https://www.scirp.org/journal/ns Natural Science, 2020, Vol. 12, (No. 8), pp: 599-619

Flora and Vegetation Associated with *Dichromanthus cinnabarinus* (La Llave & Lex.) Garay (Orchidaceae, Spiranthinae) in Northeastern Mexico

Elba Zarahy Garay-Martínez[1], Jacinto Treviño-Carreón[1], Tania Judith Hernández-López[1], Juana María Coronado-Blanco[1], Claudia C. Astudillo Sánchez[1], Leroy Soria-Díaz[2], Arturo Mora-Olivo[2]

[1]Universidad Autónoma de Tamaulipas, Facultad de Ingeniería y Ciencias, Centro Universitario Adolfo López Mateos, Ciudad Victoria, Ciudad Victoria México; [2]Instituto de Ecología Aplicada, Universidad Autónoma de Tamaulipas, División del Golfo, Col. Libertad, Ciudad Victoria, Tamaulipas, México

Correspondence to: Treviño-Carreón Jacinto, jatrevino@docentes.uat.edu.mx
Keywords: Northeastern Mexico, Flora, Vegetation, Endemism
Received: July 7, 2020 **Accepted:** August 22, 2020 **Published:** August 25, 2020

ABSTRACT

Studies conducted in northeastern Mexico have not provided information on the flora and vegetation associated with *Dichromanthus cinnabarinus*. Therefore, it is necessary to study the areas where this orchid is distributed to understand the plant vegetation interaction. Research questions: What plant species are associated with *Dichromanthus cinnabarinus*? What is the degree of similarity among the plant communities with which *Dichromanthus cinnabarinus* is associated? Study site: Northeastern Mexico, comprehending the states of Coahuila, Nuevo Leon and Tamaulipas. Methods: The study sites were selected considering the presence of *Dichromanthus cinnabarinus*. Regarding the study of the plant structure, the tree, shrub, and herbaceous strata were obtained by the methodology of quadrants. Data were collected in April and August 2017. The results were analyzed using the Importance Value Index (IVI) for each stratum present and a Parsimony Analysis of Endemicity (PAE) for the plant communities. Results: In the study area, a total of 33 families, 60 genera and 69 species were registered. The representative families are Asteraceae with eight species, Asparagaceae with six, Fabaceae with five, followed by Cactaceae, Poaceae and Roasaceae with four species each. Regarding endemic species, a total of 11 species distributed in nine genera were registered in the study sites. Conclusions: In northeastern Mexico, *Dichromanthus cinnabarinus* is found associated with *Aristida adscensionis* L., *Agave lechuguilla* Torr. *Bouteloua* sp., *Euphorbia antisyphilitica* Zucc., *Agave striata* var. *striata* (Salm-Dyck) and *Rhus virens* Lindh. ex A. Gray. Moreover, *Dichromanthus cinnabarinus* is observed in some sites with contrasting flora, according to the resulting list of endemic species. It is important

to establish priority areas for wildlife conservation in northeastern Mexico.

1. INTRODUCTION

The subfamily *Spiranthinae* is the most diverse lineage of neotropical land orchids in the world. It includes approximately 500 species and 40 genera, of which *Dichromanthus* Garay comprises four species, one of which is *D. cinnabarinus* [1, 2]. The species is widely distributed in America, from southern United States through Mexico to Guatemala. It is distributed generally in xerophilic environments with rocky soils in diverse vegetation types that range from pine-oak forests, tropical deciduous forests and even in some rosetophile scrub and grasslands with juniper [3].

In Mexico, this species has been recorded in a large part of the territory, particularly in northeastern Mexico [3], which includes the states of Coahuila, Nuevo León, and Tamaulipas. These states, from a biogeographic perspective, are in the region of the Chihuahua Desert and transition with the Sierra Madre Oriental. Among the floristic and vegetation studies that have been conducted in this region and have registered *D. cinnabarinus* is the work of Villareal-Quintanilla *et al.* [4], who studied pinion pine (*Pinus pinceana* Gordon) communities and register this species as part of the associated flora. Encina-Domínguez *et al.* [5-7] studied the plant communities of the Sierra de Zapalinamé in Saltillo, Coahuila, and recorded the species as characteristic of the region. Also, Estrada *et al.* [8] conducted a study focused on identifying species with different traditional uses in the Cumbres de Monterrey National Park, Nuevo León, where they recorded it as a wild species in an oak forest.

It is well-known that Mexico has a broad diversity of natural environments generated by its relief, the mosaic of soils and the variety of climates [9], as well as its geographic location in which its mountains form physio-ecological barriers between two important biogeographic regions: the Nearctic and the Neotropical regions [10, 11]. This has originated the existence of high levels of biodiversity and endemism [12] through the processes of speciation. There is a synergy created by these barriers in conjunction with climate and habitat factors and has induced species to adapt to the ecological conditions of a given region. In most cases, allopatric species develop in different vegetation types because of reproductive isolation [13].

From this viewpoint, arid and semi-arid zones are considered centers of origin and diversification of species. In Mexico, these regions cover approximately 60% of the territory. The Chihuahua Desert is one of these regions. It is in the north-central portion, bounded by the Sierra Madre Oriental to the east and the Sierra Madre Occidental to the west [14]. Part of this desert comprises the states of Coahuila and Nuevo León as well as the southwestern tip of Tamaulipas; the region is known as Northeastern Mexico [4].

In this region, many scientific studies have been conducted, focused on identifying the flora and vegetation. Some of these studies have registered *D. cinnabarinus* as a member of the local flora. However, the types of vegetation where it has been recorded are diverse. Studies in the state of Coahuila were conducted by several authors [15-19]. In Nuevo León, outstanding work has been done [20-23]. In Tamaulipas, studies have been undertaken by several authors [24-27]. However, it is necessary to develop studies using parsimony analysis of endemicity, taking into account the species present in each type of vegetation, to establish similarities among the sites based on the flora and to determine whether *D. cinnabarinus* is truly widely distributed or if we are dealing with different allopatric species over the vegetation types in northeastern Mexico. Hypothesis: If allopatry is a process of speciation that because both geographic and reproductive isolation forms new species, then *Dichromanthus* found in contrasting plant communities in northeastern Mexico could be different species.

The objectives of this study were to identify the plant communities in which *Dichromanthus cinnabarinus* has been recorded and to develop a parsimony analysis of endemicity to obtain the degree of similarity that exists among the communities based on the associated flora obtained in northeastern Mexico.

2. MATERIALS AND METHODS

General description of the study area: The northeastern region of Mexico (Coahuila, Nuevo León and

Tamaulipas) covers an area of 294,099 km^2; it is bounded to the north by the United States, to the east by the Gulf of Mexico, to the south by the state of San Luis Potosí and to the west by the states of Chihuahua, Durango and Zacatecas [28]. Its relief ranges in altitude between 1000 and 3050 m; annual temperatures oscillate from 5.5˚C to 35˚C and annual precipitation is approximately 175 to 400 mm (**Figure 1**) [4].

Physiography and ecoregions: The study area includes parts of two ecoregions: 1) the Desert of Chihuahua (DCH) and 2) the Sierra Madre Oriental (SMO). The DCH is characterized by the presence of plains and small isolated mountain chains [29], while the SMO includes the transition zone between the Nearctic (in the lower areas of piedmont) and the Neotropics (mountainous regions) [12].

Geology: Approximately 80% of the characteristic soils of the DCH are formed by calcareous components [30], while in the SMO and its foothills toward the high plateau, sedimentary limestones, shales, and sandstones dominate. In some sites, gypsum can be seen. Dominant soils are alluvium type, but it is feasible to find soils containing igneous rock [31, 32].

Climates: The predominant climate of the region is influenced mainly by the presence of mountain chains. However, arid, and semi-arid climates predominate; mean temperatures are 10˚C to 25˚C and mean annual precipitation is 150 to 2000 mm [31].

Vegetation: In the area of the Desert of Chihuahua (DCH) and the Sierra Madre Oriental (SMO), the plant communities are desert microphyll scrub, desert rosetophile scrub, desert crassicaule scrub, oak stands, grasslands, riparian vegetation, and pinion pine forests [11]. The outstanding plant associations are *Larrea tridentata* in the desert microphyll scrub type, *Agave lechuguilla*, *Dasylirion* spp. desert rosetophile

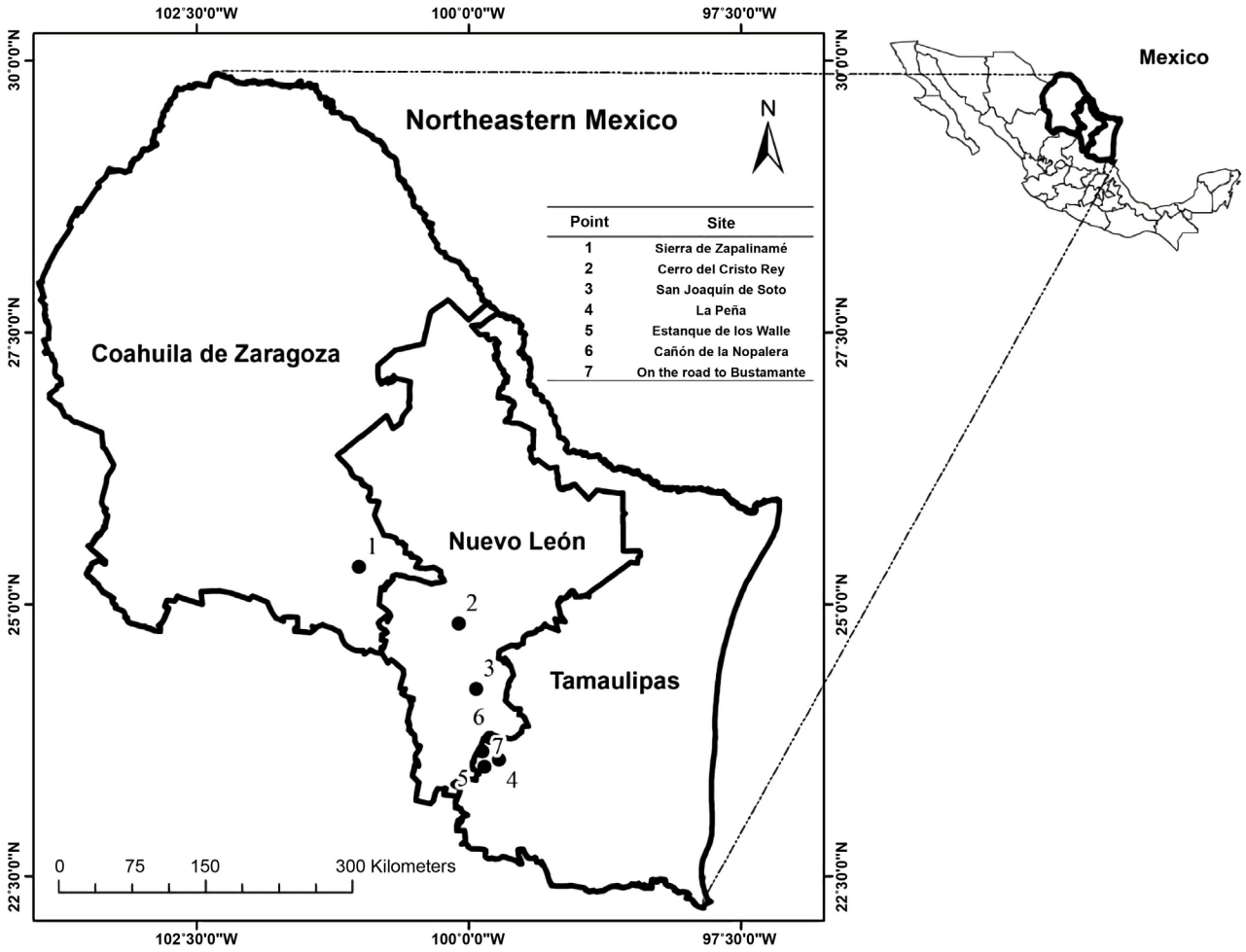

Figure 1. Geographic localization of study area.

scrub and *Yucca* sp. rosetophile forest [33], grassland, chaparral, prickly pear stands, spiney *Prosopis* spp. forest, dune vegetation and halophyte vegetation [34].

However, in the SMO there are also established plant communities of mainly *Juniperus deppeana* Steud., *Juniperus flaccida* Schltdl., and *Pinus cembroides* Zucc., as well as grasslands [34].

Study sites: Seven sampling sites, in which *Dichromanthus cinnabarinus* was registered, were selected (**Table 1**):

1) The Zapalinamé mountains located in the municipality of Saltillo, Coahuila, 25˚23'59"N and 101˚59'17"W. Here, there is clear dominance of alluvium, lithosol and rendzina soil types. Climate is hot to cool, with mean annual temperatures that oscillate between 5˚C and 12˚C and average annual precipitation of 498 mm. Predominant vegetation is rosetophile and microphyll scrub [5].

2) Cerro del Cristo Rey, located in the municipality of Galeana, Nuevo León, 24˚50'00"N and 100˚04'00"W, has a clear dominance of lithosol and fluvisol soils. The climate is cool, sub-humid with summer rains, annual temperature of 15˚C to 28˚C and average annual is precipitation 400 to 600 mm. Predominant vegetation is pine and oak forest as well as rosetophile scrub [28].

3) San Joaquín de Solo is in the municipality of Aramberri, Nuevo León, 24˚24'31"N and 99˚91'61"W; average elevation is 1077 m with a mostly warm climate with summer rains. Precipitation is between 600 and 800 mm and temperatures are between 12˚C and 18˚C. Dominant soils are lithosol, xerosol and regosol. Predominant vegetation is pine forests and oak forests [28].

4) La Peña is in the municipality of Miquihuana, Tamaulipas, 23˚48'33"N and 99˚86'67"W. Soils are lithosols. Predominant climates are extremely dry and mean annual temperature is 18˚C with mean annual precipitation that fluctuates between 350 and 500 mm [33]. The altitudinal gradient is 715 to 3265 m [35].

5) Camino al Estanque de los Walle is in the municipality of Miquihuana, Tamaulipas, 23˚34'1.41"N

Table 1. Study sites and eco-regions that converge: DCH (Desert of Chihuahua), SMO (Sierra Madre Oriental) and type of predominant vegetation, OF = oak forest, CP = chaparral, RS = rosetophile scrub.

Eco-regions	State	Municipality	Ejido	Coordinates	Altitude (m)	Vegetation
DCH and SMO	Coahuila	Saltillo	Sierra de Zapalinamé	25˚23'59"N y 101˚59'17"O	1877	CP
SMO	Nuevo León	Galeana	Cerro del Cristo Rey	24˚50'00"N y 100˚04'00"O	1600	RS
		Aramberri	San Joaquín de Soto	24˚24'31"N y 99˚91'61"O	2072	OF
DCH and SMO	Tamaulipas	Miquihuana	La Peña	23˚48'33"N y 99˚86'67"O	1975	RS
DCH and SMO			Camino Estanque de los Walle	23˚34'1.41"N y 99˚51'28.66"O	2136	RS
DCH and SMO			Cañón de la Nopalera	23˚34'1.41"N y 99˚51'28.66"O	2178	CP
DCH and SMO		Bustamante	Camino Viejo a Bustamante	99˚45'25"N y 23˚26'07"O	1712	RS

and 99˚51'28.66"W. Dominant soils are lithosols. Climate is dry; precipitation oscillates between 350 and 500 mm; mean annual temperature is 18˚C. Predominant vegetation is desert scrub [35].

6) Cañón de la Nopalera, municipality of Miquihuana, Tamaulipas, 23˚45'57.1"N and 99˚48'16.1"W, has lithosol and xerosol soils. Climate is predominantly temperate with summer rains; temperatures range from 4˚C to 41˚C, and vegetation is rosetophile scrub and pine forest [35].

7) Camino a Bustamante is in the municipality of Bustamante, Tamaulipas, 99˚45'25"N and 23˚26'07"W. Soils are leptosol and calcisol; climate is warm and dry with summer rains and annual temperature of 18˚C to 36˚C. Average altitude is 1718 m and precipitation is 500 to 900 mm. Dominant vegetation is rosetophile scrub [36].

Methods: To study the vertical structure of the community, we considered the presence of the vegetation strata (tree, shrub and herbaceous). Specimens were collected during April and August 2017. A total of 12 quadrants measuring 10 × 10 m were established in the study areas where rosetophile scrub was present and nine quadrants in the sites with forest or chaparral, surpassing the minimum sampling area reported by other authors for these vegetation types [24-37].

In the tree stratum, we considered plants taller than 2 m, and 10 × 10 m quadrants were established. Everyone was measured for total plant height, largest and smallest crown diameter, and diameter at breast height (1.30 m). For the shrub stratum, plants 1 to 2 m tall were considered, and two 2.5 × 5 m sub-quadrants were established within each 10 × 10 m quadrant. The variables obtained were total plant height and the largest and smallest diameter. For the herbaceous stratum, all plants smaller than 0.5 m tall were considered, and five 1 × 1 m quadrants were established; the variables plant height and largest and smallest cover diameter were measured [37] (**Table 2**).

The collected botanical material (plants in the reproductive stage) was processed following Lot & Chiang [38]. The material was pressed, and dichotomous taxonomic keys were used for identification. Finally, specimen identification was corroborated using lists of flora of northeastern Mexico, review of specialized literature and a visit to the herbarium of the Universidad Autónoma de Tamaulipas (UAT). In addition, we obtained the Importance Value Index (IVI) with percentage values at a scale of 0 to 100 [37].

$$\text{Importance value index} = \text{relative cover area} + \text{relative frequency} + \text{relative density}$$

$$\text{IVI} = \text{Cr} + \text{Fr} + \text{Dr}$$

where: relative cover area was obtained with the formula:

$$\text{Cr} = \frac{\text{Absolute cover area of each species}}{\text{Absolute cover area of all species}} \times 100$$

where

$$\text{Ca} = \frac{\text{Cover area of one species}}{\text{Total sampled area}}$$

Table 2. Total sampling area by sites.

Site	Minimum area (m^2)	Sampled area (m^2)
Sierra de Zapalinamé, Saltillo, Coahuila	900	1200
Cerro del Cristo Rey, Galeana, Nuevo León	900	1200
San Joaquín de Soto, Aramberri, Nuevo León	625	925
La Peña, Miquihuana, Tamaulipas	900	1200
Camino al Estanque de los Walle, Miquihuana, Tamaulipas	900	1200
Cañón de la Nopalera, Miquihuana, Tamaulipas	625	925
Camino a Bustamante, Bustamante, Tamaulipas	625	925

Cover area was estimated using the formula of the area for each species:

$$CA = \pi\left(\frac{dM + dm}{4}\right)^2$$

dM = Largest diameter.
dm = Smallest diameter.
Relative frequency was obtained with the formula:

$$Fr = \frac{\text{Absolute frequency of each species}(Fa)}{\text{Absolute frequency of all species}} \times 100$$

where:

$$Fa = \frac{\text{Number of quadrants in which each species is present}}{\text{Total number of sampled quadrants}}$$

Relative density was calculated with the formula:

$$Dr = \frac{\text{Absolute density of each species}(Da)}{\text{Absolute density of all species}} \times 100$$

where:

$$Da = \frac{\text{Number of individuals of species}}{\text{Sampled area}}$$

with the list of species at each site, a parsimony analysis of endemicity was performed using the software PAST 3.9, which permits classifying a population into a given number of groups based on the similarity that exists among the sites, considering the presence of the species that make up each plant community.

3. RESULTS

Vegetation by site. Based on the results of the IVI (Table 3), plant communities were determined based on the dominant life form of the plant species and are presented below:

Table 3. Outstanding species, according to the IVI, by study site and by stratum. Cr = Relative cover area; Dr = Relative density; Fr = Relative frequency; IVI = Importance value index.

STUDY SITE **Stratum** Species	Cr	Dr	Fr	IVI
I. SIERRA DE ZAPALINAMÉ, SALTILLO, COAHUILA				
Herbaceous stratum				
Chysactinia mexicana	21.10	14.79	16.82	52.72
Aristida adscensionis	16.55	18.34	14.95	49.84
Houstonia nigricans	12.20	10.78	23.36	46.35
Shrub stratum				
Purshia stansburyana	8.30	40.32	25.26	73.89
Purshia plicata	57.88	4.33	4.21	66.42
Nolina cespitifera	8.69	8.25	10.53	27.47

Continued

Tree stratum				
Quercus mexicana	20.72	37.84	35.00	93.55
Crataegus baroussana	50.32	21.32	20.35	91.99
II. CERRO DEL CRISTO REY, GALEANA, NUEVO LEÓN				
Herbaceous stratum				
Euphorbia antisyphilitica	50.80	30.32	18.32	99.44
Calliandra eriophylla	11.09	15.59	17.82	44.50
Mandevilla karwinskii	6.18	9.65	12.07	27.90
Shrub stratum				
Agave lechuguilla	33.25	40.07	25.34	98.66
Purshia plicata	20.73	11.34	15.38	47.46
Hechtia elliptica	7.58	9.88	13.46	30.93
III. SAN JOAQUÍN DE SOTO, ARAMBERRI, NUEVO LEÓN				
Herbaceous stratum				
Avena fatua	30.01	20.25	33.33	83.59
Tagetes lucida	28.40	19.23	25.71	73.34
Sporobolus airoides	11.38	15.99	14.29	41.66
Shrub stratum				
Mimosa biuncifera	40.02	29.03	30.23	99.28
Tree stratum				
Arbutus xalapensis	79.90	17.08	0.50	97.49
Crataegus baroussana	2.48	39.57	34.88	76.94
Quercus mexicana	13.07	46.25	0.50	59.82
IV. LA PEÑA, MIQUIHUANA, TAMAULIPAS				
Herbaceous stratum				
Aristida adscensionis	43.56	31.34	25.07	99.96
Euphorbia antisyphilitica	28.67	36.74	31.76	97.17
Dalea foliolosa	25.49	23.58	22.30	71.36
Shrub stratum				
Agave striata	32.50	8.52	9.32	50.34
Rhus virens	23.45	14.40	9.32	47.18
Leucophyllum frutescens	10.33	11.56	13.56	35.46
V. CAMINO AL ESTANQUE DE LOS WALLE, MIQUIHUANA, TAMAULIPAS				
Herbaceous stratum				
Heliotropium sp.	28.85	26.90	21.59	77.34
Zinnia juniperifolia	19.33	19.31	21.59	60.23
Dodonaea viscosa	21.70	17.59	14.77	54.06

Continued

Shrub stratum				
Hechtia hernandez-sandovalii	21.95	20.94	17.20	60.09
Mortonia greggii	24.28	18.44	17.20	59.92
Purshia stansburyana	15.09	11.56	13.98	40.63
VI. CAÑÓN DE LA NOPALERA, MIQUIHUANA, TAMAULIPAS				
Herbaceous stratum				
Aristida adscensionis	24.97	64.79	37.07	126.83
Dalea foliolosa	20.11	9.44	18.10	47.65
Tradescantia bracteata	30.96	0.73	9.48	41.16
Shrub stratum				
Quercus greggii	30.11	36.44	23.61	90.16
Rhus virens	41.02	19.74	23.61	84.37
Quercus mexicana	29.01	29.93	25.00	83.94
Tree stratum				
Pinus cembroides	41.15	24.11	34.08	99.34
VII. CAMINO A BUSTAMANTE, BUSTAMANTE, TAMAULIPAS				
Herbaceous stratum				
Chrysactinia mexicana	30.37	33.41	29.84	93.62
Dalea foliolosa	31.30	26.54	29.03	86.87
Aristida adscensionis	10.94	11.14	10.48	32.56
Shrub stratum				
Agave lechuguilla	21.16	32.35	20.90	74.41
Opuntia stenopetala	10.60	12.75	17.91	41.26
Berberis trifoliolata	13.61	12.75	11.94	38.29
Tree stratum				
Yucca filifera	30.37	32.35	20.96	83.68
Juniperus monticola	31.30	26.54	20.03	77.87

1) Sierra de Zapalinamé (SZP): The plant community is chaparral and comprises three strata: the herbaceous stratum is dominated by the species *Chysactinia mexicana* A. Gray, *Aristida adscensionis* L. and *Stenaria nigricans* Lam., while in the shrub stratum *Purshia stansburyana* (D. Don) S.L. Welsh, *Purshia plicata* (D. Don) Henrickson and *Nolina cespitifera* Trel. dominate. The tree stratum includes very few isolated individuals of *Juniperus f.* and *Quercus mexicana* Bonpl (Figure 2).

2) Cerro del Cristo Rey (CCR): The plant community recorded is *Agave striata* rosetophile scrub composed of two strata, herbaceous and shrub, the first dominated by *Euphorbia antisyphilitica*, *Dalea foliolosa* (Aiton) Barneby var. *foliolosa* and *Chrysactinia mexicana* A. Gray, while the second is dominated by *Agave striata* var. *striata* (Salm-Dick), *Opuntia stenopetala* Engelm. and *Echinocactus platyacanthus* Link & Otto (Figure 3).

3) San Joaquín de Soto (SJS): An oak forest comprising three strata was registered. The herbaceous stratum is dominated by *Avena fatua* L., *Tagetes lucida* Cav. and *Bouteloua* sp., the shrub stratum by *Crataegus*

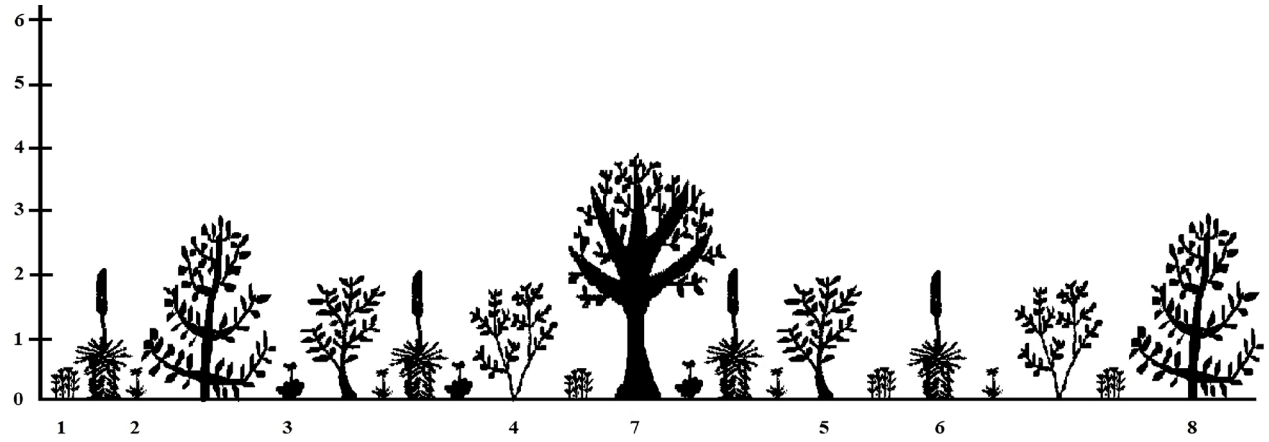

Figura 2. Diagrammatic profile of the chaparral corresponding to Sierra de Zapalinamé, Saltillo, Coahuila.1. *Chysactinia mexicana*, 2. *Aristida adscensionis*, 3. *Dalea foliolosa*, 4. *Castela texana*, 5. *Ceanothus greggii*, 6. *Dasylirion cedrosanum*, 7. *Crataegus baroussana*, 8. *Quercus mexicana*.

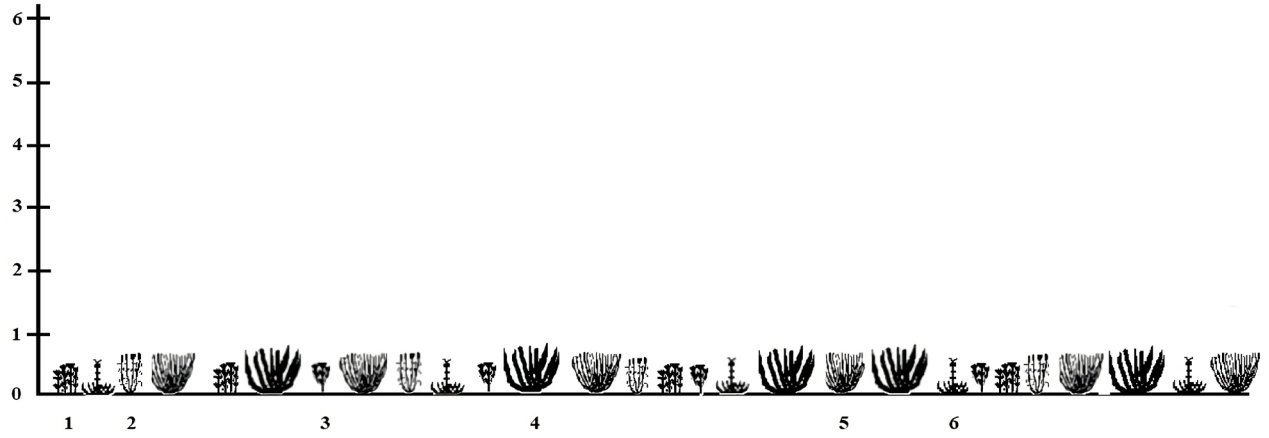

Figure 3. Diagrammatic profile of the rosetophile scrub of Cerro del Cristo Rey, Galeana, Nuevo León. 1. *Euphorbia antisyphilitica*, 2. *Dalea foliolosa*, 3. *Chrysactinia mexicana*, 4. *Agave lechuguilla*, 5. *Agave striata*, 6. *Hechtia elliptica*.

baroussana Eggl., *Rhus virens* and *Mimosa biuncifera* var. *lindheimeri* (A. Gray) BL Rob., while the tree stratum is dominated by *Q. mexicana*, *Arbutus xalapensis* Kunth and *Pinus nelsonii* (Figure 4).

4) La Peña (LPM): The community has *H. hernandez-sandovalii* rosetophile scrub vegetation with three strata. *A. adscensionis*, *E. antisyphilitica* and *D. foliolosa* dominate the herbaceous stratum, *H. hernandez-sandovalii* I. Ramírez, CF Jiménez & J. Treviño and *A. striata* are outstanding in the shrub stratum, and in the tree stratum only a few isolated individuals of *Pinus cembroides* Zucc. are found (Figure 5).

5) Camino al Estanque de los Walle (CEW): At this site, vegetation is *Hechtia hernandez-sandovalii* rosetophile scrub with two strata. The herbaceous stratum is made up of *Heliotropium* sp., *Zinnia juniperifolia* (D.C) A. Graya and *Dodonanea viscosa* Jacq., while in the shrub stratum *H. hernandez-sandovalii*, *Mortonia greggii* A. Gray, and *P. stansburyana* are outstanding (Figure 6).

6) Cañón de la Nopalera (CNM): In this chaparral-type plant community, three strata are present. The dominant species in the herbaceous stratum are *A. adscensionis*, *D. foliolosa* and *Tradescantia bracteata* Small ex Britton, while the herbaceous stratum is made up of *R. virens*, *Quercus greggii* and *Q. Mexicana*. In the tree stratum there are isolated *Pinus cembroides* individuals (Figure 7).

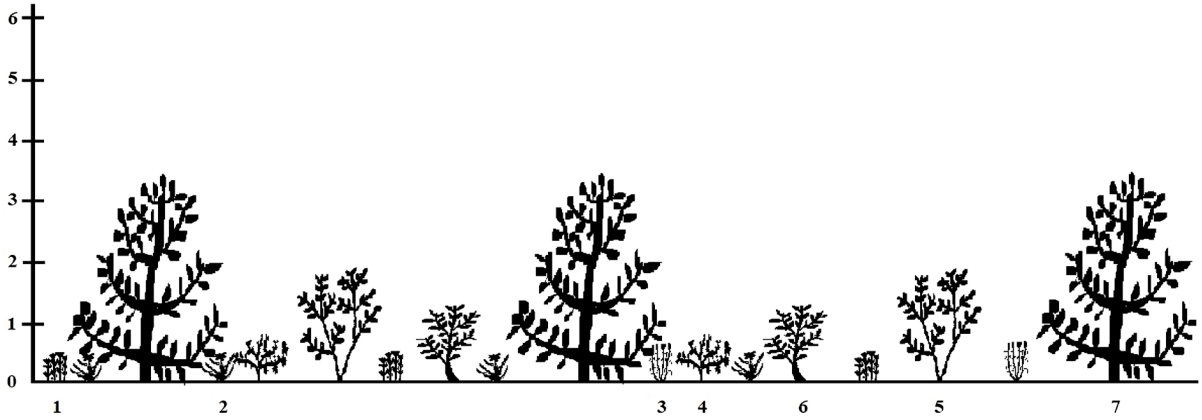

Figure 4. Diagrammatic profile of oak forest in San Joaquín de Soto, Aramberri, Nuevo León. 1. *Avena fatua*, 2. *Tagetes lucida*, 3. *Sporobolus airoides*, 4. *Mimosa biuncifera*, 5. *Arbutus xalapensis*, 6. Crataegus *baroussana* 7. *Quercus mexicana*.

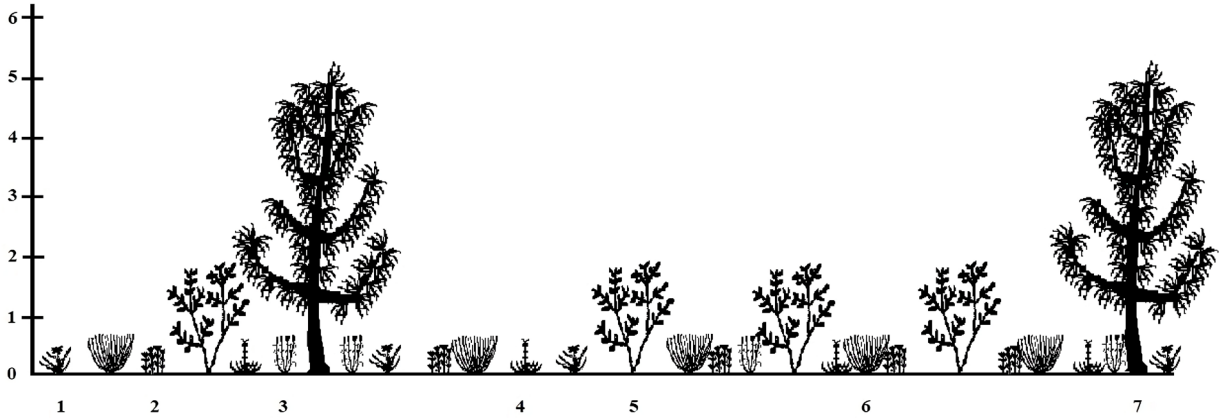

Figure 5. Diagrammatic profile of rosetophile scrub of La Peña, Miquihuana, Tamaulipas. 1. *Aristida adscensionis*, 2. *Euphorbia antisyphilitica*, 3. *Dalea foliolosa*, 4. *Hechtia hernandez-sandovalii*, 5. *Rhus virens*, 6. *Agave striata*, 7. *Pinus pseudostrobus*.

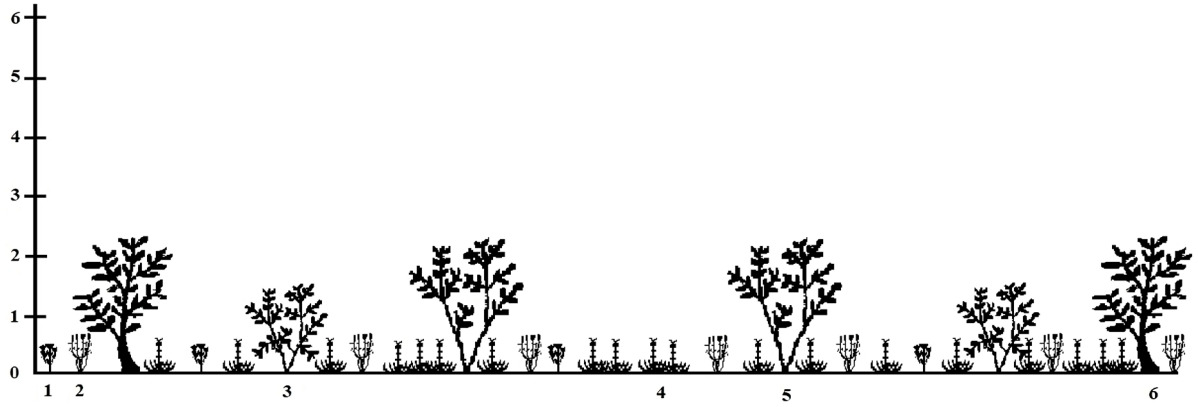

Figure 6. Diagrammatic profile of rosetophile scrub of road to Estanque de los Walle, Miquihuana, Tamaulipas. 1. *Heliotropium* sp., 2. *Zinnia juniperifolia*, 3. *Dodonanea viscosa*, 4. *Hechtia hernandez-sandovalii*, 5. *Mortonia greggii*, 6. *Purshia stansburyana*.

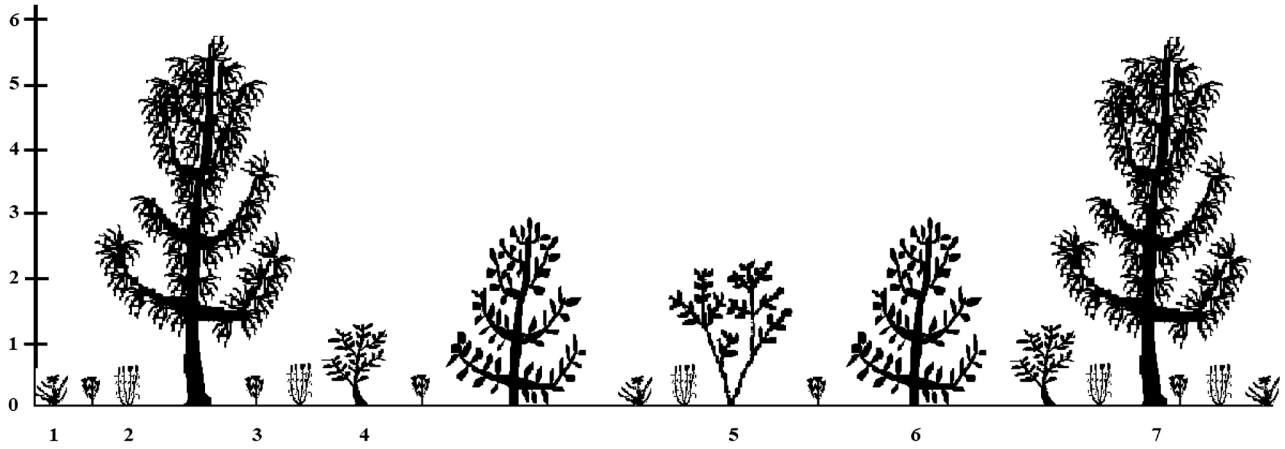

Figure 7. Diagrammatic profail of chaparral of Cañón de la Nopalera, Miquihuana, Tamaulipas. 1. *Aristida adscensionis*, 2. *Dalea foliolosa*, 3. *Tradescantia bracteata*, 4. *Rhus virens*, 5. *Quercus greggii*, 6. *Quercus mexicana*, 7. *Pinus cembroides*.

7) Camino a Bustamante (CBB): This plant community is *A. lechuguilla* rosetophile scrub and has three strata. The herbaceous stratum is represented by *C. mexicana*, *D. foliolo*sa and *A. adscensionis*, while in the shrub stratum *A. lechuguilla*, *O. stenopetala* and *Berberis trifoliolata* Moric. var. *trifoliolata* are outstanding. In the tree stratum, there are only a few *Yucca filifera* Chabaud individuals (**Figure 8**).

Floristic inventory: A total of 33 families, 60 genera and 69 species were recorded (**Table 4**). The most represented families were Asteraceae, Asparagaceae, Fabaceae, followed by Cactaceae, Poaceae and Rosaceae. The sites with higher species richness are Sierra de Zapalinamé with 23 and Camino a Bustamante with 21, followed by Cerro del Cristo Rey with 19 and Camino al Estanque de los Walle with 18, while the sites with the smallest number of species are Cañón de la Nopalera with 14, and San Joaquín de Soto and La Peña with 13 species each.

Endemism by study site: Eleven endemic species were registered (**Table 5**), representing five families. Asparagaceae is the best represented family with three species, while the families Bromeliaceae, Cactaceae, Cupressaceae, Krameriaceae and Scrophulariaceae were represented by one species each. The endemic species mentioned are distributed in the seven study sites. *A. lechuguilla*, *D. cedrosanum* and *N. cespitifera* are found in Sierra de Zapalinamé, in Saltillo, Coahuila. *A. lechuguilla* and *O. stenopetala* are found in Cerro del Cristo Rey, Galeana, Nuevo León; *A. lechuguilla*, *Agave striata*, *H. hernandez-sandovalii*, *L. frutescens* and *O. stenopetala* are endemic to La Peña, Miquihuana, Tamaulipas. *A. lechuguilla*, *D. miquihuanense*, *H. hernandez-sandovalii*, *K. cytisoides*, *L. frutescens* and *O. stenopetala* are found in Camino al Estanque de los Walle, Miquihuana, Tamaulipas. *A. striata*, *D. miquihuanense* and *O. stenopetala* are found in Cañón de la Nopalera as well as in Camino a Bustamante, Bustamante, Tamaulipas. In contrast, no endemic species were registered in San Joaquín de Soto or Aramberri, Nuevo León.

The Parsimony Analysis of Endemicity (**Figure 1**) found that the plant communities are grouped as follows. CEW belongs to *H. hernandez-sandovalii* Rosetophile Scrub and CBB is *A. lechuguilla* Rosetophile Scrub. LPM and CNM have *A. striata* Roseophile Scrub and *R. virens* Chaparral, respectively. CCR vegetation is *A. lechuguilla* Rosetophile Scrub, while in SZP *R. virens* Chaparral is observed, forming separate group (**Figure 9**).

4. DISCUSSION

Vegetation by site. Six of the sites (the exception was San Joaquín de Soto) converge in SMO and DCH, and thus, according to the vegetation identified, correspond to rosetophile scrub. In each site associations of species, such as *L. tridentata*, *A. lechuguilla*, *Y. filifera*, *Z. juniperifolia* as well as Cactaceae, are

Table 4. **Floristic list of species associated with *D. cinnabarinus* in seven sampled sites in northeastern Mexico.**

Family Species	Study sites						
	Coahuila	Nuevo León			Tamaulipas		
	SZP	CCR	SJS	LPM	CEW	CNM	CBB
I. PTERIDOPHYTA							
1. Selaginellaceae							
Selaginella extensa Underw.		*					
Selaginella lepidophylla (Hook. & Grev.)	*						
II. POLYPODIALES							
2. Pteridaceae							
Adiantum sp.		*					
Cheilanthes alabamensis (Buckley) Kunze		*					
III. PINOPHYTA							
3. Cupressaceae							
Juniperus monticola Martínez							*
4. Pinaceae							
Pinus cembroides Zucc.			*			*	
IV. MAGOLIOPHYTA							
A) LILIOPSIDA (MONOCOTILEDÓNEAS)							
5. Agavaceae							
Agave lechuguilla Torr.	*	*		*	*		*
Agave striata var. *stricta* (Salm-Dyck)				*		*	
6. Asparagaceae							
Dasylirion cedrosanum Trel.	*						
Dasylirion miquihuanense Bogler					*	*	*
Nolina cespitifera Trel.	*						
Yucca filifera Chabaud							*
7. Commelinaceae							
Tradescantia bracteata Small ex Britton						*	
Tradescantia sp.		*					
8. Cyperaceae							
Bulbostylis sp.		*					
Cyperus sp.		*					
9. Poaceae							
Aristida adscensionis L.	*			*		*	*
Avena fatua L.			*				
Bouteloua sp.		*					

Continued

Eragrostis sp.	*					
B) MAGNOLIOPSIDA (DICOTILEDÓNEAS)						
10. Anacardiaceae						
Rhus virens Lindh.ex A. Gray	*		*		*	
11. Apocynaceae						
Asclepias linaria Cav.		*		*		*
Mandevilla karwinskii (Müll. Arg.) Hemsl.	*	*				
12. Asphodelaceae						
Asphodelus fistulosus L.			*	*		
13. Asteraceae						
Chysactinia mexicana A. Gray	*		*		*	*
Porophyllum ruderale var. macrocephalum (DC.) Cronquist					*	
Psacalium peltatum (Kunt) Cass.	*					
Pseudognaphalium leucocephalum (A. Gray) Anderb.				*		
Tagetes lucida Cav.			*			
Xanthisma spinulosum var. *Scabrellum* (Greene) DR Morgan y RL Hartm.	*					
Zinnia juniperifolia (D.C) A. Gray				*		
14. Berberidaceae						
Berberis trifoliolata Moric. var. *trifoliolata*	*					
15. Boraginaceae						
Heliotropium sp.		*		*		
16. Bromeliaceae						
Hechtia elliptica LB Sm.		*				
Hechtia hernandez-sandovalii I. Ramírez, CF Jiménez y J. Treviño			*	*		
Tillandsia usneoides (L.) L.			*			
17. Cactaceae						
Echinocereus enneacanthus Engelm.						*
Echinocactus platyacanthus Link & Otto.						*
Mammillaria melanocentra Poselg.						*
Opuntia stenopetala Engelm.		*		*	*	*	*
Opuntia sp.				*		*
18. Celastraceae						
Mortonia greggii A. Gray				*		
19. Ericaceae						

Continued

Arbutus xalapensis Kunth			*			
20. Euphorbiaceae						
Euphorbia antisyphilitica Zucc.		*		*		*
Euphorbia postrata Aiton						*
21. Fabaceae						
Calliandria eriophylla Benth.		*				*
Dalea foliolosa (Aiton) Barneby var. foliolosa				*	*	*
Eysenhardtia polystachya (Ortega) Sarg.		*				
Mimosa biuncifera var. lindheimeri (A. Gray) BL Rob.			*			*
Mimosa sp.	*					
Sophora secundiflora (Ortega) Lag. ex DC						*
22. Fagaceae						
Quercus greggii (A. DC.) Trel.					*	
Quercus mexicana Bonpl.	*		*		*	*
23. Geraniaceae						
Geranium sp.			*			
24. Krameriaceae						
Krameria cytisoides Cav.				*		*
25. Lamiacaeae						
Poliomintha longiflora A. Gray	*					
Scutellaria potosina Brandegee	*			*		
26. Malvaceae						
Sida rhombifolia L.			*			
27. Orobanchaceae						
Castilleja rigida Eastw.				*		
28. Polemoniaceae						
Loeselia greggii S. Watson	*				*	
29. Rosaceae						
Crataegus baroussana Eggl.	*		*	*		
Purshia mexicana (D. Don) S.L. Welsh	*	*		*	*	
Purshia plicata (D. Don) Henrickson	*	*		*		*
30. Rubiaceae						
Bouvardia multiflora (Cav.) Schult. & Schult. f.		*				
Houstonia nigricans (Lam.) Fernald	*		*			
31. Sapindaceae						
Dododanea viscosa Jacq.				*		
32. Scrophulariaceae						

Continued

Leucophyllum frutescens (Berland.) IM Johnst.				*	*		
33. Zygophyllaceae							
Larrea tridentata (DC.) Coville				*	*		
Total families	14	14	12	11	16	12	12
Total genus	20	18	12	12	18	13	20
Total species	23	19	13	13	18	14	21

SZP = Sierra de Zapalinamé, Saltillo, Coahuila, CCR = Cerro de Cristo Rey, Galeana, Nuevo León, SJS = San Joaquín de Soto, Aramberri, Nuevo León, LPM = La Peña, Miquihuana, Tamaulipas, CEW = Camino al Estanque de los Walle, Miquihuana, Tamaulipas, CNM = Cañón de la Nopalera, Miquihuana, Tamaulipas. CBB = Camino a Bustamante, Bustamante, Tamaulipas.

Table 5. Endemisms by study site.

Rank	Species	Study site						
		Coahuila	Nuevo León		Tamaulipas			
		SZP	CCR	SJS	LPM	CEW	CNM	CBB
1.	*Agave lechuguilla*	*	*		*			
2.	*Agave striata*				*	*		
3.	*Dasylirion cedrosanum*	*						
4.	*Dasylirion miquihuanense*				*		*	
5.	*Hechtia hernandez-sandovalii*				*	*		
6.	*Juniperus monticola*							*
7.	*Krameria cytisoides*					*		*
8.	*Leucophyllum frutescens*				*	*		
9.	*Nolina cespitifera*	*						
10.	*Opuntia stenopetala*		*		*	*	*	*
11.	*Yucca filifera*							*
	Total	3	2	0	6	5	2	4

SZP = Sierra de Zapalinamé, Saltillo, Coahuila, CCR = Cerro de Cristo Rey, Galeana, Nuevo León, SJS = San Joaquín de Soto, Aramberri, Nuevo León, LPM = La Peña, Miquihuana, Tamaulipas, CEW = Camino al Estanque de los Walle, Miquihuana, Tamaulipas, CNM = Cañón de la Nopalera, Miquihuana, Tamaulipas. CBB = Camino a Bustamante, Bustamante, Tamaulipas.

found (**Figure 10**). These results coincide with Granados-Sánchez [38], it has been reported that the presence of these species is influenced mainly by soil type and composition [39].

Estrada-Castillón [40] coincides in that Asteraceae is one of the most representative families for the case of scrub vegetation. Within the outstanding group of families, Asteraceae, Asparagaceae and Fabaceae are notable, the first two of these are reported as dominant [7, 16, 18].

The plant communities were grouped as follows: CEW and CBB, with a dominance of the shrub stratum with the Asparagaceae family. For this reason, the presence of *D. cinnabarinus* is influenced by the dominance of the shrub stratum and of those species with the capacity to store water and nutrients, as is

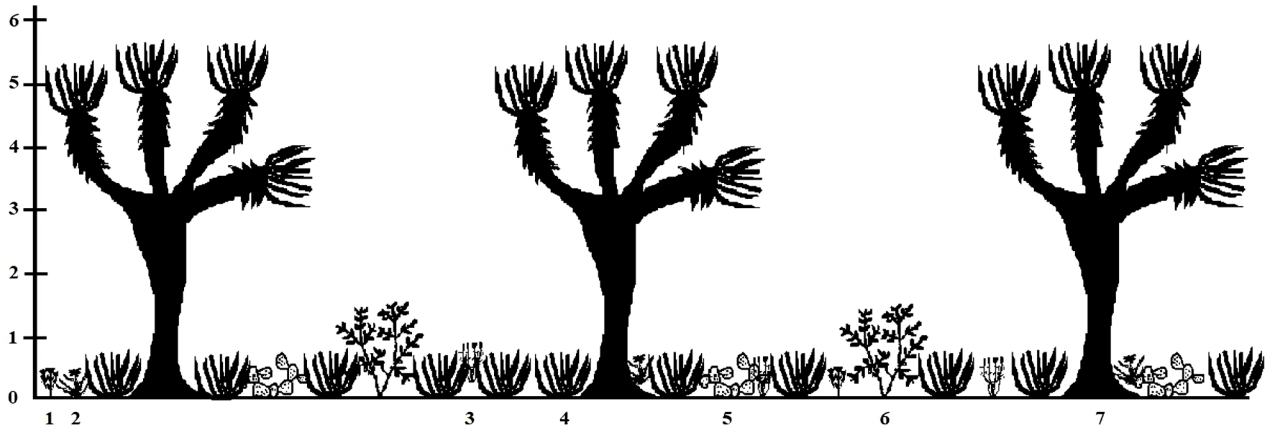

Figure 8. Diagrammatic profail of rosetophile scrub of Camino a Bustamante, Bustamante, Tamaulipas. 1. *Chysactinia mexicana*, 2. *Dalea foliolosa*, 3. *Aristida adscensionis*, 4. *Agave lechuguilla*, 5 *Opuntia stenopetala*, 6. *Berberis trifoliolata*, 7. *Yucca filifera*.

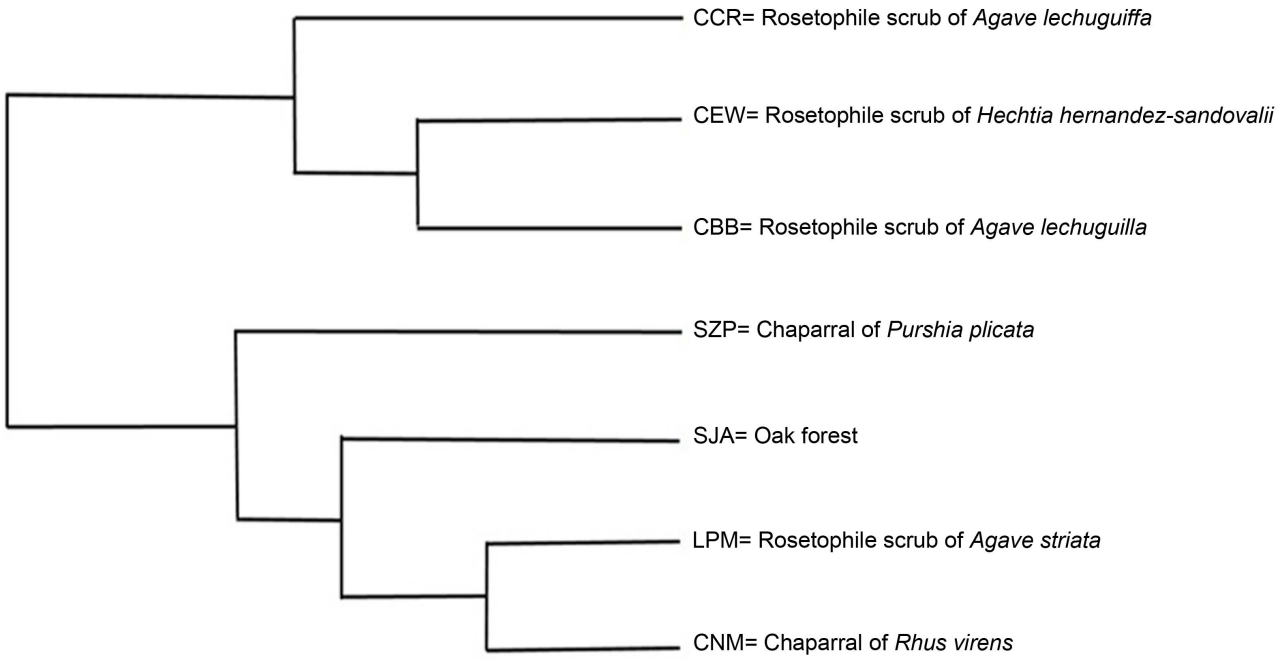

Figure 9. Results of the Parsimony Analysis of Endemicity. Site and its respective vegetation type. CCR = Cerro de Cristo Rey, Galeana, Nuevo León, CEW = Camino al Estanque de los Walle, Miquihuana, Tamaulipas, CBB = Camino a Bustamante, Bustamante, Tamaulipas, SZP = Sierra de Zapalinamé, Saltillo, Coahuila, SJA = San Joaquín de Soto, Aramberri, Nuevo León, LPM = La Peña, Miquihuana, Tamaulipas, CNM = Cañón de la Nopalera, Miquihuana, Tamaulipas.

the case of the genera *Agave*, *Hechtia* and *Dasylirion*, while in LPM and CNM the shrub stratum with *R. virens* and *Quercus greggii*, respectively, is dominant. In both sites the shrub stratum dominates, and a similar type of vegetation is present, forming another group in the dendrogram resulting from the parsimony analysis of endemicity. This is due to the difference between the vegetation of the two sites. For CCR, dominance of the shrub stratum with *A. lechuguilla* is observed, while for SZP the shrub stratum dominates, and *Purshia stansburyana* is the outstanding species. These two sites form separate groups

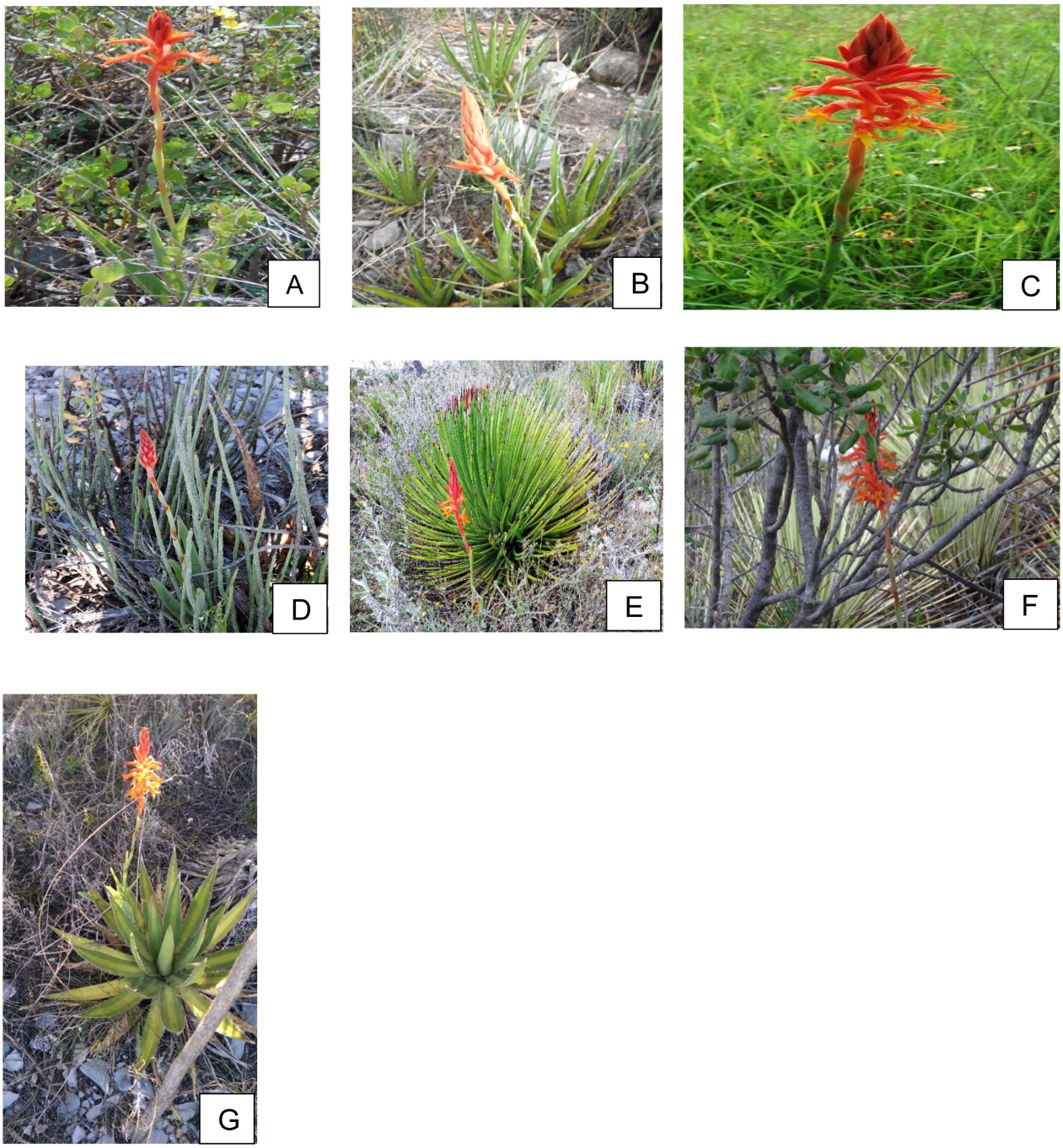

Figura 10. *Dichromanthus cinnabarinus* with associated species in each study site. A. *Dichromanthus cinnabarinus* with *Aristida adscensionis* in Sierra de Zapalinamé, Saltillo, Coahuila; B. *Dichromanthus cinnabarinus* with *Agave lechuguilla* in Cerro Cristo Rey, Galeana, Nuevo León; C. *Dichromanthus cinnabarinus* with *Sporobolus airoides* in San Joaquín de Soto, Aramberri, Nuevo León; D. *Dichromanthus cinnabarinus* with *Euphorbia* antisyphilitica in La Peña, Miquihuana, Tamaulipas; E. *Dichromanthus cinnabarinus* with *Agave striata* in road to Estanque de los Walle, Miquihuana, Tamaulipas; F. *Dichromanthus cinnabarinus* with *Rhus virens* in Cañón de la Nopalera, Miquihuana, Tamaulipas; G. *Dichromanthus cinnabarinus* with *Agave lechuguilla* in Camino a Bustamante, Bustamante, Tamaulipas.

despite having similar vegetation type. The rosetophile shrub, however, contains different species. Finally, SJS has totally different vegetation (oak forest); thus, a taxonomic and genetic study should be conducted to determine whether the *Dichromanthus* species is the same for the rest of the sites.

Floristic analysis. The floristic inventory of northeastern Mexico (**Table 4**) shows high diversity in the area containing the study sites: a total of 33 families, of which the most diverse families are Asteraceae and Asparagaceae. This coincides with Villaseñor [41]. Moreover, results of studies conducted in related areas coincide with the work of Molina [19], who reports that the outstanding families were Cactaceae and Asteraceae, while Mora-Donjuán [23] reports the families Fabaceae, Cactaceae and Asteraceae [20] and mentions the family Fabaceae as the most representative.

Sierra de Zapalinamé, in Saltillo, Coahuila (DCH), and Camino a Bustamante, Tamaulipas (SMO), contain 23 and 21 species, respectively. These sites were the most diverse, followed by Cerro del Cristo Rey in Galeana, Nuevo León (SMO) with 19 species, coinciding with the results reported by Encina *et al*. [6]. Camino al Estanque de los Walle, in Miquihuana, Tamaulipas (DCH and SMO), contains 18 species, followed by Cañón de la Nopalera, in Miquihuana, Tamaulipas (DCH and SMO) with 14 species, and San Joaquín de Soto, in Aramberri, Nuevo León (SMO) and La Peña, Miquihuana, Tamaulipas (DCH and SMO) have 13 species. Despite having relatively few species, they are areas with high biological diversity, according to Gonzáles-Elizondo [31], who mention that these eco-regions have a high degree of diversity.

Endemism. The most outstanding families were Asparagaceae, Cactaceae, Cupressaceae, Krameriaceae and Scrophulariaceae, coinciding with the results of Alanís-Flores *et al.* [42]; Villarreal-Quintanilla *et al.* [4] mention that the Cactaceae and Asparagaceae families are outstanding for the number of endemics in the northern region of Mexico.

D. cinnabarinus is found in diverse vegetation types and associated with *Aristida adscensionis* L., *Agave lechuguilla* Torr. *Bouteloua* sp., *Euphorbia antisyphilitica* Zucc., *Agave striata* var. *striata* (Salm-Dyck) and *Rhus virens* Lindh. ex A. Gray. Moreover, *Dichromanthus cinnabarinus* is observed in some sites with contrasting flora, according to the resulting list of endemic species. However, we consider that a process of speciation has occurred, and therefore, the specimens found may be new species of the genus *Dichronmanthus* in sites with contrasting vegetation and flora. The results of our study are the basis for development of later studies with DNA to corroborate the hypothesis that there may be new species of the genus *Dichromanthus*.

It is relevant to mention the importance of establishing priority areas as a strategy of conservation and sustainable management of wild species in northeastern Mexico with the aim of protecting the processes of speciation occurring in this region.

ACKNOWLEDGEMENTS

Our thanks to the Universidad Autónoma de Tamaulipas, Facultad de Ingeniería y Ciencias and to the Programa de Maestría en Ciencias Sistemas Agropecuarios y Medio Ambiente for their support. We acknowledge CONACyT for the grant conferred (781879), and Dr. Juan Castillo Landeros for his contributions to the manuscript.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest regarding the publication of this paper.

REFERENCES

1. Alanís-Flores, G.J., Alvarado-Vázquez, M.A., Ramírez-Freire, L., Foroughbakhch-Pornavab, R. and Velazco-Macías, C.G. (2011) Flora endémica de Nuevo León, México y estados colindantes. *Journal of the Botanical Research Institute of Texas*, **5**, 275-298.

2. Alanís-Rodríguez, E., Mora-Olivo, A., Jiménez-Pérez, J., González-Tagle, M.A., Yerena Yamallel, J.I., Martínez-Ávalos, J.G. and González-Rodríguez, L.E. (2015) Composición y diversidad del matorral desértico

rosetófilo en dos tipos de suelo en el Noreste de México. *Acta Botánica Mexicana*, **110**, 105-117. https://doi.org/10.21829/abm110.2015.187

3. Alanís-Rodríguez, E., Jiménez, J., Mora, A., Martínez, J.G., Mata, J.M., Chávez, A. and Rubio, E. (2015) Estructura y diversidad del matorral submontano contiguo al área metropolitana de Monterrey, Nuevo León, México. *Acta Botánica Mexicana*, **113**, 1-19. https://doi.org/10.21829/abm113.2015.1093
4. Cuevas, P.E. (2010) Distribución de Grimmiaceae y Pottiaceae (Bryophyta) en un gradiente altitudinal del Nevado de Toluca Estado de México. Tesis doctoral, Universidad Autónoma del Estado de México, Toluca.
5. Encina-Domínguez, J.A., Zárate, A., Estrada, E., Valdés Reyna, J. and Villarreal, J.A. (2009) Composición y aspectos estructurales de los bosques de encino de la Sierra de Zapalinamé, Coahuila, México. *Acta Botánica Mexicana*, **86**, 71-108. https://doi.org/10.21829/abm86.2009.1078
6. Encina-Domínguez, J.A., Castillón, E., Quintanilla, J., Villaseñor, J., Ayala, C. and Arévalo, J. (2016) La riqueza florística de la Sierra de Zapalinamé, Coahuila, México. *Phytotaxa*, **1**, 1-42. https://doi.org/10.11646/phytotaxa.283.1.1
7. Encina-Domínguez, J.A., Estrada-Castillón, E., Villarreal-Quintanilla, J.A., Villaseñor, J.L., Cantú-Ayala, C.M. and Arévalo, J.R. (2017) Floristic Richness of the Sierra de Zapalinamé, Coahuila, México. *Phytotaxa*, **283**, 16-46. https://doi.org/10.11646/phytotaxa.283.1.1
8. Encina-Domínguez, J.A., Meave, J.A. and Zárate-Lupercio, A. (2013) Structure and Woody Species Diversity of the *Dasylirion cedrosanum* (Nolinaceae) Rosette Scrub of Central and Southern Coahuila State, México. *Botanical Sciences*, **3**, 335-347. https://doi.org/10.17129/botsci.12
9. Estrada-Castillón, E., Villarreal, J.Á., Jurado, E., Cantú, C., García, M.A., Sánchez, J., Jiménez, J. and Pando, M. (2012) Clasificación, estructura y diversidad del matorral submontano adyacente a la planicie costera del Golfo Norte en el Noreste de México. *Botanical Sciences*, **1**, 37-52. https://doi.org/10.17129/botsci.384
10. Estrada-Castillón, E., Villarreal-Quintanilla, J. and Salinas-Rodríguez, M. (2013) Usos Tradicionales de los Recursos Naturales. In: Cantú-Ayala, *et al.*, Eds., *Historia Natural del Parque Nacional Cumbres de Monterrey*, UANL-CONANP, México, 297-323.
11. González-Elizondo, M.S., Moreno-Valdez, A., Durán de Aguilar, M.R. and Córdova-Bojórquez, G. (2004) Características físicas, ambientales, sociales y económicas de la Región Noreste de México. In: Semarnat, Ed., *Consejo Consultivo Nacional para el Desarrollo Sustentable*, Libro Blanco Segunda Generación, México, 23-39.
12. González-Medrano, F. (2004) Las comunidades vegetales de México. Propuesta para la unificación de la clasificación y nomenclatura de la vegetación de México. Instituto Nacional de Ecología, Secretaría de Medio Ambiente y Recursos Naturales, México.
13. González-Rodríguez, H., Ramírez-Lozano, R.G., Cantú-Silva, I., Gómez-Meza, M.V. and Uvalle-Sauceda, J.I. (2010) Composición y estructura de la vegetación en tres sitios del estado de Nuevo León, México. *Polibotánica*, **29**, 91-106.
14. Granados-Sánchez, D. and Sánchez-Gonzáles, A. (2003) Clasificación fisonómica de la vegetación de la Sierra de Catorce San Luis Potosí a lo largo de un gradiente altitudinal. *Terra*, **21**, 321-332.
15. Granados-Sánchez, Sánchez-González, D.A., Linnx, R. and Barboja de la Rosa, A. (2011) Ecología de la vegetación del desierto Chihuahuense. *Ciencias Forestales y del ambiente*, **17**, 111-130. https://doi.org/10.5154/r.rchscfa.2010.10.102
16. Guzmán-Lucio, M.A., Wendt, Tom Simpson, B., Alvarado-Vázquez, M.A., Foroughbakhch-Pournavab, R., González-Álvarez, M. and Rocha-Estrada, A. (2013) Listado florístico de especies anuales de floración invernal en el noreste de Nuevo León, México. *Revista mexicana de biodiversidad*, **3**, 884-893. https://doi.org/10.7550/rmb.27153

17. Hágsater, E., Soto, M.A., Salazar, G.A., Jiménez, R., López, M.A. and Dressler, R.L. (2005) Orquídeas de México. Instituto Chinoin, AC, Ciudad de México, Vol. 75, 1-302.

18. Halffter, G. (1964) La entomofauna americana: ideas acerca del origen y distribución. *Folia Entomológica Mexicana*, **6**, 1-108.

19. Hernández-López, T., Treviño-Carreón, J., Herrera-Monsiváis, M.C. and García-Jiménez, J. (2012) Contribución al conocimiento de las orquídeas de Tamaulipas, México. En: Conocimiento de las Orquídeas en Tamaulipas. *Recursos Naturales*, **48**, 12-25.

20. Hernández-Mendoza, A.M., Arreguín-Sánchez, M.L., García-Jiménez, J. and Herrera-Monsivais, M.C. (2015) Composición taxonómica y datos ecológicos de las licofitas y monilofitas de la Sierra de Tamaulipas, Tamaulipas, México. *Polibotánica*, **40**, 29-44. https://doi.org/10.18387/polibotanica.40.2

21. Huerta-Martínez, F.M. and García-Moya, E. (2004) Diversidad de especies perennes y su relación con el ambiente en un área semiárida del centro de México. *Interciencia*, **29**, 435-441.

22. INEGI. Instituto Nacional de Estadística y Geografía (2005) II Conteo de Población y Vivienda. Instituto Nacional de Estadística y Geografía. (MGM-II Conteo 2005).

23. INEGI. Instituto Nacional de Estadística y Geografía (2009) Carta digital, uso de suelo y vegetación, escala 1: 250,000. Serie III. Instituto Nacional de Estadística, Geografía e Informática, México.

24. INEGI. Instituto Nacional de Estadística y Geografía (2010) Compendio de información geográfica municipal de los Estados Unidos Mexicanos Miquihuana, Tamaulipas. Instituto Nacional de Estadística y Geografía 1-10. Clave geoestadística. 1-10.

25. Lot, A. and Chiang, F. (1986) Manual de herbario, administración y manejo de colecciones técnicas de recolección y preparación de ejemplares botánicos. Instituto de Biología UNAM, México, 142 p.

26. Mata-Balderas, J.M., Treviño-Garza, E.J., Jiménez-Pérez, J., Aguirre-Calderón, O.A., Alanís Rodríguez, E. and Mora-Olivo, A. (2015) Estructura y composición florística del matorral desértico rosetófilo del noreste de México. *Ciencia UANL*, **75**, 67-74.

27. Medina Guillén, R., Cantú Silva, I., Estrada Castillón, E., González Rodríguez, H. and Delgadillo Villalobos, J. (2015) Cambios en la vegetación del matorral desértico micrófilo en un área bajo manejo. *Revista Mexicana de Ciencias Forestales*, **32**, 37-48.

28. Molina Guerra, V.M., Cervantes Balderas, J.M., Soto Mata, B., Alanís Rodríguez, E., Marroquín-Castillo, J.J. and Sarmiento Muñoz, T.I. (2017) Composición y estructura del matorral desértico rosetófilo del Sureste de Coahuila, México. *Polibotánica*, **44**, 67-77.

29. Mora-Donjuán, C.A., Rubio-Camacho, E.A., Alanís-Rodríguez, E., Jiménez-Pérez, J., González-Tagle, M.A., Mata-Balderas, J.M. and Mora-Olivo, A. (2014) Composición y diversidad vegetal de un área de matorral desértico micrófilo con historial pecuario en el noreste de México. *Polibotánica*, **38**, 53-66.

30. Morrone, J. (2005) Hacia una síntesis biogeográfica de México. *Revista Mexicana de Biodiversidad*, **76**, 207-252. https://doi.org/10.22201/ib.20078706e.2005.002.303

31. Mostacedo, B. and Fredericksen, T.S. (2000) Manual de Métodos Básicos de Muestreo y Análisis en Ecología Vegetal. Santa Cruz, Bolivia, Bolfor.

32. Ríos Cruz, E. and Treviño Carreón, J. (2014) De los valles intermontanos a las montañas de Miquihuana, Tamaulipas. *Herbario CICY*, **6**, 16-19.

33. Rzedowski, J. (2006) Vegetación de México. Ciudad de México. En: Comisión Nacional para el Conocimiento y Uso de la Biodiversidad.

34. Sahagún Sánchez, F., Castro Navarro, J. and Reyes Hernández, H. (2013) Distribución geográfica de la avifauna en la Sierra Madre Oriental de San Luis Potosí, México: Un análisis regional de su estado de conservación.

Revista de Biología Tropical, **61**, 897-925. https://doi.org/10.15517/rbt.v61i2.11233

35. Salazar, G., Batista, J., Cabrera, L., Den Berg, C., Whitten, M., Smidt, E., Buzatto, C., Cantante, R., Gerlach, G., Jiménez-Machorro, R., Radins, J., Insaurralde, I., Guimaraes, L., Barros, F., Tobar, F., Linares, J., Mújica, J., Dressler, R., Blanco, M., Hágsater, E. and Chase, M. (2018) Sistemática filogenética de la subtribu Spiranthinae (Orchidaceae: Orchidoideae: Cranichideae) basada en secuencias de ADN nuclear y plastídico de una muestra genérica casi completa. *Botanical Journal of the Linnean Society*, **186**, 273-303. https://doi.org/10.1093/botlinnean/box096
36. Salazar, G., Cabrera, L. and Figueroa, C. (2011) Filogenia molecular, convergencia floral y sistemática de *Dichromanthus* y *Stenorrhynchos* (Orchidaceae: Spiranthinae). *Botanical Journal of the Linnean Society*, **167**, 1-18. https://doi.org/10.1111/j.1095-8339.2011.01161.x
37. Sutton, A. (2000) El Desierto Chihuahuense, nuestro desierto. Ciudad de México: Fondo Mundial para la Naturaleza.
38. Treviño-Carreón, J., Gutiérrez-Lozano, V., Aguirre-Bortoni, J. and Fernández-Villareal, J. (2012) La vegetación del altiplano de Tamaulipas México. Contribución al conocimiento de las orquídeas de Tamaulipas, México. En: Conocimiento de las Orquídeas en Tamaulipas. *Recursos Naturales*, **48**, 1-12.
39. Treviño-Carreón, J. and Valiente-Banuet, A. (2005) La vegetación de Tamaulipas y sus principales asociaciones vegetales. In: Barrientos, L., Correa, A., Horta, J.V. and García, J., Eds., *Biodiversidad Tamaulipeca*, Vol. I, Dir. Gral de Educación Superior e Instituto Tecnológico de Cd. Victoria, México, 22-46.
40. Villarreal-Quintanilla, J.A., Bartolomé-Hernández, J.A., Estrada-Castillón, E., Ramírez-Rodríguez, H. and Martínez-Amador, S.J. (2017) El elemento endémico de la flora vascular del Desierto Chihuahuense. *Acta Botánica Mexicana*, **118**, 65-96. https://doi.org/10.21829/abm118.2017.1201
41. Villaseñor, J.L. and Ortiz, E. (2014) Biodiversidad de las plantas con flores (División Magnoliophyta) en México. *Revista Mexicana de Biodiversidad*, **85**, 134-142. https://doi.org/10.7550/rmb.31987
42. Villaseñor, J.L. (2016) Checklist of native vascular plants of Mexico. *Revista Mexicana de Biodiversidad*, **87**, 559-902. https://doi.org/10.1016/j.rmb.2016.06.017