Article

Structure and floristic list of a range in Guadalupe Cuautepec, Oaxaca

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Abstract

In the last three decades, the plant formations of our country have faced a dynamic change of land use due to deforestation for livestock and agricultural activities. The research was developed during 2018 with the aim of determining the plant structure and identifying the forage species that develop and grow under adverse climatic conditions in a range of Guadalupe Cuautepec, Mixteca region, Oaxaca, Mexico. A stratified sampling of vegetation was performed at four sampling sites with three repetitions, including the herbaceous-graminoid, shrub and tree strata. The number of grasses per quadrant was determined and the identified species were recorded. The variables measured in the shrub and tree strata were basal diameter, crown area and total height. Four class ranges per variable were differentiated and an independence test with χ^2 and a cluster analysis between variables were applied to know their affinity. Twenty-one species located in 19 genera belonging to 18 families, and 10 unidentified species were identified. The family Convolvulaceae was the most diverse and the genus *Ipomoea* was the most representative at the sampling sites. The range had a wide diversity of the genus *Murucoides*, characteristic of the cultural landscapes of the Mexican dry tropics. Of the individuals sampled, 94% were found with a height of less than 3.05 m, which confirms the vast presence of grass, herbaceous and shrub species, which reflects the lack of tree-shrub cover, of an undisturbed low deciduous rainforest.

Keywords: basal diameter, crown area, diversity, genera, total height.

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Introduction

Mexico is considered a megadiverse country, the main criterion to belong to the group is endemism, it is part of the select group of nations that have the greatest diversity of animals, plants, diversity of species, diversity of higher taxonomic levels (genera, families, etc.) and diversity of ecosystems (Rzedowski *et al*., 2006; Mittermeier *et al*., 2011; Martínez *et al*., 2014). This richness and complexity are distributed in the geographical and ecological spaces in which these species inhabit, spaces in which numerous taxa have evolved. Miranda and Hernández-X (1963) point out that the predominant vegetation in the seasonally dry tropical region of Oaxaca is known as low deciduous rainforest (LDR) or deciduous tropical forest (Rzedowski, 1978).

It includes the vegetation of frank tropical affinity whose main characteristic is that most of the trees and shrubs are of low size, with a more or less continuous cover of the same canopy, which lose their leaves in the dry season (Halffter *et al*., 2005; León *et al*., 2012), in addition to its extraordinary presence of flora and fauna, main characteristic of this ecosystem (Bezaury-Creel, 2010). About 30% of these rainforests in Mexico present some type of disturbance. By 1980, 44% of its original area had been transformed into crops, thickets and savannas; so, 650 ha are lost each year, equivalent to 2% per year (García and Meave, 2011).

LDRs are the largest tropical ecosystems worldwide (42%) and in Mexico, they represent 60% of tropical vegetation (Arias *et al*., 2002). However, about 30% of these rainforests present some type of disturbance, there are few studies that assess the structure and floristic diversity in ranges, for LDR ecosystems (García-Romero *et al*., 2005; Meave *et al*., 2012) and the degree of disturbance due to direct generators of land use change (MEA, 2005). Currently, there is great interest in environmental diagnoses that evaluate the structure, functioning and floristic composition of the communal ranges of the arid and semiarid regions of the Mixteca Oaxaqueña, under the consideration of the natural and cultural aspects that converge in it (Arler, 2000; O'Neill and Walsh, 2000).

Socioeconomic aspects are also relevant in the assessment of the structure and floristic composition of a region, due to the growing role of man in the transformation of the environment (Scott, 1993; Gragson, 1998) and its impacts on the conservation, stability and resilience of the range (Drdos, 1992; Bastian and Röder, 1998). Dry rainforests are home to around 6 000 species of plants, almost 40% are endemic; that is, they are only found in these ecosystems and are adapted to drought (Wiersum, 2004). LDRs provide various resources to human communities, such as food, timber, clothing, medicine, and forage for cattle, sheep and goats (Bullock *et al*., 1995).

These ecosystems are among the most affected by human activities such as urbanization, agriculture and livestock farming, as well as by natural factors (hurricanes, forest fires, etc.). The aforementioned disturbances have generated the fragmentation of a large percentage of rainforests, (FAO, 2011; Velasco *et al*., 2014), causing the loss of biodiversity and a large number of potentially useful resources (Meave *et al*., 2012). All dry rainforests are ecosystems of very varied structure, dominated by trees that usually do not exceed 4 to 10 m in height (in very rare cases up to 15 m), with little dense and very open crowns, which lose their leaves during a period of five to seven months, with a great contrast in the physiognomy of the vegetation between the dry and rainy seasons (Pennington and Sarukhán, 2005).

Shrub elements constitute a very important proportion in the composition of the structure of the community. Individuals with diameters less than 2.5 cm represent about half of the vegetational components (Pineda-García *et al*., 2007). The rainforests that develop in Mexico have structural and floristic characteristics that make them unique and distinguish them from other similar neotropical rainforests, so it is important to redouble efforts to have a broad knowledge of them and contribute to their conservation and better use. The objective was to determine the plant structure and identify the forage species that develop and grow under adverse climatic conditions in a range of Guadalupe Cuautepec, Mixteca region, Oaxaca, Mexico.

Materials and methods

Study area

It was carried out in the locality of Guadalupe Cuautepec, municipality of San Juan Bautista Suchitepec, in the Mixteca Oaxaqueña, located on the northern limit of the Mixteco River basin, between the geographical coordinates 97° 41' 33.5" and 97° 37' 17.9" west longitude and 18° 3' 56.4" and 17° 59' 47.3" north latitude at 1 960 masl. The locality has the following geographical characteristics, temperate subhumid climate with rains in summer, the temperature varies from 16 to 20 °C and precipitation ranges from 700 to 800 mm per year. The Leptosol, Luvisol, Vertisol and Regosol soils stand out (INEGI, 2005).

Vegetation sampling

The sampling was carried out in the dry season (February-March), the study area was specifically the exclusion zone (range) that comprises 100 ha near the locality. The Garmin® geopositioner system (GPS) was used to identify the limits of the zone, the coordinates of the limit points and the sampled sites were taken, and they were located in a topographic chart scale 1:50000.

Four sampling sites were located according to the exposure of the slopes and homogeneity of the vegetation present in the range. For each site, three transects of 50 m long x 2 m wide were established according to the modified method of Gentry (1982). Within the transects, three quadrants of 1 m^2 were located with a separation of 15 m between each one. The number of grasses present in each quadrant, as well as the different types of existing plant strata: tree, shrubby, and herbaceous, in each transect, were determined.

Collection and identification of botanical species

A botanical press with sheets of newspaper and cardboard plates was used for the collection of specimens from the exclusion zone. In a field notebook, for each collection, the locality, altitude, type of vegetation and the collection number were recorded, as well as intrinsic characteristics of the plant (height, characteristics of flower, fruit, stems or leaves), based on the herbarium manual of Lot and Chiang (1986). The taxonomic determination was made by comparing the specimens collected with those of the herbarium of the Technological Institute of the Valley of Oaxaca, this allowed making a list of the species present in all the sites, following the classification system of

the Magnoliophyta (Cronquist, 1981) the only exception to these criteria was the recognition of the family Leguminosae, where the three families recognized by Cronquist (Caesalpiniaceae, Fabaceae and Mimosaceae) were included.

Study variables

To know the degree of development of the strata, the following were evaluated: basal diameter (BD): the trunks of the trees were measured at a height of 10 cm, for this purpose a diameter tape was used. Crown area (CA): it is the vegetation cover of trees including leaves and branches, where the proportion of land occupied by the perpendicular projection of the aerial parts of the individuals of the species considered is measured, as mentioned by authors such as Romahn-de la Vega *et al*. (1994). CA= [(Di2+Dm2)/2]* [π /4]. Where: CA= Crown area: Di= minor diameter; Dm= major diameter; π= 3.1416. Total height of the sampled individuals (TH): the measurement of the tree stratum was carried out with a Sunnto® clinometer, in the case of the shrub and herbaceous strata, it was carried out with a Truper® tape measure.

Information analysis

The generated data were captured in a spreadsheet of the Microsoft Excel® program and analyzed by means of the (SAS 9.4) statistical program. The absolute and relative frequencies of the total height of the sampled individuals were obtained. Four class ranges per variable were differentiated and an independence test with χ^2 was applied, to know their relationship with the orientation of the slope at the sampling sites. An analysis of variance and a cluster analysis between the variables to know their affinity.

Results

In the range of Guadalupe Cuautepec, 21 species, located in 19 genera, belonging to 18 families and 10 unidentified species were identified (Table 1).

Table 1. List of plant species of the range of Guadalupe Cuautepec, Oaxaca.

Common name	Species	Family
Andropogón	*Andropogon gerardii*	Poacea
Cajehuite	*Dodonaea viscosa*	Sapindaceae
Cazahuate blanco	*Ipomoea murucoides*	Convolvulaceae
Cazahuate negro	*Ipomoea pauciflora*	Convolvulaceae
Copalillo	*Bursera submoniliformis*	Burseraceae
Cuachalalate	*Amphipterygium adstringens*	Anacardiacea
Palo mulato	*Bursera morelensis*	Burseraceae
Echeveria nodulosa	*Echeveria nodulosa*	Crassulaceae
Enebro	*Juniperus montícola*	Cupresaceae
Huizache	*Acacia farnesiana*	Mimosaceae
Huaje	*Leucaena leucocephala*	Fabaceae

Common name	Species	Family
Lechuguilla	*Hechtia sphaeroblasta*	Bromeliaceae
Maguey Papalomé	*Agave potatorum*	Agavaceae
Mala mujer	*Cnidoscolus tehuacanensis*	Euphorbiaceae
Navajita azul	*Bouteloua* sp.	Poaceae
Nopal tuna de agua	*Opuntia* sp.	Cactaceae
Palo loco	*Pittocaulon praecox*	Asteraceae
Pasto rosado	*Rhynchelytrum repens*	Poaceae
Siempre viva	*Selaginella* sp.	Selaginellaceae
Tepehuaje	*Lysiloma acapulcense*	Fabaceae
Uña de gato	*Mimosa polyantha*	Fabaceae

The family Convolvulaceae was the best represented with *I. murucoides* known as cazahuate blanco or cazahuate nergo. Followed by the grasses andropogón (*A. gerardii*), navajita azul (*Bouteloua* sp.) and pasto rosado (*Rhynchelytrum* sp.), of the family Mimoseae huizache (*A. farnesiana*), of the family Fabaceae huaje (*L. esculenta*), tepehuaje (*L. acapulcense*) and uña de gato (*M. polyantha*). The range of Guadalupe Cuautepec showed a scarce presence of plant individuals, this type of ecosystems is among the least protected and most threatened, has undergone intense transformations due to human influence, such as fire and cattle grazing.

It has been proposed that the alterations promote the invasion of exotic species, which results in the displacement and loss of many native species locally in densely populated areas, as is the case of the range of Guadalupe Cuautepec. With the results obtained in the cluster analysis, it is revealed that two large groups are classified in the range of Guadalupe Cuautepec (Figure 1).

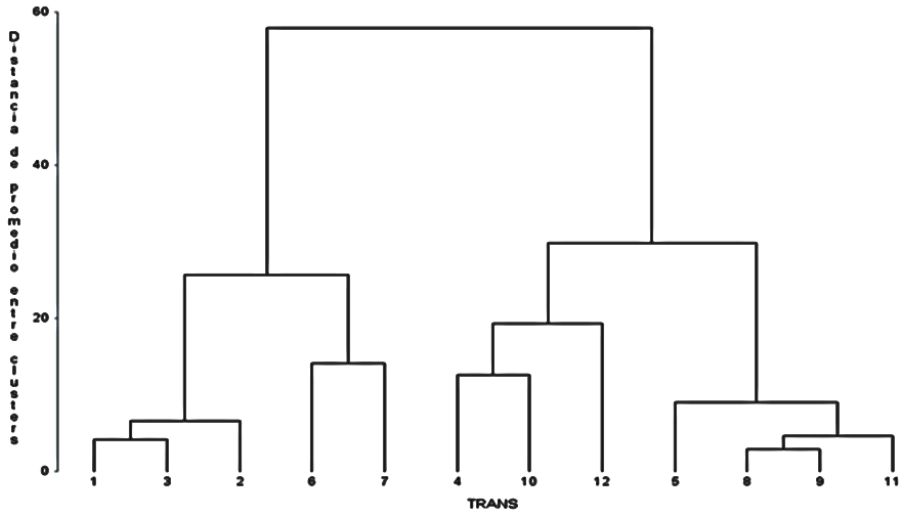

Figure 1. Dendrogram of classification of study transects in the range of Guadalupe Cuautepec, Oaxaca.

The first group integrated transects 1, 3, 2, 6 and 7, which correspond to site 2 and 3, affinity related to the orientation of the slope, elevation and presence of total species. The species with the greatest abundance in transects 1, 3, 2 were of the family Convolvulaceae, especially cazahuate blanco (*I. murucoides*), for transects 6 and 7, it was cazahuate negro (*I. pauciflora*). This genus is the one that presented the largest number of individuals at the sampling sites, followed by copalillo (*B. submoniliformis*) with 10 individuals.

The second group included transects 5, 8, 9, 11, 4, 10 and 12, which correspond to the sites that are located near human settlements, affinity of heights and moderate slopes, the species present in transect 5 were huaje (*L. leucocephala*) with 13 individuals, in transects 8 and 9 huizache (*A. farnesiana*) with 20 individuals, nopal tuna de agua (*Opuntia* sp.) with 5 individuals, the transects 4 and 10 with enebro (*J. montícola*) with 4 individuals and huizache (*A. farnesiana*) with 3 individuals in transects 11 and 12.

As a result of the variables analyzed (total species present, elevation, exposure, basal diameter, crown area and total height), with their accumulated values and an eigenvalue of 0.99, it explains 100% of the relationships between the transects of the exclusion zone of Guadalupe Cuautepec. Table 2 shows the relationship between the orientation of the slope (E= East; NE= Northeast; W= West; SE= Southeast; SW= Southwest; SOUTH= South) and total height of the species present.

Table 2. Relationship between the exposure of the slope and total height of the species in the range of Guadalupe Cuautepec.

Classes	E	NE	W	SE	SW	SOUTH	THF	TMP
(0.01, 0.25]	(62, 9.16]	(35, 5.17]	(115, 16.99]	(173, 25.55]	(42, 6.2]	(133, 19.65]	561	0.8287
(0.25, 0.49]	(15, 2.22]	(25, 3.69]	(15, 2.22]	(13, 1.92]	(12, 1.77]	(9, 1.33]	89	0.1315
(0.49, 0.73]	(5, 0.74]	(3, 0.44]	(2, 0.3]	(3, 0.44]	(2, 0.3]	(2, 0.3]	17	0.0251
(0.73, 0.97]	(2, 0.3]	(2, 0.3]	(2, 0.3]	(3, 0.44]	(0, 0]	(1, 0.15]	10	0.0148

E= East; NE= Northeast; W= West; SE= Southeast; SW= Southwest; SOUTH= South; THF= absolute frequency; TMP= total marginal probability.

The data obtained in the sampling were grouped into four classes of plant height and exposure. Associated tree, shrub, grass and herbaceous plants were included. The results of the independence test with χ^2 show a significant association of the variable total height (TH) and the SE exposure ($p< 0.01$), with the graminoid-herbaceous stratum being the one that was most related to the aforementioned exposure, with 173 individuals (25.55%) located on moderate slopes. Eighty-two percent of the total sampled was classified in a height range of 1 to 25 cm, which demonstrates the prevalence of individuals of low stratum, in soil conditions favorable for their establishment and development (herbaceous and grasses). Followed by the south (S) exposure with 133 and the west (W) exposure with 115 individuals.

The frequencies of total height of the species present in the range of Guadalupe Cuautepec reflect that 94% of the individuals sampled (352/375) have a height of less than 3.05 m, which confirms the vast presence of species from the lower strata: shrubby, herbaceous and graminoid, and 6% (23 individuals) with a height ranging from 3.8 to 5.3 m, which reflects the lack of tree-shrub cover,

due to the strong grazing impact to which this range has been subjected. Two hundred fifty-nine individuals (69%) were the most representative, which were located in the different sampling sites with a height of 0.05 and 1.55 m and a class mean of 0.8. This reflects that they are the most abundant individuals in the different sites (Table 3).

Table 3. Total height frequencies of the species present in the sampling sites in the range of the locality of Guadalupe Cuautepec.

Lower limit (m)	Upper limit (m)*	Class means (m)	Number of individuals	Relative frequency (proportion)
(0.05	1.55]	0.8	259	0.69
(1.55	3.05]	2.3	93	0.25
(3.05	4.55]	3.8	13	0.03
(4.55	6.05]	5.3	10	0.03

*= half-open intervals on the left and closed intervals on the right.

Discussion

Lists of useful plants represent the basis for understanding the patterns underlying traditional knowledge in the Mixteca region of the state of Oaxaca (Luna-José and Rendón-Aguilar, 2008). *Ipomoea murucoides* is a tree-shrub species of 3 to 10 m, native to Mexico, grows in climates that range from semi-warm to temperate at altitudes of 600 to 2 400 m, associated with deciduous tropical forest and xerophilous thicket. It is common to find it in dry and thorny thickets; it is of soft wood, with the presence of latex, with longitudinally grooved, densely lanuginous flowering stems 5 to 8 mm in diameter (McPherson, 1981).

Studies such as those of Mila-Arango *et al*. (2014), in a study carried out in the identification and photochemical study of two species of cazahuate in the poisoning of goats in a locality of the Mixteca Oaxaqueña, they concluded that in the dry season, because the vegetation decreases drastically, there are surviving plants such as cazahuate blanco and cazahuate negro, which are toxic to livestock due to the high content of terpenoids and free alkaloids, both species are identified by technicians and producers as causing poisoning in goats in the low Mixteca of Oaxaca in the dry season: *Ipomoea* is the genus that best represents the family Convolvulaceae, with about 500 species of distribution, of which 150 are found in Mexico, within this genus there are species of tree-shrub habit or woody vines that have diversified (McDonald, 1992).

Solano (1997) conducted a floristic study in the low Mixteca Oaxqueña, identifying the existence of six species of *Ipomoea*, mentioning *I. murucoides* and *I. pauciflora* among them, without mentioning the subsp. *pauciflora*. Carranza (2007) reports that the family Convolvulaceae are characteristic components of the landscapes of the Mexican dry tropics and are found in sunny and open habitats, that most of this family prefers well-drained soils, such as slopes of hills, sands and rocks such as those found in the present study.

For their part, Gallardo-Cruz *et al*. (2005) reports a floristic list of 194 species, where the family Fabaceae is the most diverse. Pineda-García *et al*. (2007) carried out a work of the richness and diversity of woody species in the LDR in El Tarimo, Guerrero, they found 24 families of which

Fabaceae was the one with the greatest specific richness with 25 species. Trejo (1999) mentions that one of the characteristics that distinguishes low deciduous rainforests is their adaptation and proliferation on soils with slopes that can range from pronounced, moderate and strong, with a floristic diversity that is reflected in the number of species and that agrees with this study.

Authors such as Leirana-Alcocer *et al*. (2009) mention that these ecosystems are subject to strong anthropic pressures such as unsustainable agriculture, overgrazing and deforestation, as a result of the establishment of ranges, poor tree cover, rocky outcrops and soils lacking diversity, where the increase of the erosive process is increasingly frequent (Ojeda *et al*., 2003), a scenario coinciding with the case of the locality of Guadalupe Cuautepec. Given this reality, it is important to design restoration and management strategies, which contribute to the process of natural succession of these plant relicts (Yepes and Villa, 2009).

Studies such as those of Dzib (2014); Meave *et al*. (2012) point out that this type of rainforests is in constant disturbance and is being transformed or replaced by agricultural systems as a result of the constant change of land use; anthropic practices that have caused the local extinction of endemic plant species, modifying the structure of the vegetation, floristic composition, diversity and abundance of the species of the remnants of rainforests. Rzedowski (2006) reports that the low rainforests include various types of shrubs, from unarmed to thorny, with heights between 1-4 m. For their part, Gutiérrez and Zamora (2012) mention that, in the rainforest of Yucatán, the largest number of individuals was found in a range of 1.5 to 4.4 m with 45.2%, which agrees with the present study carried out in the range of Guadalupe Cuautepec, where various types of shrubs with heights between 1-4 m were obtained.

Carranza *et al*. (2003) mention that LDRs are the most threatened worldwide and are represented by species that do not exceed 10 m in height, which coincides with the present study. Authors such as Moreno and Paradowska (2009) point out that, in most cases, the degradation of the LDR is due to anthropogenic activities such as livestock farming, wood extraction and forest fires. Given this situation, it is of the utmost importance to promote conservation and restoration areas that guarantee the permanence of plant wealth, that promote its conservation in space and time, reactivating successional processes with better strategies, which can be operated in a comprehensive way with a true multidisciplinary participation, involving the main actors, generating a true man-ecosystem relationship (Moreno and Paradowska, 2009).

Conclusions

The range of the community of Guadalupe Cuautepec consists of 51 species with genera belonging to 20 families, in addition to 10 unidentified species. The family Convolvulaceae is the most diverse and the genus *Murucoides* the most representative at the sampling sites. The latter had the greatest diversity of species and the highest relative abundance of individuals in the different sites sampled, followed by the species *A. gerardii*, *A. farnesian*, *L. esculenta*, *Bouteloua* sp., *Rhynchelytrum* sp. and *L. acapulcense*.

The graminoid-herbaceous-shrub stratum is the most abundant in the range, where the species present do not exceed 10 m in height, also denoting a high pressure of use by cattle in the areas closest to the rural nucleus; a situation that 15 years ago the commoners of the locality excluded from the grazing of goats.

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