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Original Article

Conservation of Nature

Composition and Functional Diversity of the Urban Flora of Alfenas-MG, Brazil

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ABSTRACT

Urban tree cover has important environmental and social functions and can act as ecological refuges. The objective of the present study was to investigate the taxonomic and functional diversities of urban plant communities in Alfenas, Minas Gerais State, Brazil. We sampled all trees DBH ≥ 3 cm in eight different urban green areas, recording 1,138 individuals and 119 species; two species were dominant: *Poincianella pluviosa* (Fabaceae) and *Syagrus romanzoffiana* (Arecaceae). The high species richness encountered reflected, in part, the presence of exotic species, which corresponded to 40% of the species and 25% of the total abundance. The functional diversity index (HF') was considered low, with the predominant functional traits among the species being small size, entomophily, zoochory, evergreen leaves, and dry fruits. We recommend that future urban afforestation projects incorporate strategies that increase the use of regional species as well as the functional diversity/complexity of those environments.

Keywords: functional diversity, green areas, regional species, urban ecology, urban trees.

1. INTRODUCTION

The global human population has increased approximately ten-fold in the last century. Urban areas currently occupy ca. 4% of the total earth surface (Töpfer et al., 2000), which considerably increases the importance of conserving biological communities in urban ecosystems. Green urban areas have significant potential to aid biodiversity conservation, provide diverse advantages to human populations (see Roy et al., 2012), contribute to the environmental quality of cities, and act as refuges for rich plant communities (Ordóñez & Duinker, 2012; Freitas et al., 2015).

Despite their potential as biodiversity refuges, urban green spaces tend to have quite peculiar floristic compositions. The presence of exotic species is a key factor determining diversity patterns in those ecosystems. They represent a substantial component of urban forests not only in Brazil but around the world (Aronson et al., 2007; Bigirimana et al., 2011; Kowarik, 2011; Kramer & Krupek, 2012). The ecological roles of exotic species remain controversial. Some evidence point to their undesirable effects on local plant communities (McKinney, 2006), while other evidence suggest their positive performance within the environmental balance of urban areas (Schlaepfer et al., 2011). There is no consensus on the use of exotic plants in urban afforestation, at the same time that the silvicultural potentials of regional native species have largely been neglected (Isernhagen et al., 2009).

Although studies of diversity patterns based on composition and natural occurrence are quite useful, functional diversity has been shown to be a promising approach for understanding ecological issues in anthropogenic habitats (Cornelissen et al., 2003; Duncan et al., 2011). The characteristics of a species, rather than its identity, will determine its contribution to ecosystem functioning (Díaz & Cabido, 2001; Knapp et al., 2010). The quantification and understanding of plant community characteristics and functions will allow more appropriate conservation and management decisions. Some researchers have investigated plant ecological attributes in urban ecosystems. They described phenomena such as the directional selection of specific traits (Aronson et al., 2007; Duncan et al., 2011) and functional redundancy along richness gradients (Knapp et al., 2008). Most studies on urban afforestation, however, have focused principally on taxonomic diversity (Cardoso-Leite et al., 2014; Freitas et al., 2015; Kramer & Krupek, 2012), with little emphasis on the functional diversity of those plant communities.

Since tropical forest physiognomies have been increasingly converted into anthropically altered environments, conservation strategies are urgently needed. They can help transform urban ecosystems into ecological refuges – and those transformations will require basic information about community functioning in those environments. The objective of this study was to investigate ecological patterns of plant communities in urban public green areas and describe aspects of their floristic compositions and functional and taxonomic diversities.

2. MATERIALS AND METHODS

2.1. Study area and sampling

The present study was conducted in Alfenas (21°25'46" S; 45°56'50" W), Minas Gerais State, Brazil. The municipality covers 850 km^2 and has approximately 74,000 inhabitants. The natural vegetation is Semideciduous Seasonal Atlantic Forest (Ibge, 2012), with dry winters and wet summers (Cwa type climate, Köppen 1948). The mean regional temperature ranges from 17.5 °C during the Austral winter to 21.1 °C in the summer, with a mean annual precipitation of 1500 mm (Alvares et al., 2014). Eight public green areas were chosen for study. Most of them lie within the urban perimeter of the municipality, except the Alfenas Municipal Park, located a few kilometers from the city (Figure 1).

Those areas represent a significant percentage of the cultivated vegetation cover in the city, are easily accessed by the local population, and are commonly used for social activities. Each of those green areas was visited between 2011 and 2012. All trees with DAP ≥ 3 cm were mapped, photographed, and identified with the help of specialized bibliography and/or expert consultations.

2.2. Species classifications

The species were classified – using information available in the specialized scientific literature and/or expert consultations – according to their geographical origins and ecological characteristics.

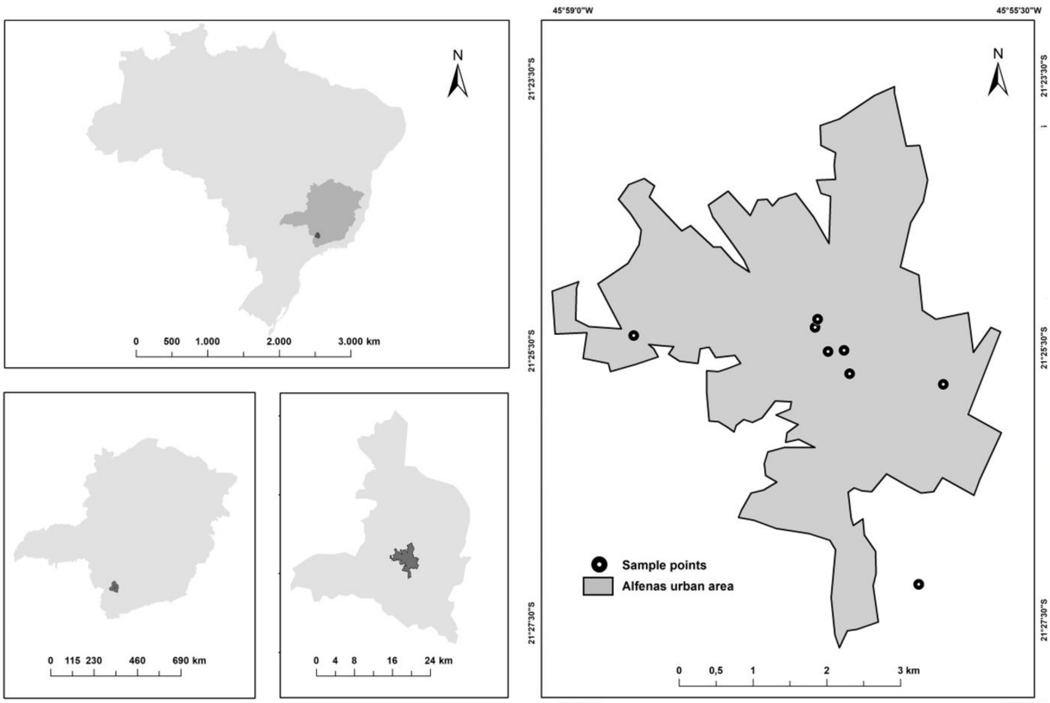

Figure 1. Location of the eight green public areas studied in Alfenas, Minas Gerais State, Brazil.

(1) Geographical origin: regional native species occur naturally in the same phytophysiognomy of the study area (Semideciduous Seasonal Atlantic Forest); native species are those occurring in other Brazilian formations; and exotic species were those having no recorded natural occurrence in any Brazilian vegetation.

(2) Ecological attributes: were chosen the ecological attributes that represent important characteristics for the performance of ecosystem functions and contribution to environmental balance in cities, adapted from Cornelissen et al. (2003) and Duncan et al. (2011):

a) Tree size: small (≤ 12 m); medium (12-20 m); and tall (> 20 m).
b) Pollination mode: anemophilous, ornithophilous, entomophilous, and chiropterophilous.
c) Dispersal mode: autochoric, hydrochoric, anemochoric, and zoochoric.
d) Leaf life span: deciduous or evergreen leaves.
e) Fruit type: fleshy or dry fruits.

2.3. Statistical analysis

The general patterns of species diversity were described based on abundance, richness, and evenness. Evenness was calculated using the Pielou J' index, whose values range from 0 to 1 reflecting the distribution uniformity of individuals within the species. The higher the J' value, the more balanced is the community composition.

To describe community structures, we also investigated dominance patterns, classifying the species according to their total abundance as: a) rare (those with only 1 individual); b) few abundant (2-5 individuals); c) abundant (6-50 individuals); d) intermediate (51-100 individuals); and e) dominant (> 100 individuals).

To investigate the functional diversity patterns (DivF) we employed a functional diversity index adapted from Shannon & Weaver (H') using the relative proportion of individuals (HF'ind) and species (HF'sp) within each group: $HF' = -\sum p_i * Ln(p_i)$, where p_i = the abundance or richness of the *i*-category.

We used analyses of variance to verify whether the mean proportions of individuals and species (after arcsine square root transformation) differed between ecological categories. The nonparametric equivalent tests (Mann-Whitney, Kruskal-Wallis) were used with data that could not be corrected by transformations in terms of the normality and homogeneity of variances. The level of significance considered was 5%.

3. RESULTS

We surveyed 1,138 individuals belonging to 119 species, 101 genera, and 43 families. The most representative family was Fabaceae (19 species and 290 individuals). The five most abundant species were *Poincianella pluviosa* var. *Peltophoroides* (Benth.) L.P. Queiroz (237 ind), *Syagrus romanzoffiana* (Cham.) Glassman (122 ind), *Handroanthus impetiginosus* (Martius ex. DC.) Mattos (72 ind), *Ficus benjamina* L. (59 ind), and *Pleroma granulosum* (Desr.) D. Don (55 ind). Together these species accounted for 48% of the total abundance (Table 1).

In terms of geographic groups, there was a notable presence of exotic species (40%) in relation to native (23%) and regional species (37%). Concerning to

Table 1. Information about the urban flora in Alfenas, Minas Gerais State, Brazil.

Family	Species	Total	Ori	Size	Pol	Dis	Leaf	Fru
ANACARDIACEAE	*Lithraea molleoides* (Vell.) Engl.	2	N	Sma	Ent	Zoo	Eve	Dry
	Mangifera indica L.	11	E	Tall	Ent	Zoo	Eve	Fle
	Schinus molle L.	53	N	Sma	Ent	Zoo	Eve	Fle
	Schinus terebinthifolia Raddi	1	R	Sma	Ent	Zoo	Eve	Fle
	Tapirira guianensis Aubl.	1	R	Sma	Ent	Zoo	Eve	Fle
ANONNACEAE	*Annona cacans* Warm.	1	R	Med	Ent	Zoo	NI	Fle
APOCYNACEAE	*Nerium oleander* L.	3	N	Sma	Ent	Ane	Eve	Dry
	Plumeria pudica Jacq.	2	E	Sma	NI	Ane	Eve	Dry
ARALIACEAE	*Aralia rex (*Ekman) J.Wen	4	E	NI	NI	Zoo	NI	Fle
	Dendropanax cuneatus (DC.) Decne. & Planch.	1	R	Sma	Ent	Zoo	Eve	Fle
	Schefflera actinophylla (Endl.) Harms	2	N	Sma	Ent	Zoo	Eve	Fle
	Schefflera arboricola (Hayata) Merr.	2	E	Sma	Ent	Zoo	Eve	Fle
ARAUCARIACEAE	*Araucaria angustifolia* (Bertol.) Kuntze	11	N	Tall	Ane	Zoo	Eve	Dry
ARECACEAE	*Archontophoenix cunninghamii* H. Wendl. & Drude	7	E	Med	Ent	Zoo	Eve	Fle
	Caryota mitis Lour.	11	E	Med	NI	Zoo	Eve	Fle
	Cocos nucifera L.	2	N	Med	Ent	Hyd	Eve	Dry
	Dypsis decaryi (Jum.) Beentje & J.Dransf.	2	E	Sma	Ent	Zoo	Eve	Fle
	Dypsis lutescens (H.Wendl.) Beentje & J.Dransf.	10	E	Sma	Ent	Zoo	Eve	Fle
	Euterpe edulis Mart.	2	R	Sma	Ent	Zoo	Eve	Fle
	Geonoma schottiana Mart.	1	R	Sma	Ent	Zoo	Eve	Fle
	Livistona chinensis (Jacq.) R.Br. ex Mart.	21	E	Med	Ent	Zoo	Eve	Fle
	Phoenix roebelenii O'Brien	16	E	Sma	NI	Zoo	Eve	Fle
	Roystonea borinquena O.F Cook	27	E	Sma	NI	Zoo	Eve	Fle
	Syagrus romanzoffiana (Cham.) Glassman	122	R	Sma	Ent	Zoo	Eve	Fle
ASPARAGACEAE	*Yucca gigantea* Lem.	9	E	Sma	Ent	Zoo	Eve	Fle
ASTERACEAE	*Baccharis dracunculifolia* DC.	1	R	Sma	Ent	Ane	Eve	Dry
BIGNONIACEAE	*Handroanthus chrysotrichus* (Mart. ex DC.) Mattos	10	N	Sma	Ent	Ane	Dec	Dry
	Handroanthus impetiginosus (Martius ex. DC.) Mattos	72	N	Sma	Ent	Ane	Dec	Dry
	Handroanthus serratifolius (Vahl) S.Grose	6	R	Med	Ent	Ane	Dec	Dry
	Handroanthus sp.	2	NI	Sma	Ent	Ane	Dec	Dry
	Jacaranda mimosifolia D.Don	1	E	Med	Ent	Ane	Dec	Dry
	Spathodea campanulata P.Beauv.	6	E	Med	Orn	Ane	Eve	Dry
	Tabebuia roseoalba (Ridl.) Sandwith	2	R	Sma	Ent	Ane	Dec	Dry
	Tecoma stans (L.) Juss. ex Kunth	3	N	Sma	Ent	Ane	Eve	Dry

Sma: small-sized; Med: medium-sized; Ent: entomo-; Ane: anemo-; Aut: auto-; Chi: chiroptero-; Dec: deciduous; Dis: dispersal mode; Eve: evergreen; E: exotic; Fle: fleshy fruits; Fru: fruit type; Hyd: hydro-; N: native; NI: No Information; Ori: geographical origin; Orn: ornito-; Pol: pollination mode; R: regional.

Table 1. Continued...

Family	Species	Total	Ori	Size	Pol	Dis	Leaf	Fru
BORAGINACEAE	*Cordia africana* Lam.	2	E	Sma	Ent	Zoo	Eve	Fle
	Cordia superba Cham.	1	N	Sma	Ent	Zoo	Eve	Fle
CASUARINACEAE	*Casuarina equisetifolia* L.	1	E	Tall	Ent	Zoo	Eve	Dry
CHRYSOBALANACEAE	*Licania tomentosa* (Benth.) Fritsch	4	N	Sma	Ane	Zoo	Eve	Fle
COMBRETACEAE	*Terminalia catappa* L.	3	N	Tall	Ane	Zoo	Dec	Dry
CUPRESSACEAE	*Callitris preissii* Miq.	2	E	Med	Orn	NI	Eve	Dry
	Cupressus funebris Endl.	3	E	Tall	Ane	Ane	Eve	Dry
	Cupressus lusitanica Mill.	52	E	Tall	Orn	Ane	Eve	Dry
	Cupressus sempervirens L.	14	E	Tall	Orn	Ane	Eve	Dry
	Thuja occidentalis L.	1	E	Med	Ane	Ane	Eve	Dry
	Thuja sp.	3	E	Med	Ane	Ane	Eve	Dry
EUPHORBIACEAE	*Actinostemon klotzschii* (Didr.) Pax	1	N	Sma	Ent	Zoo	Eve	Dry
	Alchornea glandulosa Poepp. & Endl.	1	R	Med	Ane	Zoo	Eve	Fle
	Codiaeum variegatum (L.) Rumph. Ex A.Juss.	6	E	Sma	NI	NI	Eve	Dry
	Euphorbia sp.	1	NI	Sma	Orn	Zoo	Eve	Dry
	Jatropha curcas L.	2	N	Sma	Ent	Aut	Dec	Dry
	Sapium glandulosum (L.) Morong	1	N	Med	Ent	Aut	Dec	Dry
FABACEAE	*Acacia seyal* Delile	1	E	Sma	Ent	Aut	Dec	Dry
	Bauhinia variegata L.	9	E	Sma	Ent	Aut	Dec	Dry
	Caesalpinia pulcherrima (L.) Sw.	2	N	Sma	Ent	Aut	Eve	Dry
	Calliandra tweedii Benth.	1	R	Sma	Ent	Ane	Eve	Dry
	Cassia fistula L.	2	E	Med	Ent	Aut	Dec	Dry
	Dalbergia nigra (Vell.) Allemão ex Benth.	2	R	Med	Ent	Ane	Dec	Dry
	Delonix regia (Bojer ex Hook.) Raf.	8	E	Sma	Ent	Aut	Dec	Dry
	Enterolobium contortisiliquum (Vell.) Morong	2	R	Tall	Ent	Aut	Dec	Dry
	Erythrina falcata Benth.	1	R	Med	Orn	Ane	Dec	Dry
	Hymenaea courbaril L.	1	R	Med	Chi	Zoo	Eve	Dry
	Leucaena leucocephala (Lam.) de Wit	2	N	Sma	Ent	Aut	Eve	Dry
	Lonchocarpus sericeus (Poir.) Kunth ex DC.	1	N	Med	Ent	Zoo	Dec	Dry
	Mimosa caesalpiniifolia Benth.	8	N	Med	Ent	Aut	Dec	Dry
	Paubrasilia echinata (Lam.) Gagnon, H.C.Lima & G.P.Lewis	4	R	Sma	Ent	Ane	Eve	Dry
	Peltophorum dubium (Spreng.) Taub.	3	R	Sma	Ent	Ane	Eve	Dry
	Poincianella pluviosa var. Peltophoroides (Benth.) L.P. Queiroz	237	R	Med	Ent	Aut	Eve	Dry
	Schizolobium parahyba (Vell.) Blake	4	R	Tall	Ent	Ane	Dec	Dry
	Senna macranthera (DC. ex Collad.) H.S.Irwin & Barneby	1	R	Sma	Ent	Aut	Dec	Dry
	Tipuana tipu (Benth.) Kuntze	1	E	Med	Ent	Ane	Dec	Dry
LAMIACEAE	*Callicarpa nudiflora* Hook. & Arn.	1	E	Sma	Ent	Zoo	Eve	Fle
	Tectona grandis L.f.	1	E	Tall	Ent	Zoo	Dec	Fle
LAURACEAE	*Persea americana* Mill.	3	E	Med	Ent	Zoo	Eve	Fle
LECYTHIDACEAE	*Couroupita guianensis* Aubl.	6	N	Med	Ent	Zoo	Dec	Fle
LYTHRACEAE	*Lagerstroemia indica* L.	2	E	Sma	Ane	Aut	Eve	Dry
	Punica granatum L.	2	E	Sma	Ent	Aut	Eve	Dry
MALPIGHIACEAE	*Malpighia emarginata* DC.	1	E	Sma	Ent	Zoo	Eve	Fle

Sma: small-sized; Med: medium-sized; Ent: entomo-; Ane: anemo-; Aut: auto-; Chi: chiroptero-; Dec: deciduous; Dis: dispersal mode; Eve: evergreen; E: exotic; Fle: fleshy fruits; Fru: fruit type; Hyd: hydro-; N: native; NI: No Information; Ori: geographical origin; Orn: ornito-; Pol: pollination mode; R: regional.

Table 1. Continued...

Family	Species	Total	Ori	Size	Pol	Dis	Leaf	Fru
MALVACEAE	*Ceiba speciosa* (A.St.-Hil.) Ravenna	4	R	Med	Chi	Ane	Dec	Dry
	Dombeya wallichii (Lindl.) Baill.	2	E	Sma	Ent	Zoo	Eve	Dry
	Guazuma ulmifolia Lam.	1	R	Sma	Ent	Zoo	Eve	Dry
	Hibiscus rosa-sinensis L.	4	E	Sma	Orn	NI	Eve	Dry
	Luehea divaricata Mart. & Zucc.	1	R	Med	Ent	Ane	Dec	Dry
	Pachira aquatica Aubl.	1	N	Sma	Chi	Aut	Eve	Dry
	Pachira glabra Pasq.	4	R	Sma	Chi	Aut	Eve	Dry
MELASTOMATACEAE	*Pleroma granulosum* (Desr.) D. Don	55	N	Sma	Ent	Ane	Eve	Dry
MELIACEAE	*Cedrela fissilis* Vell.	1	R	Med	Ent	Ane	Dec	Dry
MORACEAE	*Ficus benjamina* L.	59	N	Med	Ent	Zoo	Eve	Fle
	Ficus microcarpa L.f.	2	E	Med	Ent	Zoo	Eve	Fle
	Morus nigra L.	6	E	Sma	Ent	Zoo	Dec	Fle
MYRTACEAE	*Callistemon viminalis* (Sol. ex Gaertn.) G.Don	13	E	Sma	Orn	Ane	Eve	Dry
	Calyptranthes brasiliensis Spreng.	1	R	Sma	Ent	Zoo	NI	Fle
	Eucalyptus grandis W. Hill	1	E	Tall	Ent	Ane	Eve	Fle
	Eugenia florida DC.	1	R	Sma	Ent	Zoo	Eve	Fle
	Eugenia involucrata DC.	1	R	Sma	Ent	Zoo	Dec	Fle
	Eugenia uniflora L.	21	R	Sma	Ent	Zoo	Eve	Fle
	Melaleuca leucadendra (L.) L.	4	E	Sma	Ent	Ane	Eve	Dry
	Plinia cauliflora (Mart.) Kausel	11	R	Med	Ent	Zoo	Eve	Fle
	Psidium guajava L.	26	N	Sma	Ent	Zoo	Eve	Fle
	Siphoneugena densiflora O.Berg	2	R	Sma	Ent	Zoo	Eve	Fle
	Syzygium cumini (L.) Skeels	23	N	Med	Ent	Zoo	Eve	Fle
OLEACEAE	*Ligustrum lucidum* W.T.Aiton	3	E	Sma	Ent	Zoo	Eve	Dry
OXALIDACEAE	*Averrhoa carambola* L.	1	E	Sma	Ent	Zoo	Eve	Fle
PANDANACEAE	*Pandanus tectorius* Parkinson ex Du Roi.	1	E	Sma	Ent	Zoo	Dec	Fle
PINACEAE	*Pinus patula* Schiede ex Schltdl. & Cham.	1	E	Tall	Ane	Ane	Eve	Dry
PLATANACEAE	*Platanus x acerifolia* (Ait.) Willd	1	E	Tall	Ane	Ane	Dec	Dry
POLYGONACEAE	*Triplaris americana* L.	1	N	Med	Ent	Ane	Eve	Dry
	Triplaris caracasana Cham.	2	E	Sma	Ent	Ane	Dec	Dry
PRIMULACEAE	*Myrsine guianensis* (Aubl.) Kuntze	1	R	Med	Ent	Zoo	Eve	Fle
RHAMNACEAE	*Hovenia dulcis* Thunb.	1	R	Med	Ent	Zoo	Dec	Dry
ROSACEAE	*Eriobotrya japonica* (Thunb.) Lindl.	1	N	Sma	Ent	Zoo	Eve	Fle
RUBIACEAE	*Genipa americana* L.	1	R	Sma	Ent	Zoo	NI	Fle
RUTACEAE	*Citrus sp.*	1	NI	Sma	Ent	Zoo	Eve	Fle
	Citrus x limon (L.) Osbeck	4	N	Sma	Ent	Zoo	Eve	Fle
	Murraya paniculata (L.) Jack	5	E	Sma	Ent	Zoo	Eve	Fle
SALICACEAE	*Casearia sylvestris* Sw.	1	R	Sma	Ent	Zoo	Eve	Dry
SAPINDACEAE	*Allophylus edulis* (A.St.-Hil. et al.) Hieron. ex Niederl.	6	R	Sma	Ent	Zoo	Dec	Fle
SAPOTACEAE	*Micropholis guyanensis* (A.DC.) Pierre	1	R	Tall	Ent	Zoo	NI	Fle
	Brunfelsia uniflora (Pohl) D.Don	1	R	Sma	Ent	Ane	Eve	Dry
VERBENACEAE	*Duranta erecta* L.	30	R	Sma	Orn	Ane	Eve	Dry

Sma: small-sized; Med: medium-sized; Ent: entomo-; Ane: anemo-; Aut: auto-; Chi: chiroptero-; Dec: deciduous; Dis: dispersal mode; Eve: evergreen; E: exotic; Fle: fleshy fruits; Fru: fruit type; Hyd: hydro-; N: native; NI: No Information; Ori: geographical origin; Orn: ornito-; Pol: pollination mode; R: regional.

abundance pattern there were 25% exotic individuals, 31% native, and 43% regional. The exotic group was more equitable than the native and regional groups (Table 2).

The two dominant species (*Poincianella pluviosa* and *Syagrus romanzoffiana*) are regional and accounted for 32% of the total abundance. There was a notable presence of few abundant species, 72% of the total species showed equal or less than five individuals. Despite the two dominant species, the regional group was also the group with the highest percentage of rare species (Figure 2).

The diversity indices (HF') were considered low mainly for HF'ind, and showed great variations in the different categories, ranging from 0.42 (leaf life span) to 1.09 (dispersal mode). The exotic species showed higher H-values in relation to the native and regional species in a majority of the categories (Table 3).

Most species were classified as: a) small-sized (60% of the total species) ($F = 141.4$, gl = 2, $p < 0.001$); b) entomophilous (80%) ($F = 16.6$, gl = 3, $p < 0.001$); c) zoochoric (57%) ($F = 21.0$, gl = 3, $p < 0.001$); d) evergreen (71%) ($t = -9.8$, gl = 10, $p < 0.05$); and e) with dry fruits (56%) ($t = -3.2$, gl = 10, $p < 0.05$). The general pattern for individuals was more heterogeneous, with a predominance of the following attributes: a) small (48%) and medium-sized (41%) ($F = 7.5$, gl = 2, $p < 0.01$); b) entomophilous (84%) ($F = 19.2$, gl = 3, $p < 0.001$); c) zoochoric (42%), anemochoric (29%), and autochoric (28%) ($F = 14.0$, gl = 3, $p < 0.001$); d) evergreen (83%) ($t = -5.3$, gl = 10, $p < 0.05$); and (e) with dry fruits (65%) ($t = 1.9$, gl = 10, $p < 0.05$) (Figure 3).

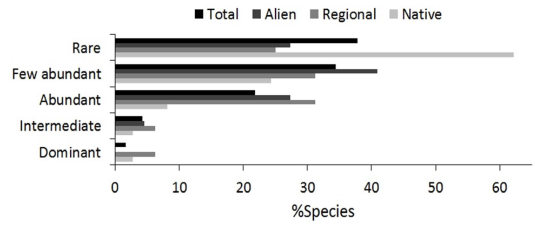

Figure 2. Percentages of species by abundance class. Rare: species with only one individual; Few abundant: 2-5 individuals; Abundant: 6-50 individuals; Intermediate: 51-100 individuals; Dominant: > 100 individuals.

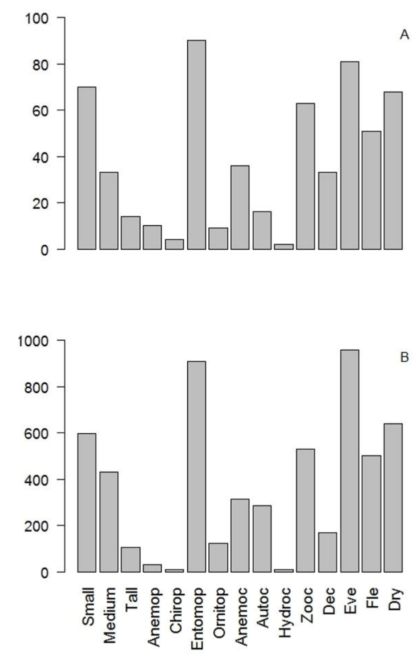

Figure 3. Number of species (A) (total richness: 119) and individuals (B) (total abundance: 1138) from urban plant assemblages in terms of their functional attributes. Small: Small-sized; Medium: Medium-sized; Tall: Tall-sized; Anemop: Anemophily; Chirop: Chiropterophily; Entomop: Entomophily; Ornitop: Ornithophily; Anemoc: Anemochory; Autoc: Autochory; Hydroc: Hydrochory; Zooc: Zoochory; Dec: Deciduous leaves; Eve: Evergreen leaves; Fle: Fleshy fruits; Dry: Dry fruits.

Table 2. Parameters of the plant assemblages in eight green public spaces in Alfenas, Minas Gerais State, Brazil.

Origin	Abundance	Richness	Evenness (J')
Regional	485	40	0.37
Native	359	28	0.51
Exotic	290	48	0.68
No Information	4	3	-
Total	1138	119	0.72

Table 3. Functional Diversity Index* (HF'), calculated based on the proportion of individuals (HF'ind) and species (HF'sp) in each functional group of the urban flora.

	HF'ind					HF'sp				
	Size	Pollination	Dispersal	Leaves	Fruit	Size	Pollination	Dispersal	Leaves	Fruit
Regional	0.75	0.34	0.97	0.24	0.65	0.27	0.25	0.28	0.26	0.26
Natives	0.77	0.38	0.86	0.67	0.73	0.21	0.19	0.23	0.19	0.20
Exotic	0.92	0.75	0.84	0.53	0.72	0.32	0.28	0.31	0.27	0.30
Total	0.93	0.53	1.09	0.42	0.70	0.92	0.71	1.04	0.6	0.68

*Adapted from Shannon's Diversity Index (Shannon & Weaver, 1948).

4. DISCUSSION

4.1. Species diversity

Intensively managed urban ecosystems are not necessarily barriers to biodiversity. Our results suggest that those spaces can act as refuges for rich plant communities. The species richness in the observed green areas was considered high in comparison with other studies undertaken in Brazil (Almeida & Barbosa (2010) reported 45 species; Kramer & Krupek (2012) 98 species; and Raber & Rebelato (2010) 45 species). However, small patches of natural remnant vegetation in the study region often harbor richer communities (Carneiro et al., 2016; Nunes et al., 2003). It suggests the need to consider urban spaces as complementary areas for the conservation of natural forest fragments. The species compositions of the urban green areas also were quite distinct from natural vegetation, as expected, with the marked presence of exotic species. The same pattern has been reported in other cities (Almeida & Barbosa, 2010; Cardoso-Leite et al., 2014; Santos et al., 2012; Wang et al., 2012). Despite increasing species richness at a local level, the introduction of exotic species to urban afforestation sites should be viewed with caution. The impact of exotic plants is an ongoing issue and numerous undesirable consequences have been reported. The consequences include competition with native species and their subsequent population declines (Vidra et al., 2007), the homogenization of the compositions of urban floras (McKinney, 2006), damage to the associated local fauna (Corbet et al., 2001), and biological invasions (Shackleton & Shackleton, 2016).

The persistence of the native flora is not always feasible in cities due to the peculiarities of urban environments and their highly restrictive conditions (Sukopp, 2004; Knapp et al., 2010). High levels of disturbance, reduced sizes of vegetation refuges, and little or no connectivity between them constitute unfavorable conditions that can hinder many complex biological processes and limit the presence of rare native specialist species in cities (Ordóñez & Duinker, 2012; Qing et al., 2015). Therefore it would be desirable for urban afforestation projects to incorporate mechanisms that would stimulate ecological complexity, for example, by increasing size and connectivity among habitat patches (Mörtberg, 2001).

Another relevant point about urban plant communities is their low species evenness. The greater part of the vegetation cover in cities usually consists of only one or a few dominant species, with many other less abundant taxa (Pauleit et al., 2002; Veloso et al., 2014). The two dominant species in Alfenas area accounted for more than 30% of the total abundance, and some of the common species in our study are found in other cities throughout Brazil (Kramer & Krupek, 2012; Santos et al., 2012; Freitas et al., 2015). In general, more diverse areas tend to be ecologically more robust than sites dominated by just a small set of species (Nagendra & Gopal, 2010), and it has been recommended that a single species not exceed 15% of the total number of planted trees (Redin et al., 2010).

4.2. Functional diversity

Functional diversity should be considered as a conservation tool in urban tree projects, as the diversity of ecosystem services performed far more important than the simple numbers of species (Flynn et al., 2009). Human choices regarding which species will form urban plant communities will act as strong selective filters of the richness and functional plant types found in urban habitats (Williams et al., 2008; Knapp et al., 2010). As such, the floristic compositions of the persistent floras of those areas typically combine both cultivated and ornamental species, regardless of their functional or phylogenetic diversity. The functional diversity index in the present study site was considered low for all ecological attributes. The lack of literature investigating that aspect in other Brazilian cities makes comparisons difficult. However, other works have pointed out that increases in tree richness do not necessarily guarantee increased functional diversity, with some ecological redundancy in urban green spaces (Knapp et al., 2008; Dolan et al., 2017). We encourage other researchers to adopt that same perspective in tropical regions.

The patterns of ecological traits found here revealed some similarities with those seen in Semideciduous Seasonal forest fragments, especially in relation to dispersal and pollination syndromes, with most species being zoochoric and entomophilous (Kinoshita et al., 2006; Vale et al., 2011). The presence of species with functional characteristics equivalent to the native flora is desirable and can transform cities into permanent ecological corridors – connecting nearby forest fragments and increasing the permeability of the urban matrix (Munshi-South, 2012). Additionally, the urban flora itself will benefit from those interactions, as the ecological processes essential to their reproduction and persistence will be maintained (Corlett, 2005).

Regarding tree size and fruit type, altered environments commonly favor plants with ruderal life history, smaller size, and dry fruits (Knapp et al., 2012; Williams et al., 2008). The establishment of other functional traits can also be restricted by intentional choices of the species to be cultivated – benefiting plants with characteristics compatible with the management of cultivated spaces. Small trees, for example, may be more suitable for sidewalks and urban power lines (Guimarães, 2006), while species with dry fruits tend to be favored over "messy" fleshy fruits. However, disregarding the ecological aspects of the urban flora can have negative effects on biodiversity (Cunha et al., 2006). The absence of larger trees can reduce the amounts and varieties of resources available to local wildlife (Guimarães, 2006), besides decreasing human thermal comfort (Araujo et al., 2017). Similarly, the lack of zoochoric species can impact local fauna that depends on fruits as food resources. Foraging on urban fruit trees has been observed in many different animals groups, such as bats (Corlett, 2005), monkeys (Cunha et al., 2006), lizards (González-García et al., 2009), and birds (Pauw & Louw, 2012).

5. CONCLUSIONS

The study of plant diversity represents a promising tool for the conservation of biodiversity in urban ecosystems. Since those habitats are becoming increasingly common with the expansion of human populations, the determination of taxonomic and functional patterns will be critical to understand community dynamics and for subsidizing management and conservation strategies. Our results indicate that urban green areas can function as refuges for rich plant communities with significant biodiversity conservation potential, although they are currently poor in regional native species and functional diversity. Urban green areas should therefore best be viewed as complementary strategies to aid in preserving forest remnants, since their floristic and functional compositions greatly differ. Ideally, the choice of species for urban floras should take into account not only socio-economic benefits to human populations, but also natural aspects that can contribute to the ecological integrity and complexity of those environments. We encourage continuing investigations of functional patterns as a tool for understanding the dynamics of biological communities in urban ecosystems. Furthermore, large regional native trees and fleshy fruits should be included in suitable areas to increase the environmental balance, maintain and attract the regional native frugivorous fauna.

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