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Diversity, spatial arrangement, and endemism of Cactaceae in the Huizache area, a hot-spot in the Chihuahuan Desert

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Abstract. We studied several aspects of the cactus diversity in the Huizache, an area located in the southern extreme of the Chihuahuan Desert Region, in San Luis Potosí, Mexico. Fieldwork was conducted in a square-shaped polygon (22°30′–23°00′ N, 100°00′–100°30′ W), where a total of 80 systematically-chosen localities were sampled for cactus species. Results showed that the Huizache is an important focal point for the conservation of the Cactaceae, due to the remarkably high diversity of members of this plant family in the area. With 75 species recorded, this area has the highest concentration of cactus species in the American Continent, in comparison with other comparably-sized regions. The outstanding diversity of cactus species in the Huizache area may be explained by the relatively favorable climate of this desert area, its environmental heterogeneity, and its location in a transitional position between three regions with distinct cactus floras: Chihuahuan Desert Region, Queretaroan-Hidalgoan Arid Zone, and Tula-Jaumave Valleys. Species richness is not distributed evenly in the area; the zones of highest species concentration are primarily located in the lowland valleys, in the northwestern portion of the grid square, where typical Chihuahuan Desert conditions prevail. Of the 75 cactus species found in the area, 63% are endemic to the Chihuahuan Desert. Among these, ten species are outstanding for being endemic or nearly endemic to the Huizache area. The Huizache grid square is part of a recently declared natural reserve, The Real de Guadalcázar Natural Reserve.

Key words: Cactaceae, Chihuahuan Desert, conservation, distribution patterns, endemism, Guadalcázar, hot-spot, Huizache, Mexico

Introduction

The Chihuahuan Desert is one of the most biologically diverse arid regions on earth. In fact, it is not surprising that it is considered to be among the three outstanding desert ecoregions in the world with an indisputable global importance (Olson and Dinerstein 1998; Dinerstein et al. 1999). Unfortunately, however, only 1.1% (6900 km^2) of the ecoregion is under formal conservation (Dinerstein et al. 1999). Mexico's National System of Protected Areas covers only a limited extension of the critical areas of this desert (Gómez-Pompa and Dirzo 1994), and the most important of these protected areas, the Mapimí Biosphere Reserve and Cuatro Ciénegas, do not correspond with

the areas of high cactus species richness and endemism (Hernández and Bárcenas 1995, 1996; Gómez-Hinostrosa and Hernández 2000; this paper).

In previous papers (Hernández and Bárcenas 1995, 1996), we analyzed the distribution patterns of a sample of 93 species of endangered cacti from the Chihuahuan Desert Region (CDR). The region was divided into grids of 30 min latitude by 30 min longitude and species richness was determined for each grid. From that study it was evident that species richness is substantially higher toward the southeastern and eastern portions of this region, particularly in northern San Luis Potosí, and southern Nuevo León and Tamaulipas (Figure 3 in Hernández and Bárcenas 1995). Within this segment of the CDR, one particular grid square, which we called Huizache, was outstanding for having the greatest collection of endangered species of cacti.

Despite the fact that the Chihuahuan Desert is the Mexican region with the highest diversity of Cactaceae both at the National and Continental levels (Hernández and Godínez 1994; Hernández and Bárcenas 1995), our basic knowledge on the floristics and biogeography of this family in the region is still fragmentary. Thus, as part of a long-term research project on the biogeography and conservation of the Cactaceae in the CDR, we designed a research project aimed at better understanding several basic biogeographic aspects of the Cactaceae occurring in the Huizache Region.

The results gathered from this project allowed us to: (1) compile an updated, and theoretically complete, list of the cactus species occurring in the Huizache area, (2) compare the cactus diversity in the area with that of several other cactus-rich Mexican regions, (3) discuss the possible causes that result in high cactus diversity, (4) determine the spatial patterns of the species at a high level of resolution, and (5) identify the biogeographic affinities of the species occurring in the area. In addition, the individual species were studied in terms of their relative geographical and ecological rarity; however, these aspects of the project will be analyzed in a separate paper.

Study area

The studied area is a square-shaped polygon approx. 2855 km^2. It is located in the southeastern extreme of the CDR (Henrickson and Straw 1976), in the northern part of the state of San Luis Potosí (22°30′–23°00′ N, 100°00′–100°30′ W), and includes most of the Municipality of Guadalcázar, along with a small part of the State of Tamaulipas (Figure 1).

The topography of the Huizache grid square, along with the distribution of rainfall and mean temperatures are shown in Figure 2. The area is dominated by extensive lowland plains, which are interrupted by numerous mountain ranges of variable altitude. The most conspicuous of these is the Sierra La Trinidad mountain range, whose highest peak reaches 2260 m in elevation, giving the area considerable climatic and vegetational diversity. The plains correspond to the driest portions of the area, usually

receiving an average of 300 mm of rainfall per year. Precipitation increases with altitude, reaching a maximum of 800 mm at the mountaintops. Temperatures are the highest in the plains (average mean temperature = 20–22 °C) gradually decreasing as the altitude increases. (Figure 2).

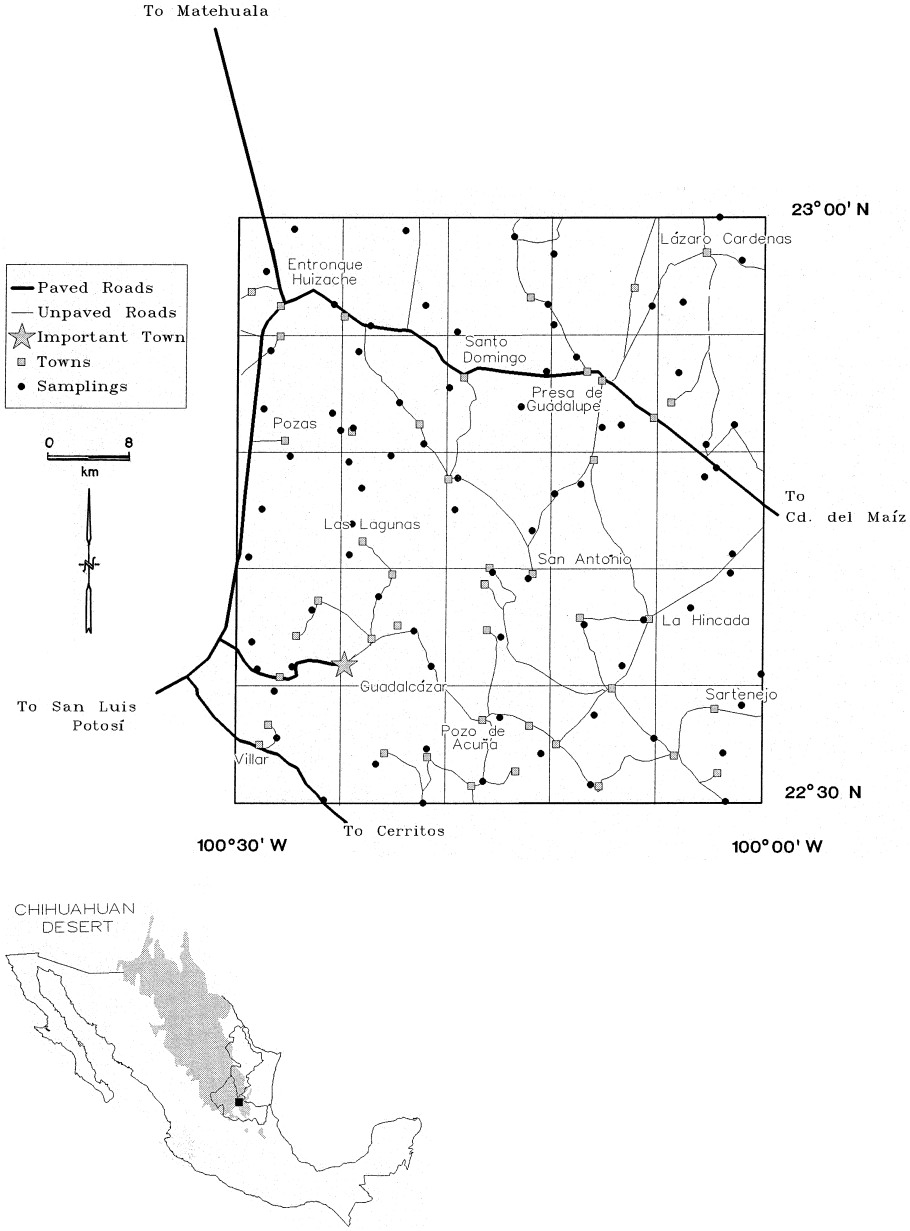

Figure 1. Location of the Huizache grid square. Solid dots indicate the localities sampled for cactus species.

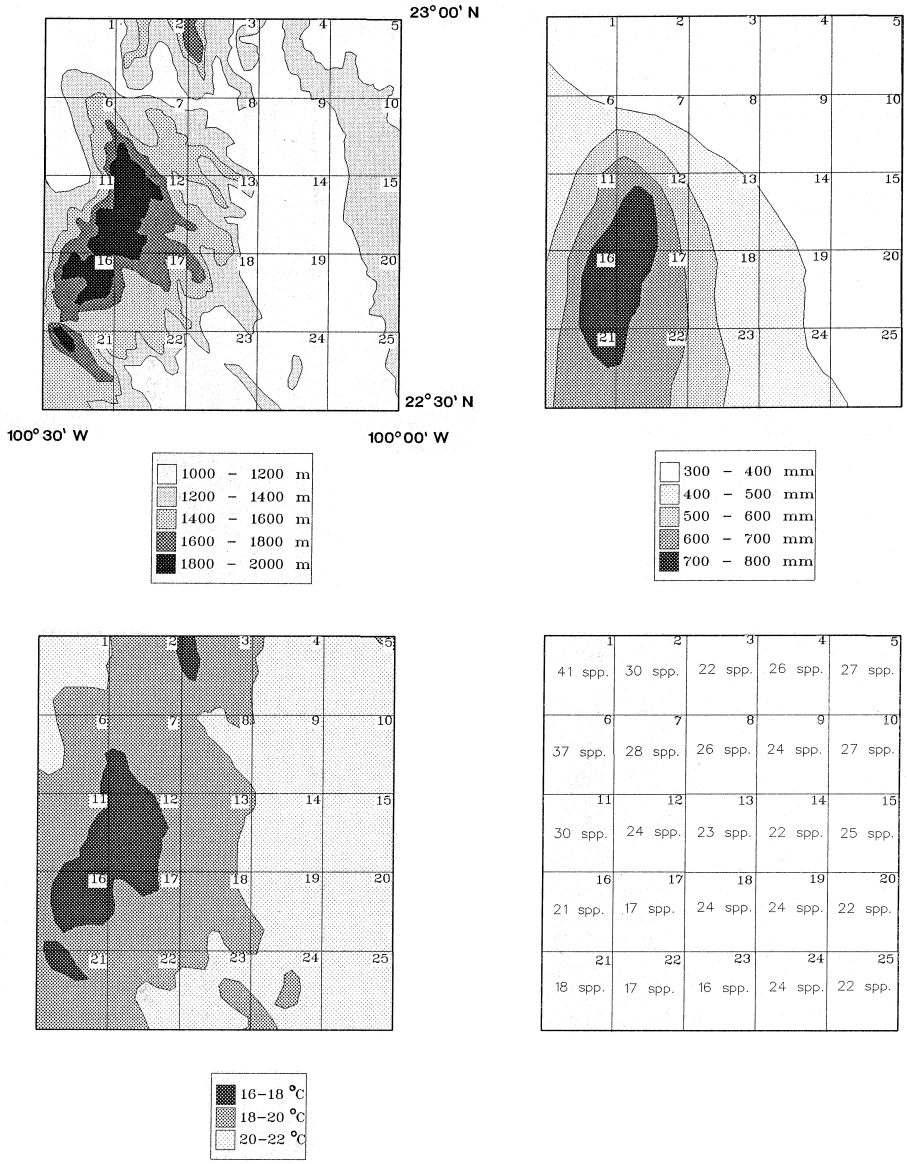

Figure 2. Topography, precipitation pattern, annual mean temperatures (°C), and spatial pattern of species richness of Cactaceae in the Huizache grid square. Topographic and climatic data from INEGI (1981).

Rzedowski (1956) published a descriptive account of the plant communities in the area. The plains, together with the lower slopes of the mountain ranges and most of the intermountain valleys, are covered by xerophytic plant associations typical of CDR (e.g., creosote bush scrub, rosetophyllous thorn scrub, and mesquite desert scrub). However, more mesic vegetation types, such as sub-montane forest, oak forest, chaparral, and grassland are represented in limited extensions at higher elevations.

Methods

Cactus populations in the CDR are usually difficult to find in the field, as they display patchy distributions and individuals are frequently extremely cryptic. Thus, in order to record the totality of the cactus species in the whole area, a systematic plan of botanical collecting was developed. The Huizache grid square was subdivided into 25 sub-squares, each measuring 6 min per side (Figures 1 and 2). In each sub-square three or four localities were intensively sampled, so that all of the cactus species in the area were recorded. Usually, samplings were made along a transect of at least 3 km, with the participation of two or three observers. The collecting sites, which were selected using as a basic criterion the presence of well preserved original vegetation, were approached using all the available roads and by foot. A total of eight 7–10-day expeditions were conducted, in which a total of 80 collecting sites were sampled for cactus species (Figure 1). Locations were carefully accounted for and positions were recorded using GPS technology. As a result of these samplings, a total of 1211 specimens were incorporated into the National Herbarium of Mexico (MEXU). The information from these specimens was incorporated into the Database of Cactus Collections from North and Central America (Hernández et al. 1993). With few exceptions, the taxonomic nomenclature used in this investigation follows Hunt (1999).

The Huizache cactus flora was compared phytogeographically with several other well-known areas within the CDR: Mier y Noriega (Gómez-Hinostrosa and Hernández 2000), Doctor Arroyo (Hernández-Valencia 1981), Sierra de la Paila (Villarreal 1994), Cuatro Ciénegas (Pinkava 1984), and Mapimí (Ruiz de Esparza 1988). Comparisons were also made with three areas of the Queretaroan-Hidalgoan Arid Zone (QHAZ): Xichú, San Luis de la Paz, and San Miguel de Allende (Bárcenas 1999). In order to do this, the pairwise similarities of all possible combinations of cactus areas were calculated using Jaccard's qualitative index (Rohlf 1998).

Results and discussion

Species diversity

According to our cactus database, a total of 46 cactus species was originally reported for the area. Fieldwork allowed us to record 29 additional species (new area records, Table 1), ten of which were new state records (e.g., *Epithelantha micromeris*, *Mammillaria albicoma*, *M. sphaerica*, *Turbinicarpus gautii*, *T. viereckii*). The results confirmed our presumption that the Huizache grid square has an extraordinary wealth of cactus species. With a total of 75 native species recorded (Table 1), we confirmed that this relatively small region has a higher number of cactus species than any other area of comparable size on the American Continent. In addition to the 75 species found

Table 1. Species of Cactaceae occurring in the Huizache grid square, San Luis Potosí, Mexico. Taxonomic concepts based on Hunt (1999) with a few exceptions.

Taxon	Voucher	New area records	New state records
Ariocarpus bravoanus	Hernández 2153		
A. kotschoubeyanus	Gómez 750		
A. retusus	Bárcenas 1080		
Astrophytum myriostigma	Hernández 3079		
Coryphantha bergeriana	Gómez 748		
C. odorata	Gómez 1589		
C. palmeri	Bárcenas 1394		
C. pulleineana	Hernández 2710		
C. villarensis	Gómez 1156		
C. wohlschlageri	Gómez 1143	A	
Echinocactus horizonthalonius	Bárcenas 1174		
E. platyacanthus	Gómez 723		
Echinocereus cinerascens	Bárcenas 1138		
E. enneacanthus	Hernández 3097	A	
E. parkeri	Hernández 3205	A	
E. pectinatus	Hernández 2731		
E. pentalophus	Hernández 3185		
E. waldeisii	Hernández 2688		
Epithelantha micromeris	Bárcenas 1001	A	S
Ferocactus echidne	Gómez 1158		
F. hamatacanthus	Hernández 3091		
F. histrix	Hernández 2686	A	
F. latispinus	Hernández 3303	A	
F. pilosus	Gómez 1122		
Leuchtenbergia principis	Hernández 2720		
Lophophora williamsii	Gómez 762		
Mammillaria albicoma	Bárcenas 1200	A	S
M. aureilanata	Bárcenas 1500		
M. candida	Bárcenas 1211		
M. compressa	Gómez 1520		
M. formosa	Gómez 1598		
M. geminispina[a]	Bárcenas 1026		
M. heyderi	Hernández 3208		
M. magnimamma	Hernández 3225		
M. microthele	Gómez 1142	A	S
M. pilispina	Gómez 1505		
M. prolifera	Hernández 2807		
M. schiedeana	Gómez 710	A	
M. sphaerica	Bárcenas 1287	A	S
M. surculosa	Bárcenas 1091		
M. uncinata	Hernández 3275	A	
Myrtillocactus geometrizans	Bárcenas 1128		
Neolloydia conoidea	Bárcenas 1319		
Opuntia engelmannii	Bárcenas 1081	A	
O. imbricata	Bárcenas 1031	A	
O. kleiniae	Gómez 1565	A	S
O. lasiacantha	Gómez 1535	A	
O. leptocaulis	Hernández 2899		
O. leucotricha	Gómez 1604	A	

Table 1. Continued.

Taxon	Voucher	New area records	New state records
O. megarrhiza	Hernández 3255	A	
O. microdasys	Hernández 2738		
O. pubescens	Hernández 2804	A	
O. rastrera	Gómez 1591		
O. robusta	Hernández 3132	A	
O. stenopetala	Gómez 1579		
O. streptacantha	Hernández 3278		
O. tomentosa	Gómez 698	A	
O. tunicata	Bárcenas 1015		
O. aff. *velutina*	Gómez 1537		
O. vilis	Hernández 2701	A	S
O. pachyrrhiza (in edit)[b]	Gómez 1534	A	S
O. hybrid[c]	Hernández 2768	A	S
Sclerocactus uncinatus	Gómez 751		
Selenicereus spinulosus	Hernández 2809	A	
Stenocactus sp.	Hernández 3247		
Stenocereus griseus	Bárcenas 1390	A	
Thelocactus bicolor	Hernández 2768		
T. conothelos	Hernández 3197	A	
T. hexaedrophorus	Bárcenas 1375		
T. tulensis	Gómez 1607		
Turbinicarpus gautii	Hernández 3193	A	S
T. knuthianus	Gómez 1490		
T. pseudopectinatus	Hernández 2932	A	
T. schmiedickeanus	Gómez 1128		
T. viereckii	Gómez 1689	A	S

Species included in CITES (1990) Appendix I, Walter and Gillett (1998) and/or SEDESOL (1994) are in boldface. [a] Same as *M. albata* Repp.; [b] Undescribed species; [c] Hybrid between *O. microdasys* and *O. engelmannii*.

in the strict limits of the grid square, two more species were recorded a few hundred meters from its boundaries: *Mammillaria crinita* subsp. *leucantha* (= *M. moeller-valdeziana*) and *Pelecyphora aselliformis*. However, the presence of these species within the Huizache grid square has yet to be confirmed. Furthermore, throughout the Huizache area there are numerous cultivated cactus species, such as *Hylocereus undatus*, *Nyctocereus serpentinus*, *Pachycereus marginatus*, and several species of prickly pears (*Opuntia* spp.).

Comparative species diversity

In order to place the Huizache area in a general context, we compared its cactus diversity with that of several other regions (Figure 3). Based on this comparison, the Huizache grid square has more cactus species than reputedly rich areas of comparable size that have been studied intensively, such as Mier y Noriega, Nuevo León (56 spp., Gómez-Hinostrosa 1998; Gómez-Hinostrosa and Hernández 2000), Cuatro Ciénegas, Coahuila (48 spp., Pinkava 1984), La Paila, Coahuila (44 spp., Villarreal

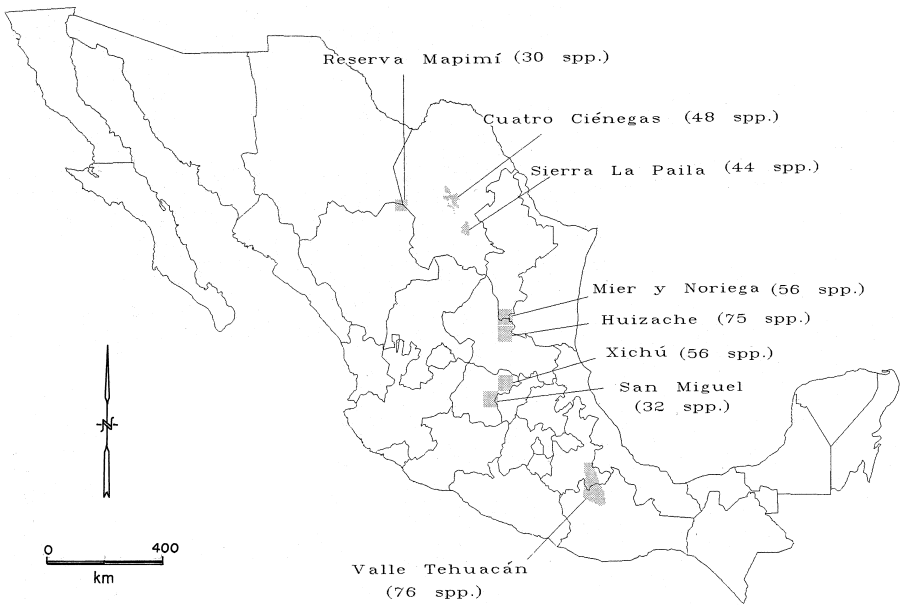

Figure 3. Comparison of species richness of Cactaceae in several Mexican regions. Data from various sources (see text).

1994), Xichú, Guanajuato (56 spp., Bárcenas 1999), and Mapimí, Durango (30 spp., Cornet 1985; Ruiz de Esparza 1988). Also, the Huizache grid square has a similar number of species as do the states of Arizona (78 spp., Lehr 1978), Texas (62 spp., Correll and Johnston 1970), Guanajuato (92 spp., Bárcenas 1999), Baja California (65 spp.), and Baja California Sur (64 spp., Rebman et al. 1999). Likewise, it has a similar number of species as all of the Central American countries combined (74 spp., Bravo and Arias 1999), and a substantially higher number than Cuba, and most South American countries (Hunt 1999).

The only area that compares with that of the Huizache is the Tehuacán–Cuicatlán Valley, in the Mexican states of Puebla and Oaxaca, where species richness is also very high (76 native species, Arias et al. 1997). However, this area is more than three times larger (10 000 km^2) than that of the Huizache. In contrast to the relatively inconspicuous species of Cactaceae found at the Huizache area, there is a predominance in the Tehuacán–Cuicatlán Valley of large, columnar or profusely-branched, arborescent species (e.g., *Cephalocereus columna–trajani*, *Mitrocereus fulviceps*, *Myrtillocactus* spp., *Neobuxbaumia* spp., *Pachycereus* spp., *Stenocereus* spp., *Polaskia* spp., *Escontria chiotilla*). On the other hand, in the Huizache the only conspicuous species are the arborescent *Myrtillocactus geometrizans* and *Stenocereus griseus*, and two barrel cacti (*Echinocactus platyacanthus* and *Ferocactus pilosus*). This divergence in the dominance of different life-forms is probably linked to the fact that in the CDR the relatively low winter temperatures inhibit the survival of columnar cactus species. In

North America, the large arborescent, columnar or candelabriform, life-forms center their geographical ranges in areas influenced by tropical climatic regimes (e.g., Tehuacán Valley, Balsas Basin, Tehuantepec Isthmus, and the Sonoran Desert).

Causes of diversity

The outstanding diversity of cactus species in the Huizache area may be explained by the combined effect of three ecological and biogeographical factors: the relatively favorable climate of the area, its environmental heterogeneity, and the fact that its location is in a transitional position between the domains of at least three diverging cactus floras.

Situated near the southern limit of the CDR, the Huizache grid square has a relatively favorable semi-arid climate, as compared with the northern portions of this desert (e.g., San Pedro de las Colonias, Cuatro Ciénegas, and Big Bend), where precipitation rates are lower, summer temperatures are higher, and winter temperatures are lower (INEGI 1981). Although some North American cactus species can tolerate very low temperatures and extremely dry environments (Gibson and Nobel 1986; Nobel 1994), most Mexican species appear to lack the ability to live in such extreme climatic conditions.

On the other hand, as indicated above, the Huizache area is dissected by the Sierra La Trinidad mountain range, providing the area with considerable climatic and vegetational heterogeneity. This results in a rich repertoire of sites with contrasting ecological conditions. The majority of the species are usually found in the driest, open, well insolated areas; however, some occur exclusively in relatively shaded areas, where higher precipitation results in a denser vegetation cover (e.g., *Coryphantha wohlschlageri*, *Ferocactus echidne*, *Mammillaria schiedeana*, *Selenicereus spinulosus*, *Turbinicarpus knuthianus*). In addition, several species show clear preferences for specific soil conditions.

Although the assemblage of cactus species in the Huizache predominantly includes typical Chihuahuan Desert elements, clear evidence exists that the grid square has been enriched with species from neighboring arid regions, such as the Queretaroan–Hidalgoan Arid Zone (QHAZ) and Tula-Jaumave Valleys. Situated at the edge of the main body of the CDR, the Huizache is located near the QHAZ, allowing species migration from the south. Although the CDR and the QHAZ are geographically separated by a complex of mountain ranges, which results in a more mesic climate, the floristic similarities between these areas are evident (Rzedowski 1973; Rzedowski and Calderón 1988, 1995), suggesting a long history of floristic interchange and perhaps a common origin. However, a high degree of differentiation is manifested by the fact that each area has a significant proportion of unique species, including many endemic cactus species. In order to assess the degree of similarity among cactus floras located in several areas of the CDR and the QHAZ, we used Jaccard's Index of similarity (Rohlf 1998). The resulting dendrogram (Figure 4) shows that these two

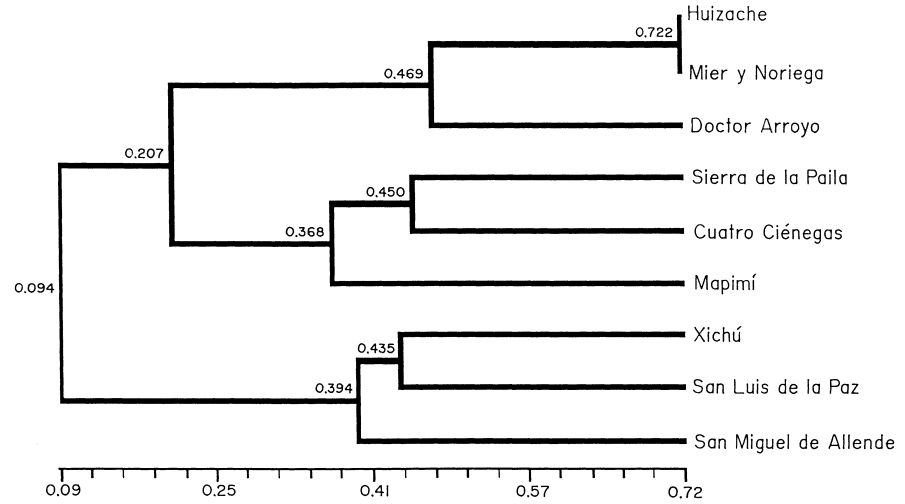

Figure 4. Dendrogram showing floristic affinities between regions located in the Chihuahuan Desert (Huizache, Mier y Noriega, Dr Arroyo, La Paila, Cuatro Ciénegas, and Mapimí), and the Queretaroan-Hidalgoan Arid Zone (Xichú, San Luis de la Paz, and San Miguel de Allende). Cophenetic value, $r = 0.95309$.

major regions are highly differentiated in terms of their cactus floras ($IS_j = 0.094$). In addition, Figure 4 shows two clusters within the CDR, which suggest two sub-regions. The first one contains the areas located near the southern extreme of the CDR (Huizache, Mier y Noriega, and Doctor Arroyo), whereas the second contains the areas found north of the Sierra de Parras (La Paila, Cuatro Ciénegas, and Mapimí). This dichotomy confirms previous suspicions that this mountain range, having an east–west orientation in southern Coahuila, has acted as a biogeographical barrier, causing a moderate degree of differentiation within the CDR biota. The existence of two major sub-regions within the CDR has been previously recognized by Morafka (1977a, b); however, further work needs to be done with other taxonomic groups in order to test the validity of this sub-division.

As previously indicated, most of the cactus species occurring in the Huizache are typical of the southern portion of the Chihuahuan Desert; however, a number of species characteristic of the QHAZ, or elsewhere from southern latitudes, were also found in the area (e.g., *Ferocactus echidne*, *F. histrix*, *F. latispinus*, *Mammillaria aureilanata*, *M. compressa*, *M. geminispina*, *M. magnimamma*, *M. schiedeana*, *M. uncinata*, *Selericereus spinulosus*). Likewise, a few species commonly found in the northern portions of the CDR, and previously unrecorded in the Huizache area, were collected (e.g., *Echinocereus enneacanthus*, *Epithelantha micromeris*, and *Turbinicarpus gautii*).

In addition to the south–north dispersal phenomenon described above, it is likely that there has also been bi-directional east–west displacement. Located east of the Huizache, the Tula-Jaumave Valleys are two regions very well known to cactus collectors for a profusion of unique, endemic species. The presence in the Huizache of

cactus species typical of these regions (e.g., *Mammillaria albicoma*, *M. sphaerica*, and *Turbinicarpus viereckii*) suggests east–west migration events. A further example supporting this is the recent discovery of *Ariocarpus agavoides* in San Luis Potosí (M. Sotomayor, pers. comm.), a species formerly known to be endemic to the Tula Valley.

Distribution patterns

The 80 samplings carried out in the Huizache grid square revealed that the number of cactus species found in each locality is highly variable, ranging from 5 to 32 species per locality. Usually, the collecting sites located in or near the lowland valleys, where the creosote bush scrub develops, contained the highest number of species; however, the richest collecting sites were those located in the interface between this plant association and the rosetophyllous thorn scrub. In contrast, the sites located at the top of the mountain ranges were the poorest in terms of cactus diversity.

Figure 2 shows the distribution pattern of cactus species in the Huizache grid square. The areas of highest species richness are concentrated in the northern portion, primarily in sub-squares 1, 2, 4–8, 10, and 11. Outstanding among these are sub-squares one and six, containing 41 and 37 cactus species, respectively. In this connection, one of the collecting sites at sub-square one was remarkable for its 32 recorded cactus species. Most of the remaining sub-squares contain between 21 and 25 species each, and several sub-squares located in the southwestern part of the grid square (sub-squares 17, 21, 22, and 23) have the lowest number of species (16 and 17 spp.). It is interesting to note that this general pattern match the results reported by Gómez-Hinostrosa and Hernández (2000) for the contiguous Mier y Noriega grid square (see also Figure 3 in Hernández and Gómez-Hinostrosa 2001).

The richest sub-square (sub-square 1) is primarily located in a depression surrounded by low hills, where relatively low precipitation and high mean temperatures prevail (Figure 2). The second richest sub-square (sub-square 6) is under similar conditions, although in this case the northern extreme of Sierra La Trinidad provides it with more topographic and climatic heterogeneity (Figure 2). Given this, it could be expected to find correspondingly high numbers of cactus species in other sub-squares that are under similar climatic conditions (e.g., sub-squares 9, 14, 19, 23, 24). However, the results do not support this prediction. In other words, there does not appear to be an obvious correlation between high species richness and dry environmental conditions. In fact, there are several sub-squares primarily at the eastern half of the grid square, which are under similar edaphic, altitudinal, and climatic conditions as those in sub-squares one and six, but where the cactus diversity is significantly lower.

Endemism

The vast majority (63%) of the cactus species occurring in the Huizache grid square are endemic to the CDR and its adjacent areas, reflecting the uniqueness of the flora

of this region. Only *Echinocactus platyacanthus*, *Echinocereus cinerascens*, *E. pectinatus*, *E. pentalophus*, *Ferocactus echidne*, *F. histrix*, *F. latispinus*, *Mammillaria heyderi*, *M. magnimamma*, *M. prolifera*, *M. sphaerica*, *M. uncinata*, *Myrtillocactus geometrizans*, *Selenicereus spinulosus*, *Stenocactus* sp., *Stenocereus griseus*, and several species of *Opuntia* extend their ranges well beyond the confines of this region. Likewise, eleven out of the 18 cactus genera found in the Huizache are essentially endemic to the CDR (*Ariocarpus*, *Astrophytum*, *Echinocactus*, *Epithelantha*, *Leuchtenbergia*, *Lophophora*, *Neolloydia*, *Sclerocactus*, *Stenocactus*, *Thelocactus*, and *Turbinicarpus*; see Hernández and Godínez 1994).

Moreover, although the Huizache area is small, it is remarkable because it holds ten cactus species endemic or nearly endemic to its limits (*Ariocarpus bravoanus*, *Coryphantha pulleineana*, *C. odorata*, *C. villarensis*, *C. wohlschlageri*, *Echinocereus waldeisii*, *Mammillaria aureilanata*, *M. microthele*, *M. surculosa* and *Turbinicarpus knuthianus*). We consider a species as nearly endemic when its range is restricted to the Huizache plus one or several of its immediately adjacent grid squares. In addition to the ten endemic species reported, it is likely that the new species of *Opuntia* (Table 1) is also restricted to the area; however, this needs to be confirmed. The high frequency of narrowly endemic species supports the hypothesis proposed by Hernández and Bárcenas (1995, 1996) that the Huizache, specifically the lowland valleys of the northwestern portion of the grid square, acted as a refuge area during the Pleistocene climatic changes.

The Real de Guadalcázar Natural Reserve

In this paper, we provide evidence that the Huizache is a critical area for the conservation of Chihuahuan Desert Cactaceae, not only for its extraordinarily high diversity and its numerous rare, narrow endemics, but also because it harbors many cactus species derived from different biogeographic units. Consequently, as the most important center of species concentration at the continental level, the Huizache area deserves immediate action for its conservation.

Based upon preliminary knowledge produced in this investigation, the Government of San Luis Potosí, decreed the creation of the 'Real de Guadalcázar Protected Natural Area' (Anonymous 1997). The protected area was designed not only to preserve the diversity of cactus species, but also the variety of vegetation types found in the area, and several other plant and animal groups whose diversity and degree of endemism is comparatively greater there than in other parts of the CDR (Rzedowski 1956; Johnston 1977; Dinerstein et al. 1999; Salazar et al. 2001).

The protected area has a surface of 188 758 ha, and covers most of the municipality of Guadalcázar, San Luis Potosí, with the exception of the largest agricultural and urban areas. It includes two large core areas surrounded by an extensive buffer area (Figure 5). The configuration of the core areas was based upon a complementarity

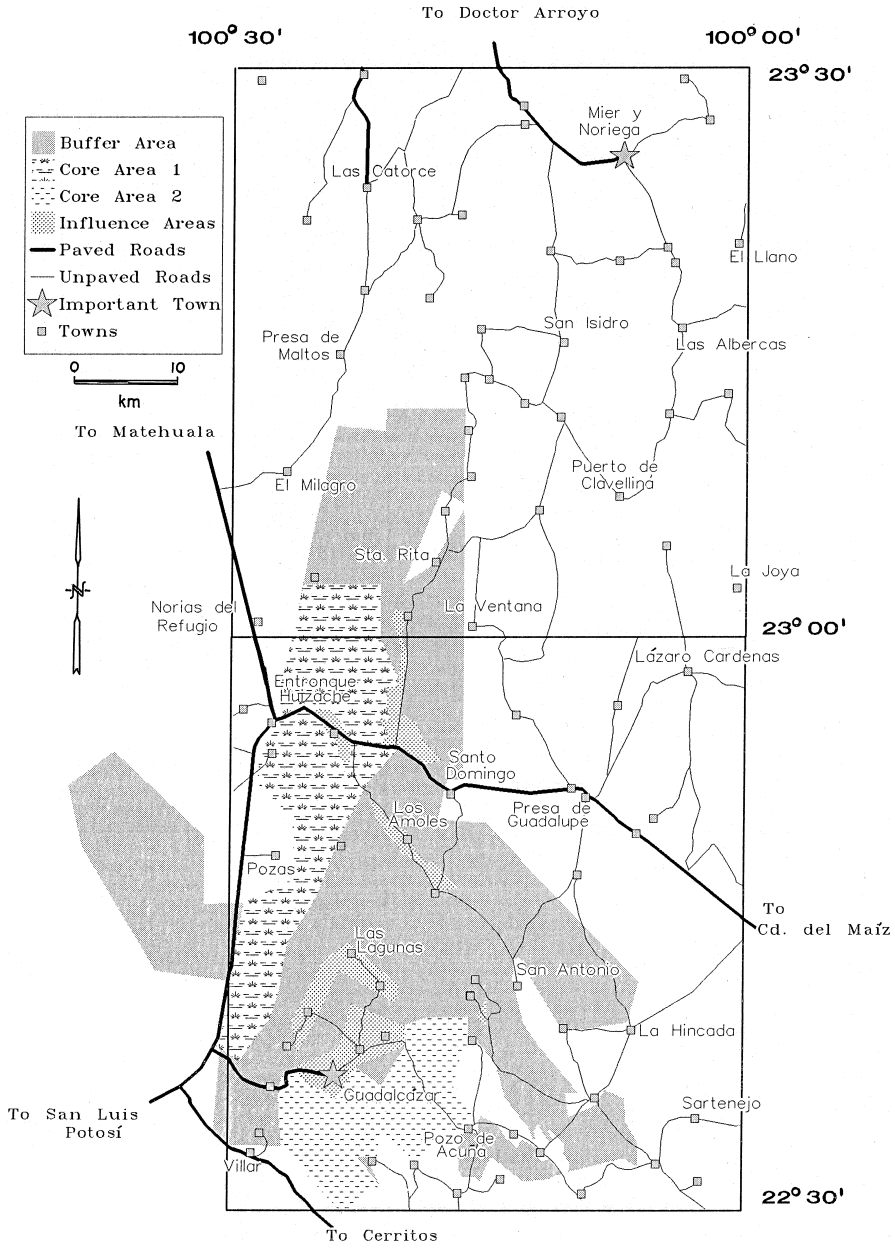

Figure 5. The Real de Guadalcázar Protected Natural Area.

analysis (Hernández and Gómez-Hinostrosa 2001), and was intended to maximize conservation of the Cactaceae, especially of the rarest and most endangered species.

Conservation in the CDR is a difficult task due to the extraordinarily high beta-diversity in this desert. In order to cover the complex distribution patterns of

the numerous narrow endemics, a network of scattered reserves has been suggested (Hernández and Bárcenas 1995). In connection to this, in view of its high cactus diversity and its high proportion of endemics, the 'Real de Guadalcázar Protected Natural Area' may be considered a significant component of this proposed network. The reserve currently has the status of state reserve; however, it urgently requires recognition at the national and international levels, perhaps under the modality of a biosphere reserve. It is discouraging, however, that the reserve has not gone beyond its official decree, and its material consolidation does not appear to be included in the conservation agendas of the current state or federal governments. The effective conservation of this critical area is a challenge for national and international agencies interested in the conservation of this region.

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