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A new microendemic species of *Hunzikeria* (Petunieae, Solanaceae) from the gypsum outcrops of southern Jalisco, Mexico

JUAN PABLO ORTIZ-BRUNEL[1,2,3], PAULINA DÍAZ-MARTÍNEZ[1,4,*], EDUARDO RUIZ-SANCHEZ[1,2,5] & AARÓN RODRÍGUEZ[1,2,6]

[1] *Departamento de Botánica y Zoología, Centro Universitario de Ciencias Biológicas y Agropecuarias, Universidad de Guadalajara, Camino Ramón Padilla Sánchez 2100, 45200 Nextipac, Zapopan, Jalisco, Mexico.*
[2] *Laboratorio Nacional de Identificación y Caracterización Vegetal (LaniVeg), Instituto de Botánica, Universidad de Guadalajara Camino Ramón Padilla Sánchez 2100, 45200, Nextipac, Zapopan, Jalisco, Mexico.*
[3] *juanpbrunel@gmail.com; https://orcid.org/0000-0002-0695-8143*
[4] *paulina.diaz5611@alumnos.udg.mx; https://orcid.org/0000-0002-4727-2543*
[5] *eduardo.ruiz@academicos.udg.mx; https://orcid.org/0000-0002-7981-4490*
[6] *aaron.rodriguez@academicos.udg.mx; https://orcid.org/0000-0003-1805-7403*
**Author for correspondence*

Abstract

Hunzikeria is a petunioid genus of Solanaceae that includes three species. The genus presents a disjunct distribution between South and North America. *Hunzikeria coulteri* and *H. texana* occur in North America, while *H. steyermarkiana* is reported from Venezuela. During botanical explorations in western Mexico, we found a population of *Hunzikeria* that differed from the three known species. Believing that we had found an undescribed species, we collected samples and prepared herbarium vouchers. We compared our material with morphological descriptions and herbarium specimens of the other species in the genus. Our results indicate that we discovered a new species, named here as *Hunzikeria gypsophila*. This new species is a microendemic gypsophyte that inhabits two gypsum ravines in southern Jalisco, Mexico. *Hunzikeria gypsophila* differs from the other three species in being a subshrub of taller stature and having petiolate leaves, wider leaf blades, longer corolla tubes, and broader corolla limbs. The most morphologically similar species is *H. steyermarkiana*, which differs in having anthers of equal size, while all the North American species have didynamous anthers. *Hunzikeria* shows a clear affinity for sedimentary soils and *H. gypsophila* is the first species recorded on gypsum. The gypsum outcrops of western Mexico have a unique flora, which likely became isolated due to volcanic activity. With this new find, *Hunzikeria* comprises four species. We provide a key for their identification and a distribution map for Mexico.

Keywords: disjunct distribution, gypsophyte, tropical dry forest

Resumen

Hunzikeria es un género petunioide de Solanaceae que incluye tres especies. El género presenta una distribución disyunta entre Sur y Norteamérica. *Hunzikeria coulteri* y *H. texana* se encuentran en Norteamérica, mientras que *H. steyermarkiana* está reportada en Venezuela. Durante exploraciones botánicas en el occidente de México, encontramos una población de *Hunzikeria* cuyos individuos difieren de las tres especies conocidas. Creemos que esta población corresponde a una especie no descrita, por lo cual colectamos muestras y preparamos ejemplares de herbario. Comparamos nuestro material con descripciones morfológicas y especímenes de herbario de las otras especies del género. Nuestros resultados indicaron que se trata de una especie nueva, nombrada aquí como *Hunzikeria gypsophila*. Esta especie nueva es una gipsófita microendémica que habita dos cañadas de yeso en el sur de Jalisco, México. *Hunzikeria gypsophila* difiere de las otras especies por ser un subarbusto más alto y por presentar hojas pecioladas, hojas más anchas, tubos de la corola más largos y limbos de la corola más amplios. Morfológicamente, la especie más parecida es *H. steyermarkiana*, pero presenta anteras de igual tamaño, mientras que todas las especies de Norteamérica desarrollan anteras didínamas. *Hunzikeria* muestra una clara afinidad por los suelos sedimentarios y *H. gypsophila* es la primera especie reportada en yeso. Los afloramientos de yeso del occidente de México tienen una flora única, probablemente aislada por la actividad volcánica en el país. Con este hallazgo, *Hunzikeria* contiene cuatro especies. Proveemos una clave para su identificación y un mapa de distribución para México.

Palabras clave: bosque tropical caducifolio, distribución disyunta, gipsófita

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Introduction

The family Solanaceae is widely distributed around the world and is highly diverse in the tropical forests of South and Central America. In North America, Mexico is also an important center of diversification (Barboza *et al.* 2016). Solanaceae is a monophyletic family with approximately 98 genera and 2,800 species (Dupin *et al*. 2017). The phylogenetic relationships within Solanaceae are not fully resolved. However, phylogenetic hypotheses based on chloroplast and nuclear DNA sequences have revealed well-defined major clades (Olmstead *et al*. 2008, Särkinen *et al.* 2013). The clade Petunieae includes plants with actinomorphic flowers (rarely monosymmetric), usually didynamous stamens, and two- or four-valved capsules. The clade includes nine genera and approximately 160 species, all restricted to the Americas (Olmstead *et al*. 2008, Särkinen *et al*. 2013). Most genera of Petunieae occur in South America, and only *Bouchetia* de Candolle ex Dunal (1852: 589), *Calibrachoa* Cervantes in La Llave & Lexarza (1825: 3), *Hunzikeria* D'Arcy (1976: 283), and *Plowmania* Hunziker & Subils (1986: 127) reach Mexico and the southern United States in North America (Villaseñor 2016, Martínez *et al.* 2017).

Hunzikeria comprises herbaceous, perennial, or sometimes woody based plants. The leaves are alternate, sessile or slightly petiolate, simple, entire, usually lanceolate or oblanceolate, and pubescent. The flowers are mainly solitary, with an obconical calyx with five lobes, and a salverform corolla with five equal lobes. The capsules are bilocular and contain approximately five ellipsoid or reniform seeds about 1.5 mm long. The salverform corolla, obconical calyx, and the shape and size of the seeds distinguish *Hunzikeria* from other genera of Petunieae (D'Arcy 1978, Martínez *et al.* 2020).

The three species of *Hunzikeria* have a disjunct distribution. *Hunzikeria texana* (Torrey 1859: 156) D'Arcy (1976: 283) has the widest range and occurs from southern Texas to northeastern Mexico. The distribution of *H. coulteri* (Gray, 1877: 165) D'Arcy (1978: 705) is limited to a small semiarid region of Mexico in the states of Hidalgo and Querétaro (D'Arcy 1978). Meanwhile, *H. steyermarkiana* D'Arcy (1978: 706) is only known from two records in northern Venezuela, but it is presumed extinct (Huérfano *et al.* 2020). Although *H. coulteri* and *H. texana* are morphologically similar, *H. coulteri* is smaller than *H. texana* with regard to the length of the leaf blades, petioles, peduncles, and calyces. In contrast, *H. steyermarkiana* has a smaller corolla, shorter corolla tube and anthers that are all equal in size, while in *H. coulteri* and *H. texana* the upper pair of anthers are reduced (D'Arcy 1978, Torrey 1859, Martínez *et al.* 2020).

On a field trip to Tolimán, Jalisco, during a botanical exploration for the project "Gypsicolous flora of western Mexico", we found a *Hunzikeria* population that consisted of subshrub plants with notedly larger petioles, leaf blades, peduncles, and corolla limbs than those of the three known species of the genus. After a morphological analysis based on the original descriptions of the species and herbarium vouchers, we found that the plants from Tolimán belonged to an undescribed species. This population is markedly disjunct from the other species, and the plants grow only on gypsum soils. Based on the morphology and distribution, we are describing the recently found *Hunzikeria* as a new taxon. Also, we provide a key for the identification of the species of the genus and a distribution map of the species in Mexico.

Material and methods

We collected vegetative and reproductive material from the only known locality. Observations and measurements were made once a month during the rainy season. The measurements of the plant's main characters were made using a centimeter rule. Small characters were measured using a millimeter scale and a Carl Zeiss Stemi DV4 dissecting microscope (Car Zeiss AG, Oberkochn, Germany). For the description, we used the morphological terminology of D'Arcy (1978) and Hunziker (2001). We reviewed the available literature of the genus to make a morphological comparison among all the species (Torrey 1859, D'Arcy 1978, Hunziker 2001, Martínez *et al.* 2020).

The distribution map of *Hunzikeria* in Mexico was mainly based on herbarium vouchers from the herbaria IBUG and MEXU (Thiers 2022). Digital collections are also very useful (Davis 2023). Therefore, we consulted the digitized herbarium vouchers from the electronic database of SEINet (https://swbiodiversity.org/seinet/) and added complementary records from the Naturalista platform (https://www.naturalista.mx). The map was generated in QGIS version 2.14.3 (QGIS Development Team, 2018).

For the conservation assessment analysis, we calculated the area of occupancy (AOO) using the GeoCAT tool (Bachman *et al.* 2011). We based our assessment on the IUCN Red List Categories and Criteria (IUCN 2022) using criteria B and D.

Results

Key to the species of *Hunzikeria*

1. Subshrubs, 40–60 cm tall; petioles 12–23 mm long, blades 16–27 mm wide; corolla limb 38–52 mm wide ..... *H. gypsophila sp. nov.*
- Herbs, woody at the base, 15–20 cm tall; petioles 5–12 mm long, blades 1.5–13 mm wide; corolla limb 16–20 mm wide 2
2. Leaves up to 40 mm long, blades puberulent adaxially, glabrate abaxially; corolla tube 10 mm long; restricted to Venezuela ..... *H. steyermarkiana*
- Leaves up to 20 mm long, blades pilose or glabrate adaxially, puberulent to strigose abaxially; corolla tube 15–25 mm long; distributed from Mexico to southern United States 3
3. Peduncles 3 mm long; calyx 4–7 mm long, puberulent; plants from Hidalgo and Querétaro ..... *H. coulteri*
- Peduncles 7 mm long; calyx 10 mm long, pilose; plants from northeastern Mexico and southern United States ..... *H. texana*

Taxonomy

Hunzikeria gypsophila Ortiz-Brunel & Díaz-Martínez, *sp. nov*. (Figs. 1 A–F, 2 C–F, 3)

TYPE:—MEXICO. Jalisco: Tolimán, Proyecto Yesos del Occidente, Sitio de muestreo 2, Predio La Sierrilla, 19°35'20" N, 103°53'35" W, 870 m, 21 August 2022 (fl, fr), *J. P. Ortiz-Brunel & P. Díaz 1677* (holotype: IBUG!, isotypes: MEXU!, ZEA!).

Hunzikeria gypsophila is a subshrub taller than *H. coulteri*, *H. steyermarkiana*, and *H. texana* (40–60 vs. 15–20 cm), has longer petioles (12–23 vs. 5–12 mm) and wider leaf blades (16–27 vs. 1.5–13 mm), develops longer corolla tubes (35–48 vs. 10–25 mm), and has broader corolla limb diameter (38–52 vs. 15–23 mm).

Subshrubs, 40–60 cm tall, branching from the base; roots fibrous; new stems herbaceous, erect or ascendent, pilose, covered with hyaline glandular trichomes; leaves alternate, petioles 12–23 mm long, blades (20–)27–42 × 16–27 mm, ovate, acute, decurrent, strigulose, reticulate nerved, nerves strigose, margin entire, ciliate with glandular trichomes; flowers solitary, extra-axillary, erect, peduncle 7–17 mm long, glandular tomentose; calyx (7–)9–12 × (6–)8–13 mm, obconical, densely tomentose, calyx lobes 5, 3–8 mm long, lanceolate, tomentose with glandular trichomes at the margin; corolla light reddish purple, purple when dry, salverform, glandular-pubescent in the external face, corolla tube (35–)39–48 × 1–2 mm, corolla limb diameter 38–52 mm, 5-lobed, all the lobes equal, rounded-obtuse, the mouth strongly constricted around the stamens and the stigma; stamens 4, didynamous, filaments inserted in the tube, two of them reduced, 1.2–1.4 × <0.2 mm, the other two noticeably thickened, 1.5–1.7 × 0.6–0.8 mm, one pair of anthers conspicuously reduced, inserted higher in the tube than the bigger pair, 0.4–0.5 × 0.4–0.6 mm, theca 0.2–0.3 mm wide, the bigger anthers 1.5–2 × 1.4–1.6 mm, theca 0.5–0.6 mm wide, recurved; stigma flattened, winged, cuneate, 3.7–4 × 1.9–2.2 mm, style flattened, 33–40 mm long, ovary globose, up to 2 mm in diameter; capsule included in the calyx, globose, 10 × 6 mm; seeds 2–8, 2 mm in diameter, reniform, pitted, light brown.

Habitat and distribution:—*Hunzikeria gypsophila* is only known from two ravines separated by 300 linear meters in the same locality. It inhabits partially shaded places within the tropical dry forest between 800 and 900 m of elevation. It grows next to *Bursera fagaroides* (Kunth 1825: 27) Engler (1880: 44), *Havardia acatlensis* (Bentham 1875: 593) Britton & Rose (1928: 42), *Hechtia* sp., and *Pseudosmodingium perniciosum* (Kunth 1825: 10) Engler (1880: 420). It grows on gypsum soil with organic material that accumulates when the trees lose their leaves.

Comparison:—*Hunzikeria gypsophila* presents the typical morphology of the genus but differs from the other species by having noticeable larger structures (Table 1) and by being a subshrub. The plants are at least 20 cm taller than those of any other species. Also, they develop longer petioles, wider leaf blades, longer peduncles, longer corolla tubes, and broader limbs. In *H. gypsophila* the stigma is flattened and cuneate, while in the other species it is bilobate or cordate. In terms of size, this species is morphologically most similar to *Hunzikeria steyermarkiana* of Venezuela. However, North American species (*H. coulteri*, *H. gypsophila*, and *H. texana*) develop didynamous anthers, while the South American *H. steyermarkiana* has anthers of equal size. Based on these observations, we could speculate that the North American species are more closely related to each other than to *H. steyermarkiana*.

Etymology:—The specific epithet refers to the preference of the plants for growing only on gypsum soil.

Phenology:—The plants develop new stems and leaves once the rainy season starts (middle June) and flower from early July to late October. The fruits ripen from September to December. The leaves start to shed once the rainy season ends in late October and some remain until December.

TABLE 1. Morphological comparison between *Hunzikeria* species.

Character	*H. gypsophila*	*H. texana*	*H. coulteri*	*H. steyermarkiana*
Plant height (cm)	40–60	20	15	20
Petiole length (mm)	12–23	2–5	0–4	5–12
Blade length (mm)	(20–)27–42	10–20	5–12	40
Blade width (mm)	16–27	5–8	1.5–6	13
Peduncle length (mm)	7–17	7	3	(3–)5–7
Calyx length (mm)	(7–)9–12	10	4–7	5
Corolla tube length (mm)	(35–)39–48	15–25	15–20	10
Corolla limb diameter (mm)	38–52	20–23	16–20	15
Anther size	Unequal	Unequal	Unequal	Equal
Stigma shape	Cuneate	Bilobate	Bilobate	Cordate or rectangular

Conservation assessment:—*Hunzikeria gypsophila* is known from two small ravines in the type locality. The GeoCAT tool estimated an AOO of 4 km^2. In our explorations, we have counted only 17 plants. Access to the location is difficult, and it is possible that more individuals occur in the zone, but more exploration is needed. In addition, the plants are restricted to gypsum soil patches, which are surrounded by more extensive calcareous or even volcanic deposits (Ortiz-Brunel *et al*. 2023). According to the IUCN (2022) criteria B and D, it should be considered as Critically Endangered (CR).

Additional specimens examined (paratypes):—MEXICO. Jalisco, Tolimán, Proyecto Yesos del occidente, Sitio de muestreo 2, Predio La Sierrilla, 19°35’20” N, 103°53’35” W, 870 m, 28 July 2022 (fl), *J. P. Ortiz-Brunel & E. Ruiz-Sánchez 1618* (IBUG); Proyecto Yesos del occidente, Predio La Sierrilla, 19°35’20” N, 103°53’45” W, 803 m, 21 August 2022 (fl), *J. P. Ortiz-Brunel & P. Díaz 1679* (IBUG); Proyecto Yesos del occidente, Sitio de muestreo 2, Predio La Sierrilla, 19°35’20” N, 103°53’35” W, 870 m, 18 September 2022 (fl, fr), *J. P. Ortiz-Brunel & P. Díaz 1722* (IBUG); Predio La Sierrilla, 19°35’20” N, 103°53’35” W, 870 m, 21 August 2022 (fl), *P. Díaz & J. P. Ortiz-Brunel 18* (IBUG); Predio La Sierrilla, 19°35’20” N, 103°53’35” W, 870 m, 22 October 2022 (fr), *P. Díaz & J. P. Ortiz-Brunel 153* (IBUG).

Discussion

Solanaceae originated in South America and then dispersed worldwide. The evidence supports that it reached North America via long distance dispersal (Raven & Axelrod 1974, Olmstead 2013, Dupin *et al.* 2017). Disjunct distributions between the two subcontinents are common, especially in the clades Lycieae and Petunieae (Olmstead 2013, Barboza *et al*. 2016, Martínez *et al*. 2017). This is particularly interesting in *Hunzikeria*, from which only one species has been recorded in South America and three in North America. The clade Petunieae originated in South America and then dispersed to Central and North America, where it later diversified (Olmstead *et al.* 2008). According to Dupin *et al*. (2017), the ancestral ranges of *Hunzikeria* and *Plowmania* are located in Central-North America. The size of the anthers could be an informative character to infer the biogeographic history of the genus. *Hunzikeria steyermarkiana* has anthers of just one size, while the North American species (*H. coulteri*, *H. gypsophila*, and *H. texana*) produce didynamous anthers. This could indicate that *Hunzikeria* originated and diversified in North America and then dispersed to South America, but a complete phylogenetic hypothesis is needed to understand the evolutionary processes of the group.

The disjunction between the South and North American species is remarkable. There are approximately 3,500 linear km of separation between the locality of *Hunzikeria steyermarkiana* and that of *H. coulteri*, which is the closest species. At the same time, *H. coulteri* is separated from the closest populations of *H. texana* by 150 linear km and from *H. gypsophila* by 450 linear km (Fig. 3). Finally, *Hunzikeria gypsophila* is isolated from the closest population of *H. texana* by 500 linear km. It is possible that these disjunctions in Mexico are related to the distribution of sedimentary soils.

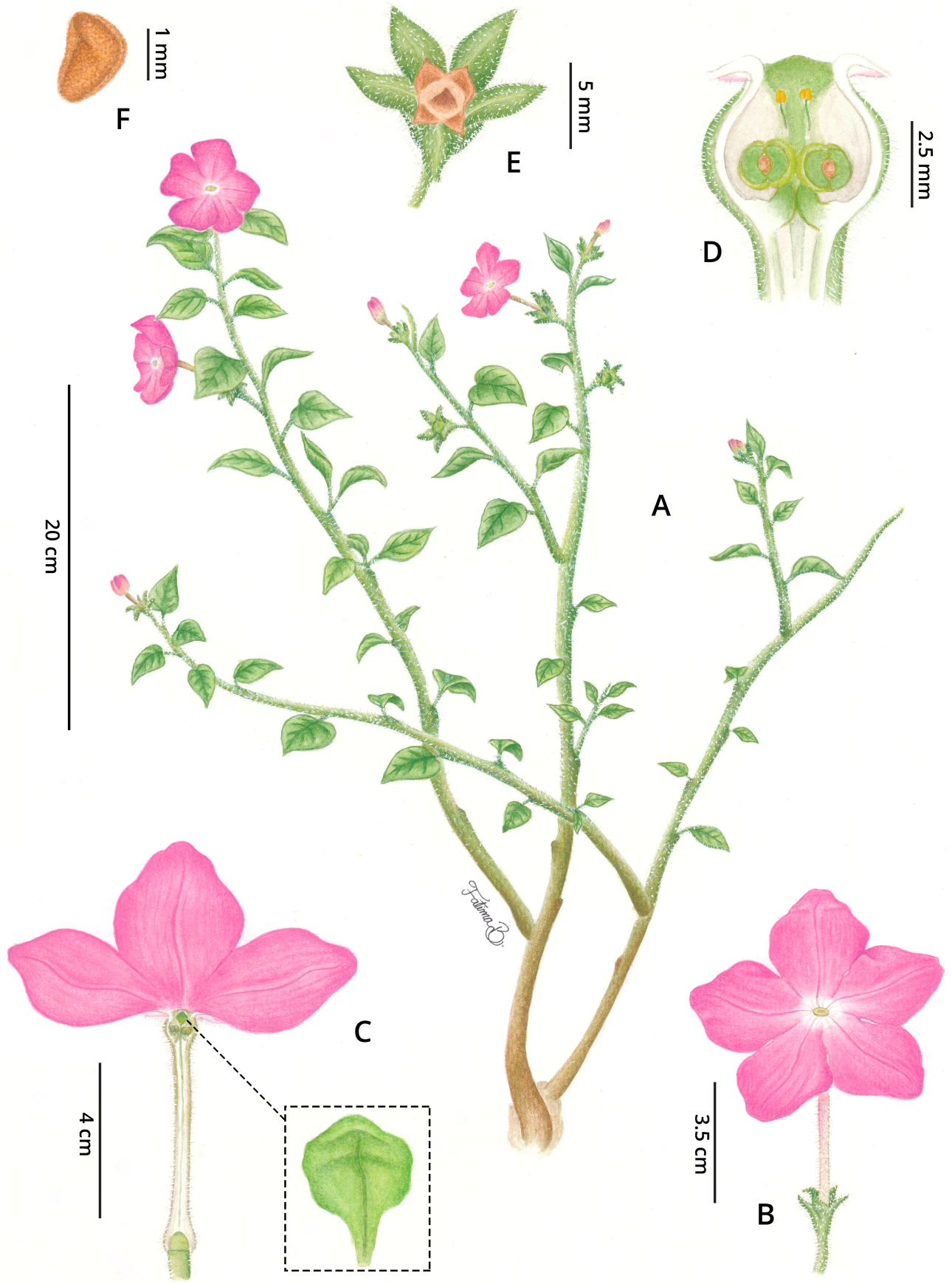

FIGURE 1. *Hunzikeria gypsophila*. A. Adult plant. B. Flower. C. Flower and stigma detail. D. Anthers and stigma. E. Capsule. F. Seed. Illustration by Fátima Bracamontes based on the type material (*J. P. Ortiz-Brunel & P. Díaz 1677*).

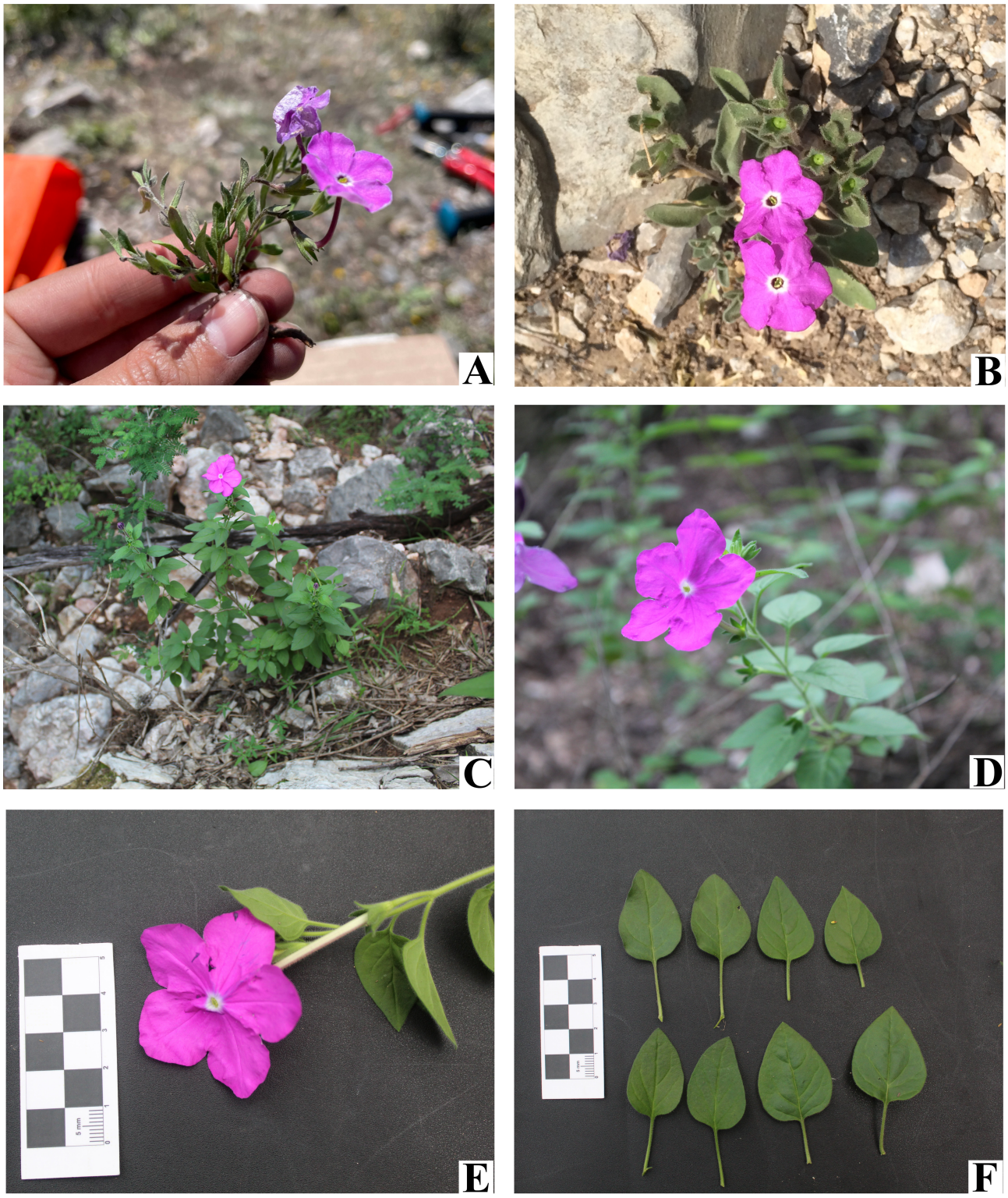

FIGURE 2. Mexican *Hunzikeria* species. A. *Hunzikeria coulteri*. B. *Hunzikeria texana*. C–F. *Hunzikeria gypsophila*. Photographs by Alejandra Martínez-Blancas (A), Miguel González-Botello (B), and Juan Pablo Ortiz-Brunel (C–F).

Hunzikeria shows a clear affinity to sedimentary soils. *Hunzikeria texana* has the widest geographical distribution, growing from the southern United States to northeastern Mexico across the Chihuahuan Desert. This species grows mainly on alluvial deposits or limestone slopes in the xerophilous scrubland between 300 and 1,800 m of elevation (D'Arcy 1978). The other three species have narrow geographical distributions. *Hunzikeria coulteri* is only known from a few localities in Mexico in the states of Hidalgo and Querétaro. This species grows on calcareous hills covered by xerophilous scrubland between 1,250 and 2,200 m of elevation (Martínez *et al*. 2020). *Hunzikeria steyermarkiana* is a microendemic species from Venezuela which was recorded in the subdesert area near to the Caribbean Coast in

Venezuela from 0 to 100 m of elevation (D'Arcy 1978). *Hunzikeria gypsophila* is the only species of the genus that grows on gypsum soil and is currently thought to be endemic to the state of Jalisco, Mexico. This species grows in a very reduced area within the tropical dry forest from 800 to 900 m in elevation (Ortiz-Brunel *et al*. 2023). The gypsum outcrops in the area correspond to a terrain of marine sedimentary rocks added to North America during the late Mesozoic (Campa & Coney 1982). While revising the collections to create the distribution map (Fig. 3), we confirmed that there is no record of *Hunzikeria* growing on volcanic soils.

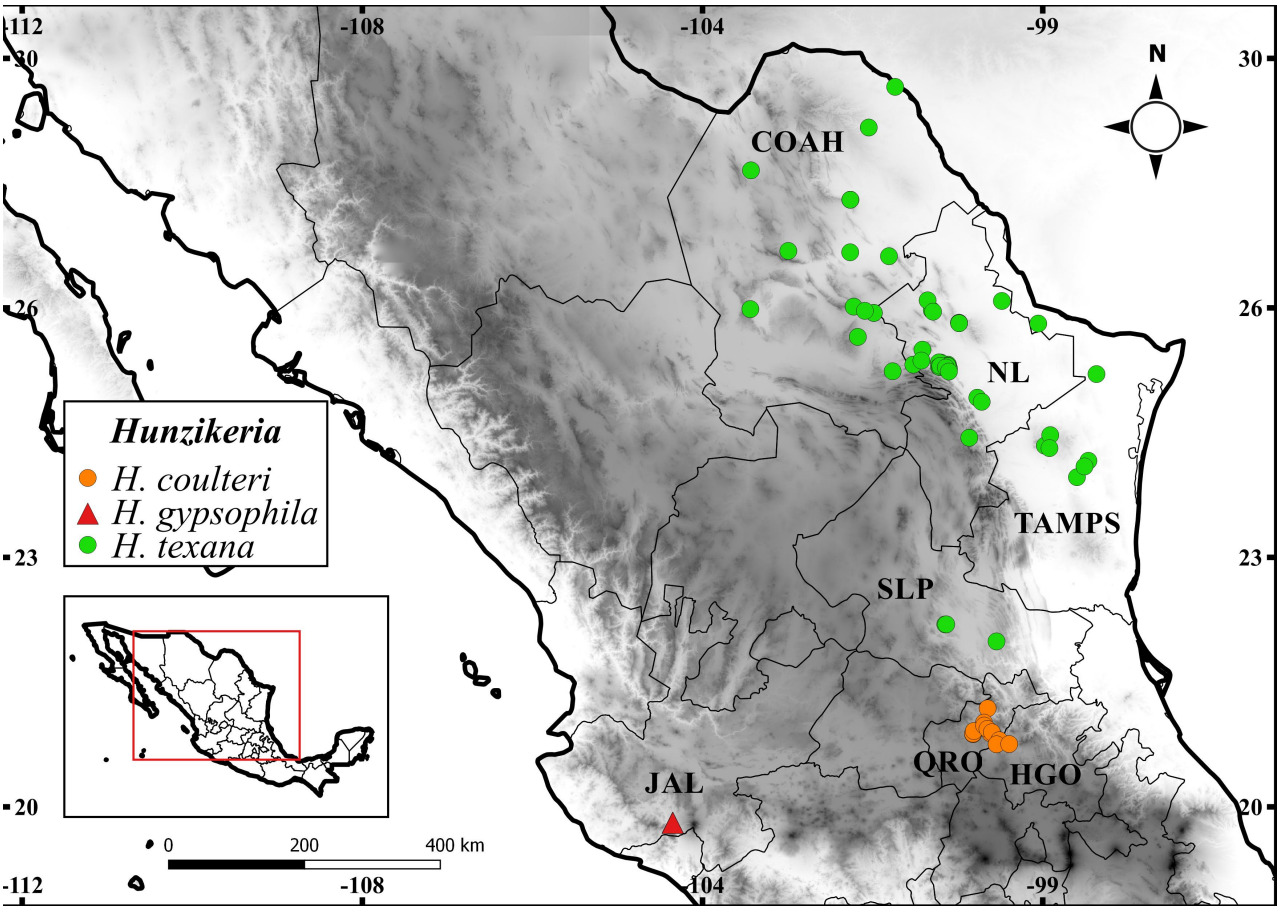

FIGURE 3. Geographic distribution of *Hunzikeria* in Mexico. State abbreviations: COAH = Coahuila, HGO = Hidalgo, JAL = Jalisco, NL = Nuevo León, QRO = Querétaro, SLP = San Luis Potosí, TAMPS = Tamaulipas.

Except for *Hunzikeria texana*, all the species of the genus occur in very restricted habitats, which makes them vulnerable to human disturbance. *Hunzikeria steyermarkiana* is presumed extinct, because it has not been observed since it was first described, and the area where the type material was collected has been widely disturbed (Huérfano *et al*. 2020). The conservation assessment of *H. gypsophila* suggests a preliminary category of Critically Endangered (CR). We believe this species may have had a broader distribution in the gypsum patches from Mesozoic origin in western Mexico. However, the volcanic material resulting from the formation of the Trans-Mexican Volcanic Belt filled the Armería-Tuxcacuesco River Basin, isolating some outcrops and burying others (Mastretta-Yanes *et al*. 2015). This probably isolated the species, and only two small ravines in the gypsum outcrops of Tolimán remain with the necessary conditions for the species to grow. After one year of explorations in the region, we have not found any other populations of *Hunzikeria*, on or off gypsum outcrops. Also, there is no record of *Hunzikeria* in other gypsum outcrops in western Mexico (Harker *et al.* 2021, Ortiz-Brunel *et al*. 2023). Other microendemic gypsophytes are known from the gypsum outcrops of western Mexico. *Pinguicula colimensis* McVaugh & Mickel (1963: 138) and *Graptopetalum glassii* Acevedo-Rosas & Cházaro (2003: 378) exemplify this.

Studies focused on pollinators, fruit dispersal and seed germination are needed to understand how this gypsophyte continues to survive in this small area of Jalisco; a population genetic study to assess its genetic makeup would also be beneficial. Future work will help to elucidate the biogeographic history of *Hunzikeria*. As stated by Ortiz-Brunel *et al.* (2023), the exploration of the gypsum outcrops of western Mexico will led into the discovery of microendemic species. We hope this discovery will promote the conservation of the gypsum outcrops of western Mexico, which are home to a very unique flora.

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