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Article

Estructura y diversidad de un matorral dominado por *Helietta parvifolia* (A. Gray ex Hemsl.) Benth.

Structure and diversity of a shrub *Helietta parvifolia* (A. Gray ex Hemsl.) Benth.

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Resumen

Helietta parvifolia es una especie de importancia económica en el norte de México, ya que es una fuente potencial de madera y leña para usos diversos. El objetivo del presente estudio fue evaluar la estructura y diversidad de un matorral maduro de *H. parvifolia* en el noroeste de México. Se determinó la diversidad de la vegetación mediante el establecimiento de 20 sitios de muestreo de 10 × 10 m cada uno (2 000 m² en total), en donde se registraron las especies, el diámetro normal y de copa de todos los árboles y arbustos con un diámetro ≥ 3 cm. Se calcularon los índices de *Margalef*, *Shannon* y *Pretzsch* para determinar la riqueza, diversidad de especies y estructura vertical, respectivamente. Se registraron 11 especies arbóreas y arbustivas, distribuidas en nueve géneros y seis familias. Fabaceae fue la que registró un mayor número de taxones (cinco); mientras que las familias restantes presentaron solamente un taxón. Tres especies concentraron 82.59 % de los valores de índice de valor de importancia (IVI): *Helietta parvifolia, Cordia boissieri* y *Havardia pallens,* con 53 %, 15.44 % y 14.15 %, respectivamente. La mayor abundancia de individuos de clases diamétricas pequeñas sugiere la existencia de un estado de regeneración activo.

Palabras clave: Diversidad de especies, *Helietta parvifolia* (A. Gray ex Hemsl.) Benth., matorral submontano, riqueza de especies, vegetación xerófila.

Abstract

Helietta parvifolia is a species of economic importance in Northern Mexico, being a potential source of wood and firewood for several uses. The objective of the study was to evaluate the structure and diversity of a mature *H. parvifolia* scrub in Northwest Mexico. Vegetation diversity was determined by establishing 20 sampling sites of 10 × 10 m each (2000 m² in total), where the normal and crown diameter of all trees and shrubs with a diameter ≥ 3 cm were recorded. The Margalef, Shannon and Pretzsch indexes were calculated for richness, species diversity and vertical structure, respectively. Eleven tree and shrub species were found, distributed in nine genera and six families. The Fabaceae family had the highest number of taxa (five), while the remaining families had only one species. Three of them concentrated 82.59 % of the importance value index values (*IVI*): *Helietta parvifolia*, *Cordia boissieri* and *Havardia pallens*, with 53 %, 15.44 % and 14.15%, respectively. The abundance of individuals of small diameter classes suggests the existence of an active regeneration state.

Keywords: Species diversity, *Helietta parvifolia* (A. Gray ex Hemsl.) Benth., submontane scrub, species richness, xerophilous vegetation.

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Introduction

The xerophilous scrub constitutes one of the most important vegetal communities in Mexico. It occupies around 40 % of the national territory, and has a floristic richness estimated in about 6 000 species, including a high proportion of endemic species (Rzedowski, 1991, Semarnat, 2006). This plant community is a source of ecological, genetic, social, economic, educational, cultural, recreational and aesthetic wealth (Hooper *et al.,* 2005; Santos and Tellería, 2006). Despite its importance, xerophytic scrub has changed in its structure and composition over time, so it has a loss of biological diversity that leads to a deficit in its functioning (Hooper *et al.,* 2005). The above has its origin in multiple human activities, which have caused constant alterations in their coverage and changes in land use.

Within the xerophytic scrubland formations, there is the submontane scrubland, which is characterized by the development of hills and mountainsides below 2 000 masl (Rzedowski, 1978; González-Medrano, 2012). It thrives in shallow sedimentary or igneous soils and in semi-arid climates with precipitation values between 450 and 900 mm (Rojas-Mendoza, 1965). The submontane scrub is located along the *Sierra Madre Oriental* in the states of *Hidalgo, Querétaro, San Luis Potosí, Tamaulipas, Coahuila* and *Nuevo León* (Alanís-Rodríguez *et al*., 2015). In this last entity, 228 species of vascular plants have been documented, and it is in the central and southern areas where there is great plant richness (Estrada-Castillón *et al*., 2012).

Although the submontane scrub of northeastern Mexico is generally considered to be in a good state of conservation, it is evident that anthropogenic pressure is increasing for these types of communities, especially in areas close to urban areas (Alanís-Rodríguez *et al*., 2015; Mora-Olivo *et al.*, 2016).

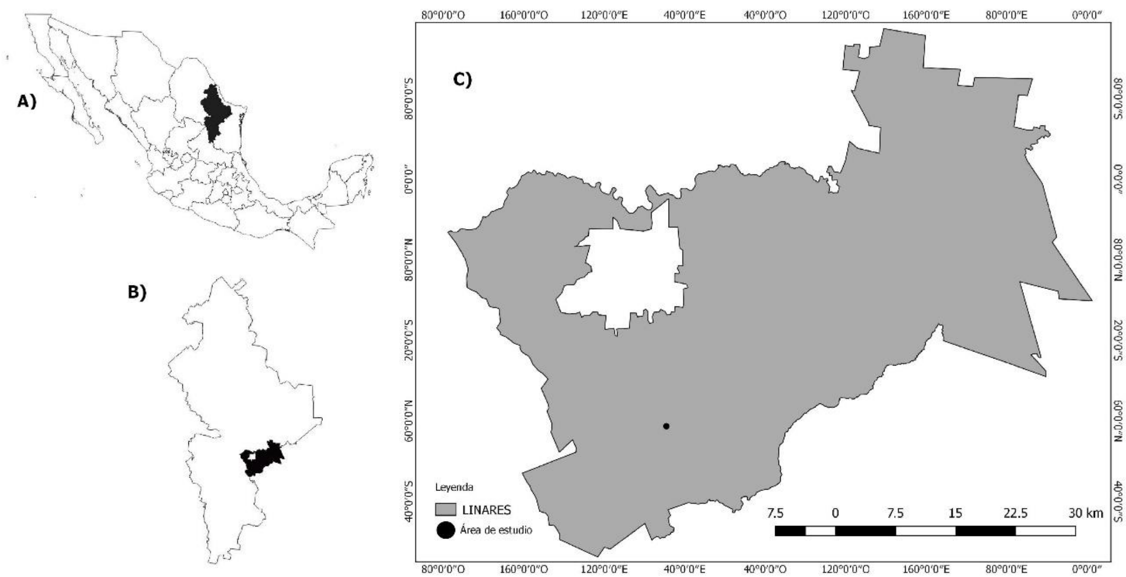
The conservation and sustainable management of plant communities requires knowledge of the functional and structural characteristics of the target vegetation (Montagnini and Jordan, 2005). For this reason, several studies assess the structure and composition of the submontane scrub in the northeast of the country, among them those by Foroughbakhch *et al*. (2003), Canizales-Velázquez *et al*. (2009), Estrada-Castillón *et al*. (2012), Alanís-Rodríguez *et al.* (2015) and Uvalle-Sauceda *et al.* (2015) for *Nuevo León*; in addition to that of Mora-Olivo *et al.* (2016) for *Tamaulipas*. However, so far these works are considered insufficient to attain a more accurate assessment of these scrublands, especially when they include in their composition species of high socioeconomic value, such as *Helietta parvifolia* (A. Gray) Benth. known as *barreta*.

Helietta parvifolia is one of the most important timber taxa in the submontane scrub of northeastern Mexico; its shaft is used by local people for the construction of fences due to its high quality and wood density. Derived from the above, research has been made to evaluate its timber production (Maginot *et al.*, 2014), wood durability (Carrillo *et al.*, 2013) and biomass (Návar *et al*., 2001), as well as its growth in forest plantations (Foroughbakhch, 1992). Therefore, the objective of this research was to analyze the structure and particularly the plant diversity of a mature submontane scrub where *Helietta parvifolia* is dominant in northwestern Mexico.

Materials and Methods

Study area

The study was carried out in the northwest of *Linares* municipality, *Nuevo León*, in a preserved area of the submontane scrub where *Helietta parvifolia* grows (Figure 1). The zone is located between 24°42'01.97'' N and 99°38'03.02'' W, at an altitude of 470 to 490 m, with a weighted average of 480 masl. According to data from INEGI (2009), the average annual temperature in the area fluctuates between 16 °C and 24 °C; the climate is a semi-warm - sub-humid with summer rains, of average humidity, and an average annual rainfall of 500 to 1 100 mm, with an average of 800 mm per year (INEGI, 2009). Based upon the information gathered, the vegetation in the study area is mature, without disturbances or previous clearing as a result of the forestry activities that dominate the region; the only use given to the plant community was the collection of edible fruits and woody material from the ground.



A) Map of Mexico with the state of *Nuevo León* in black, B) Map of the state of *Nuevo León* with the Linares municipality in black, C) Map of *Linares* with the study area marked as a black point.

Figure 1. Study area.

Field evaluation

In February 2019, 20 sampling sites of 100 m² (10 m × 10 m) were established, forming a total assessment area of 2 000 m². All scrub and tree components (normal diameter ≥ 3 cm) of each site were considered. The mensuration variables taken at the field were total height (*h*), which was measured with a Hastings® E-15-1 telescopic rod; normal diameter ($d_{1.30}$), with a 1270 mm Haglöf Mantax Blue™ caliper; and crown diameters (*k*) in N-S and E-W directions with a 10 m Truper™ tape. The species to which each individual belonged was recorded. Specialists from the Graduate School of Forest Sciences of the *Universidad Autónoma de Nuevo León* identified all species of trees and shrubs with a normal diameter ≥ 3 cm (Molina-Guerra *et al.*, 2019).

Data analysis

The abundance of each taxon was determined according to the number of trees present, its coverage from the crown area, and its frequency based on its presence in each of the sampling frames. The variables in their relative form were used to obtain a taxon-level weighted value known as the Importance Value Index (*IVI*), which grades percentage values on a scale from 0 to 100 (Alanís-Rodríguez *et al*., 2020).

The following equation was used to estimate relative abundance (Alanís-Rodríguez *et al*., 2020):

$$AR_i = \left({A_i}/{\sum A_i} \right) \times 100$$

Where:

AR_i = Relative abundance of species *i* in relation to total abundance

A_i = Absolute abundance of species *i* expressed as the number of total individuals per hectare (N_{ind} ha^{-1})

i = 1,….*n*

Dominance was estimated by the equation (Alanís-Rodríguez *et al*., 2020):

$$DR_i = \left({D_i}/{\sum D_i} \right) * 100$$

Where:

DR_i = Relative dominance of species *i* with respect to total dominance

D_i = Absolute dominance of the species *i* (m^2 ha^{-1})

i = 1,….*n*

The absolute and relative frequencies were estimated using the equations (Alanís-Rodríguez *et al*., 2020):

$$F_i = \left(\frac{f_i}{N} \right) * 100$$

$$FR_i = \left(\frac{F_i}{\sum F_i} \right) * 100$$

Where:

F_i = Absolute frequency (percentage of presence at sampling sites)

f_i = Number of sites where the species i is present

N = Number of sampling sites

FR_i = Relative frequency of species i with respect to total frequency

$i = 1, \ldots . n$

The importance value index (IVI) was calculated with the equation (Alanís-Rodríguez *et al*., 2020):

$$IVI = \frac{\sum_{n}^{i=1} AR_i, DR_i, FR_i}{3}$$

The alpha diversity was determined using three indexes: the Margalef index (D_{Mg}), which is based on the quantification of the number of species present (specific richness); the Shannon index (H'), which refers to the numerical structure of the community —i.e., the proportional distribution of the abundance of each species (Moreno, 2001)—, and the Shannon True Diversity index, which allows the unified and intuitive interpretation of diversity (Jost, 2006).

The following equation was used to estimate the Margalef index (D_{Mg}) (Clifford and Stephenson, 1975):

$$D_{Mg} = \frac{S-1}{\ln(N_{ind})}$$

Where:

S = Number of species present

N_{ind} = Total number of individuals

The Shannon Index (H) was calculated using the following formula (Shannon, 1948):

$$H' = -\sum_{i=1}^{S} p_i * \ln(p_i)$$

Where:

S = Number of species present

$p_i = n_i/N_{ind}$

N_{ind} = Total number of individuals

n_i = Number of individuals of species i

Shannon's True Diversity index was estimated using the expression (Jost, 2006):

$$^{1}D = exp^{(H')}$$

Where:

^{1}D = Shannon True Diversity Index

exp = Exponential

H´ = Shannon Diversity Index

The vertical structure was characterized according to the index of Vertical Distribution of Species (*A*) (Pretzsch, 2009), which considers three height zones or strata: zone I, with an interval of 80-100 % is the maximum height of the tree; zone II, with an interval of 50 %- 80 %; and zone III, with an interval of 0 to 50 %. This index is a modification of the Shannon index (Pretzsch, 2009), which indicates values between zero and a maximum value (A_{max}). A value of A_{max} = 0 means that the stand is made up of a species that occurs in only one stratum. A_{max} is achieved when all taxa exist in the same proportion, both in the stand and in the various strata (Pretzsch, 2009). It serves to determine the structural diversity in terms of vertical distribution of species and is calculated with the following formula:

$$A = -\sum_{i=1}^{S}\sum_{j=1}^{z} p_{ij} * ln(p_{ij})$$

Where:

S = Number of species present

Z = Number of height strata

p_{ij} = Relative number of individuals of each species per area

$$p_{ij} = {n_{i,j}}/{N}$$

Where:

$n_{i,j}$ = Number of individuals of the same species (*i*) in the area (*j*)

N = Total number of individuals

In order to compare the Pretzsch index, it was standardized by means of the value of A_{max}, which is calculated as follows:

$$A_{max} = ln(S * Z)$$

The value of *A* can then be standardized according to its relative value (A_{rel}), as follows:

$$A_{rel} = {}^{A}/_{ln}(S * Z) * 100$$

Results

Five tree species and five shrub species belonging to nine genera and six different families were recorded. Fabaceae was the most representative, with five species (*Acacia greggii* A. Gray, *Acacia rigidula* Benth, *Caesalpinia mexicana* A. Gray, *Ebenopsis ebano* (Berland.) Barneby & J. W.Grimes, and *Havardia pallens* (Benth.) Britton & Rose); while the rest of the families only had one taxon (Table 1). *Helietta parvifolia* exhibited the highest values in abundance, dominance and frequency; it concentrated 42.66 % of the *IVI*, followed by *Cordia boissieri* A. DC. and *Havardia pallens*, with 17.31 and 15.83 %, respectively (Table 2).

Table 1. Scientific name, common name, family and life form of the species in the area of study (ordered by scientific name).

Scientific name	Common name	Family	Life form
Acacia greggii A. Gray	Catclaw acacia	Fabaceae	Scrub
Acacia rigidula Benth	*Chaparro prieto*	Fabaceae	Scrub
Caesalpinia mexicana A. Gray	Mexican holdback	Fabaceae	Arboreal
Celtis pallida Torr.	Desert hackberry	Cannabaceae	Scrub
Cordia boissieri A. DC.	*Anacahuita*	Boraginaceae	Arboreal
Diospyros texana Scheele	Texas persimmon	Ebenaceae	Arboreal
Ebenopsis ebano (Berland.) Barneby & J.W.Grimes	Ebony	Fabaceae	Arboreal
Havardia pallens (Benth.) Britton & Rose	*Tenaza*	Fabaceae	Scrub
Helietta parvifolia A. Gray	*Barreta*	Rutaceae	Scrub
Juglans regia L.	Walnut	Juglandaceae	Arboreal

Table 2. Structural parameters of the species registered in the study area, ordered according to their Importance Value Index (*IVI*).

Species	Abundance		Dominance		Frequency		*IVI*
	N ha^{-1}	%	m^2ha^{-1}	%	Sites	%	
Helietta parvifolia A. Gray	1 280	52.24	11 821.65	54.22	20	21.51	42.66
Cordia boissieri A. DC.	335	13.67	4 119.33	18.89	18	19.35	17.31
Havardia pallens (Benth.) Britton & Rose	375	15.31	2 564.19	11.76	19	20.43	15.83
Junglas regia L.	215	8.78	1 304.01	5.98	13	13.98	9.58
Ebenopsis ébano (Berland.) Barneby & J.W.Grimes	110	4.49	418.50	1.92	8	8.60	5.00
Acacia rigidula Benth	65	2.65	901.42	4.13	5	5.38	4.05
Diospyros texana Scheele	35	1.43	486.08	2.23	4	4.30	2.65
Caesalpinia mexicana A. Gray	20	0.82	107.15	0.49	3	3.23	1.51
Acacia greggii A. Gray	10	0.41	53.57	0.25	2	2.15	0.93
Celtis palida Torr.	5	0.20	26.65	0.12	1	1.08	0.47
Total	2 450	100	2 1803	100	93	100	100

The density of individuals per hectare showed a negative exponential trend line as the diameter increased; the 0-10 cm diameter class exhibited the highest density of individuals, with values above 1 800 N ha^{-1} (Figure 2).

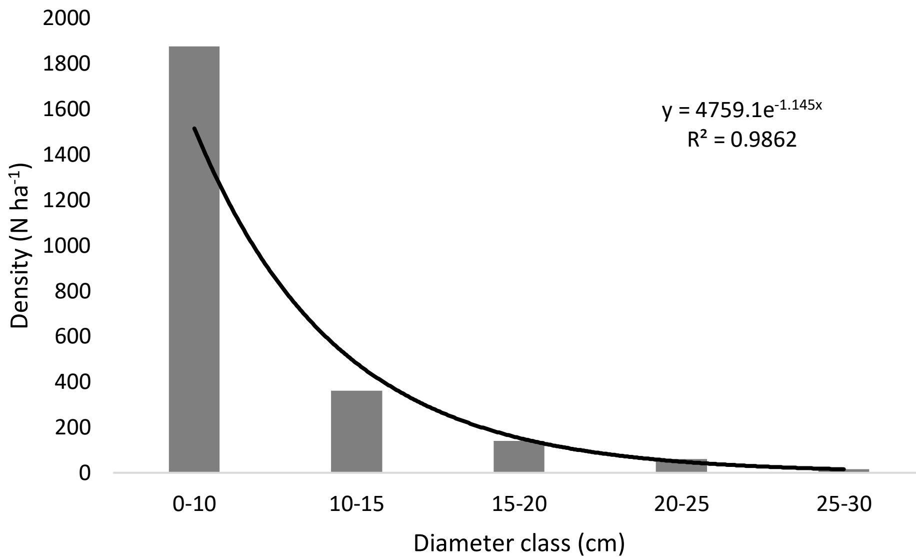


Figure 2. Density of individuals according to the diameter classes in the study area.

Helietta parvifolia had the highest Importance Value Index (Table 2); in addition, the same negative exponential trend was observed in the density of individuals, and for the 0-10 cm diameter class the highest value registered, was above 800 N ha^{-1} (Figure 3).

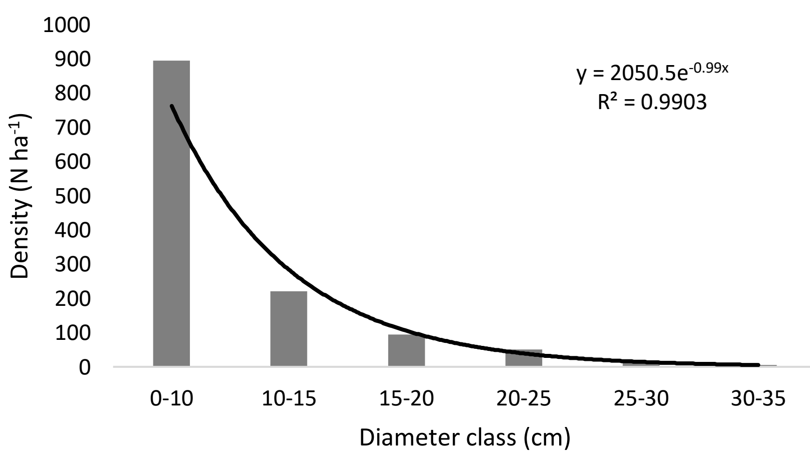


Figure 3. Density of individuals according to the diameter classes in the study area for *Helietta parvifolia* A. Gray.

The total height of the individuals varied between 2 and 12 m. The highest abundance of individuals corresponded to the 0 - 6 m height class, with 1 440 N ha^{-1}; in the higher height classes, a negative trend in the density of trees was observed as the height increased (Figure 4). Individuals with a height below or equal to 9 m amounted to 95 % of the total measured.

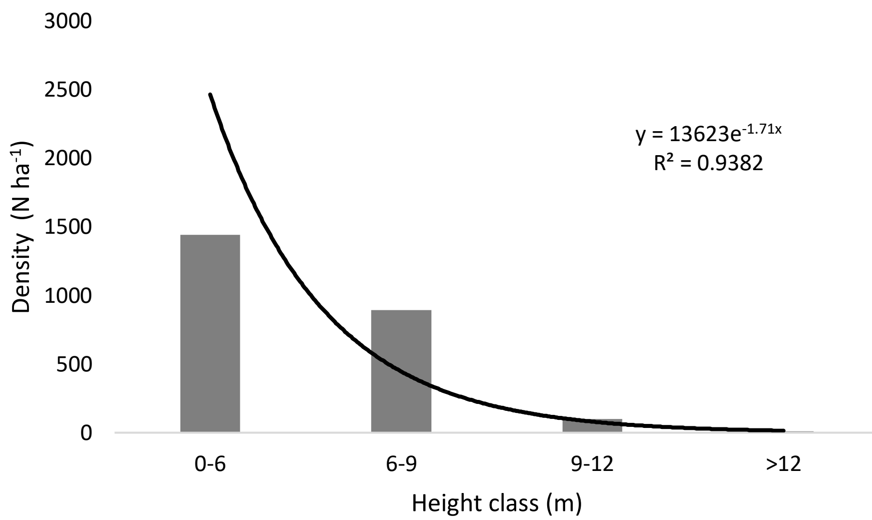


Figure 4. Density of individuals according to height classes.

In the plant community under study, Margalef index values of 1.45*,* Shannon index values of 1.47, and True Shannon Diversity index values of 4.34 were estimated. In relation to the Vertical Index of Species (*A*), a medium structural diversity was observed in the high strata, with a value of 2.16, an A_{max} of 3.40 and an A_{rel} of 63.72 %; in the third stratum, 62.8 % of the evaluated individuals were registered.

As for the analysis of vertical distribution between the high, medium and low strata, the high stratum was formed by *Helietta parvifolia* and *Havardia pallens*, with 40 and 10 N ha^{-1}, respectively, representing 2 % of the total. The middle stratum is made-up by *Helietta parvifolia, Havardia pallens, Juglans regia* L.*, Ebenopsis ebano, Acacia rigidula, Diospyros texana* Scheele and *Cordia boissieri*, with 535, 170, 25, 10, 25, 5, and 90 N ha^{-1}, respectively, *i.e.*, 35 % of the total in the study area (Table 3). *Helietta* *parvifolia, Cordia boissieri, Havardia pallens, Juglans regia, Diospyros texana, Ebenopsis ebano, Caesalpinia mexicana, Acacia rigidula*, and *Celtis pallida* Torr. were recorded in the low stratum, with 705, 245, 195, 190, 30, 100, 20, 10, 35, and 5 N ha^{-1}, respectively, amounting to 63 % of the counted individuals.

Table 3. Abundance values (N ha^{-1}), Vertical Pretzsch Index (*A*), A_{max} and A_{rel}. The three layers are shown: High (I), Medium (II) and Low (III) stratum.

Stratum	**Species**	**N**	Nha^{-1}	***Pretzsch* index**			**%**
				P_{i_j}	$\mathbf{Ln}P_{i_j}$	P_{i_j}*$\mathbf{Ln}P_{i_j}$	
I	*Helietta parvifolia* A. Gray	8	40	0.016	-4.112	-0.067	2
	Havardia pallens (Benth.) Britton & Rose	2	10	0.004	-5.499	-0.022	
	Total	10	50	0.020	-9.612	-0.089	
II	*Helietta parvifolia* A. Gray	107	535	0.218	-1.519	-0.332	35
	Havardia pallens (Benth.) Britton & Rose	34	170	0.069	-2.666	-0.185	
	Juglans regia L.	5	25	0.010	-4.582	-0.046	
	Ebenopsis ébano (Berland.) Barneby & J.W.Grimes	2	10	0.004	-5.499	-0.022	
	Acacia rigidula Benth	5	25	0.010	-4.582	-0.046	
	Diospyros texana Scheele	1	5	0.002	-6.192	-0.012	
	Cordia boissieri A. DC.	18	90	0.036	-3.301	-0.121	
	Total	172	860	0.351	-28.344	-0.768	
III	*Helietta parvifolia* A. Gray	141	705	0.288	-1.243	-0.358	63
	Cordia boissieri A. DC.	49	245	0.100	-2.300	-0.230	
	Havardia pallens (Benth.) Britton & Rose	39	195	0.079	-2.528	-0.201	
	Juglans regia L.	38	190	0.077	-2.554	-0.198	
	Diospyros texana Scheele	6	30	0.012	-4.400	-0.053	
	Ebenopsis ebano (Berland.) Barneby & J.W.Grimes	20	100	0.040	-3.196	-0.130	
	Caesalpinia mexicana A. Gray	4	20	0.008	-4.806	-0.039	
	Acacia greggii v	2	10	0.004	-5.499	-0.022	
	Acacia rigidula Benth	7	35	0.014	-4.246	-0.060	
	Celtis pallida Torr.	1	5	0.002	-6.192	-0.012	
	Total	307	1 535	0.627	-36.969	-1.309	
Total		489	2 445	1	-74.925	-2.166	100
					A	2.167	
					A_{max}	3.401	
					A_{rel}	63.723	

Discussion

The Fabaceae family was the best represented, a result that agrees with what has been observed in several researches carried out on both mature and regenerated submontane scrub plant communities (García-Hernández and Jurado, 2008; Canizales-Velázquez *et al*., 2009; Estrada-Castillón *et al*., 2012; Alanís-Rodríguez *et al*., 2015; Canizales-Velázquez *et al*., 2015; Mora-Olivo *et al*., 2016). This family is diverse and well represented in the different plant communities of northern Mexico, given their climatic affinity and the presence of different topographic and soil conditions of the region (Estrada *et al.,* 2005). The dominance of Fabaceae over other groups is due to their ability to fix nitrogen in the soil. This is because, in arid and semi-arid environments, nitrogen is the most limiting element of all soil nutrients required for plant development and growth, as well as an essential element for microbial growth and for the degradation of organic matter (Ferrara and Alarcón, 2001; Celaya-Michel and Castellanos-Villegas, 2011).

Helietta parvifolia exhibited the highest Importance Value Index (*IVI*), with 42.66 %. This species is also recorded by García-Hernández and Jurado (2008) with the highest *IVI* (25 %) in a shrub located in *Linares, Nuevo León*, Mexico; *H. parvifolia*, together with *Cordia boissieri*, *Havardia pallens*, *Acacia rigidula*, *Diospyros texana*, and *Celtis pallida* made up 79.41 % of the Value of Importance of that community. This pattern of composition and dominance strengthens the observation of Foroughbakhch and Ngangyo (2017), who suggest that a community dominated by the above species is, from a structural point of view, a high thornscrub.

Estrada-Castillón *et al*. (2012) indicate that, among the xerophilous scrubs, the submontane scrub exhibits different physiognomic characteristics that divide it into high, medium and low; the first includes the association dominated by *H. parvifolia*. Meléndez-Jaramillo *et al.* (2019) indicate that *H. parvifolia* is one of the species with the greatest presence in the submontane scrub of northeastern Mexico that is located at an altitudinal range of 500 to 800 m.

Most individuals of *Helietta parvifolia* were found in the smaller diameter categories; of these, 0-10 cm concentrated the largest number of individuals, and a minority of individuals exceeded 15 cm in diameter. In the height classes, the corresponding 0 - 6 m included the largest number of individuals, and the smallest number occurred in the class above 12 m. This agrees with the observations of the study in southeastern *Nuevo León* by Foroughbakhch *et al.* (2003), who recorded individuals with a diameter equal to or below 15 cm and heights ranging between 3 and 12 m. These findings agree with the vertical characterization of the submontane scrub, where *Helietta parvifolia* reached a maximum height of 6 m, as reported by García-Hernández and Jurado (2008).

The presence in the community under study of a high number of individuals (1 800 N ha^{-1}) belonging to the diameter class of 0 - 10 cm suggests the existence of an active regenerative community, composed mainly of saplings and young trees. Of this regenerative community, 47.7 % of them belonged to *H. parvifolia*, which had the highest Importance Value Index, was dominant in the upper stratum, and contributed more than 83 % of the individuals in the diameter classes over 20 cm.

H. parvifolia is a slow-growing, high-density wood taxon (Foroughbakhch *et al.*, 2011), whose seeds have dormancy as well as independence from direct light for germination (Jurado *et al*., 2000, 2001). All these characteristics indicate that *H. parvifolia* is long-lived and has some tolerance to shade, which explains its dominance in the regenerative community under the canopy of this mature plant community. The observation is in line with that made by García-Hernández and Jurado (2008), in the sense that *H. parvifolia* is part of a mature or undisturbed vegetation.

Furthermore, the dominance of *H. parvifolia* in this study also suggests a relationship with at least two other factors: the allelopathic characteristics of *H. parvifolia* (Graue, 1981) —a product of the alkaloid-type substances in its leaves (coumarins of the furan-quinoline type) that can inhibit the germination and growth of those plants that come into contact with them (Graue, 1981; Gómez-Calvario *et al.*, 2019)— and the history of land use in the site, which has no record of disturbances, previous clearings due to forestry activities, or exploitation of timber species like *H. parvifolia*, and has only been used for the collection of edible fruits and woody material from the ground.

Both the lower importance value indexes of the taxa typical of the first years of bush recovery (pioneers and long-lived pioneers such as *Celtis pallida*, *Acacia greggi*, *Acacia rigidula*) and the higher importance values of species with characteristics of mature vegetation organisms (increased life spectrum and greater tolerance to shade, such as *Cordia boissieri*, *H. parvifolia*) coincide with the site land-use history information, which suggests a mature scrub, as well as with the observations made by García-Hernández and Jurado (2008) regarding the composition of the bushes under pristine conditions.

The evaluated area had Margalef index values of 1.45 and Shannon index values of 1.47. The former is similar to other scrublands in northeastern Mexico; for example, the Tamaulipan thornscrub (Pequeño-Ledezma *et al*., 2012; Jiménez *et al.,* 2012, Mora *et al.,* 2013a), but lower than that cited by Alanís-Rodríguez *et al.* (2015): D_{Mg} = 6.02; and that of Canizales-Velázquez (2009): D_{Mg} = 6.02. The Shannon entropy index is low compared to the Tamaulipan thornscrub (Pequeño Ledezma *et al*., 2012; Jiménez *et al.,* 2012, Mora *et al.* 2013b); lower than that indicated by Alanís-Rodríguez *et al*. (2015), D_{Mg} = 3.02 and Canizales-Velázquez (2009), D_{Mg} = 3.00. These differences are attributable to the fact that Alanís-Rodríguez *et al.* (2015) and Canizales-Velázquez (2009) evaluated submontane scrublands at higher altitudes and recorded a high number of species typical of *Quercus* forests.

The Vertical Index of Species (*A*) was 2.16, with an A_{max} of 3.40 and an A_{rel} of 63.7 %, signifying an average structural diversity in the altitude strata. A_{rel} values close to 100 % indicate that all species are equally distributed in the three height strata (Pretzsch, 2009). These results are similar to those obtained in researches developed in thornscrub communities, by Jiménez *et al.* (2009), Mora-Donjuán *et al.* (2014), and Pequeño Ledezma *et al*. (2012), who obtained an A_{max} of 4.56, 3.08 and 2.2, and an A_{rel} of 67.1 %, 53.8 % and 63.7 %, respectively. The Vertical Index (*A*) has not been estimated for other submontane scrublands. Based on the estimated value of *A*, it may be said that the vegetal communities of the Tamaulipan thornscrub and the submontane scrubs show similarity in relation to the Vertical Index of Species. They both exhibit a well-defined vertical structure, where strata II and III (medium and low), which concentrate the largest amount of species and abundances (N ha^{-1}), are the most prominent.

Conclusions

The studied community exhibits similar values of species richness and diversity in comparison with other plant associations of arid and semi-arid climate in Northeast Mexico. Diameter and height class graphs for the plant community and, specifically, for *Helietta parvifolia* show an inverted jack, which indicates the existence of an active regenerative community, composed mainly of saplings and young trees. The most important family, due to its contribution to the community, is Fabaceae; and the most important species are *Helietta parvifolia*, *Cordia boissieri*, and *Havardia pallens*.

Conflict of interests

The authors declare that no conflict of interests.

Contribution by author

Miguel Ángel Pequeño Ledezma and Eduardo Alanís Rodríguez: research design, data analysis and drafting of the manuscript; Víctor M. Molina Guerra: coordination and execution of field activities, drafting and review of the manuscript; Alejandro Collantes-Chávez-Costa: capture, data analysis and review of the manuscript; Arturo Mora-Olivo: species identification, drafting and review of the manuscript.

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