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Article

Caracterización del arbolado urbano de la ciudad de Montemorelos, Nuevo León

Description of the urban trees of *Montemorelos* city, *Nuevo León*

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Resumen

En el presente estudio se hizo una caracterización de la estructura y diversidad del arbolado urbano de la ciudad de Montemorelos, Nuevo León, al noreste de México. Se censaron los árboles de todos los camellones y parques urbanos y se les midió la altura total (h), el diámetro normal ($d_{1.30\ m}$) y el diámetro de copa (k). Se calculó su abundancia (A_r), dominancia (D_r) y frecuencia (F_r), así como el Índice de Valor de Importancia (*IVI*) de las especies arbóreas presentes; se evaluó su diversidad con los índices de *Margalef* (D_{Mg}), *Shannon* (H'), Diversidad Real (^1D) y el área verde por habitante. Se registraron un total 918 árboles de 13 especies, pertenecientes a 11 géneros, de las cuales siete son introducidas. El área verde por habitante fue de 0.87. *Fraxinus americana* fue el taxón con mayor IVI (53.82 %.), seguido de *Quercus virginiana* (21.37 %). El arbolado urbano reúne una mayor proporción de organismos de porte alto (entre 4 y 6 m), y un diámetro normal de tamaño medio (entre 20 y 30 cm); asimismo la comunidad registró un índice de *Margalef* (D_{Mg}) de 1.9, una diversidad de *Shannon* (H') de 1.17 y un Índice de Diversidad Real de 3.22. El área verde urbana por habitante es inferior a lo recomendado en estudios previos, y presenta una baja diversidad, con respecto a otras de este tipo en distintas localidades.

Palabras clave: Abundancia, diversidad, estructura horizontal, *Fraxinus americana* L., parques urbanos, *Quercus virginiana* Mill*.*

Abstract

In the present study, the structure and diversity of the trees in the urban area of the city of *Montemorelos*, *Nuevo León*, (northeast of Mexico) were characterized. The trees of all the ridges and urban parks were enumerated. Total height (h), normal diameter ($d_{1.30\ m}$) and crown diameter (k) of the tree vegetation were evaluated and its abundance (A_r), dominance (D_r) and frequency (F_r) were calculated. In addition, the importance value index (*IVI*) of the tree species was estimated, and their diversity was evaluated with the Margalef (D_{Mg}), Shannon (H'), Real Diversity (^1D) indexes as well as the green area per inhabitant. A total of 918 trees of 13 species, belonging to 11 genera, were registered, of which seven were exotic. The green area per habitant was 0.87. The Fr*axinus americana* had the highest IVI (53.82 %.), followed by *Quercus virginiana* (21.37 %). The urban trees had a higher proportion of tall organisms (between 4 and 6 m), and a normal diameter of medium size (between 20 and 30 cm); likewise, the community registered a Margalef index (D_{Mg}) of 1.9, a Shannon diversity (H') of 1.17 and a Real Diversity index of 3.22. The urban green area per habitant is less than that recommended in previous studies, and with low diversity compared to other green areas in different locations.

Key words: Abundance, diversity, horizontal structure, *Fraxinus americana* L., urban parks, *Quercus virginiana* Mill.

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Introduction

In recent years, urban areas have experienced an expansion in both extension and population, which in turn has increased demand and importance (CAF, 2018). Since these spaces provide cities and their inhabitants with environmental services such as climate regulation, erosion control, recreation, tourism, pollination, aesthetics, habitat for wildlife, carbon capture, conservation of biodiversity, among others (Mora-Olivo and Martínez, 2012; Gómez-Baggethun *et al*., 2013), it is relevant to know them as their structure, composition and diversity to strengthen the planning and management of urban green areas for present and future generations (Flores-Xolocotzi and González-Guillén, 2010).

The literature that describes the diversity and composition of urban trees in different parts of the world is diverse (Nagendra and Gopal, 2010; Fahey *et al*., 2012; Ortíz and Luna, 2019; Moussa *et al*., 2020). In Mexico it is not so abundant but most of it comes from Mexico City (Checa-Artasu, 2016; Maldonado-Bernabé *et al*., 2019).

Research in northeastern Mexico that has assessed green areas and urban forests focus on the municipalities of the metropolitan area of *Monterrey* and *Linares* in the state of *Nuevo León* (Zamudio, 2001; Alanís-Flores, 2005; Alanís *et al*., 2014; Leal *et al*., 2018), as well as in *Ciudad Victoria*, *Tamaulipas* (Mora-Olivo and Martínez, 2012). The city of *Montemorelos* is the third most populated in *Nuevo León*, with 45 108 inhabitants (INEGI, 2010) and studies in this regard have not yet been carried out.

Based on the above, the objective of this work was to know the structure (abundance, dominance, frequency and importance value index), floristic composition, diameter and height classes, relative abundance pattern, square meters of green area per inhabitant and the diversity of trees in the different parks and ridges in the urban area of the city of *Montemorelos, Nuevo León*.

Materials and Methods

Study area

The study was carried out in the city of *Montemorelos*, a municipality of the same name, in the state of *Nuevo León*, northeast of Mexico. It is located between 24°54'and 25°25' north and 99°36 'and 100°11' west, between 500 and 2 700 masl (Figure 1). The prevailing climate is semi-warm subhumid with rains in summer, with lower humidity. The average annual temperature is 16 to 24 °C, with a precipitation interval of 500 – 1 100 mm. The dominant soil types are Leptosol and Vertisol. The urban area is established on land previously occupied by agriculture and scrubland (INEGI, 2009).

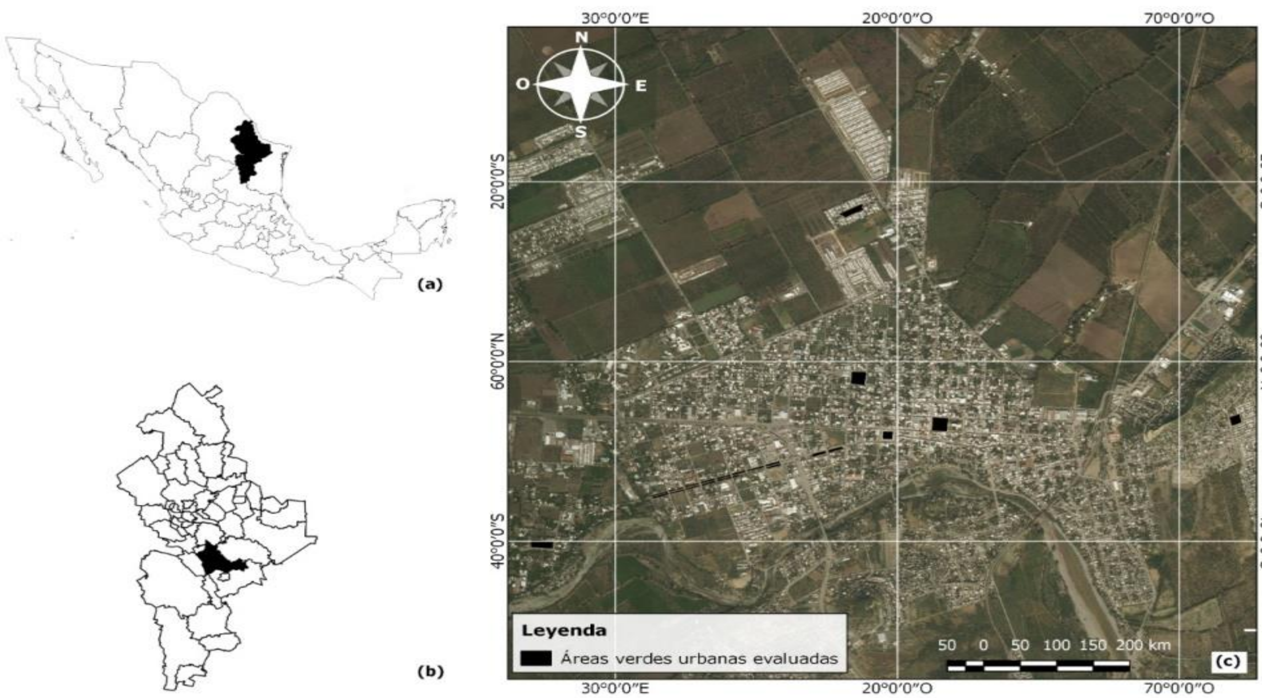


Figure 1. a). State of *Nuevo León*, b). *Montemorelos* municipality, c). Urban green areas assessed in *Montemorelos* city.

Vegetation analysis

Urban green area was defined as any public space delimited with the presence of vegetation, which may or may not be used for recreational or sports activities in the open air (public parks and ridges). In August and September 2016, the standing specimens of the arboreal plant species present in all the urban green areas of the city of *Montemorelos* were recorded.

All arboreal individuals with a normal diameter ($d_{1.30\ m}$) ≥ 8 cm were measured. The dendrometric variables evaluated were: total height (*h*), which was measured with a Vertez III™ hypsometer, normal diameter ($d_{1.30\ m}$), with a Forestry Supliers Inc™ diametric tape and cup diameter (*k*) with a tape 50 m meter of Truper™ fiberglass. To verify the correct nomenclature of the species, the Tropicos™ platform (Tropicos, 2020) was used.

Data analysis

To evaluate the horizontal structure of each species, its abundance was determined according to the number of individuals, its dominance based on its crown area, and its frequency based on its presence in the sampling sites. With these values, the Importance Value Index (*IVI*) was calculated, which acquires percentage values on a scale from 0 to 100 (Alanís-Rodríguez *et al*., 2020). Richness and diversity were estimated with the Margalef index (D_{Mg}), which is based on the quantification of the number of species present (specific richness), the Shannon entropy index (*H*'), which is based on the proportional distribution of the abundance of each species (Magurran, 2004) and Shannon's true diversity index (^{1}D) (Jost, 2006). The formulas used to determine the diversity indices and the ecological parameters are shown in Table 1.

Table 1 Formulas used to determine the diversity indexes and ecological indicators of the species.

Formula	Where
$A_i = \frac{N_i}{S}$ $AR_i = \left[A_i / \sum_{i=1}^{n} A_i\right] \times 100$	A_i = Absolute abundance AR_i = Relative abundance per species N_i = Number of individuals of the *i* species S = Sampling area (ha)
$D_i = \frac{G_i}{S}$ $DR_i = \left[D_i / \sum_{i=1}^{n} D_i\right] \times 100$	D_i = Absolute dominance DR_i = Relative dominance of the *i* species in regard to total dominance G_i = Basimetric area of the *i* species S = Area (ha).
$F_i = \frac{P_i}{NS}$ $FR_i = \left[F_i / \sum_{i=1}^{n} F_i\right] \times 100$	F_i = Absolute frequency FR_i = Relative frequency of the *i* species in regard to total frequency P_i = Number of sites in which the *i* species is present NS = Total sampling site number
$IVI = \frac{\sum_{i=1}^{n}(AR_i, DR_i, FR_i)}{3}$	AR_i = Relative abundance per species in regard to total density DR_i = Relative dominance of the *i* species in regard to total dominance FR_i = Relative frequency of the i species in regardo to total frequency

$H' = -\sum_{i=1}^{S} p_i * ln(p_i)$ $p_i = n_i/N$	*H'* = Shannon-Weiner index *S* = Number of the spresent species *N* = Total number of individuals n_i = Number of individuals of the species *ln* = Natural logarithm
$D_{Mg} = \frac{S-1}{\ln(N)}$	D_{Mg} = Margalef index *S* = Number of the spresent species *N* = Total number of individuals *ln* = Natural logarithm
$^1D = exp(H')$	^1D = Shannon's real diversity index *H'* = Shannon-Weiner index

To describe the plant community vertically and horizontally, graphs of diameter classes and height classes were generated. The volume was estimated using the formula (Alanís-Rodríguez *et al*., 2020):

$$V = g * h * CM$$

Where:

V = Volume

g = Supposed circular area of diameter ($d_{1.30\ m}$)

h = Total height of individual

CM = Morphic coefficient, which for this case = 0.5

The community structure was analyzed by using a dominance-diversity graph (Brower *et al*., 1998), which describes the relationship of the absolute abundance of the species as a function of a sequential arrangement, from the most to the least abundant (Martella *et al*., 2012). To calculate the square meters (m^2) of green area per inhabitant, the following equation was used (Mejía and Gómez, 2015):

$$m^2\ per\ inhabitant = \frac{m^2\ of\ green\ areas\ and\ recreation\ areas}{number\ of\ d\ inhabitants\ of\ Montemorelos, N.L.}$$

Results

There are 21 ridges and 6 parks in *Montemorelos* city, in which all the tree species were registered, which together totaled 47 173 m^2. 918 individuals were registered, 497 in ridges and 421 in parks. 13 species distributed in 11 genera and nine families were identified. Seven are to exotic and six, native. The most representative families were Fagaceae and Fabaceae, with three species each (Table 2). The green area per inhabitant was calculated at 0.87 m^2.

Table 2. Tree species found in the urban green areas of *Montemorelos* city.

Scientific name	Common name	Family	Origin
Casuarina equisetifolia L.	*Casuarina*	Casuarinaceae	Introduced
Cordia boissieri A. DC.	*Anacahuita*	Boraginaceae	Native
Cupressus sempervirens L.	*Ciprés*	Cupressaceae	Introduced
Delonix regia (Bojer ex Hook.) Raf.	*Framboyán*	Fabaceae	Introduced
Ebenopsis ebano (Berland.) Barneby & J.W. Grimes	*Ébano*	Fabaceae	Native
Ehretia anacua (Terán & Berland.) I.M. Johnst.	*Anacua*	Fabaceae	Native
Fraxinus americana L.	*Fresno*	Oleaceae	Introduced
Koelreuteria bipinnata Franch.	*Jabonero*	Sapindaceae	Introduced
Populus mexicana Wesm. ex DC.	*Álamo*	Salicaceae	Native
Quercus laurina Bonpl.	*Encino laurelillo*	Fagaceae	Native
Quercus rubra L.	*Encino rojo*	Fagaceae	Introduced
Quercus virginiana Mill.	*Encino blanco*	Fagaceae	Native
Washingtonia robusta H. Wendl.	*Palma blanca*	Arecaceae	Introduced

Total density of trees was 194.6 N ha^{-1} and absolute dominance of 7 425.23 m^2 ha^{-1} (tables 3 and 4). The sum of the area of the total urban trees was 54.80 m^2, with a crown area of 35 044.88 m^2 and a volume of 187.73 m^3. The species with the highest average height were *Washingtonia filifera* (Linden ex André) H.Wendl., *Quercus laurina* Bonpl., *Casuarina equisetifolia* L. and *Quercus rubra* L.

Table 3. Basimetric area (m^2), crown area (m^2), volume (m^3) and average height of the species.

Species	Basimetric area (m^2)	Crown area (m^2)	Volume (m^3)	Average height (m)
Casuarina equisetifolia L.	0.68	376.89	3.15	7.87
Cordia boissieri A. DC.	0.01	19.48	0.03	4.80
Cupressus sempervirens L.	0.01	104.00	0.02	4.63
Delonix regia (Bojer ex Hook.) Raf.	0.06	28.04	0.20	6.40
Ebenopsis ebano (Berland.) Barneby & J.W. Grimes	3.33	1745.07	11.55	6.26
Ehretia anacua (Terán & Berland.) I.M. Johnst	0.03	14.86	0.10	6.80
Fraxinus americana L.	36.45	24989.92	114.80	5.86
Koelretueria bipinnata Franch.	0.46	529.45	1.26	5.45
Populus mexicana Wesm. ex DC.	1.24	317.62	4.58	7.30
Quercus lauriana Bonpl.	0.79	631.61	3.49	8.97
Quercus rubra L.	0.21	189.23	0.81	7.70
Quercus virginiana Mill.	6.91	5598.26	25.79	5.09
Washingtonia filifera (Linden ex André) H.Wendl.	4.60	500.47	21.95	9.41
Sum	54.80	35044.88	187.73	

The relative abundance of *Fraxinus americana* L. was the most outstanding (62.75 %), as well as the carrier of the largest crown area, with 71.31 % of relative dominance. The second most abundant species was *Quercus virginiana* Mill. (22.11 %) and with a relative dominance of 15.97 %. The most frequent species were *Q. virginiana* and *F. americana* with 26.03 % and 27.40 % respectively but in Table 4, they were ordered according to their Importance Value Index (*IVI*) value; thus, the highest were

F. americana (53.82 %), *Q. virginiana* (21.37 %) and *Ebenopsis ebano* (Berland.) Barneby & J.W. Grimes (9.72 %).

Table 4. Ecological parameters of abundance, dominance, frequency and importance value index of the tree species registered in the urban green areas of the city of *Montemorelos*.

Species	Abundance		Dominance		Frequency		*IVI*
	N ha^{-1}	%	m^2 ha^{-1}	%	N/site	%	
Fraxinus americana L.	122.10	62.75	5294.81	71.31	74.07	27.40	53.82
Quercus virginiana Mill.	43.03	22.11	1186.15	15.97	70.37	26.03	21.37
Ebenopsis ebano (Berland.) Barneby & J.W. Grimes	9.75	5.01	369.74	4.98	51.85	19.18	9.72
Washingtonia robusta H. Wendl.	9.96	5.12	106.04	1.43	14.81	5.48	4.01
Koelreuteria bipinnata Franch.	2.54	1.31	112.18	1.51	11.11	4.11	2.31
Casuarina equisetifolia L.	1.91	0.98	79.85	1.08	11.11	4.11	2.06
Populus mexicana Wesm. ex DC.	1.70	0.87	67.30	0.91	11.11	4.11	1.96
Quercus laurina Bonpl.	1.91	0.98	133.82	1.80	7.41	2.74	1.84
Quercus rubra L.	0.42	0.22	40.09	0.54	3.70	1.37	0.71
Cupressus sempervirens L.	0.64	0.33	22.03	0.30	3.70	1.37	0.66
Delonix regia (Bojer ex Hook.) Raf	0.21	0.11	5.94	0.08	3.70	1.37	0.52
Cordia boissieri A. DC.	0.21	0.11	4.13	0.06	3.70	1.37	0.51
Ehretia anacua (Terán & Berland.) I.M. Johnst	0.21	0.11	3.15	0.04	3.70	1.37	0.51
Sum	194.60	100.00	7425.23	100.00	270.37	100.00	100.00

In the diameter classes, the individuals followed a normal distribution with a slight positive asymmetry (Figure 2). The highest abundance was recorded in the diameters of 20.01 - 30 cm (74 N ha^{-1}), while the 10.01 - 20cm and 30.01 - 40 cm categories concentrated 41 and 40 N ha^{-1}, respectively. Under the assumption that the diameter could be indicative of the state of development of the trees, most of the urban trees of the city are made up of young specimens and few mature and long-lived individuals (Table 5).

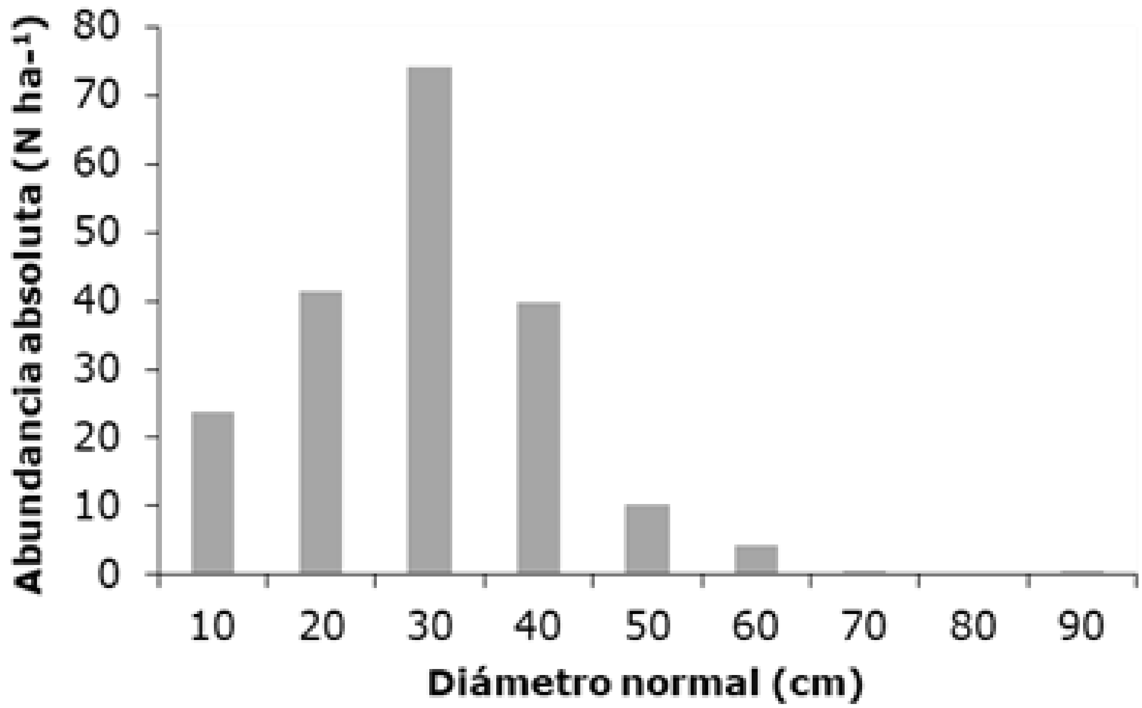


Figure 2. Absolute abundance (N ha^{-1}) of the individuals in the urban green areas of *Montemorelos* city according to normal diameter (cm).

Table 5. Number of individuals, species richness, basimetric area (m^2), crown area (m^2) and volume (m^3) of the species.

Plaza or ridge name	Number of individuals	Species richness	Crown area (m^2)	Basimetric area (m^2)	Volume (m^3)
Almazán Ridge 1	18	1	201.85	1.77	8.96
Almazan Ridge 2	16	1	159.18	1.45	7.35
La Estación Ridge 1	13	1	90.54	0.06	0.14
La Estación Ridge 2	7	1	41.75	0.05	0.10
José M. Parás Ballesteros Ridge 1	34	2	672.38	1.68	5.04
José M. Parás Ballesteros Ridge 2	40	2	749.14	1.80	5.26
José M. Parás Ballesteros Ridge 3	34	3	627.69	1.02	2.87
José M. Parás Ballesteros Ridge 4	16	5	412.79	1.22	4.20
José M. Parás Ballesteros Ridge 5	27	3	847.87	1.23	3.54
José M. Parás Ballesteros Ridge 6	10	3	185.35	0.32	0.85
José M. Parás Ballesteros Ridge 7	28	2	628.01	1.15	3.27
José M. Parás Ballesteros Ridge 8	31	2	776.53	1.00	2.77
José M. Parás Ballesteros Ridge 9	18	3	409.97	0.65	1.89
José M. Parás Ballesteros Ridge 10	14	1	390.54	1.52	6.55
José M. Parás Ballesteros Ridge 11	36	2	944.23	2.16	6.60
José M. Parás Ballesteros Ridge 12	20	3	540.92	1.12	3.37
José M. Parás Ballesteros Ridge 13	25	5	620.06	1.08	3.15
José M. Parás Ballesteros Ridge 14	33	4	858.39	1.94	5.94
José M. Parás Ballesteros Ridge 15	29	3	806.33	2.12	6.54
José M. Parás Ballesteros Ridge 16	33	3	878.87	1.80	5.37
La Central Ridge	15	1	127.19	0.12	0.27
Gil de Leyva Plaza	146	7	6389.74	8.47	26.86
Infonavit Plaza	41	5	4418.55	0.99	2.33
Las Palmas Plaza	53	3	2559.90	3.43	10.99
Matamoros Plaza	111	6	5792.83	9.97	35.11
Principal Plaza	39	4	3177.61	4.11	16.87
Zaragoza Plaza	31	2	1736.67	2.56	11.55
General total	918		35044.88	54.80	187.73

The height class graph shows a scarce presence of short trees (category 2 - 4 m; 19 N ha^{-1}) and the highest in the category 4.01 to 6 m (91 N ha^{-1}). The distribution of individuals in height categories had a positive asymmetric distribution (Figure 3).

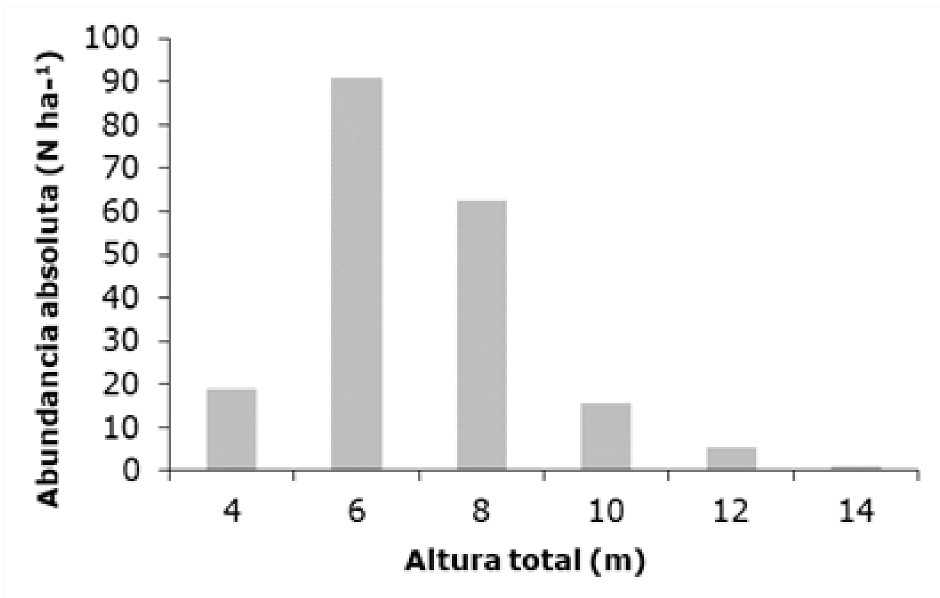
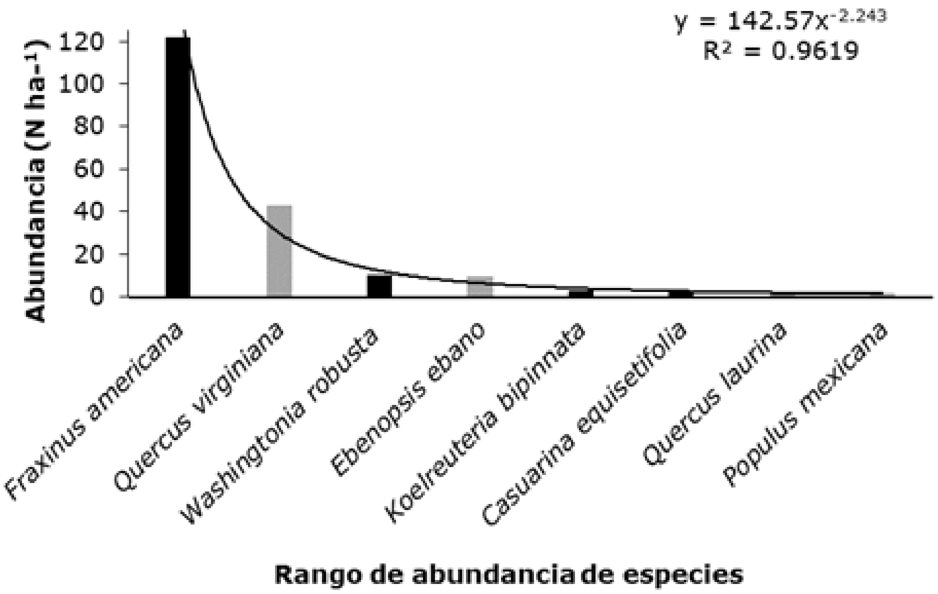


Figure 3. Absolute abundance (N ha^{-1}) of individuals in the urban green areas of *Montemorelos* city according to total height (m).

The list of ridges and plazas in *Montemorelos* (Table 5) indicates the number of individuals, species richness, basal area (m^2), crown area (m^2) and volume (m^3) of the identified taxa. In general, it is noted that the squares always had the highest values in all the variables compared to those of the ridges.

The range / abundance curve showed a negative exponential trend, in which *F. americana* exhibits a clear dominance in the tree community of the urban green areas of *Montemorelos* municipality (Figure 4). The evaluated area recorded a Margalef index of D_{Mg} = 1.9, while the Shannon entropy index was H'= 1.17. Shannon's true diversity index was 3.22.



Gray bars indicate native species, black bars indicate introduced species.

Figure 4. Range of species / abundance of species curve of urban green areas of *Montemorelos* city.

Discussion

The number of taxa identified in the study (13 species, 11 genera and nine families), was lower than the results of similar studies in northeastern Mexico, such as those of Zamudio (2001) and Leal *et al.* (2018) both in *Linares* municipality, who recorded 41 and 39 species respectively, while Alanís *et al.* (2014) counted 39 species in 16 families for the green areas of a university campus also in that locality. In larger urban areas such as the *Monterrey* Metropolitan Area (AMM) *Nuevo León*, Rocha *et al.* (1998) documented 137 tree species belonging to 68 families. In the same metropolitan area, Alanís-Flores (2005) determined that the tree diversity was 115 species, grouped into 37 families. This difference in the number of taxa observed in the different urban green areas can be explained by the difference in surface area, since the city of *Montemorelos* makes up around 50 % of the surface of the AMM. However, several studies indicate that the difference in the number of taxa is not only explained by the different extensions, but also responds, to a large extent, to the management actions carried out in them, as it is the case with the high number of vascular species in urban parks (Cornelis and Hermy, 2004).

In the present study, the Fabaceae and Fagaceae families were the most representative with a total of three species each one. Leal *et al.* (2018) considered the first as the most important with six species in green areas of the *Linares* municipality, which coincides with the results of Alanís-Flores (2005) and Alanís *et al.* (2014).

In spite of the fact that native species have the advantage of their natural adaptation to the environment, and, therefore, better growth and lower maintenance costs (Alanís-Flores, 2005), the introduced species make up a high percentage of the trees within urban areas, and this is considered a good practice, by easily and rapidly increasing diversity (McKinney, 2006), which is also related to the correct application of management measures (Cornelis and Hermy, 2004).

In the case of *Montemorelos*, seven (54 %) have this condition. Similar results have been described in different parts of the world. Thus, Alanís-Flores (2005) determined 53 % of species introduced for the AMM, while Ortíz and Luna (2019) for the city of *Resistencia,* Argentina, 69 %. For the *Chennai* district in India, Muthulingam and Thang Pavel (2012) recorded 33 % non-native species.

In the present study, the green area per inhabitant (0.87 m^2) was lower than that observed by Mejía Salazar and Gómez (2015) for *Tepic*, *Nayarit* (1.2 m^2) and lower than that calculated by Alanís-Flores (2005) for *Monterrey* (4.6 m^2). All these values, including the one in this study, were lower than the provision of urban green areas suggested by various authors, which represents a deficit in these places, both in *Montemorelos* municipality as in other cities in Mexico (Palomo, 2003; Wang, 2009; Molinar, 2015).

Regarding abundance, that registered in the area of interest (194.6 N ha^{-1}) was lower than that of Alanís *et al*. (2014) for the trees of a university campus in *Linares* (207 N ha^{-1}) and that of Benavides and Fernández (2012) for a section of *Bosque de Chapultepec* (295 N ha^{-1}) but greater than that of Leal *et al*. (2018) for the urban trees of *Linares* (75.43 N ha^{-1}). The abundance value in this study (194.6 N ha^{-1}) compared to the other investigations is considered acceptable.

Regarding dominance, both Alanís *et al.* (2014) as Leal *et al*. (2018) reported lower coverage values than those of the present study (7 359.99 m^2 ha^{-1} and 2 611.31 m^2 ha^{-1}, respectively *vs* 7 425.23 m^2 ha^{-1}). The latter and those of Alanís *et al.* (2014) are very similar, with 74 % canopy coverage. Regarding the coverage of urban trees (35 044.88 m^2), only 0.25 % of the urban area has it.

Fraxinus americana is the taxon with the highest ecological importance *(IVI* of 53.82 %), that is, it has the highest representativeness in the study area according to its abundance, dominance and frequency values. Alanís *et al.* (2014) and Leal *et al.* (2018) have consigned this species as the most ecologically relevant in the urban green areas of northeastern Mexico, as other authors agree in these areas of the country (Rocha Estrada *et al.,* 1998*;* Zamudio, 2001*)* and that it is extensive to spaces of this nature from Argentina, for example (Ortíz and Luna, 2019).

On the other hand, Alanís-Flores (2005) refers that this species was frequently used in urban reforestations in northeastern Mexico in the 1980s; and, despite the fact that in some cities it was replaced by native oak species and by others of tall stature such as *Ebenopsis ebano* (Berland.) Barneby & J.W. Grimes *and Ehretia anacua* (Terán & Berland.) I.M. Johnst*.,* among others, there are still localities such as *Montemorelos* in which *F. americana* is the most common in its green areas.

Quercus virginiana was the second species in abundance and in regard to the value index of ecological importance (21.37 %), which coincides with that confirmed by Leal *et al.* (2018) (*IVI* of 22.46 %) in *Linares*. This observation is associated with the fact that the *Quercus* genus has become relevant in the forestation of green areas in cities. In this regard, Alanís-Flores (2005) points out that in the *San Pedro Garza García* municipality in the 80s, the use of native species (mainly oak) was encouraged, and later, in the 90s, this practice became general in the AMM, with massive plantations.

On the other hand, under the objective of protection and conservation against exotic or native pests and diseases, Santamour (1990) proposed the 10-20-30 rule for urban forests (which includes parks, ridges and other metropolitan green spaces). The objective of the 10-20-30 rule is to achieve diversity in urban plantations and maintain a range of ages to plan the removal and replacement of dead specimens (Flores *et al*., 2018). This strategy assumes that, in terms of the arboreal diversity of these spaces, it is correct that the presence of a tree species does not exceed 10 % to 20 % of the same genus, nor 30 % of a taxonomic family (Kendal *et al*., 2014). For this case, *Fraxinus americana* and *Quercus virginiana* exceed 10 % of presence in regard to the species and *Quercus*, 20 % in terms of genus, but no family exceeded 30 % as recommended.

Similar results occur in other urban green areas evaluated as an urban forest in Mexico City, where a frequency greater than 10 % was determined for four species, one that exceeded 20 % per genus and no family greater than 30 % (Saavedra-Romero *et al*., 2019). For the trees of a university campus in the Valley of Mexico, Islas-Rodríguez *et al.* (2012) reported that three of the most abundant species did not comply with the 10-20-30 rule. However, in the study area, the management and design practices have not been in charge of diversifying and maximizing the potential of the species by not complying with the also known rule of 10 % (Flores *et al*., 2018).

According to the results obtained for density (N ha^{-1}) -Normal diameter (cm), it can be observed that the distribution is normal, with a high number of mature trees, since most of the individuals (74 N ha^{-1}) are grouped into the 30 cm and 40 cm category (40 N ha^{-1}). These data were different from those of Alanís *et al.* (2014), who evaluated the green areas of a 30-year-old university campus where they have made constant plantings and have a high number of low diameter class trees and a reduced number of high class trees, which has resulted in a negative exponential trend line in the density of individuals as the diameter increases.

The range of species / abundance curve indicates that there is a dominance of *F. americana* (Figure 4). This may be due to the preference for this tree for ornamental use in the northeast region of the country (Alanís-Flores, 2005; Alanís *et al*., 2014; Leal *et al*., 2018). However, this dominance is not recommended in communities established in urban environments (Santamour, 1990), where, as a matter of pest control, a greater diversity of species is sought.

Ortíz and Luna (2019) took as a minimum criterion in an urban area the value of 1.5 for the Shannon diversity index for Barcelona, so their results indicate low total diversity with an entropy index of *H* '= 1.17 and a diversity true of 3.22 for the area of interest. The values recorded in the present study are also lower than those of others of this type in northeastern Mexico; Leal *et al*. (2018) obtained an entropy index of H' = 1.99 for the urban trees of the city of *Linares*. For the year 1995 Zamudio (2001) calculated an entropy value of H' = 2.54 and for 1999, of H' = 2.27 for the urban environment of *Linares*, and Alanís *et al.* (2014) of 3.05 for the trees of the university campus in *Linares*. Ortíz and Luna (2019) reported a value of 3.60 for the Shannon diversity index, for the city of *Resistencia,* Argentina.

Finally, it is considered that the value obtained from the richness of species is low (1.9) in regard to that of other assessed areas such as that of the *Linares* university *campus*, which was 7.62 (Alanís *et al*., 2014) and that is classified as high, and that registered by Leal *et al*. (2014) of 5.24. In the urban area of the city of *Resistencia,* Argentina*,* Ortíz and Luna (2019) determined 10.55 for the Margalef index, which represents an outstanding species richness. The foregoing suggests that the management and design actions of the different cities have promoted a greater mix of species in urban green areas.

Another argument that could explain this contrast is that *Montemorelos* municipality has a smaller surface area of urban green areas compared to *Linares* and the *Monterrey* Metropolitan Area. Likewise, the diversity of species is a relevant factor for the permanence of the vegetation, since it controls the reproduction of pathogenic organisms and a low plant diversity leads to the reduction of green areas (Flores *et al.,* 2018).

Conclusions

The diameter class curve indicates that there is a higher proportion of individuals of intermediate size (DN = 30 cm). The dominance-diversity curve characterizes an arboreal community with high dominance of few species. The green area per inhabitant (0.87 m^2) is lower than that recommended in previous studies. There are low values of richness and diversity of species compared to other urban green areas in northeast Mexico. More than half of the species are introduced, among which *Fraxinus americana* stands out for its importance value index. This research evaluates and quantifies important variables of the urban trees of *Montemorelos, Nuevo León*, which provides the necessary information for its proper management.

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Conflict of interests

The authors declare no conflict of interests.

Contribution by author

Pamela A. Carrizales Velázquez: writing and editing of the manuscript; Eduardo Alanís Rodríguez: data analysis and writing of the manuscript; Victor A. Holguín Estrada: review and editing of the manuscript; Samuel García García: statistical analysis and review of the manuscript; Alejandro Collantes Chávez Costa: review, correction and editing of the manuscript.

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