*Acta Botanica Mexicana* 100: 293-315 (2012)

# ENDEMIC ANGIOSPERM LINEAGES IN MEXICO: HOTSPOTS FOR CONSERVATION

Victoria Sosa[1,4] and J. Arturo De-Nova[2,3]

[1]Instituto de Ecología A.C., Biología Evolutiva,
Apdo. postal 63, 91070 Xalapa, Veracruz, Mexico.
[2]Universidad Autónoma de San Luis Potosí, Instituto de Investigación en Zonas Desérticas, Altair 200, 78377 San Luis Potosí, Mexico.
[3]Universidad Autónoma de San Luis Potosí, Facultad de Agronomía, km 14.5 carretera San Luis Potosí-Matehuala, 78321 San Luis Potosí, Mexico.
[4]Autor para la correspondencia: victoria.sosa@inecol.edu.mx

## ABSTRACT

As a megadiverse country, Mexico harbors 4 to 8% of the flora of the world and of this, 51% is endemic. There is concern because several factors are impeding its conservation. In this paper, areas of endemism for the flowering plants of Mexico are identified to prioritize regions for conservation. To categorize zones for preservation, the approach followed takes biodiversity, weighted endemism and evolutionary history into account. Lineages of angiosperms, families, genera, and formal or informal groups within genera previously retrieved as monophyletic are selected to represent evolutionary history in equivalent spatial units. A database with 9416 entries based on specimens of species belonging to 259 monophyletic groups of angiosperms from Mexico was compiled, and their presence-absence recorded for every unit area. Species richness and weighted endemism index was calculated for each of these units. The results indicate that the majority of the regions with the highest indices of endemism have a dry climate with xeric vegetation, with the exception of two areas of tropical and temperate forests. They are: the northeastern rosette scrub in Nuevo León and Coahuila, gypsum grasslands in San Luis Potosí, the Sierra Gorda in Queréraro, Tolantongo in Hidalgo, the Tehuacán-Cuicatlán Valley in Puebla and Oaxaca, El Salto in Durango, Sierra de Quila in Jalisco, a western portion of the Balsas River Basin in Michoacán, Guerrero, Morelos and State of Mexico, the Tehuantepec area in Oaxaca, the Central Depression of Chiapas and El Triunfo in Chiapas. Some of the areas of endemism in the Chihuahuan Desert, Balsas River Basin, the Central Depression of Chiapas and the southern area of Oaxaca are not sufficiently protected. Approximately 340 species

were microendemic, i.e. restricted to a single quadrat, and the Cactaceae account for the majority of the species on the Mexican Red List.

Key words: Cactaceae, Chihuahuan Desert, endemism, Mega-Mexico, xeric vegetation.

## RESUMEN

México está considerado como uno de los países megadiversos y en su territorio se encuentran entre 4 y 8% del número de total de especies de plantas del mundo, de las cuales 51% son endémicas. Existe una gran preocupación sobre la conservación de la flora mexicana, ya que se han detectado varias actividades y factores que la amenazan. En este trabajo se identifican áreas de endemismo para las angiospermas de México con el objetivo de priorizar regiones para conservación. Para categorizar estas zonas se sigue el enfoque que toma en cuenta la biodiversidad, el índice de endemismo ponderado y la historia evolutiva. Se identificaron los linajes de angiospermas, ya sean familias, géneros, o grupos infragenéricos con o sin estatus taxonómico que previamente se habían determinado como monofiléticos para representar la historia evolutiva en unidades espaciales equivalentes. Se construyó una base de datos de 9416 registros de especies de 259 grupos monofiléticos de angiospermas restringidas a México y se registró su presencia en estas áreas. Para cada una se calculó la riqueza de taxones y el índice de endemismo ponderado. Los resultados muestran que la mayoría de las zonas de más alto endemismo están en climas secos, con vegetación xérica, con dos excepciones de vegetación tropical y templada. Los índices de endemismo ponderado más altos se localizaron en: el área norte de matorral rosetófilo en Nuevo León y Coahuila, matorrales gipsófilos en San Luis Potosí, la Sierra Gorda en Querérato, Tolantongo en Hidalgo, el Valle de Tehuacán-Cuicatlán en Puebla y Oaxaca, El Salto en Durango, la Sierra de Quila en Jalisco, la zona oeste de la Depresión del Balsas en Michoacán, Guerrero, Morelos y el Estado de México, la zona de Tehuantepec en Oaxaca y El Triunfo en Chiapas. Algunas áreas de endemismo en el Desierto Chihuahuense, en la Cuenca del Balsas y en la Depresión de Chiapas, así como del sur de Oaxaca no están suficientemente protegidas. Se registraron aproximadamente 340 especies con distribución restringida a un solo cuadrante y de éstas la mayoría de las que se incluyen en la lista de taxones amenazados de México pertenecen a las Cactaceae.

Palabras clave: Cactaceae, Desierto Chihuahuense, endemismo, Mega-México, vegetación xérica.

## INTRODUCTION

Different criteria have been applied to prioritize areas for conservation and undoubtedly the most widely used is the concentration of endemic species undergoing increased habitat loss. The areas defined this way are known as "biodiversity hotspots" (Myers et al., 2000). Globally, thirty-five biodiversity hotspots, comprising 44% of the total number of species of vascular plants, have been identified and Mesoamerica is one of them (Myers et al., 2000; Mittermeier et al., 2011).

Other approaches for prioritizing areas for conservation have added the element of evolutionary history, because diversity and evolutionary history are unequally distributed in different areas of the world (Vane-Wright et al., 1991). Among these approaches, phylogenetic endemism uses phylogenetic diversity and weighted endemism as measures to identify areas for conservation based on equivalent spatial units (Rosauer et al., 2009). Additionally, attributes such as scarcity (Cadotte & Davies, 2010), local and global rarity of taxa (e.g. Crain et al., 2011), phylogenetic distinctiveness and isolation (e.g. Collen et al., 2011), phylogenetic diversity (Forest et al., 2007) and functional diversity (e.g. Devictor et al., 2010; Pio et al., 2011) have variously been incorporated to the evolutionary history approach.

In this paper, we identify areas of endemism for the flowering plants of Mexico to prioritize areas for conservation. The concept followed here for an area of endemism is that of a geographic region that includes the distributions of two or more monophyletic taxa with phylogenetic and distributional congruence (Harold & Mooi, 1994). Areas of endemism have several attributes: they have a single history, they are smaller than the entire study area, they do not overlap with other areas of endemism, they host at least two taxa with ranges restricted to the area and they are maximally congruent (Linder, 2001; Szumik et al., 2004; Ebach et al., 2008).

Thus, to categorize areas for preservation we follow an approach that combines biodiversity, weighted endemism and evolutionary history. Lineages of Mexican angiosperms, families, genera or formal and informal groups within genera that have been previously recognized as monophyletic were selected to represent evolutionary history in equivalent spatial units.

As a megadiverse country, Mexico houses 4 to 8% of the flora of the world and there is concern because several factors are impeding its conservation. The greatest threats to the flora of Mexico are intensification of habitat loss, the adverse effects of climate change and the overexploitation of the majority of habitats (Dávila et al., 2011).

Angiosperms were chosen because they are one of the most diverse groups of organisms in Mexico. Their diversity has been estimated at 24,500-29,000 species

(Villaseñor, 2003; Espejo-Serna et al., 2004) and more than 50% are endemic to the country (Rzedowski, 1993). Furthermore, the genera distributed in Mexico have been documented (Villaseñor, 2004), and the floristic knowledge of the country has been recently summarized (Anonymous, 2009). The groups of angiosperms distributed in the area known as Mega-Mexico were used in this study. This biogeographic province was proposed by Rzedowski (1993) and includes, in addition to Mexico's current territory, the areas of the Sonoran Desert, the Chihuahuan Desert and the Tamaulipan scrub that lie in the United States of America, as well as those portions of Central America as far south as northern Nicaragua.

The families with the largest number of endemic Mexican genera are Cactaceae and Asteraceae (Turner, 1996-2010; Guzmán et al., 2003; Hernández & Gómez-Hinostrosa, 2011a,b). Setchellanthaceae, a monotypic family, only grows in Mexico (Iltis, 1999). In the monocots, a clade of geophyte genera in the Asparagaceae, the *Milla* clade, grows in Mega-Mexico (Gándara et al., 2009) and a group in the Crassulaceae, the *Acre* clade includes several genera exclusive to Mexico (Acevedo-Rosas et al., 2004; Carrillo-Reyes et al., 2010). Three related genera, *Morkilia, Sericodes* and *Viscainoa* in the Zygophyllaceae (Sheahan & Chase, 2006), and two genera in the Anacardiaceae, *Bonetiella* and *Pseudosmodingium* (Aguilar-Ortigoza et al., 2004) are found in this biogeographic province. In the Acanthaceae, nine genera and a clade within *Ruellia* are endemic to Mexico (Daniel, 1993; Tripp, 2010). In addition, among the more remarkable endemic groups of Mexico are clades of *Bursera* (Rzedowski et al., 2005; De-Nova et al., 2012), *Agave* and groups nested within this genus such as *Manfreda*, *Polianthes* and *Prochnyanthes* (García-Mendoza, 1995; Rocha et al., 2006, Good-Avila et al., 2006), the section *Physodium* in *Melochia* (Dorr & Barret, 1989), a clade in the *Zea diploperennis* group (Poaceae) (Buckler & Holtsford, 1996), and a clade of *Yucca* within the *Sarcocarpa* group (Pellmyr et al., 2007). *Fouquieria* and *Leucophyllum* are arid land groups in Mega-Mexico (Henrickson & Flyr, 1985; Schultheis & Baldwin, 1999). Enigmatic genera like *Velascoa* (Crossosomataceae) (Sosa & Chase, 2003), *Chiangiodendron* (Achariaceae) (Sosa et al., 2005), *Enriquebeltrania* (Euphorbiaceae) (De-Nova et al., 2006), *Cerdia* (Caryophyllaceae) (Sosa et al., 2006), *Olmeca* (Bambusoideae, Poaceae) (Dávila-Aranda et al., 2004; Ruiz-Sanchez et al., 2011), *Peltophorum* (Leguminosae) (Sousa, 2005), the parasitic *Eremitilla* (Orobanchaceae) (Yatskievych & Contreras-Jiménez, 2009), *Echinopterys* (Malpighiaceae) (Davis et al., 2001), *Nowickea* (Phytolaccaceae) (Martínez & McDonald, 1989), and *Mexipedium* (Orchidaceae) (Albert & Chase, 1992) are endemic to Mexico, to mention just a few examples. We recorded 259 monophyletic angiosperm groups endemic to Mega-Mexico.

The objectives of this paper are: 1) to identify the areas of endemism of the angiosperms of Mexico, using monophyletic groups to prioritize areas for conservation, and 2) to detect species from these natural groups with a restricted distribution to highlight the threatened taxa.

## MATERIALS AND METHODS

### Taxa

Mexican angiosperm lineages, families, genera, and infrageneric groups with or without formal taxonomic status were compiled based on the literature (Rzedowski, 1993; Villaseñor, 2004; Anonymous, 2009). Distribution records were obtained from herbarium specimens in ANSM, ENCB, HCIB, IBUG, IEB, MEXU, MO, NY, TEX, UAMIZ, US and XAL, and by consulting the Mexican Biodiversity Database (REMIB) (www.conabio.org).

### Study area

The study area includes the entire country of Mexico. Even though the distribution of some groups extends into the south of the United States of America and northern Central America in Mega-Mexico, only the localities within Mexico were used. A system of land quadrats based on one degree squares was used to define arbitrary area units, resulting in a set of 237 area units with records of endemic taxa. The occurrence of every specimen of each monophyletic group in each quadrat was recorded. The data matrix had a total of 9416 georeferenced records. Quadrats with no records were eliminated. Species restricted to a single quadrat were identified as microendemics.

### Areas of endemism

First, the number of species was added up for each quadrat to estimate its diversity (unweighted species richness, Pearson & Juliano, 1993; Kershaw et al., 1995). Then, the weighted endemism index, a method that weights species inversely to their distribution areas was also calculated (Linder, 2001).

### Microendemic species

The species with a restricted distribution, i.e., those only found in a single quadrat, were recorded and of these the taxa on the Mexican Red List (Anonymous, 2010) were identified.

## RESULTS

### Areas of endemism

The data matrix included the presence/absence data for 878 species belonging to 259 monophyletic groups for 237 area units. The highest unweighted species richness values for each quadrat are shown in Table 1 and Fig. 1. The areas with the highest number of endemic species are in Tehuacán-Cuicatlán, in the eastern of the Balsas River Basin, in Tolantongo and Tepeapulco, Hidalgo and in the Sierra Gorda.

The weighted endemism values are listed in Table 1 and shown in Fig. 2. Eleven areas with the highest weighted endemism values (10.657-34.819) were identified: 1) A northeastern area of rossette scrub in Nuevo León and Coahuila (Ramos Arizpe, Aramberri, Galeana and Zaragoza); 2) an area of gypsum grasslands in San Luis Potosí, 3) the Sierra Gorda, Querétaro (extending to San Luis Potosí); 4) Tolantongo in Hidalgo, 4) the area of Tehuacán-Cuicatlán, Puebla and Oaxaca; 5) El Salto, Durango; 6) the Sierra de Quila in Jalisco; 7) the western area of the Balsas River Basin (Michoacán, Guerrero, Morelos, State of Mexico); 8) the Tehuantepec area,

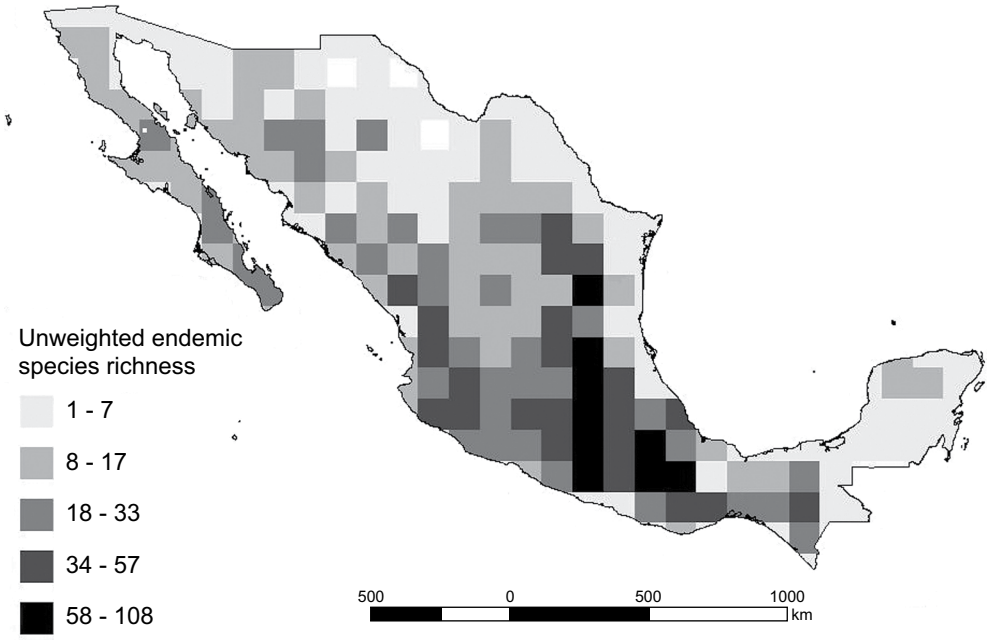


Fig. 1. Distribution map of the Mexican lineages of angiosperms (unweighted richness).

Table 1. Areas of endemism of the Mexican lineages of angiosperms with the highest species richness (number of species 23-108) and the highest indices of weighted endemism (6.61-34.81). Values for each land quadrat for every area of endemism are included.

| Areas of endemism | Unweighted endemic species richness | Weighted endemism |
|---|---|---|
| Tehuacán-Cuicatlán | 108 | 34.81888723 |
| | 94 | 30.53009253 |
| Balsas River Basin | 64 | 20.95559334 |
| | 66 | 19.20541089 |
| Northeastern rosette scrub | 61 | 18.9554685 |
| Sierra Gorda | 71 | 18.76557059 |
| | 64 | 16.97099585 |
| Northeastern rosette scrub | 53 | 16.89719931 |
| Tolantongo | 55 | 16.79210378 |
| Balsas River Basin | 74 | 16.68154352 |
| Tehuacán-Cuicatlán | 67 | 16.08813242 |
| Balsas River Basin | 47 | 15.86234919 |
| | 39 | 15.67449119 |
| Sierra de Quila | 57 | 14.40864616 |
| Central Depression of Chiapas | 39 | 15.67449119 |
| Tehuantepec Region | 50 | 14.27457894 |
| Northeastern rosette scrub | 39 | 13.88012541 |
| El Triunfo | 25 | 13.71388889 |
| Northeastern rosette scrub | 44 | 13.52460031 |
| Balsas River Basin | 52 | 12.92819513 |
| El Salto | 38 | 11.6864493 |
| Gypsum grasslands | 40 | 11.59780087 |
| Sierra de Órganos | 33 | 8.122629758 |
| Baja California Sur | 31 | 8.805300868 |
| | 24 | 7.578488054 |
| | 23 | 6.938598987 |
| | 23 | 6.618010751 |

Oaxaca; 9) the Central Depression of Chiapas; 10) El Triunfo, Chiapas. Among the areas with high weighted endemism indices is the southern area of Baja California and the Sierra de Órganos, Zacatecas (Fig. 2).

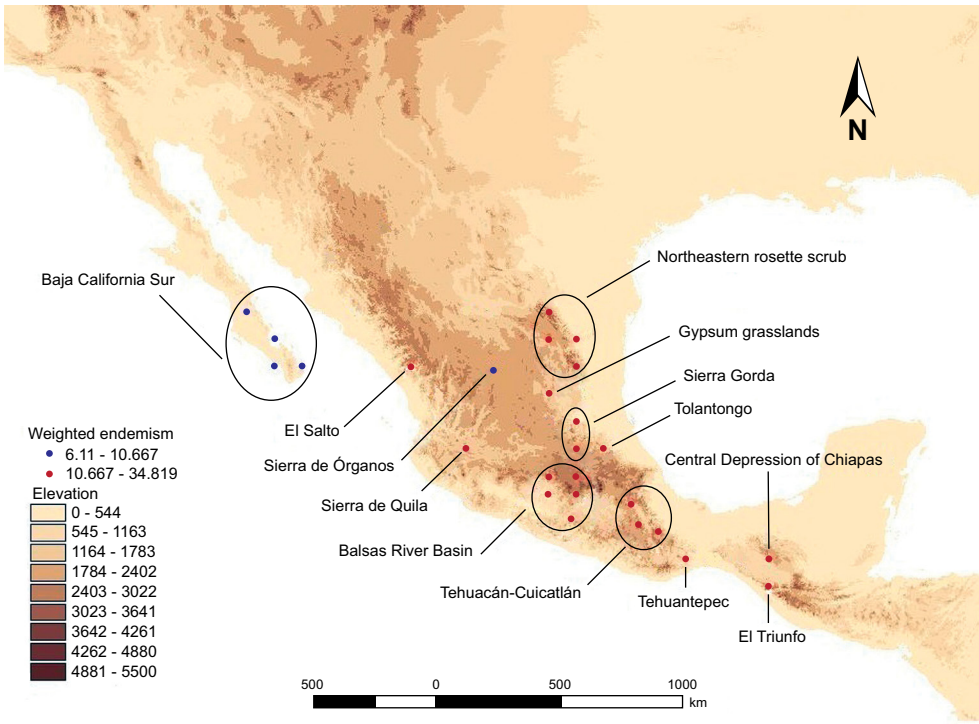


Fig. 2. Areas of endemism for the Mexican lineages of angiosperms (weighted endemism).

Microendemics

Appendix lists the 340 species whose distribution is restricted to a single quadrat, with their threatened status indicated when applicable.

## DISCUSSION

Rzedowski (1993) pointed out that the distribution of areas with endemic species for the flora of Mexico does not coincide with the distribution of biodiversity. He indicated that the endemic taxa are concentrated in areas of dry climate and this conclusion was reached based on species richness alone, without taking the historical element into account. The latter has been included in this paper by identifying areas of endemism shared by at least two monophyletic groups. Our results indicate that majority of the areas: the northeastern rosette scrub, the gypsum grasslands,

the Sierra Gorda, the southern portion of the Chihuahuan Desert, the area of Tehuacán-Cuicatlán, the Sierra de Quila, the western area of the Balsas River Basin, the Tehuantepec area and the Central Depression of Chiapas, have a dry climate, corroborating Rzedowski's hypothesis. The endemic groups occur at low to middle elevations, in xeric vegetation. The only area with a tropical climate and a high weighted endemism index is El Triunfo in Chiapas, and El Salto in Durango has a temperate climate.

The Sierra Gorda was previously recognized as an area with significant endemism and it is included in the Mexican System of Natural Protected Areas, the SINAP (Arriaga-Cabrera et al., 2000). Additionally, the Tehuacán-Cuicatlán area is comprised of arid vegetation and is perhaps the most important biosphere reserve in Mexico (Arriaga-Cabrera et al., 2000). It is a floristic province, and an ecological island given the high number of endemics, estimated at 365 species (Méndez-Larios et al., 2004; Dávila et al., 2002).

The area of Metztitlán-Tolantongo was previously known for having high endemism and it was decreed as a biological reserve in 2000 (Hiriart-Valencia & González-Medrano, 1983; Arriaga-Cabrera et al., 2000). Furthermore, Sierra de Quila was earlier identified as a hotspot for conservation based on mammal distributional predictions as biodiversity surrogates (Sánchez-Cordero et al., 2005). In addition, the semiarid gypsum karstlands in north central Mexico characterized by a mosaic of shrubby communities and endemic gypsophile grasslands were formerly acknowledged as areas with elevated endemism and important to preserve (Henrickson & Johnston, 1986; Meyer et al., 1992; Huerta-Martínez & García-Moya, 2004).

The western area of the Balsas River Basin in Michoacán, Guerrero, Morelos and State of Mexico, is another region with high indices of endemism. Rodríguez-Jiménez et al. (2005) have identified 337 endemic species of vascular plants in this biogeographic province. Cañón del Zopilote and Infiernillo are two proposed areas for conservation in this province (Arriaga-Cabrera et al., 2000), yet they represent only a small area within the Balsas River Basin.

Several regions in Nuevo León harbor extremely large numbers of endemisms in the Cactaceae (Juárez et al., 2009), and a high concentration of narrowly distributed Asteraceae (González-Zamora et al., 2007; Alanís-Flores et al., 2011). Moreover, these regions coincided with one of the areas of high endemism identified in this study: the Northeastern rosette scrub.

Our results detected the Sierra La Laguna in Baja California Sur as a territory with high endemism. Plant diversity and endemism on the entire Baja California Peninsula have previously attracted attention (Riemann & Ezcurra, 2007).

The notable endemism in the Sierra La Laguna, Baja California, had also been pointed out (León de la Luz & Breceda, 2006) and resulted in the Sierra La Laguna reserve being decreed one of Mexico's biosphere reserves (Arriaga-Cabrera et al., 2000).

El Triunfo is a biosphere reserve with elevated endemism and richness, for which approximately 1000 species of vascular plants have been reported. The area includes several habitats such as cloud, oak and tropical forest (Martínez-Meléndez et al., 2008; Pérez-Farrera et al., 2012). It was decreed as a reserve because it is considered to be a Pleistocene refugium for several tropical species (Arriaga-Cabrerra et al., 2000). As well, the pine and oak forests in El Salto have provided suitable habitats for several gymnosperm relict species (Valenzuela-Núñez & Granados-Sánchez, 2009).

The Central Depression of Chiapas has been earlier identified as an area with seasonally dry tropical forests and tropical oak forests where approximately 3.4% of the total number of vascular plant species in Mexico are distributed (Reyes-García & Sousa, 1997). Furthermore, among the habitats of Tehuantepec, the tropical dry forests harbor the largest diversity including several taxa of endemic angiosperm (Acosta et al., 2003; Pérez-García et al., 2010).

It is noteworthy that the majority of the areas with the highest endemism indices, such as El Salto (Durango), the Central Depression of Chiapas, Tehuantepec, (Oaxaca), and Tolantongo in the southern area of the Chihuahuan Desert are not protected under the SINAP scheme (Arriaga-Cabrera et al., 2000).

Microendemic species

It is crucial to take the rarity of species into account when setting conservation priorities (Mooers & Redding, 2009). It has been mentioned that in areas of endemism the species with restricted distributions are usually on the red lists (e.g., Argentina, Szumik et al., in press). The same happens in Mexico where we found that a large number of the species whose distribution is restricted to a single quadrat in our study area are included on the Mexican List of Threatened Species (Anonymous, 2010).

Most of the species on this list with a limited distribution are cacti. More than 900 species of Cactaceae are present throughout Mexico (Ortega-Baes & Godínez-Álvarez, 2006). This is one of the groups that are most used as ornamental plants and so have been continuously extracted from their habitats, with the result that they are now the most threatened group in Mexico (Gómez-Hinostrosa & Hernández, 2000; Hernández & Gómez-Hinostrosa, 2011a,b).

## CONCLUSIONS

Future research should examine the probable causes of diversification for the angiosperm lineages in the areas of endemism in Mega-Mexico. For other areas with high degrees of endemism, such as the Andes, isolation caused diversification, similar in many respects to the floras of remote oceanic islands (Särkinem et al., in press) or along elevational gradients (Kessler, 2000). Climate was the factor that promoted speciation in Australia's areas of endemism (Ladiges et al., 2011), while tectonic stability in central and southern China influenced the permanence of areas of plant endemism (López-Pujol et al., 2011). In Sub-Saharan Africa, elevation range and low seasonality were core environmental predictors for centers of endemism (Jetz et al., 2004). Diversification in hotspots of biodiversity and endemism in Brazil were attributed to the effect of fire on vegetation (Simon et al., 2009), while serpentine soils and a benign climate favored endemism in California (Anacker & Harrison, in press).

Our results suggest that various causes promoted the diversification of several groups of plants in the areas of endemism, and a dry climate together with isolation are probably the most remarkable. Nine areas of endemism have a dry climate. Furthermore, the Central Depression of Chiapas and the Balsas River Basin are two areas that remained isolated, bordered by mountain ranges. In contrast, El Triunfo in Chiapas probably acted as a refugium for angiosperm lineages that remained there throughout the Pleistocene. Gypsum soils probably favored endemism in the northeastern rosette scrub and the grasslands of San Luis Potosí. However investigation is needed to corroborate these hypotheses.

It should be emphasized that hotspots do not necessarily coincide with species richness, the degree of threat or areas of endemism (Orme et al., 2005). The areas of endemism identified in our study do not coincide with the areas with elevated diversity of the flora of Mexico, as Rzedowski (1993) pointed out, and some of the areas of endemism in the Chihuahuan Desert, Balsas River Basin and the southern area of Oaxaca are not sufficiently protected.

## ACKNOWLEDGEMENTS

We are grateful to Patricia Dávila and Jorge Meave del Castillo for their useful comments that improved the manuscript. We are grateful to Manuel Cuéllar and Ismael G. Valdivieso for their help designing the database, and to Rosario Landgrave for her invaluable help producing the maps, as well as to Manuel Cuéllar

and Diego Angulo. Jerzy Rzedowski provided important information on the endemism of the Mexican flora; Carolina Calviño provided information on Apiaceae (*Eryngium*), Etelvina Gándara on Asparagaceae (*Milla* clade) and Scrophulariaceae (*Leucophyllum*); John Bain, Jose Panero, Edward Schilling and José Luis Villaseñor on Asteraceae; Salvador Arias and Héctor Hernández on Cactaceae; Mark Simmonds on Celastraceae; Pablo Carrillo Reyes and Raúl Acevedo-Rosas on Crassulaceae; Rafael Lira on Cucurbitaceae; Eduardo Estrada, Lourdes Rico and Jenny Sotuyo on Fabaceae; Susana Valencia on Fagaceae; Paul Peterson, María Elena Siqueiros and J. Travis Columbus on Poaceae; Rafael Fernández Nava on Rhamnaceae and Lynn Boss and Aarón Rodríguez on Solanaceae.

## LITERATURE CITED

Acevedo-Rosas, R., K. Cameron, V. Sosa & S. Pell. 2004. A molecular phylogenetic study of *Graptopetalum* (Crassulaceae) based on ETS, ITS, *rpl16* and *trnL-F* nucleotide sequences. Am. J. Bot. 91: 1099-1104.

Acosta, S., A. Flores, A. Saynes, R. Aguilar & G. Manzanero. 2003. Vegetación y flora de una zona semiárida de la cuenca alta del río Tehuantepec, Oaxaca, México. Polibotánica 16: 125-152.

Aguilar-Ortigoza, C., V. Sosa & G. Angeles. 2004. Phylogenetic relationships of three genera in Anacardiaceae: *Bonetiella, Pseudosmodingium* and *Smodingium*. Brittonia 56: 169-184.

Alanís-Flores, G. J., M. A. Alvarado-Vázquez, L. Ramírez-Freire, R. Foroughbakhch-Pornavab & C. G. Velazco-Macías. 2011. Flora endémica de Nuevo León, México y estados colindantes. J. Bot. Res. Inst. Texas 5: 275-298.

Albert, V. A. & M. W. Chase. 1992. *Mexipedium*: a new genus of slipper orchid (Cypripeioideae: Orchidaceae). Lindleyana 7: 172-176.

Anacker, B. L. & S. P. Harrison (in press). Climate and the evolution of serpentine endemism in California. Evol. Ecol. doi 10.1007/s10682-011-9532-4.

Anonymous. 2009. Catálogo taxonómico de especies de México. Vol. 1. Capital Natural de México. Comisión Nacional para el Conocimiento y Uso de la Biodiversidad. México, D.F., Mexico.

Anonymous. 2010. Norma Oficial Mexicana NOM-059-ECOL-2010. Protección ambiental-especies nativas de México de flora y fauna silvestres-categorías de riesgo y especificaciones para su inclusión, exclusión o cambio-lista especies en riesgo. Diario Oficial de la Federación. México, D.F., Mexico.

Arriaga-Cabrera, L., J. M. Espinoza-Rodríguez, C. Aguilar-Zúñiga, E. Martínez-Romero, L. Gómez-Mendoza & E. Loa-Loza. 2000. Regiones terrestres prioritarias de México. Comisión Nacional para el Conocimiento y Uso de la Biodiversidad. México, D.F., Mexico. pp. 1-609.

Buckler, E. & T. P. Holtsford. 1996. *Zea* systematics: ribosomal ITS evidence. Mol. Biol. Evol. 13: 612-622.

Cadotte, M. W. & T. J. Davies. 2010. Rarest of the rare: advances in combining evolutionary distinctiveness and scarcity to inform conservation at biogeographical scales. Divers. Distrib. 16: 376-385.

Carrillo-Reyes, P., V. Sosa & M. E. Mort. 2010. Molecular phylogeny of the *Acre* clade (Crassulaceae): dealing with the lack of definitions for *Echeveria* and *Sedum*. Mol. Phylogenet. Evol. 53: 267-276.

Collen, B., S. T. Turvey, C. Waterman, H. M. R. Meredith, T. S. Kuhn, J. E. M. Baillie & N. J. B. Isaac. 2011. Investing in evolutionary history: implementing a phylogenetic approach for mammal conservation. Philos. Trans. R. Soc. Lond. Biol. Sci. 366: 2611-2622.

Crain, B. J., J. W. White & S. J. Steinberg. 2011. Geographic discrepancies between global and local rarity richness patterns and the implications for conservation. Biodivers. Conserv. 20: 3489-3500.

Daniel, T. F. 1993. Mexican Acanthaceae: diversity and distribution. In: Ramamoorthy, T. P., R. Bye, A. Lot & J. Fa (eds.). Biological diversity of Mexico: origins and distribution. Oxford University Press. Oxford, UK. pp. 541-558.

Dávila-Aranda, P., R. Lira & J. Valdés-Reyna. 2004. Endemic grasses of Mexico: a phytogeographic approach. Biodivers. Conserv. 13: 1101-1121.

Dávila, P., M. D. Arizmendi, A. Valiente-Banuet, J. L. Villaseñor, A. Casas & R. Lira. 2002. Biological diversity in the Tehuacán-Cuicatlán Valley, Mexico. Biodivers. Conserv. 11: 421-442.

Dávila, P., H. Benítez, Y. Barrios, A. Cruz-Angón & N. Alvarez-Girard. 2011. Definition and insertion of the GSPC in the political context of Mexico. Bot. J. Linn. Soc. 166: 326-330.

Davis, C. C., W. R. Anderson & M. J. Donoghue. 2001. Phylogeny of Malpighiaceae from chloroplast *ndhF* and *trnL-F* nucleotide sequences. Am. J. Bot. 88: 1830-1846.

De-Nova, A., V. Sosa & K. J. Wurdack. 2006. Phylogenetic relationships and description of a new species in *Enriquebeltrania* (Euphorbiaceae s.s.): an enigmatic genus endemic to Mexico. Syst. Bot. 31: 533-546.

De-Nova, J. A., R. Medina, J. C. Montero, A. Weeks, J. A. Rosell, M. E. Olson, L. E. Eguiarte & S. Magallón. 2012. Insights into the historical construction of species-rich Mesoamerican seasonally dry tropical forests: the diversification of *Bursera* (Burseraceae, Sapindales). New Phytol. 193: 276-276.

Devictor, V., D. Mouillot, C. Meynard, F. Jiguet, W. Thuiller & N. Mouquet. 2010. Spatial mismatch and congruence between taxonomic, phylogenetic and functional diversity: the need for integrative conservation strategies in a changing world. Ecol. Lett. 13: 1030-1040.

Dorr, L. J. & L. C. Barret. 1989. A revision of *Melochia* section *Physodium* (Sterculiaceae) from Mexico. Brittonia 41: 404-423.

Ebach, M. C., J. J. Morrone, L. R. Parenti & A. L. Viloria. 2008. International Code of Area Nomenclature. J. Biogeogr. 35: 1153-1157.

Espejo-Serna, A., A. R. López-Ferrari & I. Salgado. 2004. A current estimate of angiosperm diversity in Mexico. Taxon 53: 127-130.

Forest, F., R. Grenyer, M. Rouget, T. J. Davies, R. M. Cowling, D. P. Faith, A. Balmford, J. C. Manning, S. Proches, M. van der Bank, G. Reeves, T. A. J. Henderson & V. Savolainen. 2007. Preserving the evolutionary potential of floras in biodiversity hotspots. Nature 445: 757-760.

Gándara, E., V. Sosa & J. L. León de la Luz. 2009. Morphological and molecular delimitation of *Behria* and *Bessera* two genera of the *Milla* complex (Themidaceae). Bol. Soc. Bot. Méx. 85: 113-124.

García-Mendoza, A. 1995. Riqueza y endemismo de la familia Agavaceae en México. In: Linares, E., P. Dávila, F. Chiang, R. Bye & T. Elias (eds.). Conservación de plantas en peligro de extinción: diferentes enfoques. Instituto de Biología, Universidad Nacional Autónoma de México. México, D.F., Mexico. pp. 51-75.

Gómez-Hinostrosa, C. & H. M. Hernández. 2000. Diversity, geographical distribution, and conservation of Cactaceae in the Mier y Noriega region, Mexico. Biodivers. Conserv. 9: 403-418.

González-Zamora, A., I. Luna-Vega, J. L. Villaseñor & C. A. Ruiz-Jiménez. 2007. Distributional patterns and conservation of species of Asteraceae endemic to eastern Mexico. Syst. Biodivers. 5: 135-144.

Good-Avila, S. V., V. Souza, B. S. Gaut & L. E. Eguiarte. 2006. Timing and rate of speciation in *Agave* (Agavaceae). Proc. Natl. Acad. Sci. 103: 9124-9129.

Guzmán, U., S. Arias & P. Dávila. 2003. Catálogo de cactáceas mexicanas. Universidad Nacional Autónoma de México-Comisión Nacional para el Uso y Conocimiento de la Biodiversidad. México, D.F., Mexico. pp 234.

Harold, A. S. & R. D. Mooi. 1994. Areas of endemism: definition and recognition criteria. Syst. Biol. 43: 261-266.

Henrickson, J. & L. D. Flyr. 1985. Systematics of *Leucophyllum* and *Eremogeton* (Scrophulariaceae). Sida 11: 107-172.

Henrickson, J. & M. C. Johnston. 1986. Vegetation and community types of the Chihuahuan Desert . In: Barlow, J. C. (ed.). Chihuahuan Desert-U.S. and Mexico, II. Alpine, Texas: Sul Ross State University, USA. pp. 20-39.

Hernández, H. M. & C. Gómez-Hinostrosa. 2011a. Areas of endemism of Cactaceae and the effectiveness of the protected area network in the Chihuahuan Desert. Oryx 45: 191-200.

Hernández, H. M. & C. Gómez-Hinostrosa. 2011b. Mapping the cacti of Mexico. DH Books. Milborne Port, UK. 128 pp.

Hiriart-Valencia, P. & F. González-Medrano. 1983. Vegetación y fitogeografía de la barranca de Tolantongo, Hidalgo, México. An. Inst. Biol. Univ. Nac. Méx. Ser. Bot. 54: 29-96.

Huerta-Martínez, F. & E. García-Moya. 2004. Diversidad de especies perennes y su relación con el ambiente en un área semiárida del centro de México: implicaciones para la conservación. Interciencia 29: 435-441.

Iltis, H. H. 1999. Setchellanthaceae (Capparales), a new family for a relictual, glucosinolate-producing endemic of the Mexican deserts. Taxon 48: 257-275.

Jetz, W., C. Rahbek & R. K. Colwell. 2004. The coincidence of rarity and richness and the potential signature of history in centres of endemism. Ecol. Lett. 7: 1180-1191.

Juárez, H. S. D., R. Contreras-Medina & I. Luna-Vega. 2009. Biogeographic analysis of endemic cacti of the Sierra Madre Oriental, Mexico. Biol. J. Linn. Soc. 97: 373-389.

Kershaw, M., G. M. Mace & P. H. Williams. 1995. Threatened status, rarity, and diversity as alternative selection measures for protected areas: a test using Afrotropical antelopes. Conserv. Biol. 9: 324-334.

Kessler, M. 2000. Elevational gradients in species richness and endemism of selected plant groups in the central Bolivian Andes. Plant Ecol. 149: 181-193.

Ladiges, P., C. Parra-O, A. Gibbs, F. Udovicic, G. Nelson & M. Bayly. 2011. Historical biogeographical patterns in continental Australia: congruence among areas of endemism of two major clades of eucalypts. Cladistics 27: 29-41.

León de la Luz, J. L. & A. Breceda. 2006. Using endemic plant species to establish critical habitats in the Sierra de La Laguna Biosphere Reserve, Baja California Sur, Mexico. Biodivers. Conserv. 15: 1043-1055.

Linder, H. P. 2001. On areas of endemism, with an example from the African Restoniaceae. Syst. Biol. 50: 892-912.

López-Pujol, J., F. M. Zhang, H. Q. Sun, T. S. Ying & S. Ge. 2011. Centres of plant endemism in China: places for survival or for speciation? J. Biogeogr. 38: 1267-1280.

Martínez, J. & J. A. McDonald. 1989. *Nowickea* (Phytolaccaceae), a new genus with two species from Mexico. Brittonia 41: 399-403.

Martínez-Meléndez, J., M. A. Pérez-Farrera & O. Farrera-Sarmiento. 2008. Floristic inventory of Mt. El Cebu and adjacent zones in the El Triunfo Biosphere Reserve (Polygon V), Chiapas, Mexico. Bol. Soc. Bot. Méx. 82: 21-40.

Méndez-Larios, I., E. Ortiz & J. L. Villaseñor. 2004. Las Magnoliophyta endémicas de la porción xerofítica de la provincia florística del Valle de Tehuacán-Cuicatlán, México. An. Inst. Biol. Univ. Nac. Méx. Ser. Bot. 75: 87-104.

Meyer, S. E., E. García-Moya & L. C. Lagunes-Espinoza. 1992. Topographic and soil surface effects on gypsophile plant community patterns in central Mexico. J. Veg. Sci. 3: 429-438.

Mittermeier, T. A., W. R. Turner, F. W. Larsen, T. M. Brooks & C. Gascon. 2011. Global biodiversity conservation: the critical role of hotspots. In: Zachos, F. E. & J. C. Habel (eds.). Biodiversity hotspots: distribution and protection of conservation priority areas. Springer-Verlag. Berlin, Germany. pp. 3-14.

Mooers, A. O. & D. W. Redding. 2009. Where the rare species are. Mol. Ecol. 18: 3955-3957.

Myers, N., R. A. Mittermeier, C. G. Mittermeier, G. A. B. da Fonseca & J. Kent. 2000. Biodiversity hotspots for conservation priorities. Nature 403: 853-858.

Orme, C. D. L., R. G. Davies, M. Burgess, F. Eigenbrod, N. Pickup, V. A. Olson, A. J. Webster, T-S Ding, P. C. Rasmussen, R. S. Ridgely, A. J. Stattersfield, P. M. Bennett, T. M. Blackburn, K. J. Gaston & I. P. F. Owens. 2005. Global hotspots of species richness are not congruent with endemism or threat. Nature 436: 1016-1019.

Ortega-Baes, P. & H. Godínez-Álvarez. 2006. Global diversity and conservation priorities in the Cactaceae. Biodivers. Conserv. 15: 817-827.

Pearson, D. L. & S. A. Juliano. 1993. Evidence for the influence of historical processes in co-occurrence and diversity of tiger beetle species. In: Rickleffs, R. E. & D. Schluter (eds). Species diversity in ecological communities: historical and biogeographical perspectives. University of Chicago Press. Chicago, USA. pp. 194-202.

Pellmyr, O., K. A. Segraves, D. M. Althoff, M. Balcázar-Lara & J. Leebens-Mack. 2007. The phylogeny of yuccas. Mol. Phylogenet. Evol. 43: 493-501.

Pérez-Farrera, M. A., R. Martínez-Camilo, N. Martínez-Meléndez, O. Farrera-Sarmiento & S. M. Villalobos-Méndez. 2012. Listado florístico del Cerro Quetzal (Polígono III) de la Reserva de la Biósfera El Triunfo, Chiapas, México. Bot. Sci. 80: 1-30.

Pérez-García, E. A., J. A. Meave, J. L. Villaseñor, J. A. Gallardo-Cruz & E. E. Lebrija-Trejos. 2010. Vegetation heterogeneity and life-strategy diversity in the flora of the heterogeneous landscape of Nizanda, Oaxaca, Mexico. Folia Geobot. 45: 143-161.

Pio, D. V, O. Broennimann, T. G. Barraclough, G. Reeves, A. G. Rebelo, W. Thuiller, A. Guisan & N. Salamin. 2011. Spatial predictions of phylogenetic diversity in conservation decision making. Conserv. Biol. 25: 1129-1239.

Reyes-García, A. & M. Sousa. 1997. Depresión Central de Chiapas La Selva Baja Caducifolia. Listados Florísticos de México 17: 1-46.

Riemann, H. & E. Ezcurra. 2007. Endemic regions of the vascular flora of the peninsula of Baja California, Mexico. J. Veg. Sci. 18: 327-336.

Rocha, M., S. V. Good-Avila, F. Molina-Freaner, H. Arita, A. Castillo, A. García-Mendoza, A. Silva-Montellano, B. Gaut, V. Souza & L. E. Eguiarte. 2006. Pollination biology and adaptive radiation of Agavaceae, with special emphasis in the genus *Agave*. Aliso 22: 329-344.

Rodríguez-Jiménez, C., R. Fernández-Nava, M. L. Arreguín-Sánchez & A. Rodríguez-Jiménez. 2005. Plantas vasculares de la cuenca del Río Balsas, México. Polibotánica 20: 73-99.

Rosauer, D., S. W. Laffan, M. D. Crisp, S. C. Donnellan & L. G. Cook. 2009. Phylogenetic endemism: a new approach for identifying geographical concentrations of evolutionary history. Mol. Ecol. 18: 4061-4072.

Ruiz-Sanchez, E., V. Sosa & M. T. Mejía-Saules. 2011. Molecular phylogenetics of the Mesoamerican bamboo *Olmeca* (Poaceae: Bambusoideae): implications for taxonomy. Taxon 60: 89-98.

Rzedowski, J. 1993. Diversity and origins of the phanerogamic flora of Mexico. In: Ramamoorthy, T. P., R. Bye, A. Lot & J. Fa (eds.). Biological diversity of Mexico: origins and distribution. Oxford University Press. Oxford, UK. pp. 129-148.

Rzedowski, J., R. Medina-Lemos & G. C. Rzedowski. 2005. Inventario del conocimiento taxonómico, así como de la diversidad y del endemismo regionales de las especies mexicanas de *Bursera* (Burseraceae). Acta Bot. Mex. 70: 85-111.

Sánchez-Cordero V., V. Cirelli, M. Munguía & S. Sarkar. 2005. Place prioritization for biodiversity representation using species ecological niche modeling. Biod. Info. 2: 11-23.

Särkinem, R., R. T. Pennington, M. Lavin, M. F. Simon & C. E. Hughes. (in press). Evolutionary islands in the Andes: persistence and isolation explain high endemism in Andean dry tropical forests. J. Biogeogr. doi 10.1111/j.1365-2699.2011.02644.x

Schultheis, L. M. & B. G. Baldwin. 1999. Molecular phylogenetics of Fouquieriaceae: evidence from nuclear rDNA ITS studies. Am. J. Bot. 86: 578-589.

Sheahan, M. C. & M. W. Chase. 2006. Phylogenetic relationships within Zygophyllaceae based on DNA sequences of three plastid regions with special emphasis on Zygophylloideae. Syst. Bot. 25: 371-384.

Simon, M. F., R. Grether, L. P. de Queiroz, C. Skema, T. Pennington & C. E. Hughes. 2009. Recent assembly of the Cerrado, a neotropical plant diversity hotspot, by in situ evolution of adaptations to fire. Proceed. Natl. Acad. Sci. 106: 20359-20364.

Sosa, V., H. Ochoterena & M. Escamilla. 2006. A revision of *Cerdia* (Caryophyllaceae). Bot. J. Linn. Soc. 152: 1-13.

Sosa, V. & M. W. Chase. 2003. Phylogenetics of Crossosomataceae based on *rbcL* sequence data. Syst. Bot. 28: 96-105.

Sosa, V., M. W. Chase & C. Bárcenas. 2005. *Chiangiodendron* (Achariaceae): an example of the Laurasian flora of tropical forests of Central America. Taxon 56: 519-524.

Sousa, M. 2005. *Heteroflorum*: un nuevo género del grupo *Peltophorum* (Leguminosae, Caesalpinieae), endémico para México. Novon 15: 213-218.

Szumik, C. A., F. Cuezzo, P. A. Goloboff & A. E. Chalup. 2004. Areas of endemism: an improved optimality criterion. Syst. Biol. 53: 968-977.

Szumik, C., L. Aagesen, D. Casagranda, V. Arzamendia, D. Baldo, L. E. Claps, F. Cuezzo, J. M. Díaz-Gómez, A. Di-Giuacomo, A. Giraudo, P. Goloboff, C. Gramajo, C. Kopuchian, S. Dretzschmar, M. Lizarralde, A. Molina, M. Mollerach, F. Navarro, S. Nomdedeu, A. Panizza, V. V. Pereyra, M. Sandoval, G. Scrocchi & F. O. Zuloaga. (in press). Detecting areas of endemism with a taxonomically diverse data set: plants, mammals, reptiles, amphibians, birds, and insects from Argentina. Cladistics. doi 10.1111/j.1096-0031.2011.00385.x

Tripp, E. A. 2010. Taxonomic revision of *Ruellia* section *Chiropterophila* (Acanthaceae): a lineage of rare and endemic species from Mexico. Syst. Bot. 35: 629-661.

Turner, B. L. 1996-2010. The Comps of Mexico. A systematic account of the family Asteraceae. Phytol. Memoirs. Vols. 1-10.

Valenzuela-Núñez, L. M. & D. Granados-Sánchez. 2009. Caracterización fisionómica y ordenación de la vegetación en el área de influencia de El Salto, Durango, México. Rev. Chapingo Ser. Ciencias Forestales y del Ambiente 15: 29-42.

Vane-Wright, R. I., C. J. Humphries & P. H. Williams. 1991. What to protect-systematics and the agony of choice. Biol. Conserv. 55: 235-254.

Villaseñor, J. L. 2003. Diversidad y distribución de las Magnoliophyta de México. Interciencia 28: 160-167.

Villaseñor, J. L. 2004. Los géneros de plantas vasculares de la flora de México. Bol. Soc. Bot. Méx. 75: 105-135.

Yatskievych, G. & J. L. Contreras-Jiménez. 2009. A new genus of holoparasitic Orobanchaceae from Mexico. Novon 19: 266-276.

Recibido en abril de 2012.

Aceptado en junio de 2012.

# APPENDIX

Microendemic species of the Mexican lineages of angiosperms. These are restricted to a single quadrat. Species that are on the Mexican Red List (Anonymous, 2010) are indicated with the following designations in parentheses: A = threatened, P = endangered, Pr = under special protection.

**Acanthaceae**
*Gypsacanthus nelsonii* E.J. Lott, V. Jaram. & Rzed.
*Holographis anisophylla* T.F. Daniel
*Holographis argyrea* (Leonard) T.F. Daniel **(Pr)**
*Holographis caput-medusae* T.F. Daniel
*Holographis hintonii* (Leonard) T.F. Daniel
*Holographis pallida* Leonard & Gentry
*Holographis tamaulipica* T.F. Daniel
*Holographis tolantongensis* T.F. Daniel
*Ixtlania acicularis* M.E. Jones
*Mexacanthus mcvaughii* T.F. Daniel
*Mirandea andradenia* T.F. Daniel
*Mirandea huastecensis* T.F. Daniel
*Mirandea hyssopus* (Nees) T.F. Daniel
*Ruellia conzattii* Standl.
*Ruellia guerrerensis* T.F. Daniel
*Ruellia laslobasensis* E.A. Tripp
*Ruellia sarukhaniana* Ramamoorthy
*Ruellia sororia* Standl.

**Achariaceae**
*Chiangiodendron mexicanum* T. Wendt

**Achatocarpaceae**
*Phaulothamnus spinescens* A. Gray

**Amaryllidaceae**
*Sprekelia clintiae* Traub

**Anacardiaceae**
*Pseudosmodingium andrieuxii* Engl.

**Apiaceae**
*Eryngium humile* Cav.
*Eryngium mexicanum* S. Watson

**Apocynaceae**
*Thenardia gonoloboides* Woodson

**Asparagaceae**
*Beaucarnea purpusii* Rose
*Beschorneria tubiflora* Kunth **(Pr)**
*Dasylirion inerme* S. Watson
*Hemiphylacus mahindae* L. Hern.
*Hemiphylacus novogalicianus* L. Hern.
*Jaimehintonia gypsophila* B.L. Turner
*Milla magnifica* H.E. Moore
*Milla rosea* H.E. Moore
*Nolina humilis* S. Watson
*Nolina lindheimeriana* S. Watson
*Nolina pliabilis* (Baker) Lundell
*Nolina pumila* Rose
*Yucca baccata* Torr.
*Yucca capensis* L.W. Lenz

**Asteraceae**
*Ageratum albidum* (DC.) Hemsl.
*Ageratum conyzoides* L.
*Ageratum maritimum* Kunth
*Ageratum microcephalum* Hemsl.
*Ageratum munaense* R.M. King & H. Rob.
*Ageratum paleaceum* (Gay ex DC.) Hemsl.
*Ageratum tomentosum* (Benth.) Hemsl.
*Alomia hintonii* R.M. King & H. Rob.
*Alvordia angusta* S.F. Blake
*Amauria carterae* A.M. Powell
*Arnicastrum glandulosum* Greenm.
*Axiniphyllum pinnatisectum* (Paul G. Wilson) B.L. Turner
*Axiniphyllum sagittalobum* B.L. Turner
*Axiniphyllum tomentosum* Benth.
*Baeriopsis guadalupensis* J.T. Howell
*Bahiopsis carterae* (E.E. Schill.) E.E. Schill. & Panero
*Bahiopsis chenopodina* (Greene) E.E. Schill. & Panero
*Bahiopsis laciniata* (A. Gray) E.E. Schill. & Panero

Appendix. Continuation.

*Bahiopsis lanata* Kellogg
*Bahiopsis tomentosa* (A. Gray) E.E. Schill. & Panero
*Brickellia adenolepis* (B.L. Rob.) Shinners
*Brickellia adontophylla* A. Gray
*Brickellia amblyoleopsis* (B.L. Rob.) R.M. King & H. Rob.
*Brickellia aramberrana* B.L. Turner
*Brickellia cardiophylla* B.L. Rob.
*Brickellia coahuilensis* (A. Gray) Harc. & Beaman
*Brickellia floribunda* A. Gray
*Brickellia frutescens* A. Gray
*Brickellia glabrata* (Rose) B.L. Rob.
*Brickellia glutinosa* A. Gray
*Brickellia hastata* Benth.
*Brickellia hebercarpa* (DC.) A. Gray
*Brickellia kellermanii* Greenm.
*Brickellia pedunculosa* (DC.) Harc. & Beaman
*Brickellia peninsularis* Brandegee
*Brickellia rusbyi* A. Gray
*Brickellia simplex* A. Gray
*Brickellia urolepis* S.F. Blake
*Brickellia vernicosa* B.L. Rob.
*Brickellia wislizeni* A. Gray
*Calanticaria brevifolia* (Greenm.) E.E. Schill. & Panero
*Conoclinium mayfieldii* T.F. Patterson
*Correllia montana* A.M. Powell
*Eryngiophyllum pinnatisectum* Paul G. Wilson
*Eryngiophyllum rosei* Greenm.
*Eupatoriastrum triangulare* (DC.) B.L. Rob.
*Faxonia pusilla* Brandegee
*Gonzalezia hypargyrea* (Greenm.) E.E. Schill. & Panero
*Gonzalezia rosei* (Greenm.) E.E. Schill. & Panero
*Gymnolaena serratifolia* Rydb.
*Gymnolomia scaposa* Brandegee
*Henricksonia mexicana* B.L. Turner
*Hofmeisteria gayleana* B.L. Turner
*Hybridella anthemidifolia* (B.L. Rob. & Greenm.) Olsen
*Hydropectis aquatica* Rydb.
*Jaliscoa goldmanii* (B.L. Rob.) R.M. King & H. Rob.
*Jaliscoa paleacea* (Cronquist) R.M. King & H. Rob.
*Jaliscoa pappifera* S.F. Blake
*Jefea gnaphalioides* (A. Gray) Strother
*Jefea pringlei* (Greenm.) Strother
*Lundellianthus breedlovei* (B.L. Turner) Strother
*Lundellianthus guatemalensis* (Donn. Sm.) Strother
*Lundellianthus salvinii* (Hemsl.) Strother
*Marshalljohnstonia gypsophila* Henrickson
*Mexerion sarmentosum* (Klatt) G.L. Nesom
*Nesomia chiapensis* B.L. Turner
*Otopappus acuminatus* S. Watson
*Otopappus pittieri* (Greenm.) B.L. Turner
*Paneroa stachyofolia* (B.L. Rob.) E.E. Schill.
*Perymenium ovalifolium* (A. Gray) B.L. Turner
*Philactis zinnioides* Schrad.
*Pittocaulon bombycophole* (Bullock) H. Rob. & Brettell
*Pleurocoronis gentryi* (Wiggins) R.M. King & H. Rob.
*Pleurocoronis pluriseta* (A. Gray) R.M. King & H. Rob.
*Psacaliopsis purpusii* (Greenm. ex Brandegee) H. Rob. & Brettell
*Psacalium brachycomum* (S.F. Blake) H. Rob. & Brettell
*Psacalium calvum* (Brandegee) Pippen
*Psacalium decompositum* (A. Gray) H. Rob. & Brettell
*Psacalium globosum* (B.L. Rob. & Fernald) H. Rob. & Brettell
*Psacalium hintonii* (Pippen) H. Rob. & Brettell
*Psacalium hintoniorum* B.L. Turner
*Psacalium pachyphyllum* (Sch. Bip.) Rydb.
*Psacalium paucicapitatum* (B.L. Rob. & Greenm.) H. Rob. & Brettell
*Psacalium peltigerum* (B.L. Rob. & Seaton) Rydb.
*Psacalium radulifolium* (Kunth) H. Rob. & Brettell
*Psacalium tussilaginoides* (Kunth) H. Rob. & Brettell
*Robinsonecio porphyresthes* (T.M. Barkley) T.M. Barkley & Janovec
*Squamopappus skutchii* (S.F. Blake) R.K. Jansen, N.A. Harriman & Urbatsch
*Sidneya tenuifolia* (A. Gray) E.E. Schill. & Panero
*Stenocarpha ritovegana* B.L. Turner

Appendix. Continuation.

*Stephanodoria tomentella* Greene
*Stevia chilapensis* Soejima & Yahara
*Stevia coahuilensis* Soejima & Yahara
*Stevia crassifolia* Soejima & Yahara
*Stevia ecatepecana* Soejima, Yahara & K. Watan.
*Stevia filodecaballoana* Soejima, Yahara & K. Watan.
*Stevia mascotensis* Soejima & Yahara
*Stevia mexicana* Soejima, Yahara & K. Watan.
*Stevia oaxacana* Soejima & Yahara
*Stevia oligophylla* Soejima & Yahara
*Stevia potosina* Soejima, Yahara & K. Watan.
*Stevia rotundifolia* Soejima, Yahara & K. Watan.
*Stevia scabrelloides* Soejima & Yahara
*Stevia viejoana* Soejima, Yahara & K. Watan.
*Steviopsis adenosperma* (Sch. Bip.) B.L. Turner
*Steviopsis amblyolepis* (B.L. Rob.) R.M. King & H. Rob.
*Steviopsis nesomii* B.L. Turner
*Steviopsis squamulosa* (A. Gray) B.L. Turner
*Steviopsis vigintiseta* (DC.) R.M. King & H. Rob.
*Stuessya apiculata* (S.F. Blake) B.L. Turner & F.G. Davies
*Stuessya perennans* B.L. Turner & F.G. Davies
*Tetrachyron chimalapanum* B.L. Turner
*Tetrachyron grayi* (Klatt) Wussow & Urbatsch
*Tetrachyron orizabensis* (Klatt) Wussow & Urbatsch
*Tuxtla pittieri* (Greenm.) Villaseñor & Strother
*Wamalchitamia appressipila* (S.F. Blake) Strother
*Wamalchitamia aurantiaca* (Klatt) Strother
*Wamalchitamia dionysi* Strother
*Zexmenia virgulta* Klatt

**Boraginaceae**
*Lasiarrhenum confundum* B.L. Turner
*Lashiarrhenum pinetorum* I.M. Johnst.
*Mimophytum omphalodoides* Greenm.

**Brassicaceae**
*Lexarzanthe mexicana* (Iltis & Al-Shehbaz) Diego & Calderón
*Raphanorhyncha crassa* Rollins

**Burseraceae**
*Beiselia mexicana* Forman
*Bursera rzedowskii* C.A. Toledo

**Cactaceae**
*Astrophytum asterias* Lem. **(P)**
*Aztekium hintonii* (Glass & W.A. Fitz Maur.) **(Pr)**
*Aztekium ritteri* Boed. **(A)**
*Cumarinia odorata* (Boed.) Buxb. **(Pr)**
*Geohintonia mexicana* Glass & W.A. Fitz Maur. **(Pr)**
*Leuchtenbergia principis* Hook. **(A)**
*Neobuxbaumia multiareolata* (Daws.) Bravo, Scheinvar & Sánchez-Mej.
*Obregonia denegrii* Frič & A. Berger **(A)**
*Pachycereus tepamo* S. Gama-López & S. Arias
*Pelecyphora aselliformis* Ehrenb. **(Pr)**
*Pelecyphora strobiliformis* (Werderm.) Frič & Schelle ex Kreuz. **(A)**
*Thelocactus hastifer* (Werderm. & Boed.) F.M. Knuth **(A)**
*Turbinicarpus alonsoi* Glass & S. Arias
*Turbinicarpus hoferi* Lüthy & A.B. Lau **(A)**
*Turbinicarpus lophophoroides* (Werderm.) Buxb. & Backeb. **(Pr)**
*Turbinicarpus pseudopectinatus* (Backeb.) Glass & R.A. Foster **(Pr)**

**Caryophyllaceae**
*Cerdia virescens* Moc. & Sessé

**Convolvulaceae**
*Ipomoea decemcornuta* O'Donell

**Crassulaceae**
*Cremnophila linguifolia* (Lem.) Moran
*Cremnophila nutans* (Rose) Rose
*Graptopetalum amethystinum* E. Walther
*Graptopetalum bartramii* Rose
*Pachyphytum amethystinum* Rose
*Pachyphytum brachetii* J. Reyes, O. González & A. Gut.
*Pachyphytum brevifolium* Rose
*Pachyphytum caesium* Kimnach & Moran
*Pachyphytum coeruleum* J. Meyrán
*Pachyphytum contrerasii* Pérez-Calix, I. García & Cházaro
*Pachyphytum fittkaui* Moran

Appendix. Continuation.

*Pachyphytum garciae* Pérez-Calix & Glass
*Pachyphytum hookeri* A. Berger
*Pachyphytum kimnachii* Moran
*Pachyphytum longifolium* Rose
*Pachyphytum machucae* I. García, Glass & Cházaro
*Pachyphytum oviferum* J.A. Purpus
*Pachyphytum rzedowskii* I. García, Pérez-Calix & J. Meyrán
*Pachyphytum saltense* Brachet, J. Reyes & Mondragón
*Pachyphytum werdermannii* Poelln.
*Thompsonella garcia-mendozae* P. Carrillo & Pérez-Calix
*Thompsonella mixtecana* J. Reyes & L. López
*Thompsonella spathulata* Kimnach
*Thompsonella xochipalensis* M. Gual Diaz, S. Peralta & Pérez-Calix

**Crossosomataceae**
*Velascoa recondita* Calderón & Rzed.

**Cucurbitaceae**
*Cucurbita fraterna* L.H. Bailey
*Cucurbita pedatifolia* L.H. Bailey
*Apatzingania arachoidea* I.M. Johnston
*Vaseyanthus brandegeei* Rose

**Cyperaceae**
*Cypringlea evadens* (C.D. Adams) Reznicek & S. González

**Euphorbiaceae**
*Euphorbia coalcomanensis* (Croizat) V.W. Steinm. **(A)**
*Euphorbia cyri* V.W. Steinm. **(E)**
*Euphorbia dressleri* V.W. Steinm. **(E)**
*Euphorbia finkii* (Boiss.) V.W. Steinm. **(A)**
*Euphorbia peritropoides* (Millsp.) V.W. Steinm.
*Euphorbia personata* (Croizat) V.W. Steinm.
*Euphorbia tehuacana* (Brandegee) V.W. Steinm. **(A)**
*Euphorbia tithymaloides* L.

**Fabaceae**
*Acaciella barrancana* (Gentry) L. Rico
*Acaciella goldmanii* Britton & Rose
*Acaciella igualensis* Britton & Rose
*Acaciella sotoi* L. Rico
*Calliandropsis nervosus* (Britton & Rose) H.M. Hern. & P. Guinet
*Dalea laniceps* Barneby
*Dalea parrasana* Brandegee
*Hesperothamnus ehrenbergii* (Harms) Harms
*Hesperothamnus littoralis* (Brandegee) Brandegee
*Hesperothamnus purpusii* (Harms) Harms
*Marina brevis* León de la Luz
*Marina capensis* Barneby
*Marina catalinae* Barneby
*Marina divaricata* (Benth.) Barneby
*Marina interstes* Barneby
*Marina oculata* (Rydb.) Barneby
*Mariosousa acatlensis* (Benth.) Seigler & Ebinger

**Fagaceae**
*Quercus clivicola* Trel. & C.H. Mull.
*Quercus radiata* Trel.
*Quercus tarahumara* Spellenb., J.D. Bacon & Breedlove
*Quercus verde* C.H. Mull.

**Fouquieriaceae**
*Fouquieria leonilae* Miranda **(Pr)**
*Fouquieria purpusii* Brandegee **(P)**

**Gentianaceae**
*Geniostemon atarjanus* B.L. Turner
*Geniostemon rotundifolius* Rzed. & Calderón

**Gesneriaceae**
*Achimenes candida* Lindl.
*Achimenes hintoniana* Ramírez Roa & L.E. Skog
*Achimenes nayaritensis* L.E. Skog
*Achimenes occidentalis* C.V. Morton
*Achimenes pedunculata* Benth.
*Smithiantha aurantiaca* Wiehler

**Iridaceae**
*Ainea conzattii* (R.C. Foster) Ravenna **(A)**

**Iteaceae**
*Pterostemon bravoanus* J. Jiménez Ram. & M. Martínez

Appendix. Continuation.

**Lamiaceae**
*Salvia canescens* C.A. Mey.
*Salvia dolichantha* E. Peter
*Salvia univerticillata* Ramamoorthy ex Klitg.

**Lauraceae**
*Mocinnodaphne cinnamomoidea* Lorea-Hern.

**Liliaceae**
*Hesperaloe tenuifolia* G.D. Starr

**Loasaceae**
*Schismocarpus matudae* Steyerm.
*Schismocarpus pachypus* S.F. Blake

**Malphighiaceae**
*Lasiocarpus multiflorus* Nied.
*Lasiocarpus ovalifolius* Nied.

**Malvaceae**
*Bastardiastrum tarasoides* Fryxell
*Bastardiastrum tricarpellatum* (B.L. & Rob. & Greenm.) D.M. Bates
*Periptera lobelioides* Fryxell & S.D. Koch
*Periptera trichostemon* Bullock

**Nyctaginaceae**
*Grajalesia fasciculata* (Standl.) Miranda
*Grajalesia ferruginea* Miranda

**Oleaceae**
*Hesperelaea palmeri* A. Gray **(P)**

**Onagraceae**
*Lopezia clavata* Brandegee
*Lopezia lopezioides* (Hook. & Arn.) Plitmann, P.H. Raven & Breedlove
*Lopezia ovata* (Plitmann, P.H. Raven & Breedlove) Plitmann, P.H. Raven & Breedlove
*Lopezia smithii* Rose
*Lopezia suffrutescens* Munz
*Megacorax gracielanus* S. González & W.L. Wagner

**Orchidaceae**
*Hagsatera rosilloi* R. González
*Mexipedium xerophyticum* (Soto Arenas, Salazar & Hágsater) V.A. Albert & M.W. Chase **(P)**
*Nezahualcoyotlia gracilis* (L.O. Williams) R. González
*Physogyne garayana* R. González & Szlach.
*Physogyne sparsiflora* (C. Schweinf.) Garay
*Svenkoeltzia luzmariana* R. González
*Svenkoeltzia pamelae* Szlach., Rutk. & Mytnik

**Orobanchaceae**
*Castilleja filiflora* G.L. Nesom
*Castilleja hidalgensis* J.M. Egger
*Castilleja macrostigma* B.L. Rob.
*Castilleja ornata* Eastw.
*Castilleja perelegans* G.L. Nesom
*Castilleja sphaerostigma* Eastw.
*Castilleja stipifolia* G.L. Nesom
*Castilleja tancitaroana* G.L. Nesom
*Eremitilla mexicana* Yatsk. & J.L. Contr.
*Lamourouxia brachyantha* Greenm.
*Lamourouxia macrantha* M. Martens & Galeotti
*Lamourouxia nelsonii* B.L. Rob. & Greenm.

**Phytolaccaceae**
*Nowickea glabra* J. Martínez & J.A. McDonald
*Nowickea xolocotzii* J. Martínez & J.A. McDonald

**Poaceae**
*Muhlenbergia brevis* C.O. Goodd.
*Muhlenbergia majalcensis* P.M. Peterson
*Olmeca clarkiae* (Davidse & R.W. Pohl) Ruiz-Sanchez, Sosa & Mejía-Saules
*Olmeca zapotecorum* Ruiz-Sanchez, E., Sosa & Mejía Saules
*Otatea glauca* L.G. Clark & G. Cortés
*Otatea ramirezii* Ruiz-Sanchez
*Otatea transvolcanica* Ruiz-Sanchez & L.G. Clark
*Otatea ximenae* Ruiz-Sanchez & L.G. Clark

**Rhamnaceae**
*Karwinskia calderonii* Urb.
*Karwinskia johnstonii* R. Fernandez

Appendix. Continuation.

**Rubiaceae**
*Carterella alexanderae* (A.M. Carter) Terrell
*Habroneuron radicans* (Wernham) S.P. Darwin
*Omiltemia parvifolia* Borhidi & K.Velasco
*Placocarpa mexicana* Hook. f.
*Stenotis gracilenta* (I.M. Johnst.) Terrell
*Stenotis peninsularis* (Brandegee) Terrell
*Stylosiphonia glabra* Brandegee

**Rutaceae**
*Ptelea baldwinii* Torr. & A. Gray
*Ptelea confinis* Greene
*Ptelea megacarpa* Rose ex Greene
*Ptelea obscura* Greene
*Ptelea obtusata* Greene
*Ptelea subintegra* Greene

**Sapindaceae**
*Balsas guerrerensis* Cruz Durán & K. Vega

**Scrophulariaceae**
*Leucophyllum alejandrae* G.L. Nesom
*Leucophyllum flyrii* B.L. Turner
*Leucophyllum hintoniorum* G.L. Nesom
*Leucophyllum langmaniae* Flyr
*Leucophyllum lanosum* Flyr
*Leucophyllum mojinense* Henrickson & T. Van Devender
*Leucophyllum ultramonticola* Flyr
*Leucophyllum virescens* I.M. Johnst.

**Solanaceae**
*Physalis heterophylla* Nees
*Physalis virginiana* Mill.
*Physalis walteri* Nutt.
*Solanum johnstonii* Whalen
*Solanum morelliforme* Bitter & Münch
*Solanum tribulosum* S. Schauer
*Tzeltalia amphitricha* (Bitter) E. Estrada & M. Martínez
*Tzeltalia calidaria* (Standl. & Steyerm.) E. Estrada & M. Martínez

**Zygophyllaceae**
*Morkillia acuminata* Rose & Painter
*Viscainoa pinnata* Gentry