Differences in vegetation structure and diversity of a forest in an altitudinal gradient of the Sierra La Laguna Biosphere Reserve, Mexico

Jesús Manuel Rascón-Ayala[1], Eduardo Alanís-Rodríguez[1]*, Arturo Mora-Olivo[2], Enrique Buendía-Rodríguez[3], Laura Sánchez-Castillo[1], and Jesús Eduardo Silva-García[1]

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Abstract

Background: The Sierra La Laguna Biosphere Reserve is located which is considered an "island of vegetation" within an arid environment. Considering that this protected natural area has an altitudinal gradient that ranges from 500 to 2,100 meters above sea level.

Hypothesis: Higher altitudinal gradient decreases abundance, basal area and diversity of plant species.

Studied species and data description: The data analyzed in this study included the structural variables of abundance (N ha^{-1}), basal area (m^2 ha^{-1}) and diversity (alfa and beta) of arborous species in areas with different elevations.

Study site and dates: This study was carried out in four localities of the tropical deciduous forest and broadleaved forest. In the spring of 2016.

Methods: Five circular sampling plots of 500 m^2 for arborous vegetation and 1m^2 for herbaceous vegetation were established in every vegetation community, resulting in 20 sampling plots.

Results: Sixteen families, 22 genera and 22 vascular plant species were recorded. The most diverse family was Fabacea with four species followed by Cactaceae with three species. The abundance, dominance and diversity of vegetation species did not show any decrease (or increase) tendency of values as the altitudinal gradient augmented.

Conclusions: The hypothesis is rejected because abundance, dominance and diversity of vegetation species do not show any decrease or increase tendency as the altitudinal gradient augmented. The vegetation communities showed a high similarity in the composition of species.

Key words: Altitudinal gradient, Baja California, diversity, species richness, vegetation structure.

Resumen

Antecedentes: La Reserva de la Biosfera Sierra la Laguna se encuentra en lo que es considerado una "isla de vegetación" dentro de un ambiente árido. Considerando que esta área natural protegida tiene un rango altitudinal que va desde los 500 a 2,100 metros sobre el nivel del mar.

Hipótesis: A mayor gradiente altitudinal disminuye la abundancia, área basal y diversidad de las especies vegetales.

Especies de estudio y descripción de datos: La información analizada en este estudio incluyó las variables estructurales de abundancia (N ha^{-1}), el área basal (m^2 ha^{-1}) y diversidad (alfa y beta) de especies arbóreas en áreas con diferentes elevaciones.

Sitio de estudio y año de estudio: Este estudio fue realizado en cuatro comunidades de selva baja caducifolia y bosque de latifoliadas. En la primavera de 2016.

Métodos: Cinco parcelas circulares de 500 m^2 para vegetación arbórea y 1m^2 para vegetacion herbácea fueron establecidas en cada comunidad vegetal, resultado en 20 parcelas de muestreo.

Resultados: Dieciséis familias, 22 géneros y 22 especies de plantas vasculares fueron registradas. La familia más diversa fue Fabacea con cuatro especies, seguido de Cactaceae con tres especies. La abundancia, dominancia y diversidad de especies vegetales no mostró una tendencia decreciente (o incremento) conforme el gradiente altitudinal aumentó.

Conclusiones: La hipótesis fue rechazada debido a que la abundancia, dominancia y diversidad de especies vegetales no mostró ninguna tendencia decreciente (o incremento) en los valores conforme el gradiente altitudinal aumenta. Las comunidades vegetales mostraron una alta similitud en la composición de especies.

Palabras clave: Baja California, diversidad, estructura vegetal, gradiente altitudinal, riqueza de especies.

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[1] Universidad Autónoma de Nuevo León, Facultad de Ciencias Forestales, Linares, Nuevo León, México.
[2] Universidad Autónoma de Tamaulipas, Instituto de Ecología Aplicada, Ciudad Victoria, Tamaulipas, México.
[3] Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias, Campo Experimental Valle de México, Texcoco, Estado de México, México.
* Corresponding author: eduardo.alanisrd@uanl.edu.mx

Ecological studies that describe the variation of both structure and floristic composition along an altitudinal gradient are common in mountainous areas of many parts of the world (Vetaas & Grytnes 2002, Gould *et al*. 2006, Alves *et al*. 2010). Although in Mexico these studies are not abundant, some have been carried out, such as: Sierra de Catorce in San Luis Potosi (Granados-Sánchez & Sánchez-González 2003) and Sierra Nevada in Mexico state (Sánchez-González & López-Mata 2003). However, in Northwest Mexico, particularly Baja California the information is scarce.

The Baja California Peninsula includes mountainous massifs throughout its territory, the southern part known, as the Cabo Region is perhaps the most interesting due to its floristic, biogeographic and evolutionary characteristics (Wiggins 1980, León de la Luz & Domínguez-Cadena 1989). In this area is located the Sierra La Laguna, which is considered an "island of vegetation" within the environment characterized by arid areas (Padilla *et al*. 1988). The biophysical characteristics of this mountain area justified the creation of the Sierra La Laguna Biosphere Reserve in 1994 (CONANP, 2003).

The Sierra La Laguna includes six main vegetation types (sarcocaule and sarcocrasicaule scrub, deciduous and semi deciduous lowland rainforest, oak forest, pine-oak forest, gallery forest and natural grassland), although the mesic and tropical communities are considered of greater relevance (Arriaga & León-de la Luz 1989, CONANP 2003). From a floristic point of view, this reserve has been well studied since 1892, registering more than 900 species of vascular plants of which, about 89 are endemic (León-de la Luz & Domínguez-Cadena 1989, León de la Luz *et al*. 1999, CONANP 2003, León-de la Luz & Breceda 2005). However, ecological studies of vegetation have not been abundant and are restricted usually to conservation and phytogeographic studies (León-de la Luz *et al*. 2000, León-de la Luz & Breceda 2005).

Considering that this protected natural area has an altitudinal gradient that ranges from 500 to 2,100 meters above sea level (CONANP 2003) and that until now, the vegetation communities with these specific characteristics have not been compared, this study was proposed. The objective of this study was to evaluate the structural variables of abundance ($N\ ha^{-1}$), basal area ($m^2\ ha^{-1}$) and diversity (alfa and beta) of arboreous species in areas with different elevations in the Sierra La Laguna Biosphere Reserve. The results of this study are expected to confirm the hypothesis that establishes that higher altitudinal gradient decreases abundance, basal area and diversity of plant species.

Materials and methods

Study area. This study was carried out in four localities (Las Tinajas, El Portezuelo, Agua Blanca and El Parteaguas) of the tropical deciduous forest and broadleaved forest of the Sierra La Laguna Biosphere Reserve in the municipalities of La Paz and Los Cabos, Baja California Sur (Northwest Mexico; Figure 1). The study area is located on 23º 24’ 11.63’’ N and 110º 4’ 49.54’’ W. Table 1 shows some physical and climatic variables as a description of the studied areas.

Sampling method. In the spring of 2016, five circular sampling plots of 500 m^2 for arboreous vegetation and 1.0 m^2 for herbaceous vegetation were established in every vegetation community, resulting in 20 sampling plots. A distance of 50 meters between sampling plots on each vegetation community was established in order to avoid differences on physical and climatic characteristics. Individuals with diameters higher than 7.5 cm and heights above 1.30 m, were considered arboreous. The diameter and taxonomical information of each specimen was obtained.

Data analysis. In order to evaluate the importance of the species using the information obtained from the sample plots, the Importance Value Index (IVI) was calculated. The Importance Value Index defines which species contributes to the characteristics and structure of the ecosystem (Cottam & Curtis 1956), and is calculated as showed in Formula 1. Where, Relative Abundance (A_{rel}) that is, the percentage of number of individuals of each species in relation to the total number of individuals of all species per 100; Relative dominance (D_{rel}) that is, the percentage

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Jesús Manuel Rascón-Ayala: Fieldwork, Framing experimental design. Eduardo Alanís-Rodríguez: Data analysis and interpretation. Enrique Buendía- Rodríguez: Fieldwork, Data analysis. Arturo Mora-Olivo: Identification of specimens. Laura Sanchez-Castillo: Manuscript translation. Jesús Eduardo Silva-García: Manuscript preparation. All authors wrote and approved the final manuscript.

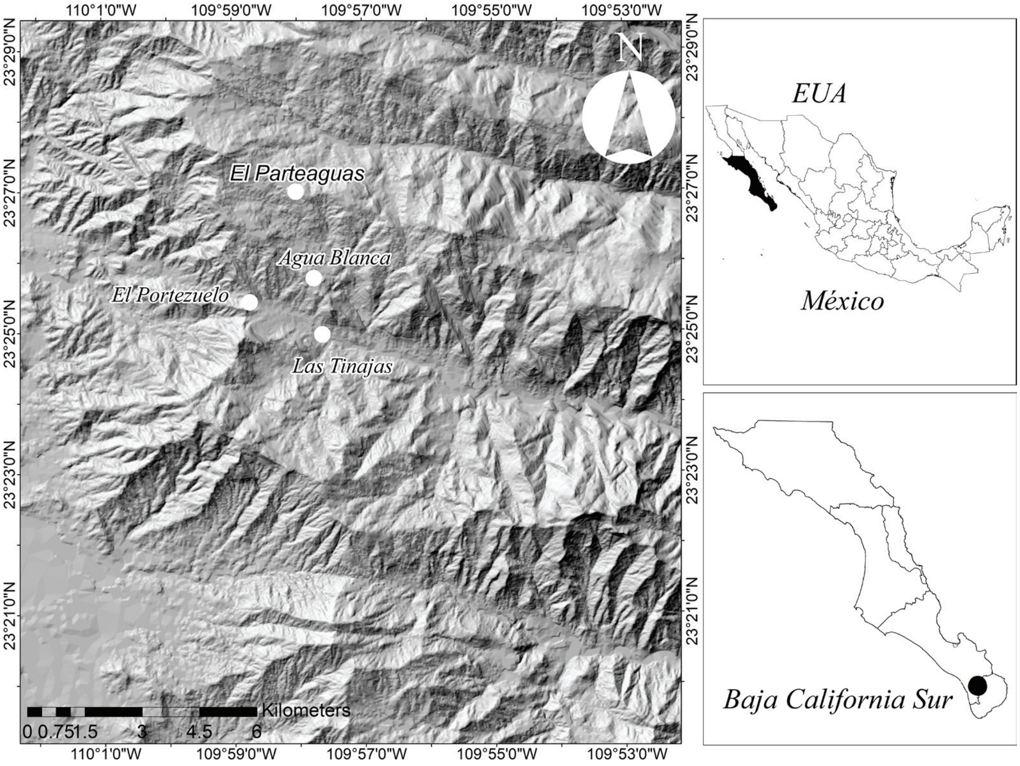

Figure 1. Study area (Left side: the four localities studied; Upper-right: Northwest Mexico; Lower-right: Baja California Sur, Mexico.

of basal area of a species between the basal area of all the species in the sampling plot per 100, and Relative Frequency (F_{rel}) that is, the percentage of subplots in which the species appears in relation with the frequency of all species per 100 (Dombois & Ellenberg 1974, Mostacedo & Fredericksen 2000).

$$IVI = (A_{rel} + D_{rel} + F_{rel}) / 3 \tag{1}$$

Table 1. Physical and climatic characteristics of the areas.

Locality	Las Tinajas	El Portezuelo	Agua Blanca	El Parteaguas
Altitudinal Gradient	I	II	III	IV
Vegetation	Tropicaldeciduous forest	Tropicaldeciduous forest	Broadleaved forest	Broadleaved forest
Abbreviation	SBC	SBC	BL	BL
Coordinates	23° 24′ 50.8′′ N 109°57′27.2′′W	23° 25′ 26.3′′ N 109°58′48.0′′W	23° 25′ 52.5′′ N 109° 57′ 36.3′′W	23° 27′ 01.8′′N 109° 58′ 05.1′′ W
Altitude (m a.s.l.)	508	1,032	1,092	1,521
Average annual temperature (°C)	27 to 31	18 to 25	16 to 22	12 to 18
Average annual rainfall (mm)	75 to 150	200 to 300	200 to 300	300 to 400
Soil type	Vertisol	Regosol, Vertisol	Regosol, Vertisol	Regosol

To evaluate the alpha diversity the Index of Shannon-Weaver (*H'*) was used. This Index considers that individuals are shown randomly from an infinitely large population and assumes that all species are represented in the sample (Shannon & Weaver 1949; Magurran 1988).

$$H' = -\sum_{i}^{S} p_i \times ln(p_i) \qquad (2)$$

where S is the number of species; p_i is the proportion of the species and $p_i = n_i/N$; n_i is the number of individuals of the species i and N the total number of individuals.

To calculate the species richness in the study area, the Margalef index (D_{Mg}) (Margalef 1958) was used, which is the simplest way to measure biodiversity (Moreno 2001). Particularly, this index is one of the most used and is defined as follows:

$$D_{Mg} = \frac{(S-1)}{ln(N)} \qquad (3)$$

where S is the number of species and N is the total number of individuals.

Statistical tests were carried out to verify that all the assumptions of the residuals were fulfilled, normality test by means of Shapiro-Wilk and the homogeneity of variances by the Levene test, both with a degree of significance ($p < 0.05$). After the assumptions were fulfilled, an analysis of variance (ANOVA) of a single factor (Altitude) for Shannon-Weaver index, Specific Richness, Abundance and Dominance was performed. The Duncan test was used to determine if there were significant differences ($p < 0.05$) of the variables analyzed by altitude group. Tests were performed using the IBM© SPSS© Statistic version 19 (Zar 2010).

To evaluate the beta diversity, a Bray-Curtis ordering model was generated using BioDiversity Pro 2.0 (McAleece *et al*. 1997); this model is a graphic representation of the variation of plant composition (0-100 %) in an extent of distance (Beals 1984). The Bray-Curtis ordering model is the most appropriate when a multivariate phytosociological analysis is needed.

Results

Sixteen families, 22 genera and 22 vascular plant species were recorded (Appendix 1). The most diverse family was Fabaceae with four species, followed by Cactaceae with three species.

Abundance. The most abundant species in the altitudinal gradients were shrubs, agaves and cacti. In the altitudinal gradient I (altitude 508 m a.s.l.), the most abundant species were *Mimosa xanti* (300 N ha^{-1}), *Ruellia californica* (300 N ha^{-1}) and *Jatropha cinerea* (240 N ha^{-1}). In the altitudinal gradient II (altitude 1032 m a.s.l.) were *Agave promontorii* (360 N ha^{-1}), *Lysiloma divaricatum* (240 N ha^{-1}) and *Ruellia californica* (210 N ha^{-1}). In the altitudinal gradient III (altitude 1092 m a.s.l.) *Tecoma stans* (540 N ha^{-1}), *Dodonaea viscosa* (490 N ha^{-1}) and *Lysiloma divaricatum* (440 N ha^{-1}). In the altitudinal gradient IV (altitude 1,521 m a.s.l.) *Ruellia californica* (256 N ha^{-1}), *Turnera diffusa* (253 N ha^{-1}) and *Jatropha cinerea* (250 N ha^{-1}). From the three most abundant species in each altitudinal gradient, the altitude one and four share *Ruellia californica* and the altitude II and III share *Lysiloma divaricatum*.

Dominance: The arboreal *Quercus tuberculata* was the most dominant species in the altitudinal gradients I, III and IV and the second in gradient II. The space occupied by this species ranged from 4.5 m^2 ha^{-1} (altitudinal gradient I) to 22.3 m^2 ha^{-1} (altitudinal gradient III). The second most dominant species in the altitudinal gradient one and four is *Bursera microphylla*. The space occupied by this species ranged from 3.4 m^2 ha^{-1} (altitudinal gradient I) to 4.3 m^2 ha^{-1} (altitudinal gradient IV).

Frequency: In altitudinal gradients II, III and IV, the most frequent species were *Mimosa xanti* with 13.8 %, 17.1 % and 17.3 % respectively. In altitudinal gradient I the most frequent species were *Bursera microphylla* (14.7%), *Jatroha cinerea* (13.9 %) and *Quercus tuberculate* (13.9 %).

Importance value index (IVI): The species with the highest value of IVI in the altitudinal gradient I were: *Mimosa xanti* (13.6 %), *Ruellia californica* (13.6 %) and *Jatropha cinerea* (10.9 %). In the altitudinal gradient II: *Agave promontorii* (18.9%), *Lysiloma divaricatum* (12.8 %) and *Ruellia californica* (11.0 %). In the III: *Tecoma stans* (16.8 %), *Dodonaea viscosa* (15.3 %) and *Lysiloma divaricatum* (13.9 %). In the IV: *Ruellia californica* (11.2 %), *Jatropha cinerea* (11.1 %) and *Brahea brandegeei* (11.0 %). The three species with higher IVI and abundance in each altitudinal gradient, gradient I and IV share *Jatropha cinerea*, and gradient II and III share *Lysiloma divaricatum* (Table 2).

Table 2. Abundance (N ha^{-1}), dominance (m^2 ha^{-1}), frequency (Freq ha^{-1}) and Importance Value Index by altitudinal gradient (Species data is arranged in decreasing order according with IVI values).

Species	Abundance		Dominance		Frequency		IVI
	Abs	Rel	Abs	Rel	Abs	Rel	Rel
	N ha^{-1}	%	m^2 ha^{-1}	%	Freq ha^{-1}	%	%
Altitudinal gradient I (508 m a.s.l.)							
Mimosa xanti	300	13.8	0.2	1	0.3	6.9	13.6
Ruellia californica	300	13.8	0.2	0.9	0.2	3.5	13.6
Jatropha cinerea	240	11	0.3	1.4	0.6	13.9	10.9
Lysiloma divaricatum	176	8.1	2.9	13.1	0.2	4.6	8.1
Quercus tuberculata	170	7.8	4.5	20.5	0.6	13.9	7.9
Viguiera deltoidea	170	7.8	2	9.2	0.2	4.6	7.8
Stenocereus thurberi	160	7.3	2.4	10.7	0.4	9.3	7.4
Karwinskia humboldtiana	140	6.4	0.2	1	0.4	9.3	6.4
Randia capitata	120	5.5	0.3	1.1	0.3	7.7	5.5
Bursera microphylla	113	5.2	3.4	15.6	0.6	14.7	5.3
Agave promontorii	110	5	1.5	6.8	0.2	4.6	5.1
Brahea brandegeei	100	4.6	3.1	13.8	0.1	2.3	4.7
Opuntia lagunae	80	3.7	1	4.7	0.2	4.6	3.7
Subtotal	**2179**	**100**	**22.2**	**100**	**4.3**	**100**	**100**
Altitudinal gradient II (1,032 m a.s.l.)							
Agave promontorii	360	19.2	0	0	0.2	3.9	18.9
Lysiloma microphyllum	240	12.8	3.4	13.1	0.4	6.9	12.8
Ruellia californica	210	11.2	0	0	0.2	3.9	11
Mimosa xantii	160	8.5	1.2	4.4	0.7	13.8	8.5
Tecoma stans	115	6.1	0.6	2.1	0.3	4.9	6.1
Jatropha cinerea	110	5.9	0.3	1.1	0.4	8.4	5.8
Randia megacarpa	110	5.9	0.2	0.6	0.4	8.6	5.8
Quercus tuberculata	100	5.3	6.3	24.2	0.6	11.8	5.6
Viguieria deltoidea	100	5.3	0.6	2.3	0.2	3.9	5.3
Bursera microphylla	80	4.3	1.9	7.3	0.6	11.8	4.3
Pachycereus pringlei	80	4.3	1.3	5.1	0.1	2	4.3
Stenocereus thurberi	53	2.8	0.7	2.8	0.4	7.9	2.9
Opuntia laguneae	47	2.5	0.2	0.6	0.2	3.9	2.5
Yucca valida	40	2.1	7.2	27.5	0.1	1	2.5

Table 2. Continuation.

Species	Abundance		Dominance		Frequency		IVI
	Abs	Rel	Abs	Rel	Abs	Rel	Rel
	N ha^{-1}	%	m^2 ha^{-1}	%	Freq ha^{-1}	%	%
Karwinskia humboldtiana	30	1.6	0.7	2.6	0.3	5.4	1.6
Erythrina flabelliformis	20	1.1	1.6	6.2	0.1	1	1.1
Lippia palmeri	20	1.1	0	0.1	0.1	1	1.1
Subtotal	**1875**	**100**	**26.1**	**100**	**5.1**	**100**	**100**
Altitudinal gradient III (1,092 m a.s.l.)							
Tecoma stans	540	17.1	0.8	1.5	0.3	6.1	16.8
Dodonaea viscosa	490	15.5	0.6	1.2	0.4	8.5	15.3
Lysiloma divaricatum	440	13.9	7.1	13.3	0.4	8.5	13.9
Ruellia californica	370	11.7	0.3	0.5	0.2	4.9	11.5
Stenocereus thurberi	360	11.4	7	13.1	0.4	9.8	11.4
Quercus tuberculata	250	7.9	22.2	41.4	0.6	14.6	8.5
Jatropha cinerea	240	7.6	0.3	0.6	0.5	12.2	7.5
Mimosa xanti	230	7.3	5.9	10.9	0.7	17.1	7.4
Bursera microphylla	160	5.1	2.6	4.9	0.6	14.6	5.1
Senna atomaria	40	1.3	5.6	10.4	0.1	1.2	1.4
Pachycereus pringlei	40	1.3	1.1	2.1	0.1	2.4	1.3
Subtotal	**3160**	**100**	**53.6**	**100**	**4.1**	**100**	**100**
Altitudinal gradient IV (1,521 m a.s.l.)							
Ruellia californica	256	11.3	0.1	0.8	0.2	4.9	11.2
Turnera diffusa	253	11.2	0	0	0.2	3.7	11.1
Jatropha cinerea	250	11.1	0.3	1.3	0.4	9.9	11
Dodonaea viscosa	207	9.2	0.1	0.6	0.4	8.6	9.1
Quercus tuberculata	190	8.4	7.8	40.1	0.6	14.8	8.7
Mimosa xanti	192	8.5	0.2	0.9	0.7	17.3	8.5
Bursera microphylla	180	8	4.3	22.3	0.6	14.8	8.1
Merremia aurea	150	6.6	2.2	11.4	0.1	2.5	6.7
Randia capitata	140	6.2	0.3	1.7	0.2	4.9	6.2
Viguiera deltoidea	140	6.2	0.2	1	0.2	4.9	6.2
Agave promontorii	140	6.2	0	0	0.2	4.9	6.1
Brahea brandegeei	80	3.5	2.5	12.8	0.1	2.5	3.6
Stenocereus thurberi	80	3.5	1.4	7	0.3	6.2	3.6
Subtotal	**2258**	**100**	**19.4**	**100**	**4.1**	100	100

The values of the Shannon-Weaver index, Margalef index, abundance and dominance showed significant differences in the altitudinal gradients ($p < 0.05$), not showing any tendency of decrease or increase of the values as the altitudinal gradient increased. The altitudinal gradient III presented the lowest values of Shannon-Weaver and Margalef index values and the highest values of abundance and dominance (Figure 2).

The values of the Shannon index showed average values that range between 1.37 ± 0.17 and 1.83 ± 0.15 (± standard deviation). The values of the Margalef Index were between 0.89 ± 0.27

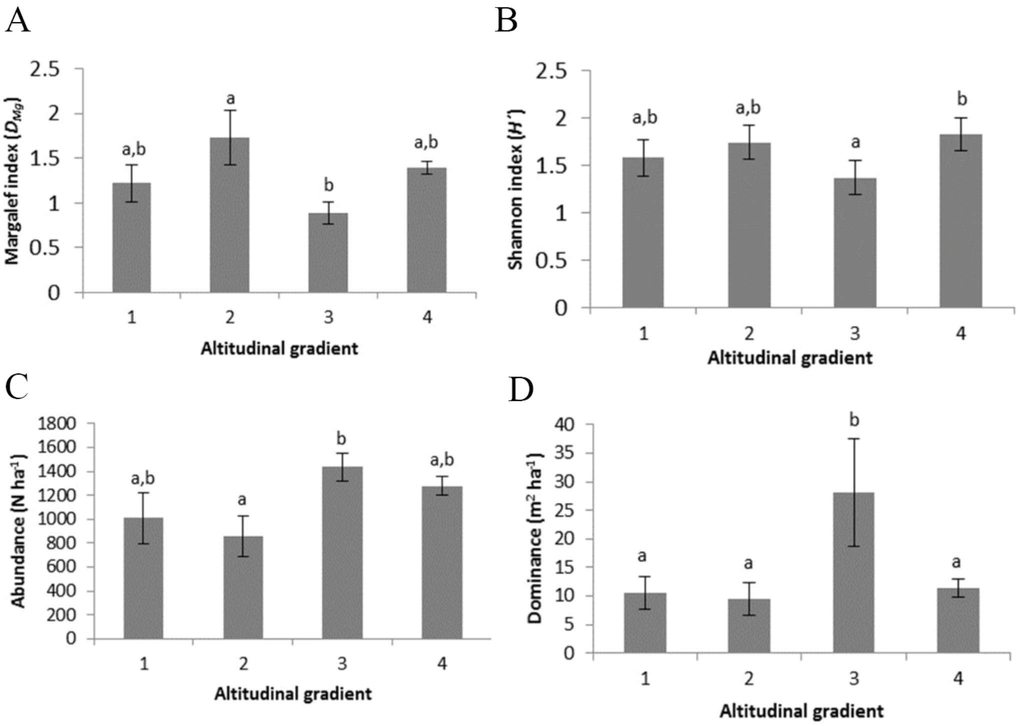

Figure 2. Means and standard error of A) Margalef index, B) Shannon index, C) Abundance and D) Dominance for plant communities in the altitudinal gradients. Altitudinal gradient 1: 508 m a.s.l., 2: 1,032 m a.s.l., 3: 1,092 m a.s.l. and 4: 1,521 m a.s.l. Means followed by different letters (a and b) indicate different levels of significance for $p < 0.05$.

and 1.73 ± 0.70. The abundance showed values from 856 ± 375 N ha^{-1} to 1436 ± 255 N ha^{-1} and the dominance of 9.57 ± 6.4 to 28.1 ± 21.04 (Figure 2).

The dendrogram of plant communities depending on altitudinal ranges can be observed in Figure 3. In general, a high similarity is present among communities. In the first group (that joins the other two) exists a 55 % of similarity, the gradient III and IV have a similarity of 60 %

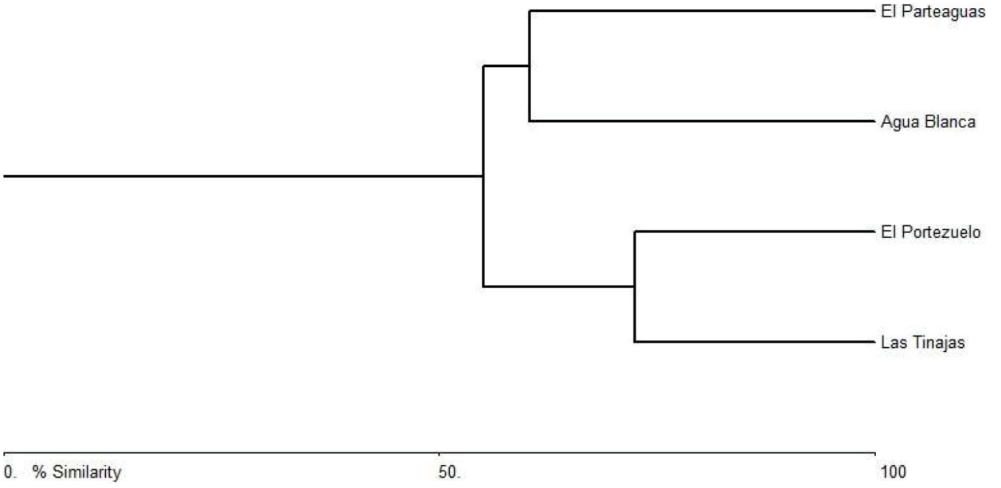

Figure 3. Dendrogram of similarity between the different altitudinal ranges based on the Bray-Curtis analysis. Las Tinajas altitudinal gradient (508 m a.s.l.), El Portezuelo (1,032 m a.s.l.), Agua Blanca (1,092 m a.s.l.) and El Parteaguas (1,521 m a.s.l.).

and I and II of 72 %. This analysis indicates that plant communities have a high number of species in common, which could be considered generalist, since they have the capacity to develop in a wide range of environmental conditions (Figure 3).

Discussion

Species richness-elevation relationships have received considerable attention during the last two decades, as a response to the major challenge of documentation and explanation of global and regional gradients of species richness (Kessler *et al*. 2011, Trigas *et al*. 2013). Most studies indicate that vascular plants show a decrease in species richness as elevation increases, either in a hump-shaped or monotonically (Bachman *et al*. 2004, Wang *et al*. 2007).

Climatic factors play an important role in the distribution of plant communities (Rüdiger *et al*. 2001). In dry regions, the floristic composition and the structure of the vegetation are determined mainly by water availability, so it is assumed that this is the main limiting factor in these regions (Paruelo *et al*. 2000, Tateno *et al*. 2017). The availability of water is directly related not only to the annual rainfall, but also to factors such as topography and soil characteristics since they play an important role (Reynolds *et al*. 2000, Tateno *et al*. 2017). Altitude represents a complex combination of climatic variables to which the species have to adapt and is considered an environmental factor that affects the structure and organization of the communities (Pavón *et al*. 2000, Rüdiger *et al*. 2001). The variables of average annual temperature and total annual precipitation are significantly correlated with altitude (Wang *et al*. 2015).

The results obtained indicated that in Sierra de la Laguna, different plant communities can be recognized physiognomically along the altitudinal gradient, which had already been mentioned in the Management Program of National Protected Areas (CONANP, 2003). Five species (*Erythrina flabelliformis, Lippia palmeri, Senna atomaria, Turnera difusa* and *Yucca valida*) that are distributed only in a single altitudinal gradient were recorded and all of them have low importance value index values. In contrast, there are five species (*Ruellia californica, Jatropha cinerea, Quercus tuberculata, Mimosa xanti* and *Bursera microphylla*) with presence in all altitudinal gradients and have intermediate or high values of importance value index. Arriaga and León (1989) also recorded *Jatropha cinerea* and *Bursera microphylla* as species with high density and coverage in lowland rainforest of Baja California.

Because there is a high number of species in all studied communities and all showed high abundance values, there is a high similarity between the composition of species in the communities (≥ 55 % in all cases), which could be considered generalist, since they have the capacity to develop in a wide range of environmental conditions.

The topographic pattern of "Sierra La Laguna" have different characteristics, in higher altitude parts there are very steep slopes, in intermediate altitude sites slopes are less inclined and the lower altitudes are constituted of expositions with scarce slopes because are located at sea level. The topographical variation (longitude, form and inclination of slope) is attributed to humidity distribution so that higher parts retain less humidity. The Föhn effect that is characterized by an increase in evaporation rate and a decrease in relative humidity is an important factor in the physiognomy and distribution of plant communities, since it affects considerably the availability of water and temperature (Zhao *et al*., 2018). The rainfall is other important factor because occurs in very low amounts, which influences the development of vegetation.

In this study, the values of Shannon-Weaver Index and Margalef Index showed significant differences in the altitudinal gradients but did not show any increasing or decreasing tendency of values as the altitudinal gradient increased. This information is different from the results of numerous authors that reported a decreasing of species and diversity richness as the altitudinal gradient increases (Vetaas & Grytnes 2002, Gould *et al*. 2006). An explanation of why in our study there no trends of declining values as altitude are increased, can be related to temperature and precipitation influences. Table 1 illustrates the average values of the temperature and indicate that even the maximum altitude (1,521 m a.s.l.) show values above the freezing point, which gives the environmental conditions to develop a high variety of species. In addition, all altitudinal gradients are arid (precipitation less than 400 mm), which led to the conditions for establishing this generalist species adapted to arid zones.

In accordance to the results of this research, the hypothesis is rejected because abundance, dominance and diversity of vegetation species do not show any decrease (or increase) tendency of values as the altitudinal gradient augmented. The vegetation communities showed a high similarity in the composition of species (≥ 55 %), because *Ruellia californica, Jatropha cinerea, Quercus tuberculata, Mimosa xanti* and *Bursera microphylla* are dominant species and are distributed in all altitudinal gradients.

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Appendix 1. Study Area floristic inventory including common names.

ACANTHACEAE	Spanish common name
Ruellia californica (Rose) I.M. Johnst.	“Rama prieta”
ASPARAGACEAE	
Agave promontorii Trel.	“Maguey”
Yucca valida Brandegee	“Datilillo”
ARECACEAE	
Brahea brandegeei (Purpus) H.E. Moore	“Palma”
ASTERACEAE	
Viguiera deltoidea A. Gray	“Tacote”
BIGNONIACEAE	
Tecoma stans (L.) Kunth	“Palo de arco”
BURSERACEAE	
Bursera microphylla A. Gray	“Torote colorado”
CACTACEAE	
Opuntia lagunae Baxter in Bravo	“Nopal tuna roja”
Pachycereus pringlei Britton & Rose	“Cardón”
Stenocereus thurberi (Engelm.) Buxb.	“Pitaya dulce”
CONVOLVULACEAE	
Merremia aurea (Kellogg) O'Donell	“Yuca”
EUPHORBIACEAE	
Jatropha cinerea Müll. Arg.	“Lomboy blanco”
FABACEAE	
Erythrina flabelliformis Kearney	“Chilicote”
Lysiloma divaricatum (Jacq.) Benth.	“Mauto”
Mimosa xanti A. Gray	“Celosa”
Senna atomaria (L.) H.S. Irwin & Barneby	“Palo zorrillo”
FAGACEAE	
Quercus tuberculata Liebm.	“Encino roble”
PASSIFLORACEAE	
Turnera diffusa Willd.	“Damiana”
RHAMNACEAE	
Karwinskia humboldtiana (Schult.) Zucc.	“Cacachila”
RUBIACEAE	
Randia capitata DC.	“Papache”
SAPINDACEAE	
Dodonaea viscosa Jacq.	“Guayabillo”
VERBENACEAE	
Lippia palmeri S. Watson	“Oreganillo”