-	-	-	-	-	1	-
Asparagus densiflorus (Kunth) Jessop	Aspar	AE	0.12	0.05	1	-	1	-	-	-	-	-	-	-	-	-	-	-
Asteraceae indeterminada	Aster	AE	0.12	0.05	1	-	-	-	-	-	-	-	-	-	1	-	-	-
Cattleya loddigesii Lindl.	Orch	CHL	0.12	0.05	1	-	-	-	-	-	-	-	1	-	-	-	-	-
Cyclopogon argyrifolius Barb.Rodr.	Orch	AE	0.12	0.05	1	-	-	-	-	1	-	-	-		-	-	-	-
Cucurbitaceae indeterminada	Cucur	AE	0.12	0.05	1	-	-	-	-	-	-	-	-	-	-	1	-	-
Hypoxis decumbens L.	Hypox	AE	0.12	0.05	1	-	-	-	-	-	1	-	-	-	-	-	-	-
Impatiens walleriana Hook.f.	Balsam	AE	0.12	0.05	1	-	-	-	-	-	-	-	-	-	-	-	1	-
Kalanchoe delagoensis Eckl. & Zeyh.	Crass	AE	0.12	0.05	1	-	-	-	-	-	-	1	-	-	-	-	-	-
Malvaceae indeterminada	Malv	AE	0.12	0.05	1	-	-	-	-	-	-	-	-	-	1	-	-	-
Murraya paniculata (L.) Jack	Rut	AE	0.12	0.05	1	1	-	-	-	-	-	-	-	-	-	-	-	-
Oncidium baueri Lindl.	Orch	CHL	0.12	0.05	1	-	-	-	-	-	-	-	1	-	-	-	-	-
Phlebodium pseudoaureum (Cav.) Lellinger	Polyp	AE	0.12	0.05	1	-	-	-	-	-	-	-	-	-	-	-	1	-
Phyllanthus sp.	Phyll	AE	0.12	0.05	1	-	-	-	1	-	-	-	-	-	-	-	-	-
Setaria parviflora (Poir.) Kerguéle	Poac	AE	0.12	0.05	1	-	-	-	-	-	1	-	-	-	-	-	-	-
Solanum cf. *paniculatum* L.	Solan	AE	0.12	0.05	1	-	-	-	-	-	-	1	-	-	-	-	-	-
Tillandsia usneoides (L.) L.	Brom	CHL	0.12	0.05	1	-	-	-	-	-	-	-	-	-	-	-	1	-
Turnera subulata Sm.	Turne	AE	0.12	0.05	1	-	-	-	-	-	-	-	-	-	-	1	-	-
Unidentified Eudicot 2	-	AE	0.12	0.05	1	-	1	-	-	-	-	-	-	-	-	-	-	-
Unidentified Eudicot 3	-	AE	0.12	0.05	1	-	-	-	-	-	-	1	-	-	-	-	-	-
Unidentified Eudicot 4	-	AE	0.12	0.05	1	-	-	-	-	-	-	-	-	-	-	-	1	-
Unidentified Eudicot 5	-	AE	0.12	0.05	1	-	-	-	-	-	-	-	-	-	-	1	-	-
Unidentified Eudicot 6	-	AE	0.12	0.05	1	-	-	-	-	-	-	-	-	-	1	-	-	-

Fam (Families): Api = Apiaceae; Arac = Araceae; Aspar = Asparagaceae; Aster = Asteraceae; 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; Turne = Turneraceae. **EC (Ecological Categories):** AE = Accidental Epiphyte; CHL = Characteristic Holoepiphyte; Hem = Hemiepiphyte. **Frequencies:** AF = Absolute Frequency; RF = Relative Frequency; TO = Total Occurrences in the squares. **Squares:** (1) Armando Toschi Ministrinho; (2) Menelick de Carvalho; (3) Pedro Marques; (4) Jarbas de Lery; (5) Presidente Antônio Carlos; (6) Agassis; (7) Presidente Garrastazu Médici; (8) Parque Halfeld; (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 phorophytes in each square.

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 nutritive exocarp which are dispersed by mammals and ants (Kaufmann 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).

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

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 Ministrinho; 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.

153 phorophytes) (Table 2). These species were also prominent in other studies performed in urban areas (Hefler & Faustioni, 2004; Fabricante et al., 2006; Alves et al., 2014; Lapo & Magenta, 2014; Becker et al., 2015), and suggested high resistance to the disturbed environment, by presenting important adaptations to cope with the hydric stress (Fahn & Cutler, 1992), for example, dense coverage of scales adapted to water absorption (*Tillandsia* species), leaf hypodermis (*Microgramma* species) and crassulacean acid metabolism (CAM) (*Rhipsalis* species) (Benzing, 1976, 1990; Calvente et al., 2008; Rocha et al., 2013).

The two *Tillandsia* (*T. recurvata* and *T. tricholepis*) species are remarkable, as they are often dominant in urban environments (Fabricante et al., 2006; Becker et al., 2015). Both species are related to studies about air pollution because they are resistant to heavy metals launched in the atmosphere (Costa et al., 2019), which is possibly the reason for such dominance in this environment. According to Dislich & Mantovani (1998), the rarity of Orchidaceae, the richest family among the vascular epiphytes (Benzing, 1990; Zotz, 2016), must be related to direct human interference by clearing forest and collecting plants (thus reducing the source of propagules for colonizing the trees), or even indirect by air pollution, resulting in the uncommon floristic composition found, as orchids often are very sensitive to environmental disturbance.

The presence and high frequency of these species in the studied environment showed that they are very tolerant to the impact of anthropization on biodiversity (for example, the hydric stress due to paving the soil and inexistence of a continuous canopy), also presenting wide geographic distribution and ecological spectrum (Fabricante et al., 2006). Vascular epiphytes also demonstrate an extraordinary adaptive variety whose evolutionary response is related to more or less unique restrictions and opportunities for treetop habitat, besides, to highlight how these plants influence the ecosystems that host them (Benzing, 2004). According to Benzing (1990), the occurrence of epiphytes in drier sites is less common and is often represented by few taxa, but does not necessarily present low abundance and/or frequency, as found for *Tillandsia*, which is also highlighted by Furtado & Menini (2015), when they support the explanation for the significant occurrence of Bromeliaceae in comparison with Orchidaceae in urban areas.

The *H'* and *J* values for the 13 studied squares were 2.02 and 0.59, respectively (Table 3). Both indices were lower than others found in the urban environment (Fabricante et al., 2006), and the last value showed the strong dominance of four species (*T. tricholepis*, *T. recurvata*, *M. squamulosa*, and *R. lindbergiana*), which were responsible for the low diversity of the community. Such dominance is probably related to the distinct conditions of those typical for the occurrence of epiphytic species so that some species can dominate new habitats over less capable species to "cope" with disturbed environments (for example, as seen 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).

Table 4. Main species of phorophytes recorded in the green areas studied in the municipality of Juiz de Fora, in the State of Minas Gerais, Brazil.

Species	Families	N Ind.	N Green areas	Origin
Tipuana tipu (Benth.) Kuntze	Fabaceae	84	9	exotic
Magnolia champaca (L.) Baill. ex Pierre	Magnoliaceae	52	9	exotic
Caesalpinia peltophoroides Benth.	Fabaceae	51	8	native
Spathodea campanulata P.Beauv.	Bignoniaceae	36	5	exotic
Ligustrum lucidum W.T.Aiton	Oleaceae	28	5	exotic
Tabebuia heptaphylla (Vell.) Toledo	Bignoniaceae	25	6	native
Delonix regia (Bojer ex Hook.) Raf.	Fabaceae	24	6	exotic
Tabebuia chrysotricha (Mart. ex A.DC.) Standl.	Bignoniaceae	22	7	native
Dracaena fragrans (L.) Ker Gawl.	Asparagaceae	19	3	exotic
Syagrus romanzoffiana (Cham.) Glassman	Arecaceae	17	8	native
Cupressus lusitanica Mill.	Cupressaceae	16	2	exotic
Lagerstroemia indica L.	Lythraceae	16	5	exotic
Ravenala madagascariensis Sonn.	Strelitziaceae	16	1	exotic
Terminalia catappa L.	Combretaceae	16	5	exotic
Ficus benjamina L.	Moraceae	15	1	exotic
Livistona chinensis (Jacq.) R.Br. ex Mart.	Arecaceae	15	5	exotic
Cedrella fissilis Vell.	Meliaceae	14	3	native
Dypsis lutescens (H.Wendl.) Beentje & J.Dransf.	Arecaceae	12	3	exotic
Sapindus saponaria L.	Sapindaceae	12	6	exotic
Tabebuia impetiginosa (Mart. ex DC.) Standl.	Bignoniaceae	10	3	native
Licania tomentosa (Benth.) Fritsch	Chrysobalanaceae	10	1	native
Triplaris americana L.	Polygonaceae	10	4	native
Other species	-	307	-	-
Total of sampled phorophytes	-	827	-	-

N Ind. = number of individuals found in each phorophyte species; N Green areas = number of total green areas where the phorophytes were found.

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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References

Alves ES, Moura BB, Domingos M. Structural analysis of *Tillandsia usneoides* L. exposed to air pollutants in São Paulo City-Brazil. *Water, Air, and Soil Pollution* 2008; 189(1-4): 61-68. http://dx.doi.org/10.1007/s11270-007-9555-1.

Alves ME, Brun C, Dal Forno RS, Essi L. Levantamento de espécies epífitas vasculares da zona urbana do município de Palmeira das Missões, RS, Brasil. *Ciência e Natura* 2014; 36(3): 268-276. http://dx.doi.org/10.5902/2179460X12437.

Barthlott W, Schmit-Neuerburg V, Nieder J, Engwald S. Diversity and abundance of vascular epiphytes: a comparison of secondary vegetation and primary montane rain forest in the Venezuelan Andes. *Plant Ecology* 2001; 152(2): 145-156. http://dx.doi.org/10.1023/A:1011483901452.

Bataghin FA, Fiori A, Toppa RH. Efeito de borda sobre epífitos vasculares em floresta ombrófila mista, Rio Grande do Sul, Brasil. O. *Mundo da Saude* 2008; 32: 329-338. http://dx.doi.org/10.15343/0104-7809.2008323329338.

Becker DFP, Padoin TOH, Nascimento CA, Robalski JL, Linden R, Schmitt JL. Riqueza e composição de epífitos vasculares em áreas urbanas da Bacia Hidrográfica do Rio dos Sinos, RS, Brasil. *Pesquisas Botânicas* 2015; 68: 227-238.

Benzing DH. Bromeliad trichomes: structure, function, and ecological significance. *Selbyana* 1976; 1: 330-348.

Benzing DH. Vascular epiphytes. In: Lowman MD, Rinker HB, editors. *Forest canopies*. 2nd ed. Cambridge: Academic Press; 2004. http://dx.doi.org/10.1016/B978-012457553-0/50014-9.

Benzing DH. *Vascular epiphytes: general biology and related biota*. Cambridge: Cambridge University Press; 1990. http://dx.doi.org/10.1017/CBO9780511525438.

Bermudez GMA, Rodriguez JH, Pignata ML. Comparison of the air pollution biomonitoring ability of three *Tillandsia* species and the lichen *Ramalina celastri* in Argentina. *Environmental Research* 2009; 109(1): 6-14. http://dx.doi.org/10.1016/j.envres.2008.08.014. PMid:18951124.

Biondi D. *Floresta urbana*. Curitiba: Edição do Autor; 2015.

Brazil Flora Group – BFG. Brazilian Flora 2020: innovation and collaboration to meet Target 1 of the Global Strategy for Plant Conservation (GSPC). *Rodriguésia* 2018; 66(4): 1085-1113.

Burns KC, Zotz G. A hierarchical framework for investigating epiphyte assemblages: networks, meta-communities, and scale. *Ecology* 2010; 91(2): 377-385. http://dx.doi.org/10.1890/08-2004.1. PMid:20392003.

Calvente AM, Andreata RHP, Vieira RC. Stem anatomy of *Rhipsalis* (Cactaceae) and its relevance for taxonomy. *Plant Systematics and Evolution* 2008; 276(1-2): 1-7. http://dx.doi.org/10.1007/s00606-008-0052-9.

Companhia de Saneamento Básico de Juiz de Fora – CESAMA. *Dados climáticos de Juiz de Fora, MG* [online]. Juiz de For a: CESAMA; 2010 [cited 2019 Nov. 5]. Available from: www.cesama.com.br

Costa FCB, Chiavegatto B, Barbosa DEF, Furtado SG, Menini Neto L. Espécies de *Tillandsia* L. (Tillandsioideae, Bromeliaceae) como bioindicadoras de poluição atmosférica. *CES Revista* 2019; 33(1): 235-257.

Dettke GA, Orfrini AC, Milaneze-Gutierre MA. Composição florística e distribuição de epífitas vasculares em um remanescente alterado de Floresta Estacional Semidecidual no Paraná, Brasil. *Rodriguésia* 2008; 59(4): 859-872. http://dx.doi.org/10.1590/2175-7860200859414.

Dislich R, Mantovani W. A flora de epífitas vasculares da Reserva da Cidade Universitária "Armando de Salles Oliveira" (São Paulo, Brasil). *Boletim de Botânica da Universidade de São Paulo* 1998; 17(0): 61-83. http://dx.doi.org/10.11606/issn.2316-9052.v17i0p61-83.

Elias C, Fernandes AN, França EJF, Bacchi MA. Seleção de epífitas acumuladoras de elementos químicos na Mata Atlântica. *Biota Neotropica* 2006; 6(1): 1-9. http://dx.doi.org/10.1590/S1676-06032006000100010.

Fabricante JR, Andrade LA, Marques FJ. Componentes epifítico vascular ocorrente em árvores urbanas. *Cerne* 2006; 12(4): 399-405.

Fahn A, Cutler DF. *Xerophytes: encyclopedia of plant taxonomy*. Berlin: Gebrüder Borntraeger; 1992.

Farache FHA, Do Ó VT, Pereira RA. New occurrence of non-pollinating fig wasps (Hymenoptera: Chalcidoidea) in *Ficus microcarpa* in

Brazil. *Neotropical Entomology* 2009; 38(5): 683-685. http://dx.doi.org/10.1590/S1519-566X2009000500020. PMid:19943020.

Freitas L, Salino A, Menini L No, Almeida TE, Mortara S, Stehmann J et al. A comprehensive checklist of vascular epiphytes of the Atlantic Forest reveals outstanding endemic rates. *PhytoKeys* 2016; 58(58): 65-79. http://dx.doi.org/10.3897/phytokeys.58.5643. PMid:26884706.

Freitas WK, Pinheiro MAS, Abrahão LLF. Análise da arborização de quatro praças no bairro da Tijuca, RJ, Brasil. *Floresta e Ambiente* 2015; 22(1): 23-31. http://dx.doi.org/10.1590/2179-8087.025612.

Furtado SG, Menini L No. Diversity of vascular epiphytes in urban environment: a case study in a biodiversity hotspot, the Brazilian Atlantic Forest. *CES Revista* 2015; 29(2): 82-101.

Gentry AH, Dodson CH. Diversity and biogeography of neotropical vascular epiphytes. *Annals of the Missouri Botanical Garden* 1987; 74(2): 205-233. http://dx.doi.org/10.2307/2399395.

Gomes MAS, Soares BR. A vegetação nos centros urbanos: considerações sobre os espaços verdes em cidades médias brasileiras. *Estudios Geográficos* 2003; 1(1): 29-39.

Gotsch SG, Nadkarni N, Amici A. The functional roles of epiphytes and arboreal soils in tropical montane cloud forests. *Journal of Tropical Ecology* 2016; 32(5): 455-468. http://dx.doi.org/10.1017/S026646741600033X.

Graciano C, Fernández LV, Caldiz DO. *Tillandsia recurvata* L. as a bioindicator of sulfur atmospheric pollution. *Ecología Austral* 2003; 13(1): 3-14.

Hefler SM, Faustioni P. Levantamento florístico de epífitos vasculares do bosque São Cristovão-Curitiba-Paraná-Brasil. *Revista Estudos de Biologia* 2004; 26(54): 11-19. http://dx.doi.org/10.7213/reb.v26i54.21273.

Hoeber V, Weichgrebe T, Zotz G. Accidental epiphytism in the Harz Mountains, Central Europe. *Journal of Vegetation Science* 2019; 30(4): 765-775. http://dx.doi.org/10.1111/jvs.12776.

Instituto Brasileiro de Geografia e Estatística – IBGE. *Manual técnico da vegetação brasileira*. 2. ed. Rio de Janeiro: IBGE; 2012.

Instituto Hórus de Desenvolvimento e Conservação Ambiental. *Base de dados nacional de espécies exóticas invasoras* [online]. Florianópolis: I3N Brasil; 2016 [cited 2019 Nov. 5]. Available from: http://i3n.institutohorus.org.br

Jardim Botânico do Rio de Janeiro – JBRJ. *Programa REFLORA* [online]. Rio de Janeiro: JBRJ; 2019 [cited 2019 Nov. 5]. Available from: http://reflora.jbrj.gov.br

Kaufmann S, McKey DB, Hossaert-McKey M, Horvitz CC. Adaptations for a two-phase seed dispersal system involving vertebrates and ants in a hemiepiphytic fig (*Ficus microcarpa*: moraceae). *American Journal of Botany* 1991; 78(7): 971-977. http://dx.doi.org/10.1002/j.1537-2197.1991.tb14501.x.

Kersten RA. Epífitas vasculares: histórico, participação taxonômica e aspectos relevantes, com ênfase na Mata Atlântica. *Hoehnea* 2010; 37(1): 9-38. http://dx.doi.org/10.1590/S2236-89062010000100001.

Kramer JA, Krupek RA. Caracterização florística e ecológica da arborização de praças públicas do município de Guarapuava, PR. *Revista Árvore* 2012; 36(4): 647-658. http://dx.doi.org/10.1590/S0100-67622012000400007.

Krömer T, García-Franco JG, Toledo-Aceves T. Epífitas vasculares como bioindicadores de la calidad forestal: impacto antrópico sobre su diversidad y composición. In: Zuart CAG, editor. *Los bioindicadores: guardianes de nuestro futuro ecológico*. 1. ed. Chiapas: San Cristóbel de Las Casas; 2014.

Lapo CA, Magenta MAG. Urban trees, epiphytism and avifauna in central districts of Santos-SP. *Unisanta BioScience* 2014; 3(4): 226-236.

Lowman MD, Rinker HB. *Forest canopies*. 2nd ed. Cambridge: Academic Press; 2004.

Marques JS. *Epífitas vasculares em diferentes estádios sucessionais de um fragmento urbano de Floresta Estacional Semidecidual* [dissertação]. Juiz de Fora: Programa de Pós-graduação em Ecologia, Universidade Federal de Juiz de Fora; 2016.

Monalisa-Francisco N, Ramos FN. Composition and functional diversity of the urban flora of Alfenas-MG, Brazil. *Floresta e Ambiente* 2019; 26(3): e20171110. http://dx.doi.org/10.1590/2179-8087.111017.

Oliveira NE No, Fonseca CR, Carvalho FA. O problema das espécies arbóreas exóticas comercializadas nos viveiros florestais: estudo de caso no município de Juiz de Fora (MG). *Revista de Biologia Neotropical* 2014; 11(1): 28-46. http://dx.doi.org/10.5216/rbn.v11i1.28346.

Pauleit S, Jones N, Garcia Martin G, Garcia Valdecantos JL, Riviere LM, Vidal Beaudet L et al. Tree establishment practice in towns and cities-results from a European survey. *Urban Forestry & Urban Greening* 2002; 1(2): 83-96. http://dx.doi.org/10.1078/1618-8667-00009.

Rocha GC, Latuf MO, Carmo LFZ. Mapeamento de riscos ambientais à escorregamentos na área urbana de Juiz de Fora, MG. *Geografia* 2003; 12(1): 509-516.

Rocha LD, Droste A, Gehlen G, Schmitt JL. Leaf dimorphism of *Microgramma squamulosa* (Polypodiaceae): a qualitative and quantitative analysis focusing on adaptations to epiphytism. *Revista de Biología Tropical* 2013; 61(1): 291-299. PMid:23894982.

Santana LD, Furtado S, Nardy C, Leite FS, Menini L No. Diversity, vertical structure and floristic relationships of vascular epiphytes in an urban remnant of the Brazilian Atlantic forest. *Hoehnea* 2017; 44(1): 123-138. http://dx.doi.org/10.1590/2236-8906-57/2016.

Santos HB Jr, Jardim MAG. Epífitas e lianas em palmeiras amazônicas. *Biota Amazônia* 2017; 7(4): 13-16.

Santos TOB, Lisboa CMCA, Carvalho FG. Análise da arborização viária do bairro de Petropólis, Natal, RN: uma abordagem para diagnóstico e planejamento da flora urbana. *Revista da Sociedade Brasileira de Arborização Urbana* 2012; 7(4): 90-106. http://dx.doi.org/10.5380/revsbau.v7i4.66546.

Silva A, Musa CI, Renner S, Horn TB, Rempel C, Ferla NJ. A influência do efeito de borda na abundância e diversidade de epífitas no Jardim Botânico de Lajeado, Rio Grande do Sul. *Destaques Acadêmicos* 2013; 5(3): 75-88.

Siqueira JC. Bioinvasão Vegetal: dispersão e propagação de espécies nativas e exóticas no *campus* da Pontifica Universidade Católica do Rio de Janeiro (PUC - Rio). *Pesquisas Botânicas* 2006; 57: 319-330.

Zotz G. *Plants on plants: The biology of vascular epiphytes.* Berlin: Springer; 2016. https://doi.org/10.1007/978-3-319-39237-