



Acta Botanica
Mexicana

Agave × *hidrocalida* (Asparagaceae, Agavoideae), a new putative hybrid from Aguascalientes, Mexico

Agave × *hidrocalida* (Asparagaceae, Agavoideae), un nuevo híbrido putativo de Aguascalientes, México

C. Santiago Rosales-Martínez^{1,6} , Dante S. Figueroa^{2,3} , Octavio Carrillo-Macías⁴ , J. Antonio Vázquez-García⁵ 

Abstract:

Background and Aims: Hybridization is a common phenomenon in *Agave* and is considered an important component of the evolution of the genus. Recent botanical explorations in the state of Aguascalientes, Mexico, led to the discovery of populations of an *Agave* exhibiting morphological characters intermediate between *A. angustifolia* and *A. filifera*. The aims of this study are to describe these populations as a new nothospecies, compare it with its putative parental species and morphologically similar taxa, and document its geographic distribution.

Methods: Field expeditions conducted in Aguascalientes between 2020 and 2022 resulted in the collection of a new putative hybrid of *Agave*. Morphological comparisons with the putative parental species and related taxa were conducted. A distribution map was generated from herbarium and field records, and the conservation status was assessed following IUCN criteria.

Key results: *Agave* × *hidrocalida* is described as a new intersubgeneric nothospecies endemic to Aguascalientes, Mexico. Morphological and ecological evidence supports its origin from hybridization between *A. angustifolia* (subg. *Agave*) and *A. filifera* (subg. *Littaea*). The nothospecies exhibits characters intermediate between its putative parental species, including entire leaf margins and a raceme-like paniculate inflorescence. A preliminary conservation assessment places it in the Vulnerable (VU) category.

Conclusions: *Agave* × *hidrocalida* expands the diversity of known nothospecies in *Agave* and provides additional evidence of the role of hybridization in the evolution of the genus. The occurrence of multiple, morphologically homogeneous populations across its distribution range warrants further studies to determine whether hybrid speciation has taken place.

Key words: *Agave angustifolia*, *Agave filifera*, intersubgeneric hybrid, nothospecies, raceme-like panicle, sympatry.

Resumen:

Antecedentes y Objetivos: La hibridación es un fenómeno común en *Agave* y se considera un componente importante en la evolución del género. Exploraciones botánicas recientes en el estado de Aguascalientes, México, llevaron al descubrimiento de poblaciones de un *Agave* que exhibe caracteres morfológicos intermedios entre *A. angustifolia* y *A. filifera*. El objetivo de este estudio es describir estas poblaciones como una nueva notoespecie, compararla con sus especies parentales putativas y con taxones morfológicamente similares, y documentar su distribución geográfica.

Métodos: Expediciones de campo realizadas en Aguascalientes entre 2020 y 2022 dieron como resultado la colecta de un nuevo híbrido putativo de *Agave*. Se realizaron comparaciones morfológicas con las especies parentales putativas y taxones relacionados. Se generó un mapa de distribución a partir de registros de herbario y de campo, y el estado de conservación fue evaluado siguiendo los criterios de la UICN.

Resultados clave: Se describe a *Agave* × *hidrocalida* como una nueva notoespecie intersubgenérica endémica de Aguascalientes, México. La evidencia morfológica y ecológica respalda su origen a partir de la hibridación entre *A. angustifolia* (subg. *Agave*) y *A. filifera* (subg. *Littaea*). La notoespecie exhibe caracteres intermedios entre sus especies parentales putativas, incluyendo márgenes foliares enteros y una inflorescencia paniculada racemiforme. Una evaluación preliminar de conservación la sitúa en la categoría Vulnerable (VU).

Conclusiones: *Agave* × *hidrocalida* amplía la diversidad de notoespecies conocidas en *Agave* y proporciona evidencia adicional sobre el papel de la hibridación en la evolución del género. La presencia de múltiples poblaciones morfológicamente homogéneas a través de su rango de distribución justifica estudios adicionales para determinar si ha tenido lugar la especiación híbrida.

Palabras clave: *Agave angustifolia*, *Agave filifera*, híbrido intersubgenérico, notoespecie, panícula en forma de racimo, simpatría.

¹Instituto Tecnológico y de Estudios Superiores de Occidente, 45604 Tlaquepaque, Jalisco, Mexico.

²Centro de Estudios Bioculturales A.C., 49344 Tapalpa, Jalisco, Mexico.

³Plantas de Aquí, 45189 Zapopan, Jalisco, Mexico.

⁴Independent researcher, 20923 Jesús María, Aguascalientes, Mexico.

⁵Universidad de Guadalajara, Centro Universitario de Ciencias Biológicas y Agropecuarias, Departamento de Botánica, 45220 Zapopan, Jalisco, Mexico.

⁶Author for correspondence: santiagorosales412@gmail.com

Received: June 7, 2026.

Reviewed: June 30, 2026.

Accepted by Marie-Stéphanie Samain: August 6, 2026.

Published Online first: August 11, 2026.

Published: Acta Botanica Mexicana 133(2026).



This is an open access article under the Creative Commons 4.0 Attribution-NonCommercial Licence (CC BY-NC 4.0 Internacional).

To cite as: Rosales-Martínez, C. S., D. S. Figueroa, O. Carrillo-Macías and J. A. Vázquez-García. 2026. *Agave* × *hidrocalida* (Asparagaceae, Agavoideae), a new putative hybrid from Aguascalientes, Mexico. Acta Botanica Mexicana 133: e2623. DOI: <https://doi.org/10.21829/abm133.2026.2623>

e-ISSN: 2448-7589

Introduction

Agave L. *sensu stricto* is a genus within the Asparagaceae family, Agavoideae subfamily, that comprises perennial plants with usually short stems, succulent and fibrous leaves that are spirally arranged in rosettes, paniculate inflorescences in subg. *Agave* or spiciform inflorescences in subg. *Littaea* (Tagl.) Baker, and tubular flowers with six tepals and inferior ovaries (Gentry, 1982; Thiede, 2020). The distribution of *Agave* is limited to the Americas, ranging from the United States of America to northern South America, as well as the Caribbean Islands (García-Mendoza, 2007). Nonetheless, the greatest diversity of *Agave* is found in Mexico, which is home to approximately 170 of the ca. 220 currently accepted species. Evidence from recent phylogenetic studies supported the segregation of several lineages formerly included within *Agave sensu lato*, resulting in the recognition of the genera *Echinoagave* A.Vázquez, Rosales & García-Mor., *Paleoagave* A.Vázquez, Rosales & García-Mor., and *Paraagave* A.Vázquez, Rosales & García-Mor. (Vázquez-García et al., 2024).

According to the available literature (de la Cerda-Lemus et al., 2004; de la Cerda-Lemus, 2007; Thiede, 2020; Gutiérrez-Gutiérrez et al., 2025) and own observations, about nine species of *Agave* occur in the state of Aguascalientes: *A. angustifolia* Haw., *A. appianata* K.Koch, *A. asperima* Jacobi, *A. filifera* Salm-Dyck, *A. parryi* Engelm., *A. schidigera* Lem., *A. salmiana* Otto ex Salm-Dyck, *A. villalobosii* A.Vázquez & B.Gut., and *A. vimoriniana* A.Berger. However, a collection and photographs from 1994 show an unusual *Agave* (Abisaí García Mendoza et al. 5984 (MEXU)) from the municipality Aguascalientes that does not coincide with any of the aforementioned species. On the label of the specimen, it was stated that it could be a hybrid between *A. angustifolia* and *A. filifera*, which were growing in the same area.

Hybridization can be defined as the interbreeding of individuals belonging to genetically distinct groups (Barton and Hewitt, 1985), usually between two subspecies, species subgenera or genera. In *Agave*, gene flow among species is facilitated by relatively weak reproductive barriers, shared ecological niches, and shared pollinators, including nectar-feeding bats, hawkmoths, large bees, and hummingbirds

(Rocha et al., 2006). Consequently, numerous cases of natural hybrids have been reported from areas where the flowering periods of two sympatric species overlap. Most of these cases correspond to intersubgeneric hybrids, which are frequently recognized by their intermediate inflorescences between racemes and panicles, for example: *A. × arizonica* Gentry & J.H.Weber (= *A. toumeyana* ssp. *bella* (Breitung) Gentry × *A. chrysantha* Peebles), *A. × ajoensis* W.C.Hodgs. (= *A. deserti* ssp. *simplex* Gentry × *A. schottii* var. *schottii* Engelm.), *A. × madreñensis* Villarreal, Ram.-Gam. & A.E.Estrada (= *A. lechuguilla* Torr. × *A. gentryi* B.Ullrich) and *A. × peacockii* Croucher (= *A. kerchovei* Lem. × *A. marmorata* Roezl). Intrasubgeneric hybridization appears to be less evident, as only a few cases have been recorded, such as *A. chrysantha* × *A. delamateri* W.C.Hodgs. & L.Slauson (both of subg. *Agave*) and *A. lechuguilla* × *A. nickelsiae* Rol.-Goss. (both of subg. *Littaea*). Although hybrids generally have low percentages of pollen and seed fertility (García-Mendoza, 2007), seed-perpetuated populations are known in *A. asperima* × *A. nickelsiae* (González-Elizondo et al., 2011) and quite possibly in *A. × glomeruliflora* (Engelm.) A.Berger (Gentry, 1982). Other hybrids propagate asexually through suckers or bulbils.

Recent explorations in the state of Aguascalientes allowed us to document several seed-perpetuated populations of the unusual *Agave* and conclude that it corresponds to a putative intersubgeneric hybrid between *A. angustifolia* (subg. *Agave*) and *A. filifera* (subg. *Littaea*). In the present work, this new nothospecies is described and compared with *A. × ajoensis*, the morphologically most similar taxon, as well as with its putative parental species.

Materials and Methods

In 2020, 2021 and 2022, several expeditions were carried out in different municipalities of Aguascalientes with the aim of studying an unidentified *Agave* with intermediate inflorescences. In August 2021, a flowering plant was collected near the town of Jesús María, Aguascalientes, and it was brought to the Instituto de Botánica del Centro Universitario de Ciencias Biológicas y Agropecuarias (Guadalajara), where leaves and fragments of inflorescences were prepared for herbarium specimens. For further study, two



specimens available in the MEXU virtual herbarium (UNAM, 2025) were consulted and measured. The description was based on these three herbarium specimens and complemented with morphological measurements of ten living individuals in the field.

To evaluate the hypothesis that it represents an inter-subgeneric hybrid, the sympatric putative parental species *Agave angustifolia* and *A. filifera* were documented and compared. A morphological comparison including the similar hybrid *A. × ajoensis* was also conducted. In addition, morphological traits reported for other hybrids within the genus, as well as for species with intermediate inflorescences, were reviewed from relevant literature sources (Gentry, 1982; Vázquez-García et al., 2007; Villarreal Quintanilla et al., 2014; Thiede, 2020).

The distribution map was generated using QGIS v. 2.14.3 (QGIS Development Team, 2018). Records of the new nothospecies were taken from the herbarium specimens and additional field observations of living individuals in Aguascalientes. Records of the putative parental species were compiled from the IBUG and MEXU herbaria, the Global Biodiversity Information Facility (GBIF, 2023a, b), the Red de Herbarios del Noroeste de México (RMH, 2025), and own field observations. The template of the biogeographic provinces of Mexico *sensu* Morrone et al. (2017) was employed.

To assess the conservation status of the new nothospecies, its Extent of Occurrence (EOO) and Area of Occupancy (AOO) were calculated using the GeoCAT tool (Bachman et al., 2011). The proposed risk category was obtained using the IUCN Red List Categories and Criteria (IUCN, 2022).

Results

Taxonomy

Agave × hidrocalida Rosales, Figueroa & O.Carrillo, **nothosp. nov.** Fig. 1.

TYPE: MEXICO. Aguascalientes, municipio Jesús María, 4 km al oeste del pueblo de Jesús María, matorral xerófilo arriba de Mesa Grande, 2000 m, 29.VIII.2021,

S. Rosales Martínez et al. 12 (holotype: IBUG!; isotype: MEXU!).

Agave × hidrocalida is the putative natural hybrid between *A. angustifolia* and *A. filifera*. It combines the long lanceolate leaves and terminal spine of *A. angustifolia* with the green foliage and surculose habit of *A. filifera*, but differs from the parental species by its entire leaf margins, lacking both teeth and filaments, and by a raceme-like inflorescence with flowers arranged in short, congested branches. It also resembles *A. × ajoensis* in its linear-lanceolate leaves and the raceme-like inflorescence, but differs by having a leaf length of 60-90 cm (vs. 16-34 cm), a red to reddish-brown margin (vs. reddish-brown and white), 6-12 flowers per branch (vs. 3-6), yellowish to green-purplish tepals (vs. golden-yellow), and a fruit length of 2.2-2.7 cm (vs. 1.2-2.1 cm).

Plants perennial, acaulescent, surculose, sometimes cespitose; rosettes 80-100 cm high, 100-120 cm wide, openly spreading, moderately dense; leaves 60-90 cm long, 4-6 cm wide, lanceolate to linear-lanceolate, straight to somewhat incurved, flat to slightly concave above, convex below, thickened to the base, rigid, smooth, bright green to dark green, often green-purplish when stressed, sometimes with light cross bands or with a pale central stripe, with inconspicuous imprints; margins entire, minutely denticulate in young plants, straight, corneous, continuous, thin, razor-sharp, red to reddish-brown, grayish with age, with a hyaline golden stripe between the margin and the leaf tissue; teeth when present 1 mm long, straight to slightly curved, red to reddish-brown, sparse; terminal spine 2-3.5 cm long, thin, conical, channeled above, rounded concave below, indurate, pungent, decurrent along the margin, shortly penetrating into the leaf tissue, reddish-brown to dark; inflorescence a raceme-like panicle, 2.5-3 m tall, erect; peduncle comprising 60-70% of the inflorescence length, bracteate, green with a purplish hue; bracts laxly arranged, linear-triangular, straight, ascending, chartaceous, caducous, provided with a terminal spine, the lower ones 10 cm long and 4 cm wide at the base, the upper ones 5 cm long and 2 cm wide at the base; fertile part comprising 30-40% of the inflorescence



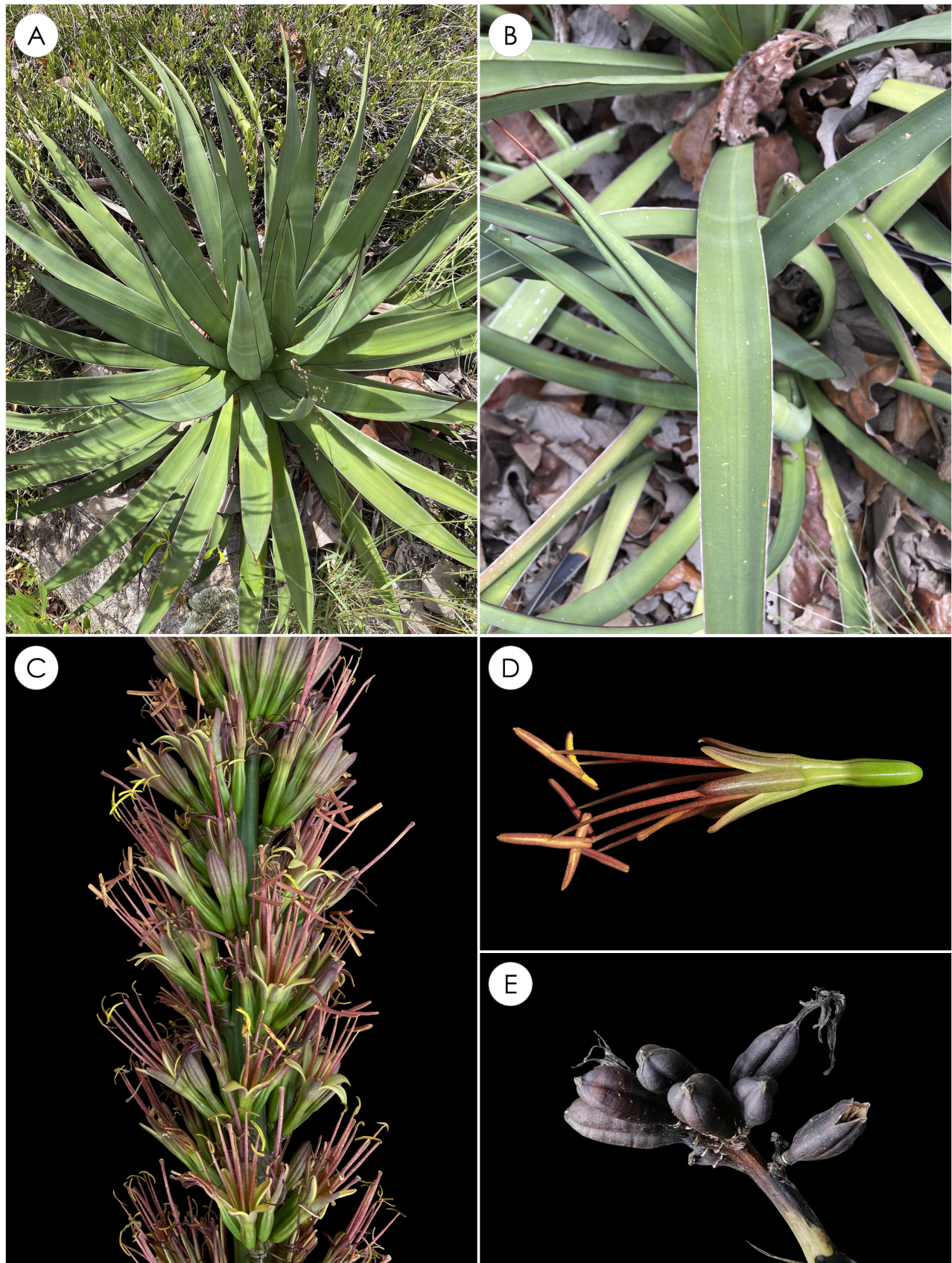


Figure 1: *Agave* $\times$ *hidrocalida* Rosales, Figueroa & O.Carrillo. A. rosette; B. leaf detail; C. inflorescence fragment; D. flower; E. infructescence branch. Photographs by the authors.

length; branches numerous, short, congested; pedicels 2-4 mm long, often thickened in the middle part, green to reddish, elongating at fruiting time; flowers 6-12 per branch, 4.5-5.6 cm long, somewhat campanulate, ascending; ovary 1.5-2 cm long, cylindrical, green, neck constricted; tepals yellowish to green-purplish on the outer face, green-yellowish on the inner face; tube 0.7-1.2 cm long, narrowly funnel-shaped; lobes 1.9-2.7 cm long, linear-lanceolate, cucullate, the inner keeled; filaments 4.5-5.4 cm long, inserted at the rim of the tube, red-purplish; anthers 1-2.3 cm long, red to orange-reddish, pollen yellow; style 4-4.7 cm long, stout, red to purplish; stigma trilobate; fruits 2.2-2.7 cm long, ellipsoid, light green, brown after dehiscence; seeds 3.1-4.3 mm long, 4.2-5.1 mm wide, lunulate, black.

Etymology: the epithet *hidrocalida* is derived from the Spanish adjective “hidrocálido”, meaning native to Aguascalientes, Mexico, where this new putative hybrid occurs.

Distribution and habitat: *Agave* × *hidrocalida* is known from eight populations in the state of Aguascalientes (in the municipalities Aguascalientes, Calvillo, Jesús María, San José de Gracia, Pabellón de Arteaga and Rincón de Ramos), in an elevational range of 1580-2440 m. It occurs in the transition zone between the Chihuahuan Desert and Sierra Madre Occidental biogeographic provinces (Fig. 2), where it grows on rocky soils in different types of vegetation and is associated with a wide variety of species, including its parental species. In xerophytic scrub, it grows with *Dasyllirion* sp., *Echeveria paniculata* A.Gray, *Bursera* sp., *Commelina* sp., *Ferocactus histrix* (DC.) G.E.Linds., *Melinis repens* (Willd.) Zizka, *Opuntia* spp. and *Yucca* sp., among others. In pine-oak forest, it grows with *Arctostaphylos pungens* Kunth, *Mammillaria perezdelarosae* Bravo & Scheinvar and *Quercus* sp. Less frequently, it occurs in tropical deciduous forest with *Amphipterygium molle* Hemsl. & Rose, *Ceiba aesculifolia* Britten & Baker f., and others.

Phenology: plants flower from late June to early September and fruit from October to December.

Conservation status: the Extent of Occurrence (EOO) was estimated to be 1089 km², while the Area of Occupancy (AOO) is 52 km². Although these values fall within the thresholds for Endangered (EN) under criteria B1 and B2 of the IUCN (2022), the taxon is known from more than five localities and its populations do not appear to be severely fragmented. Therefore, a preliminary conservation status of Vulnerable (VU) is proposed.

Additional material examined: MEXICO. Aguascalientes, municipality Aguascalientes, 4 km al E de El Milagro, carretera a San José de Gracia, 2080 m, 23.VI.1994, A. García Mendoza et al. 5984 (MEXU). Municipality Calvillo, 1 km al E de Río Gil, 1850 m, 7.VIII.1995, M. de la Cerda 5544 (MEXU).

Discussion

Hybridization within the genus *Agave* is common, and various cases of natural and artificial hybrids have been documented over time (Gentry 1967, 1982; Thiede 2020). It is considered that the ease of hybridization has played a significant role in the evolution of the group and speciation (Thiede, 2020; Eguiarte et al., 2021) as has been shown in phylogenetic reconstructions (Jiménez-Barrón et al., 2020; Eguiarte et al., 2021). The genus has been regarded as “a rather promiscuous group actively generating species today” (Gentry, 1967). Despite this, few documented cases are known of hybrid-origin populations that self-propagate via sexual reproduction (Pinkava and Baker, 1985; Reveal and Hodgson, 2002; Thiede, 2020). Most cases of hybrids fail to establish new generations due to infertility (García-Mendoza, 2007).

Among currently known nothospecies of *Agave*, *A. × ajoensis* is the most similar morphologically. Both are intersubgeneric hybrids involving a species with dentate leaf margins (*A. deserti* ssp. *simplex* of subg. *Agave*) and a species of subg. *Littaea* with filiferous leaf margins (*A. schottii* var. *schottii* of subg. *Littaea*) (Hodgson, 2001). Nevertheless, *A. × hidrocalida* differs in several aspects (Table 1) and is endemic to Aguascalientes, Mexico, while *A. × ajoensis* is only found in Arizona, United States of America.



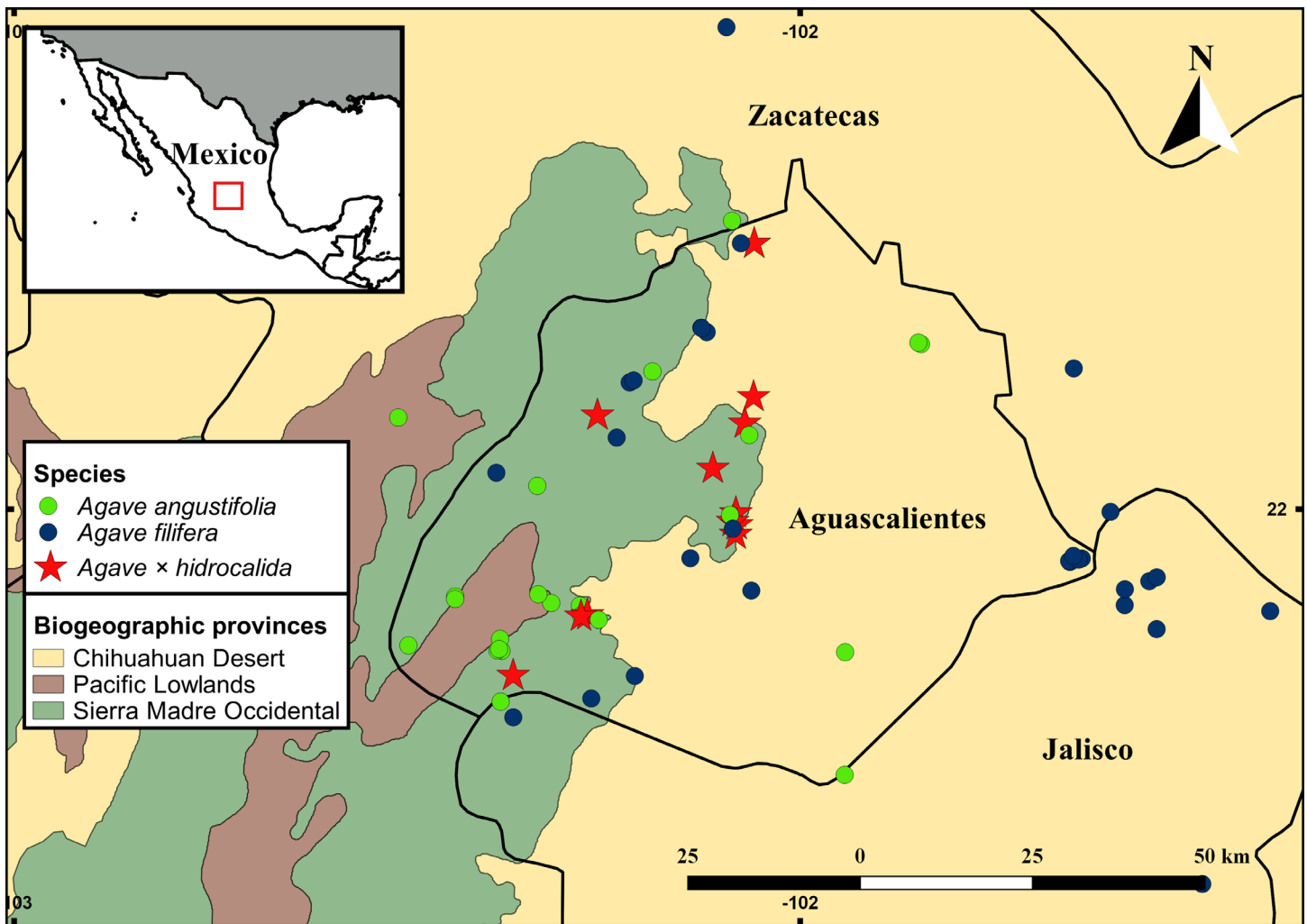


Figure 2: Records of *Agave × hidrocalida* Rosales, Figueroa & O.Carrillo and its putative parental species in Aguascalientes and neighboring regions.

Relevant evidence of hybridization between the putative parental species, *Agave angustifolia* (Fig. 3) and *A. filifera* (Fig. 4), supports the recognition of *A. × hidrocalida* as a new nothospecies. The three herbarium specimens used for the description, including flowering and fruiting material, exhibit characters intermediate between the putative parental species (Table 1). Plants form acaulescent rosettes that frequently produce basal suckers and may develop small clumps. Leaves are bright green to dark green, sometimes showing purplish pigmentation under stress, transverse bands, or a pale central stripe. The leaf margin is entire, lacking both the teeth characteristic of *A. angustifolia* and the marginal filaments characteristic of *A. filifera*, although minute denticulation may occasionally be present in young plants. The inflorescence is a raceme-like

panicle with numerous flowers arranged in short, congested branches, representing an intermediate condition between the paniculate inflorescences of subg. *Agave* and the spiciform inflorescences of subg. *Littaea*. Flowers are medium-sized and vary from yellowish-green to greenish-purple. The hypothesis that *A. × hidrocalida* originated through hybridization is further supported by the distribution of its putative parental species. Throughout the known range of the nothospecies, *A. angustifolia* and *A. filifera* were found growing in sympatry. Moreover, the reproductive periods of the three taxa overlap, with the hybrid flowering between June and September, *A. filifera* between March and August, and *A. angustifolia* mainly between March and July.

However, it is unknown whether hybrid speciation has taken place. Doubling of chromosome numbers in



Table 1: Morphological comparison of *Agave* × *hidrocalida* Rosales, Figueroa & O.Carrillo with its putative parental species and *A.* × *ajoensis* W.C.Hodgs.

	<i>Agave</i> × <i>hidrocalida</i> Rosales, Figueroa & O.Carrillo	<i>A. angustifolia</i> Haw.	<i>A. filifera</i> Salm-Dyck	<i>A.</i> × <i>ajoensis</i> W.C.Hodgs.
Habit	Surculose, sometimes cespitose	Surculose	Surculose, sometimes cespitose	Solitary or more commonly cespitose
Leaf length (cm)	60-90	60-100(-130)	15-30	16-34
Leaf shape	Lanceolate to linear-lanceolate	Lanceolate to linear-lanceolate	Lanceolate	Linear-lanceolate
Leaf color	Bright green to dark green, often green-purplish when stressed, sometimes crossbanded or with a pale central stripe	Glaucous to light green, frequently crossbanded	Green, with conspicuous white imprints and sometimes with a pale central stripe	Light green, sometimes with a pale central stripe
Leaf margin	Entire, minutely denticulate in young plants, red to reddish-brown	Dentate	Filiferous, reddish-brown and white	With small teeth near the leaf base, reddish-brown and white
Terminal spine length (cm)	2-3.5	(1.5-)2-3.5	1-2	1.5-2.5
Inflorescence type	Raceme-like	Paniculate	Spiciform	Raceme-like
Inflorescence length (m)	2.5-3	2.5-3(-4)	2-2.5	2.5-3.5
Fertile part (%)	30-40	30-50	50	30-40
Number of flowers per branch	6-12	Variable, from 15 and up	2	3-6
Flower length (cm)	4.5-5.6	(4-)5-6(-8)	3-3.5	3.2-5.3
Tube length (cm)	0.7-1.2	0.7-1(-2)	0.5-0.6	(0.4-)0.6-2.1
Tepal color	Yellowish to green-purplish	Greenish-brown to greenish-yellow	Reddish	Golden-yellow
Filament insertion	At the rim of the tube	In the middle or to the upper fourth of the tube	At the rim of the tube	At the rim of the tube or close
Fruit length (cm)	2.2-2.7	3-6	1.5-1.7	1.2-2.1

hybrids (allopolyploidy) with respect to their putative parents is a shortcut to determine that hybrid speciation has taken place. Allopolyploidy directly causes reproductive isolation through improper chromosome pairing during meiosis (Soltis and Soltis, 2009). Alternatively, specific experimental genetic studies combined with molecular approaches are needed to test whether hybridization has caused reproductive isolation from the putative parental species (Schumer et al., 2014). Homoploid hybrid speciation is another possibility. As no change in chromosome number is involved, reproductive isolation must evolve despite ongoing gene flow with the parental species, making

this mode of speciation difficult to test (Barton, 2001; Soltis and Soltis, 2009). It is noteworthy that no hybrid swarm was observed in *A.* × *hidrocalida*. Instead, several populations composed of individuals at different developmental stages were observed, all showing homogeneity in vegetative and reproductive morphological characters. This pattern is consistent with reproductive isolation. The current sympatric distribution and shared habitat of *A.* × *hidrocalida* and its putative parental species show no evidence of geographic isolation through orographic barriers to gene flow. Thus, ecological speciation appears unlikely under this scenario.



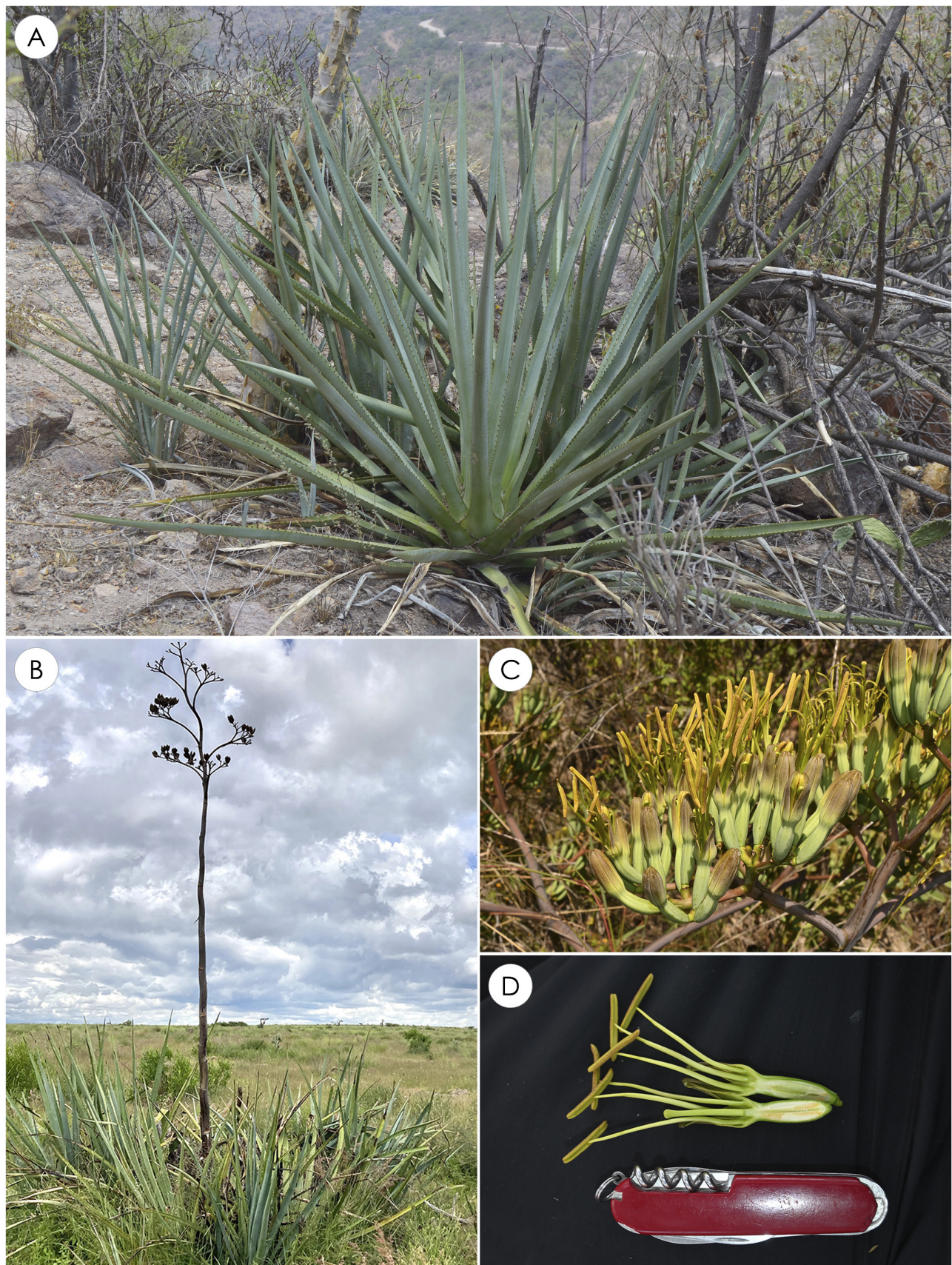


Figure 3: *Agave angustifolia* Haw. from the study region. A. rosettes; B. plant with dry infructescence; C. inflorescence branch; D. flower section. Photographs by the authors, except “A” by Julia Etter and Martin Kristen.

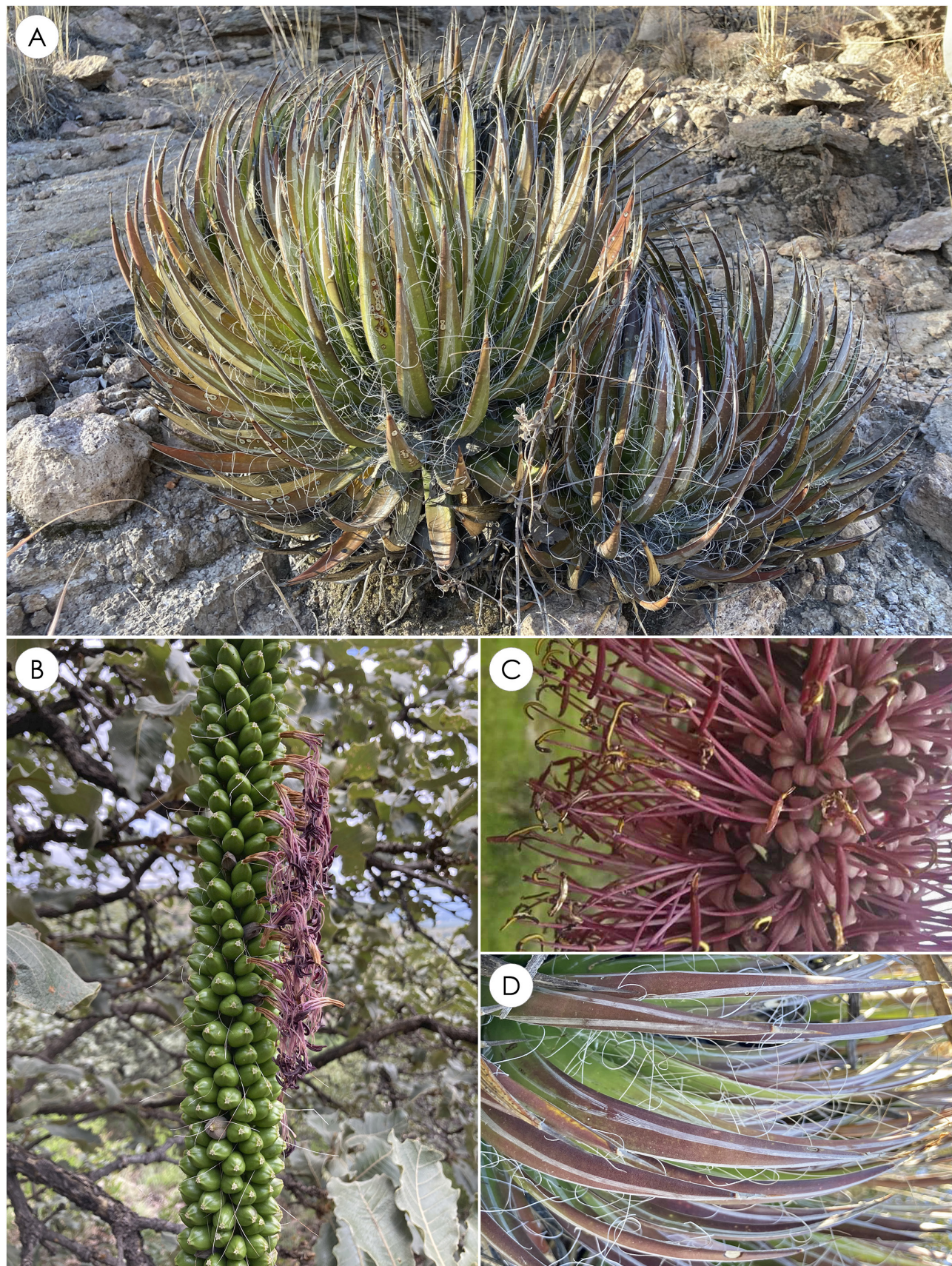


Figure 4: *Agave filifera* Salm-Dyck from the study region. A. rosettes; B. infructescence fragment; C. inflorescence detail; D. leaf margin. Photographs by the authors.

Author contributions

Conceptualization: CSRM, DSF; Funding: CSRM, DSF, OCM, JAVG; Investigation: CSRM, OCM; Methodology: CSRM, DSF; Project administration: CSRM; Validation: CSRM, DSF, OCM, JAVG; Visualization: CSRM; Writing - original draft: CSRM, DSF, JAVG; Writing - review & editing: CSRM, DSF, OCM, JAVG.

Funding

This study was supported by personal funds provided by the authors.

Acknowledgements

We are grateful to the two anonymous reviewers, the Editor in Chief, and the Technical Editors for their valuable comments, which helped improve this manuscript; to Juan Pablo Ortiz Brunel for his assistance with the preparation of the distribution map; to Carlos Javier Rosales Martínez for his companionship during fieldwork in Aguascalientes and for his help in collecting the new nothospecies; to Jesús Padilla Lepe for documenting the fruiting process of *Agave* × *hidrocalida* at the Instituto de Botánica, Centro Universitario de Ciencias Biológicas y Agropecuarias (Guadalajara); to Julia Etter and Martin Kristen for allowing us to use their photograph of *Agave angustifolia*; and to the Universidad de Guadalajara-CUCBA, SECIHTI-SNII and PRO-DEP-SEP of Mexico for supporting research.

Declaration of use of Artificial Intelligence

ChatGPT (OpenAI) was used for language editing and stylistic revision of the manuscript. No artificial intelligence tools were used to generate data, results, or conclusions.

Literature cited

Bachman, S., J. Moat, A. W. Hill, J. de la Torre and B. Scott. 2011. Supporting Red List threat assessments with GeoCAT: geospatial conservation assessment tool. *ZooKeys* 150: 117-126. DOI: <https://doi.org/10.3897/zookeys.150.2109>

Barton, N. H. 2001. The role of hybridization in evolution. *Molecular Ecology* 10(3): 551-568. DOI: <https://doi.org/10.1046/j.1365-294x.2001.01216.x>

Barton, N. H. and G. M. Hewitt. 1985. Analysis of hybrid zones. *Annual Review of Ecology, Evolution, and Systematics* 16: 113-148.

de la Cerda-Lemus, M. E. 2007. El género *Agave* en el estado de Aguascalientes, México. In: Vázquez-García, J. A., M. J. Cházaro-Basáñez, G. Hernández-Vera, E. Flores-Berrios and Y. L. Vargas-Rodríguez (eds.). *Agaves del Occidente de México*. Universidad de Guadalajara. Guadalajara, Mexico. Pp. 83-91.

de la Cerda-Lemus, M. E., G. García Regalado and G. González Adame. 2004. Contribución al conocimiento de la flora del estado de Aguascalientes (Agavaceae). *Scientiae Naturae* 6(2): 5-7.

Eguiarte, L. E., O. A. Jiménez-Barrón, E. Aguirre-Planter, E. Scheinvar, N. Gámez, J. Gasca-Pineda, G. Castellanos-Morales, A. Moreno-Letelier and V. Souza. 2021. Evolutionary ecology of *Agave*: distribution patterns, phylogeny, and coevolution (an homage to Howard S. Gentry). *American Journal of Botany* 108(2): 216-235. DOI: <https://doi.org/10.1002/ajb2.1609>

García-Mendoza, A. J. 2007. Los agaves de México. *Ciencias* 87: 14-23.

GBIF. 2023a. GBIF Occurrence. <https://doi.org/10.15468/dl.8u56fm> (consulted November, 2025).

GBIF. 2023b. GBIF Occurrence. <https://doi.org/10.15468/dl.q3zg3d> (consulted November, 2025).

Gentry, H. S. 1967. Putative hybrids in *Agave*. *Journal of Heredity* 58(1): 32-36. DOI: <https://doi.org/10.1093/oxfordjournals.jhered.a107536>

Gentry, H. S. 1982. *Agaves of Continental North America*. University of Arizona Press. Tucson, USA. 670 pp.

González-Elizondo, M. S., M. González-Elizondo, I. L. López-Enríquez, L. Reséndiz-Rojas, J. A. Tena-Flores and F. I. Retana-Rentería. 2011. El complejo *Agave victoriae-reginae* (Agavaceae). *Acta Botanica Mexicana* 95: 65-94. DOI: <https://doi.org/10.21829/abm95.2011.268>

Gutiérrez-Gutiérrez, B. G., J. L. Luquin-Arce, J. Padilla-Lepe, G. Nieves Hernández, P. J. Y. Oropeza Gutiérrez and J. A. Vázquez-García. 2025. *Agave villalobosii* (sección Ditepalae, Agavaceae), una especie nueva de la meseta central mexicana de Aguascalientes y Zacatecas. *Boletín Nakari* 36(3): 73-82. DOI: <https://doi.org/10.48550/arXiv.2512.11101>



- Hodgson, W. C. 2001. Taxonomic Novelties in American *Agave* (Agavaceae). *Novon* 11(4): 410-416. DOI: <https://doi.org/10.2307/3393152>
- IUCN. 2022. Guidelines for Using the IUCN Red List Categories and Criteria Ver. 15.1. Standards and Petitions Committee. <https://www.iucnredlist.org/resources/redlistguidelines> (consulted December, 2025).
- Jiménez-Barrón, O. A., R. García-Sandoval, S. Magallón, A. García-Mendoza, J. Nieto-Sotelo, E. Aguirre-Planter and L. E. Eguiarte. 2020. Phylogeny, diversification rate, and divergence time of *Agave sensu lato* (Asparagaceae), a group of recent origin in the process of diversification. *Frontiers in Plant Science* 11: 536135. DOI: <https://doi.org/10.3389/fpls.2020.536135>
- Morrone, J. J., T. Escalante and G. Rodríguez-Tapia. 2017. Mexican biogeographic provinces: Map and shapefiles. *Zootaxa* 4277(2): 16. DOI: <https://doi.org/10.11646/zootaxa.4277.2.8>
- Pinkava, D. J. and M. A. Baker. 1985. Chromosome and hybridization studies of *Agave*. *Desert Plants* 7: 93-100.
- QGIS Development Team. 2018. QGIS Geographic Information System. Open-Source Geospatial Foundation Project. <https://www.qgis.org/> (consulted November, 2025).
- Reveal, J. L. and W. C. Hodgson. 2002. *Agave* Linnaeus. In: *Flora of North America* Editorial Committee (eds). *Flora of North America: North of Mexico*. Oxford University Press. New York, USA. Pp. 442-461.
- RHM. 2025. Red de Herbarios Mexicanos. <http://herbanwmex.net/portal/index.php> (consulted November, 2025).
- Rocha, M., S. V. Good-Ávila, F. Molina-Freaner, H. T. Arita, A. Castillo, A. García-Mendoza, A. Silva-Montellano, B. S. Gaut, V. Souza and L. E. Eguiarte. 2006. Pollination biology and adaptive radiation of Agavaceae, with special emphasis on the genus *Agave*. *Aliso* 22(1): 329-344. DOI: <https://doi.org/10.5642/aliso.20062201.27>
- Schumer, M., G. G. Rosenthal and P. Andolfatto. 2014. How common is homoploid hybrid speciation? *Evolution* 68(6): 1553-1560. DOI: <https://doi.org/10.1111/evo.12399>
- Soltis, P. S. and D. E. Soltis. 2009. The role of hybridization in plant speciation. *Annual Review Plant Biology* 60: 561-588. DOI: <https://doi.org/10.1146/annurev.arplant.043008.092039>
- Thiede, J. 2020. *Agave*. In: Egli, U. and R. Nyffeler (eds.). *Illustrated handbook of succulent plants: Monocotyledons*. Springer. Berlin, Germany. Pp. 21-311. DOI: https://doi.org/10.1007/978-3-662-56486-8_111
- UNAM. 2025. IBdata: Base de Datos de las Colecciones Biológicas del Instituto de Biología, UNAM. <http://ibdata.ib.unam.mx> (consulted November, 2025).
- Vázquez-García, J. A., M. J. Cházaro-Basáñez, G. Hernández-Vera, E. Flores-Berrios and Y. L. Vargas-Rodríguez. 2007. *Agaves del Occidente de México*. Universidad de Guadalajara. Guadalajara, Mexico. 221 pp.
- Vázquez-García, J. A., C. S. Rosales-Martínez, J. Padilla-Lepe, G. Hernández-Vera and L. J. García-Morales. 2024. New genera and new combinations in Agavaceae (Asparagales). *Phytoneuron* 2024-02: 1-14.
- Villarreal Quintanilla, J. A., A. Ramírez Gámez, E. Estrada Castillón, D. U. González Uribe and D. Jasso de Rodríguez. 2014. *Agave* × *madrensis*, a putative hybrid from the Sierra Madre Oriental, Mexico. *Journal of the Botanical Research Institute of Texas* 82(2): 441-447.

