

***Quetzalcoatlia* (Crassulaceae), high small-scale diversification in western Mexico: a synopsis with four new species**

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Abstract

The genus *Quetzalcoatlia* was recently segregated from the paraphyletic genus *Graptopetalum* and consists of six species, confined to western Mexico, in the states of Jalisco, Michoacán and Colima (Vázquez-García *et al.* 2023). The alpha-taxonomy of *Quetzalcoatlia* (Crassulaceae, Saxifragales) has been summarized below, which includes the addition of four new species: *Q. grulloensis* and *Q. santanamichelii* from the state of Jalisco, and *Q. itzicuaruensis* and *Q. latipetala* from the state of Michoacán. One species is endemic to the state of Colima (*Q. glassii*); five species are endemic to the state of Jalisco (*Q. grulloensis*, *Q. rosanevadoensis*, *Q. superba*, *Q. santanamichelii*, and *Q. trujilloi*); three are endemic to the state of Michoacán (*Q. itzicuaruensis*, *Q. kristenii*, and *Q. latipetala*), and one is from unknown origin (*Q. pentandra*), only confirmed from cultivated material at the Huntington Botanical Garden. *Quetzalcoatlia*, through a pattern of allopatric speciation, exhibits a high small-scale diversification in western Mexico, with all ten species confined within a radius of ca. 100 km. The *Quetzalcoatlia* species have potential for horticulture in subtropical and tropical areas. The study provides a distribution map, habitat and phenology data, and a key to species of *Quetzalcoatlia*. Additionally, the conservation status of each species was evaluated. The results have implications for understanding *Quetzalcoatlia* biogeography and its adaptive radiation in western Mexico.

Key words: allopatric radiation, endemic, *Graptopetalum*, haplostemonous, Jalisco, Michoacán, western Mexico

Resumen

El género *Quetzalcoatlia* fue recientemente segregado del género parafilético *Graptopetalum* y consta de seis especies confinadas al oeste de México, en los estados de Jalisco, Michoacán y Colima. Se ha resumido la taxonomía alfa de *Quetzalcoatlia* (Crassulaceae, Saxifragales), incluyendo cuatro especies nuevas: *Q. grulloensis* y *Q. santanamichelii* del estado de Jalisco, y *Q. itzicuaroensis* y *Q. latipetala* del estado de Michoacán. Una especie es endémica del estado de Colima (*Q. glassii*); cinco especies son endémicas del estado de Jalisco (*Q. grulloensis*, *Q. rosanevadoensis*, *Q. superba*, *Q. santanamichelii* y *Q. trujilloi*); tres son endémicas del estado de Michoacán (*Q. itzicuaroensis*, *Q. kristenii* y *Q. latipetala*), y una resultó de origen desconocido (*Q. pentandra*), solo confirmada a partir de material cultivado en el Jardín Botánico de Huntington. *Quetzalcoatlia*, a través de su patrón de especiación alopátrica, exhibe una alta diversificación a pequeña escala en el oeste de México, con todas las especies (diez) confinadas dentro de un radio de ca. 100 km. Las especies de *Quetzalcoatlia* tienen potencial para la horticultura en áreas tropicales y subtropicales. El estudio proporciona un mapa de distribución, datos de hábitat y fenología, y una clave para las especies de *Quetzalcoatlia*. Además, se evaluó el estado de conservación de cada especie. Los resultados tienen implicaciones para comprender la biogeografía de *Quetzalcoatlia* y su radiación adaptativa en el occidente de México.

Palabras clave: endémica, *Graptopetalum*, haplostémono, Jalisco, Michoacán, occidente de México, radiación alopátrica

Introduction

Quetzalcoatlia A. Vázquez, Rosales & Padilla-Lepe in Vázquez-García *et al.* (2023: 38), formerly treated as *Graptopetalum* subg. *Glassia* Byalt (2012: 79), was recently segregated from *Graptopetalum* Rose (1911: 296) (Vázquez-García *et al.* 2023), a genus of the Crassulaceae family, the later known from semiarid environments in Arizona, southern USA to Oaxaca, Mexico (Britton & Rose 1905; Walther 1931, Meyrán-García & López-Chávez 2003; Thiede & Eggli 2007). *Quetzalcoatlia* currently includes six species occurring in western Mexico (Acevedo-Rosas *et al.* 2018, Vázquez-García *et al.* 2021, 2022, 2023; Etter *et al.* 2022): *Q. glassii* (Acevedo-Rosas & Cházaro-Basáñez 2003: 378) A. Vázquez, Rosales & Padilla-Lepe in Vázquez-García *et al.* (2023: 39); from the municipalities of Colima, Ixtlahuacán and Tecoman in the state of Colima (Cházaro-Basáñez & Acevedo-Rosas 2008, iNaturalistMx 2024); *Q. kristenii* (Etter, A. Vázquez & Rosales 2022: 140) A. Vázquez & Rosales in Vázquez-García *et al.* (2023: 39) from Pinzan, Sierra de Coalcomán, Michoacán; *Q. pentandra* (Moran 1971: 56) Vázquez & Rosales in Vázquez-García *et al.* (2023: 39) from an unknown location in the wild, and obtained from a nursery in Guadalajara, Jalisco; *Q. rosanevadoensis* (A. Vázquez & Acev.-Rosas 2021: 162) Vázquez & Rosales in Vázquez-García *et al.* (2023: 39) from the Nevado de Colima in Jalisco (Vázquez-García *et al.* 2021); *Q. superba* (Acev.-Rosas 2003: 380) Vázquez & Rosales in Vázquez-García *et al.* (2023: 39) from Los Corrales ravine, Juchitlán, Jalisco (Cházaro-Basáñez & Flores 1992), and *Q. trujilloi* (A. Vázquez & Rosales 2022: 282) A. Vázquez & Rosales in Vázquez-García *et al.* (2023: 39) from the Tapalpa microwatershed in the San Gabriel municipality in Jalisco.

All these species are endemic to western Mexico, a region known as Nueva Galicia (McVaugh 1961). Three of them belong to a well-supported subclade characterized by sharing the synapomorphy of haplostemonous (pentandrous) flowers (Acevedo-Rosas *et al.* 2004a, 2004b, Byalt 2012), the other three species and the four new additions, here proposed, are yet to be evaluated molecularly.

Based on a comprehensive revision of the haplostemonous taxa of *Graptopetalum*, and field work to assess their geographic distribution, in situ variability, and habitat characteristics, we propose that the four distant populations represent new species, two of them, formerly treated as *Graptopetalum pentandrum* (Kimmach 1987, Cházaro-Basáñez *et al.* 2004). Two of the proposed new species occur in Jalisco: one from El Grullo, Jalisco, the other from Casimiro Castillo, Jalisco, while the other two new additions occur in Michoacán: one from El Salto waterfall, municipality of Aguililla (Kimmach 1987) and another from Los Chorros del Varal, municipality of Los Reyes (Cházaro-Basáñez *et al.* 2004).

The aims of this study are to 1) summarize the alpha taxonomy, distribution, habitat, phenology, and conservation status of *Quetzalcoatlia* in western Mexico, and 2) determine the taxonomic position of four poorly understood and distant populations.

Material and methods

To document the morphological variation of the species within the recently recognized genus, specimens collected and available in the main pertinent herbaria (BH, IBUG, CIMI, HNT, IEB, XAL, MEXU, MICH, WIS, MO, NY, SD, US, ZEA) were examined and measurements were made. The information was complemented with measurements of the morphological characters observed during field studies and with available photographs.

Plants from four populations [1) Chorros del Varal, Los Reyes, Michoacán, 2) El Salto waterfall, Aguililla, Michoacán, 3) La Calera, Casimiro Castillo, Jalisco, and 4) El Tigre, El Grullo, Jalisco] were contrasted with morphological data against all the known haplostemonous species (Table 1). The comparison of morphological characters was made taking as reference protologues and descriptions, as well as living specimens and images of the morphologically closest species.

The distribution map of the haplostemonous species of *Quetzalcoatlina* was generated using the SimpleMapper website (Shorthouse 2010) from georeferenced records on iNaturalistMX (2024), herbaria data and literature, and posteriorly edited in Adobe Photoshop (2004).

The conservation status was evaluated following the guidelines and criteria of the IUCN Red List (IUCN 2022). The Area of Occupancy (AOO) and Extent of Occurrence (EOO) were calculated using the standard 2×2 km grid area from the GeoCAT software tool from the Royal Botanic Gardens, Kew (Bachman *et al.* 2011).

Results

Taxonomic treatment

Quetzalcoatlina A. Vázquez, Rosales & Padilla-Lepe, *Boletín Nakari* 34(2): 37–43 (2023).

= *Graptopetalum* subg. *Glassia* V.V. Byalt, *Novosti Sistematiki Vysshikh Rastenii* 43: 79 (2012).

Type:—*Quetzalcoatlina pentandra* (Moran) A. Vázquez & Rosales, *Boletín Nakari* 34(2): 39 (2023).

≡ *Graptopetalum pentandrum* Moran, *Cactus and Succulent Journal (Los Angeles)* 43: 255, figs. 1–4 (1971).

Mostly branching plants, mainly long and soft stems with medium-sized terminal rosettes, delicately pruinose leaves, usually with pink or violet hues; haplostemonous flowers usually with five stamens, rarely four or six to eight, the staminal filaments and sepals more or less yellowish, but reddish at the apex. There are six species in the Nueva Galicia area in western Mexico.

Quetzalcoatlina differs morphologically from species of *Graptopetalum* in having flowers haplostemonous (mostly 5-staminate, rarely 4- or 6 to 8-staminate) vs. diplostemonous (usually 10 staminate); usually stems elongated (often pendulous serpentine); and usually with leaves of pink or violet tones. The three species of *Quetzalcoatlina* [treated as *Graptopetalum*] included in molecular phylogenetic analyses (Acevedo-Rosas *et al.* 2004a; de la Cruz-López *et al.* 2019) represent a highly supported clade and are weakly related to other clades involving species of *Graptopetalum*.

Key to the species of *Quetzalcoatlina*

1. Caespitose rosettes closely attached to the cliffs, if sinuously-pendant still close to the cliff2
- None caespitose rosettes, nor close to the cliffs, sinuously-pendant ramose or erect to decumbent5
2. Inflorescence length 6.0–12.0 cm, endemic to Colima *Q. glassii*
- Inflorescence length 12.9–28.0 cm, endemic to Michoacán3
3. Rosettes (2.8–)3.5–5.0 cm in diameter, from Coalcomán, Michoacán *Q. kristenii*
- Rosettes 5.8–8.4 cm in diameter4
4. Serpentine-pendant habit, flowers 14.0–16.2 mm in diameter, from Chorros del Varal, Michoacán *Q. itzicuaroensis*
- Erect, possibly decumbent, flowers 20.0–21.0 mm in diameter, from Aguililla, Michoacán *Q. latipetala*
5. Stems 0.9–1.4 cm in diameter, tuberculate6
- Stems ≤ 0.9 cm in diameter, smooth7
6. Basal leaves navicular, leaf apex acute without an apical mucro, inflorescence 8.0–29.0 cm, branches per full-size inflorescence 7–9, corolla tube 3.7–3.8 mm, petals yellowish with purple spots on the apex, from El Grullo, Sierra de Amula, Jalisco *Q. grulloensis*
- Basal leaves flat, leaf apex obtuse with an apical mucro, inflorescence 30.0–40.0 cm, branches per full-size inflorescence 12–15, corolla tube 2.9–3.1 mm, petals proximally creamy-white to distally red wine and inconspicuously striped, from Juchitlán,

	Jalisco	<i>Q. superba</i>
7.	Flower diameter 14.9–18.0 mm.....	8.
-	Flower diameter 8.5–13.1 mm.....	9.
8.	Plants 40.0–96.0 cm tall, flower diameter 14.9–15.1 mm, petal width 2.9–3.0 mm, from the slopes of Nevado de Colima.....	<i>Q. rosanevadoensis</i>
-	Plants 19.0–24.0 cm tall, flower diameter 17.9–18.0 mm, petal width 1.7–1.75 mm, only known from cultivation.....	<i>Q. pentandra</i>
9.	Number of flowers per full-size inflorescence (10–)15–27, flower diameter 8.5–11.0 mm, corolla lobes 3.9–4.0 mm long, petals whitish-pale yellow with red spots, diffuse horizontal stripes toward the apex, orange-yellow near the base, from the westernmost Sierra de Manantlán, Jalisco.....	<i>Q. santanamichelii</i>
-	Number of flowers per full-size inflorescence 30–50, flower diameter 12.9–13.1 mm, corolla lobes 4.9–5.2 mm long, petals proximally greenish to distally red & striped, from Sierra de Tapalpa, Jalisco	<i>Q. trujilloi</i>

Quetzalcoatlia is confined to western Mexico within a radius of *ca.* 100 km (Fig. 1). A comparative analysis of *Quetzalcoatlia* species including two populations from Jalisco [1) El Tigre, El Grullo and 2) La Calera, Casimiro Castillo], and two populations from Michoacán [3) Los Reyes (Chorros del Varal), and 4) El Salto waterfall, Aguililla], against their morphologically closest species, allowed us to unveil that four of them belong to new species of the genus *Quetzalcoatlia*.

1) *Quetzalcoatlia* sp., from El Grullo municipality, Jalisco, is similar to *Q. superba* in having a ramose decumbent or pendulous habit, rosette size, tuberculate stems, leaf size, and oblanceolate leaves, but it differs from the latter in having basal navicular leaves; leaf apex acute; shorter inflorescence; less numerous branches per full-size inflorescence; shorter corolla tube; and petals yellowish with purple spots on the apex.

2) *Quetzalcoatlia* sp., from Casimiro Castillo municipality, Jalisco, is similar to *Q. superba* in having a ramose pendulous habit, plant size, and oblanceolate leaves, but it differs from the latter in having shorter and narrower leaves; leaves pinkish–grayish green; less numerous branches per full-size inflorescence; less numerous flowers per branch; less numerous flowers per basal branch; less numerous flowers per full-size inflorescence; smaller flower diameter; shorter corolla lobes; abaxial carpels yellowish, only reddish toward the apex.

3) *Quetzalcoatlia* sp., from Los Reyes municipality, Michoacán, shares its obovate leaves with its morphological closest species, *Q. pentandra*, but it differs from the latter in having a pendant and caespitose habit; much longer stems; shorter full-size leaves; adaxial surface usually concave; leaf apex mostly acute; shorter pedicels; less numerous flowers on full-size inflorescence; smaller corolla; smaller and wider petal segments; longer and wider corolla tube and shorter carpel length.

4) *Quetzalcoatlia* sp., from Aguililla municipality, Michoacán, also shares with its morphologically closest species, *Q. pentandra*, its obovate leaves, but it differs from it by having stouter stems, inflorescence, branches, and pedicels; leaves mostly concave and upward; leaf apex acute or at right angle; basal bracts shorter, narrower, ovoid and acute at the apex; petals wider, distally less reddened, banded and spotted at the lower half (Table 1).

Quetzalcoatlia glassii (Acev.-Rosas & Cházaro) A. Vázquez & Rosales, *Boletín Nakari* 34(2): 39 (2023) (Figs. 1–4).

≡ *Graptopetalum glassii* Acev.-Rosas & Cházaro, *Novon* 13(4): 378, Fig. 1 (2003).

Type:—MEXICO. Colima: municipality of Ixtlahuacán, carretera libre de Ixtlahuacán a Colima, justo enfrente del señalamiento del km 21 de la autopista Colima—Tecomán, sobre una pared de suelo yesoso con exposición NE, 410 m, 12 January 2000, *R. Acevedo et al.* 1724 (holotype XAL!, isotypes MO!, NY!).

Description:—**Plants** herbaceous, perennial, 16.0–20.0 cm tall, shortly caulescent or stemless, caespitose-ramose, forming compact clusters, branching by ascending (when young) and pendent (with age) slender stems from below rosette; stems 5.6–6.0 × 0.3–0.5 cm, mostly decumbent, suberect at first, then pendent, smooth, at first nearly white-glaucous, later red-brown-glaucous; rosettes 2.5–3.0 × 2.0–3.0(–4.0) cm, with 30–50 crowded leaves. **Leaves** 1.3–2.0 × 0.8–1.2 cm, 2.0–5.0 mm thick, oblanceolate to broadly oblanceolate, slightly concave on the inner surface, markedly convex on the outer surface and vaguely keeled in upper 2.0–4.0 mm, ascending-erect when young, later the apical ones ascending-erect and the basal ones expanding, glabrous, pale blue-greenish to white-greenish to yellow-green with palest rosy blush, especially in youngest leaves and with exposure to more intense light, slightly glaucous; apex acute or slightly apiculate, light green. **Inflorescences** as compound cymes, generally 6.0–12.0 cm, with 8–17 flowers, unbranched or with 1–2(–3) simple or bifurcate branches, each with 2–3 flowers, the basal branch with 1–2 flowers; peduncle 2.5–8.0 cm tall, 2.0–3.5 mm thick, smooth, light green, pink or red-tinged; bracts 16–18, soon deciduous, 7.0–10.0 × 6.0–7.0 mm, 2.5 mm thick, similar to rosette leaves but ovate rather than oblanceolate, diminishing markedly

TABLE 1. Morphological differences among species of *Quetzalcoatlia*. Updated values from additional material (herbarium specimens, living plants, and pictures), new species in boldface.

	<i>Q. glassii</i>	<i>Q. grulloensis</i>	<i>Q. itzicuaroensis</i>	<i>Q. kristenii</i>	<i>Q. latipetala</i>	<i>Q. pentandra</i>	<i>Q. rosanevadoensis</i>	<i>Q. santanamichelii</i>	<i>Q. superba</i>	<i>Q. trujilloi</i>
Plant habit	Herbaceous, caespitose-ramose	Suffrutex, decumbent, pendulous	Herbaceous, caespitose, sinuously-pendant	Herbaceous, caespitose-ramose	Herbaceous, erect to suffrutex, decumbent, ramose	Suffrutex, erect, decumbent	Suffrutex, ramose	Suffrutex, ramose	Suffrutex, ramose	Suffrutex, ramose
Plant size (cm)	16.0–20.0	30.0–45.6	9.0–55.0	8.0–30.0	15.0–16.0	19.0–24.0	40.0–96.0	10.0–88.0	40.0–80.0	15.0–35.0 (–41.0)
Rosette length × Rosette width (cm)	2.5–3.0 × 2.0–4.0	3.5–5.6 × 7.5–13.5	3.0–7.0 × 6.4–8.4	(2.3–)4.0–8.0 × (2.8–)3.5–5.0	3.2–3.8 × 5.8–6.8	3.0–9.0 × 6.0–8.0	4.0–5.0 × 10.0–16.0	2.8–3.0 (–6.5) × 4.8–6.5 (–12.5)	4.0–4.5 × 9.0–14.0	7.0–8.0 × 9.0–12.0
Stem length (cm)	5.6–6.0	19.0–40.0	6.0–48.0	4.0–22.0	8.4–9.5	5.0–15.0	30.0–80.0	7.0–85.0	14.0–15.0	8.0–27.0
Stem diameter (cm)	0.3–0.5	0.9–1.4	0.3–0.6	0.25–0.30	0.5–0.6	0.3–0.6	0.7–0.8	0.6–0.9	1.0–1.2	0.6–0.8
Stem surface	Smooth	Smooth and tuberculate	Smooth	Smooth	Smooth with brown scars	Smooth, with bumped tan scars	Smooth	Smooth with pale green scars	Squamose and tuberculate	Smooth
Leaves per rosette	30–50	11–26	12–34	15–30	17–18	15–36	31–47	17–26	12–20	15–32 (–52)
Leaf size (cm) / shape	1.3–2.0 × 0.8–1.2 / Oblanceolate to broadly oblanceolate	3.5–6.5 × 1.7–2.8 / Oblong-obovate	1.9–2 (–3.8) × 1.0–1.5 / Obovate	1.4–2.7 (–3.2) × 0.7–1.3 / Broadly oblong, straight to incurved, shortly acuminate	2.1–3.1 × 1.2–1.6 / Obovate to broadly obovate to broadly ellipsoid, apiculate	3.0–4.0 (–5.5) × 1.5–2.3 cm / Oblanceolate	1.5–7.6 × 1.4–1.9 / Oblong-obovate, obtuse to rounded	2.1–3.8 (–6.5) × 1.2–1.9 / Oblanceolate–spatulate	4.0–5.5 (6.4) × 2.0–2.5 / Mostly obovate or broadly oblanceolate, cuneate	4.0–7.5 × 2.3–2.8 / Obovate to oblanceolate
Leaf apex	Acute or slightly apiculate	Acuminate to rounded	Mostly acute, rarely obtuse or rounded or truncated	Acute	Obtuse to acute	Mostly obtuse or rounded or truncated	Acute	Obtuse-rounded, rarely acute, mucronate	Acute, with an apical mucro	Acute, in right angle or obtuse
Leaf color	Pale blue-greenish to white-greenish to yellow-green with palest rosy blush	Glaucous greenish to pink-gray, yellowish in the sun	Glaucous greenish to grayish, the margins or tips often pinkish	green-brownish to grayish, pinkish to green-glaucous	Yellowish to bluish green, slightly pinkish at the margin	Blue-glaucous to tinged with lavender	Glaucous to brownish green, pink when young	Pinkish–grayish green	Gray-bluish to pink-violet	Glaucous greenish to pinkish
Inflorescence length (cm)	6.0–12.0	8.0–29.0	12.9–16.4 (–18)	18.0–28.0	13.0–21.3	20.0–35.0	9.8–60.0	12.0–21.1	30.0–40.0	15.0–32.0
Number of branches per full-size inflorescence	1–2 (–3)	7–9	4–7	2–4	3–4	3	5–6	4–8	12–15	7–10

.....continued on the next page

TABLE 1. (Continued)

	<i>Q. glassii</i>	<i>Q. grulloensis</i>	<i>Q. itzicuaroensis</i>	<i>Q. kristenii</i>	<i>Q. latipetala</i>	<i>Q. pentandra</i>	<i>Q. rosanevadoensis</i>	<i>Q. santanamicheltii</i>	<i>Q. superba</i>	<i>Q. trujilloi</i>
Number of flowers per branch	2–3	2–8, 11–14 if forked	2–14	1–7	5–8	3–11	2–4	1–5	8–15	3–7
Number of flowers per basal branch	1–2	3–5	2–8	1–4	5–8	3–11	2–4 (–7)	1–3	8–12	3–6
Number of flowers per full-sized inflorescence	8–17	35–69	12–34	(10–)15–24	23–27	31–36	14–34	(10–)15–27	57–121	30–50
Pedicel length (cm)	0.6–0.7	0.5–2.0	1.0–2.0	0.6–1.1	0.8–1.7	1.8–2.3	0.3–1.4	0.4–1.0	1.0–1.4	0.9–1.1
Flower diameter (mm)	12.0–14.0	14.0–16.0	14.0–16.2	12.5–15.5	20.0–21.0	17.9–18.0	14.9–15.1	8.5–11.0	15.0–16.0	12.9–13.1
Corolla tube (mm)	2.7–2.8	3.7–3.8	4.5–4.6	2.4–2.9	2.9–3.1	3.0–3.5	2.9–3.1	3.0–4.0	2.9–3.1	3.7–3.8
Corolla lobes (mm)	5.5–5.6 × 2.5–3.5	5.8–6.0 × 2.4–2.5	5.9–6.1 × 3.0–3.4	4.9–6.2 × 2.2–2.6	8.0–8.1 × 4.5–4.6	6.9–7.0 × 1.7–1.75	5.4–5.5 × 2.9–3.0	3.9–4.0 × 1.9–2.0	5.5–6.0 × 2.0–2.7	4.9–5.2 × 2.7–2.8
Petal color	Proximally yellowish green to yellow white and distally red and inconspicuously striped	Yellowish with red-purple spots on the apex	Proximally greenish to distal half red-striped or dark-red	Proximally white-pinkish, to distally reddish-wine	Creamy white to greenish at the base, rusty reddish at the distal third, faintly red-banded or dotted	Proximally yellowish-white, distal half-dark red	Proximally ivory-yellowish to distally red & striped	Whitish-pale yellow with red spots, forming diffuse horizontal stripes toward the apex, orange-yellow near the base	Proximally creamy-white to yellowish green, distally red-wine & inconspicuously striped	Proximally greenish to distally red & striped
Nectary color	Yellow	Yellow	Bright yellow	Yellow	?	Bright yellow	Yellow	Orange-yellow	?	Bright yellow
Abaxial carpel shape / color	Rounded/proximally green-yellow to distally pinkish to reddish apically	Acute costate, green to yellowish, whitish at the base, pistil pink	Obtuse /proximally yellowish to distally pinkish	Obtuse to rounded/yellow to distally reddish	At a right angle, pinkish at the middle, reddish at the apex	Obtuse & keeled / proximally greenish-white to distally reddish	Rounded/ ivory yellowish to distally reddish	Rounded, yellowish, reddish toward the apex and the pistil	Obtuse to rounded/ entirely red	Obtuse/ greenish to pinkish
Fruit size (mm)	Unknown	2.4–2.6 × 1.5–1.6	4.9–5.6 × 1.2–1.5	5.4–5.6 × 1.2–1.4	9.1–9.2 × 0.5–0.6	Unknown	Unknown	4.75–5.25 × 1.5–1.52	5.3–5.9 × 1.4–1.6	7.4–7.6 × 3.2–3.4
Seed size (mm)	Unknown	0.41–0.53 × 0.17–0.20	0.37–0.49 × 0.09–0.17	0.41–0.49 × 0.15–0.18	0.48–0.52 × 0.24–0.36	Unknown	Unknown	0.52–0.64 × 0.23–0.29	0.35–0.42 × 0.15–0.19	Unknown

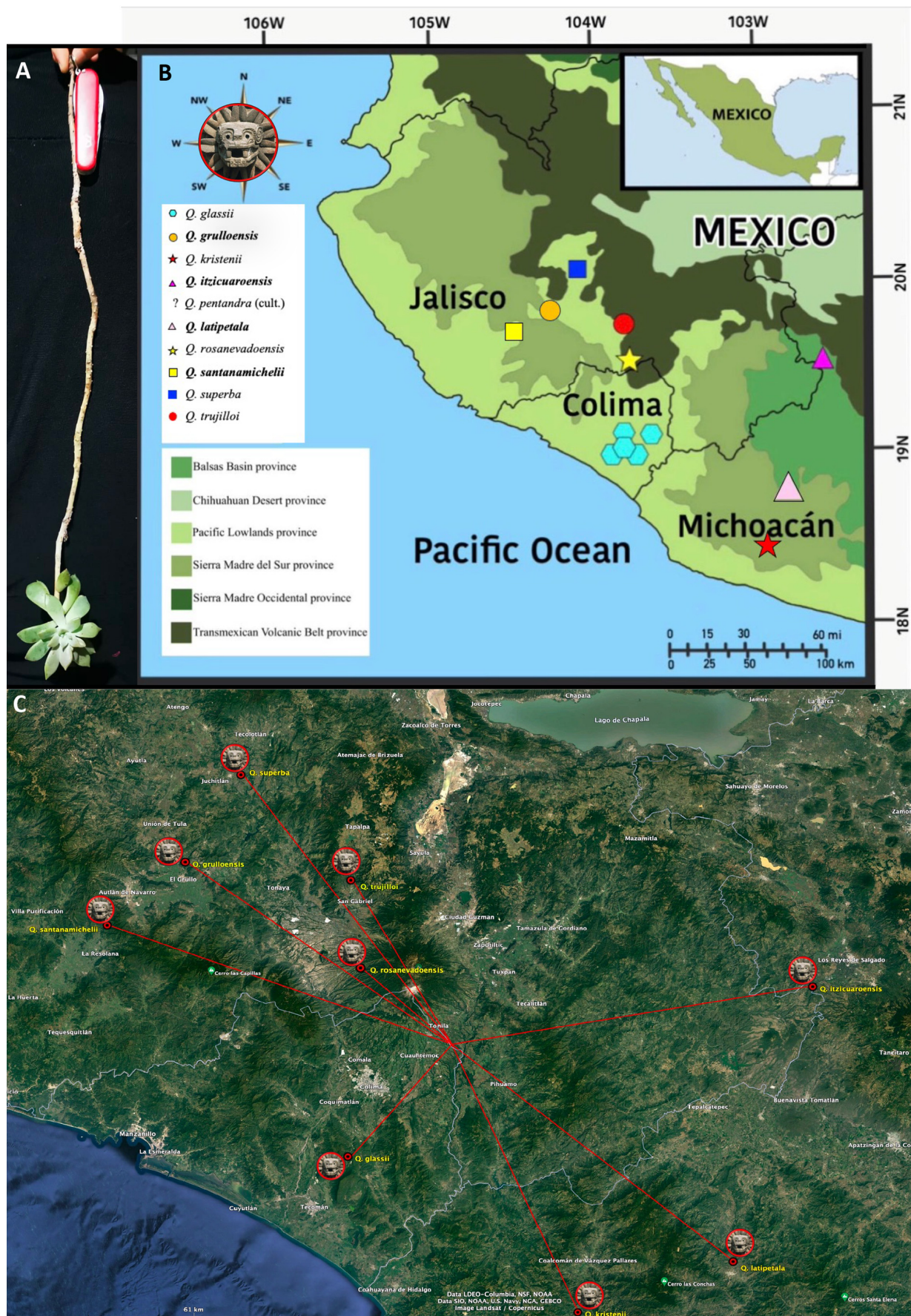


FIGURE 1. Geographic distribution of species of *Quetzalcoatlia*. All species of *Quetzalcoatlia* within a radius equal to or less than 101 km.

in size, 7.0–10.0 × 6.0–7.0 mm; bracteoles mostly elliptic to lanceolate, 1.5–3.0 × 1.0–1.5 mm; pedicels 0.6–0.7 cm; flower buds about 9.0 mm long. **Flowers** 8.0–9.0 mm long when unopened, 12.0–14.0 mm wide when expanded; calyx lobes 5, gray-green, lips 3.0 mm long; corolla tube 2.7–2.8 mm long, rotate in the distal half; corolla lobes 5.5–5.6 × 2.5–3.5 mm wide near base, triangular-lanceolate, acute, proximally yellowish green to yellow white and distally red and inconspicuously striped toward the tips, tin lips nearly solid red; nectaries 5, 0.3 mm tall, 0.5 mm wide, 0.3 mm thick, somewhat reniform, the inner face strongly concave, the external convex, yellow; stamens 5, 6.0–7.0 mm long, ca. 0.1 mm wide, antesealous, at first erect, after anthesis strongly reflexed between the petals, base adnate to corolla tube, the filaments white, the apical half pink or red dotted, the anthers with gray-yellow pollen; gynoecium 6.0–6.5 mm long, 3.0–3.5 mm thick, obovate, carpels, rounded, proximally green-yellow to distally pinkish to reddish apically; styles 1.0 mm long or less. **Fruits** and seeds unknown.

Notes:—*Quetzalcoatlia glassii* differs from *Q. pentandra* in its shorter herbaceous habit, caespitose growth, smaller stems, rosettes, and leaves, and a shorter but thicker inflorescence (Table 1). *Quetzalcoatlia glassii* can be recognized in the field among other known species of the genus by its small, attractive, light green and dense rosettes, its shorter and slender stems, and the numerous conglomerate leaves (30–50). Plants of *Quetzalcoatlia glassii* are sold as “*Graptopetalum sotoi*”, a *nomen nudum*, that was initially meant to be applied to this species (Cházaro-Basáñez & Acevedo-Rosas 2008). Figure 4A depicts a cultivated plant, which is more branched and robust than wild plants. Table 1 outlines the key distinctions between *Quetzalcoatlia glassii* and all the species of the genus.

Distribution, habitat, and phenology:—Endemic to the state of Colima, at an elevation of 380–440 m, where the species occurs in tropical deciduous forests, on shaded gypsum slopes harboring a rich succulent flora including *Agave colimana* Gentry, *A. pablocarrilloi* A. Vázquez, Muñoz-Castro & Padilla-Lepe, *Bursera schlechtendalii* Engl., *Bursera* spp, *Ficus* sp, *Hechtia laevis* L.B. Sm., *Matelea cyclophylla* (Standl.) Woodson, *Cephalocereus nudus* E.Y. Dawson; *Euphorbia* spp, *Ficus cotinifolia* Kunth, *Pinguicula colimensis* McVaugh & Mickel, *Pittocaulon filare* (McVaugh) H. Rob. & Brettell, *Plumeria rubra* L., *Ceiba aesculifolia* (Kunth) Britten & Baker f. and *Pseudobombax ellipticum* (Kunth) Dugand. *Quetzalcoatlia glassii* flowers from late February to April or June. Flowers produce a fetid odor.

Etymology:—The species is named after Charles Glass (1934–1998), who discovered and collected plants of the new taxon for the first time in the winter of 1995, during vacation time, on gypsum slopes halfway between Tecomán and Colima. Mr. Glass worked as the Curator of Plants for Cante, A.C. (a non-governmental organization), a small botanical garden located in San Miguel de Allende, Guanajuato, Mexico, where he studied succulent plants such as Cactaceae and Crassulaceae. Mr. Glass conducted many field trips to remote and interesting places in Mexico, where he found and described new taxa of these groups. Plants of this species are sold as “*Graptopetalum sotoi*”, a *nomen nudum*, because Miguel Cházaro and Charles Glass were planning to publish it.

Preliminary conservation assessment:—Following IUCN Red List criteria B1ab(iii) (IUCN 2022), the species was assessed as Endangered (EN): the EOO is less than 5000 km² (criterion B1), the AOO is <500 km² (B2), its habitat is severely fragmented (condition a); and we inferred a decline in the quality of its habitat through land use change, from mining and agricultural expansion (condition b(iii)). The authors have observed that this species is reproduced in several private collections and sold in various nurseries.

Additional specimens examined:—MEXICO. Colima: Near La Salada, approx. 25 km S of Colima on a steep and shaded gypsum slope, 29 December 1995. *C. Glass* & *M. Mendoza* 8910 (Cante, A.C); Cultivated from collected material from La Salada, rocky, gypsum slope, southwest of Colima, approx. 25 km, old road to Tecomán. 3 August 1997, *I. García* 4610 (CIMI!); La Salada, sur y oeste de Ixtlahuacán, Colima. 25 March 1999, *I. García* & *Fco. J. Santana-Michel* 5577 (CIMI!, ZEA!); La Salada, property owned by the cement mining company Holcim, 28 June 2014, *R. Cuevas G., et al.* 11276 (ZEA!).

Additional on-line observations:—*I. Novoa-Leyva* (*ismael76*) <https://www.inaturalist.org/photos/102113659>; *P. González Zamora* (*pierre-glez*) <https://www.inaturalist.org/photos/112649177>; *jarturoq* (*jarturoq*) <https://www.inaturalist.org/photos/130159619>; *jarturoq* (*jarturoq*) <https://www.inaturalist.org/photos/130159518>

***Quetzalcoatlia grulloensis* A. Vázquez & Padilla-Lepe sp. nov.** (Figs. 1–3 & 5–6).

Type:—MEXICO. Jalisco: municipality of El Grullo, Sierra de Amula, on steep rocky slopes, on the base of trees, in tropical dry forest with *Calliandra*, *Cephalocereus*, *Ficus*, *Inga*, *Lysiloma*, *Pachycereus*, *Plumeria*, *Pseudobombax*, 3 June 2022 (fr), *G. Nieves-Hernández* y *J. Padilla-Lepe*, recorded by *J. Antonio Vázquez-García* 10194 (holotype IBUG!, isotype ZEA!).

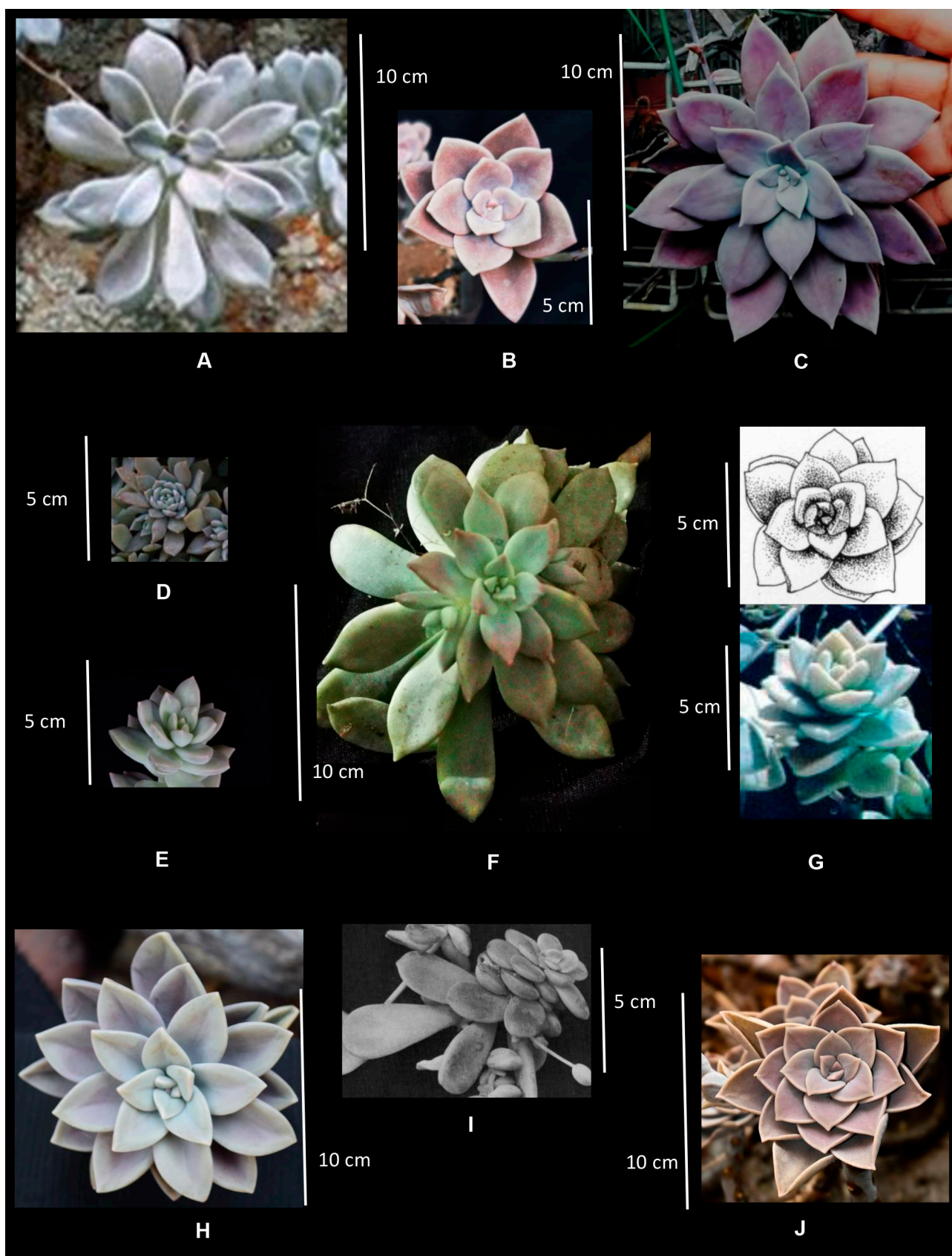


FIGURE 2. High small-scale rosette diversity in *Quetzalcoatlia*, half of their actual size. A. *Quetzalcoatlia trujilloi*. B. *Q. itzicuarioensis*. C. *Q. superba*. D. *Q. glassii*. E. *Q. kristenii*. F. *Q. rosanevadoensis*. G. *Q. latipetala*. H. *Q. grulloensis*. I. *Q. pentandra*. J. *Q. santamichelii*. Photographs: A & D–E by J. Etter & M. Kristen, B–C & F by A. Vázquez-García, April 2022, G Reproduced from Kimnach (1987), H by J. Padilla-Lepe, I Reproduced from Moran (1971), J. by D. Figueroa-S.

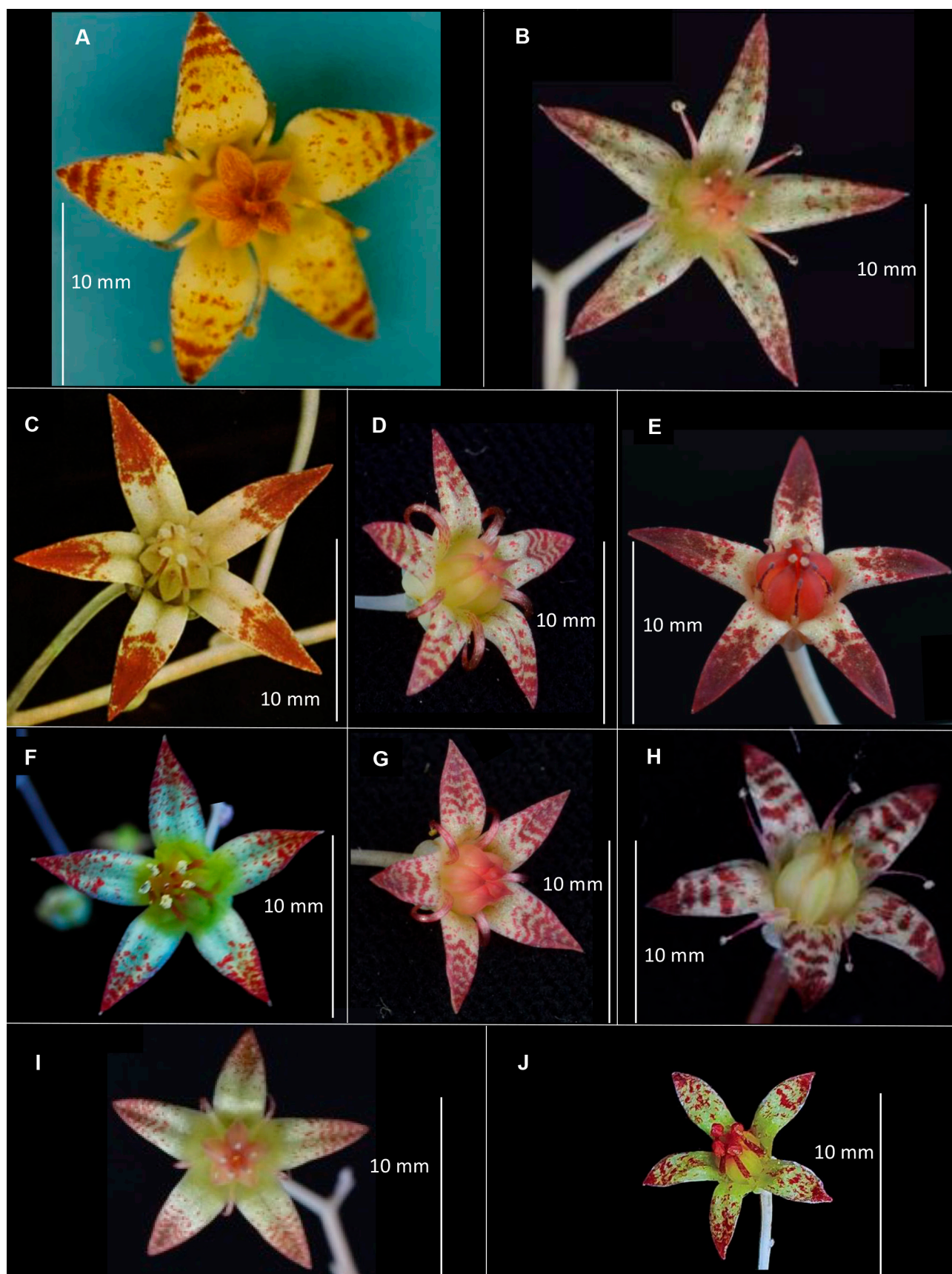


FIGURE 3. *Quetzalcoatlina*. High small-scale flower diversity in western Mexico, size-proportions kept among the flowers. A. *Quetzalcoatlina latipetala*. B. *Q. glassii*. C. *Q. pentandra*. D. *Q. itzicuaruensis*. E. *Q. superba*. F. *Q. grulloensis*. G. *Q. rosanevadoensis*. H. *Q. kristenii*. I. *Q. trujilloi*. J. *Q. santamichelii*. Photographs: A by I. García Ruiz, B, D–E & G–I by J. Etter & M. Kristen, C reproduced from R. Moran (1971), F by J. Padilla-Lepe, and J by A. Vázquez-García.



FIGURE 4. *Quetzalcoatlia glassii*. Photographs by J. Etter & M. Kristen.



FIGURE 5. *Quetzalcoatlia grulloensis*. A. Rosette. B. Rosette and infructescence, C. Inflorescence. D. Flower after male phase. E. Flower at anthesis. Photographs A, C–E by A. Vázquez-García (2023) and B by J. Padilla-Lepe.



FIGURE 6. *Quetzalcoatlia grulloensis*. A–D Habitat, tropical dry forest, Sierra de Amula, Jalisco, Mexico. Photographs by J. Padilla-Lepe, June 2022.

Diagnosis:—*Quetzalcoatlia grulloensis* is similar to *Q. superba* in having a ramoso decumbent or pendulous habit, rosette size, tuberculate stems, leaf size and oblanceolate leaves, but it differs from the latter in having longer stems 19.0–40.0 (vs. 14.0–15.0 cm) basal leaves navicular (vs. flat); leaf apex acuminate to rounded (vs. obtuse with an apical mucro 1.0–1.5 mm long and wide); leaves greenish to pink-grayish (vs. gray-bluish to pink-violet); shorter inflorescence 8.0–29.0 cm (vs. 30.0–40.0); less numerous branches per full-size inflorescence 7–9 (vs. 12–15); less numerous flower per basal branch 3–5 (vs. 8–12); longer corolla tube 3.7–3.8 mm (vs. 2.9–3.1); and petals yellowish with red-purple spots toward the apex (vs. proximally creamy-white to yellowish green, distally red wine and inconspicuously striped); and shorter fruits 2.4–2.6 (vs. 4.75–5.25 mm).

Description:—**Plants** suffrutescent, perennial, 30.0–45.6 cm tall, caulescent, decumbent, pendulous; stems 19.0–40.0 × 0.9–1.4 cm, branched at 10.0–27.0 cm, smooth and tuberculous, slightly glossy brown; rosettes 3.5–5.6 × 7.5–13.5 cm, 11–26 clumped leaves. **Leaves** 3.5–6.5 × 1.7–2.8 cm, 6.0–8.5 mm thick, oblong-obovate, adaxially concave, acuminate to rounded at the apex, the basal leaves navicular; glaucous greenish to pink-gray, yellowish in the sun, sometimes with a faint pinkish tinge around the edges. **Inflorescences** 8.0–29.0 cm, 7–9 alternate branches per full-size inflorescence, 1–2 bifurcated, longest branches 6.5–9.0 cm, with 2–8 flowers each, 11–14 flowers when bifurcated, 3–5 flowers on basal branches, 35–69 flowers per inflorescence; phyllotaxy 3; pedicels 0.5–2.0 × 0.1 cm; flower buds 1.21–1.29 × 0.75–0.88 mm. **Flowers** 14.0–16.0 mm in diameter; sepals 5.0 × 2.5 mm, ovate, obtuse at the base and acute at the apex; corolla tube 3.7–3.8 mm, corolla lobes 5.8–6.0 × 2.4–2.5, lanceolate, acute at the apex, yellowish, spotted with red-purple from the middle to the upper 1/3; nectaries reniform and yellow; stamens 6.0 mm long; gynoecium 6.0 mm long, carpels costate, acute at the apex, green to yellowish, whitish at the base, pistil pink to reddish, apiculate. **Fruits** 2.4–2.6 × 1.5–1.6 cm; seeds 0.41–0.53 × 0.17–0.2 mm.

Distribution, habitat, and phenology:—It is found in the state of Jalisco in the municipality of El Grullo, within the Sierra de Amula near the Puerta del Barro town, around the El Tigre stream. This rupicolous species hangs on basalt rock cliffs within the deciduous tropical forest above 1000–1100 m a.s.l., it is accompanied by plant species such as *Calliandra caeciliae* Harms., *Plumeria rubra* L., *Lysiloma acapulcensis* (Kunth) Benth., *Ficus* sp., *Pachycereus pecten-aboriginum* (Engelm. ex S. Watson) Britton & Rose, *Pseudobombax palmeri* (S. Watson) Dugand, *Cephalocereus alensis* (F.A.C. Weber) Britton & Rose, *Agave stringens* Trel., *Tillandsia capitata* Griseb., and *Oncidium* sp. This species flowers from May to June and bears fruit in June.

Etymology:—The species is named after the municipality El Grullo, in Jalisco, and is so far endemic to this area.

Notes:—Its glaucous green to pink-gray rosettes make it distinctive, growing easily from seeds and leaf cuttings. This species was first discovered in El Grullo, Jalisco, collected vegetative (Hernández *et al.* 2409) and cultivated on October 20, 2021 by M. Sc. Leticia Hernández-López, from the University of Guadalajara. Soon after, this taxon was treated as *Graptopetalum superbum* (M. Kimmach) Acevedo-Rosas, (Hernández-López & Carrillo-Reyes 2019). Some years later, Gregorio Nieves and Jesús Padilla obtained mature plants, which bloomed at Zapopan in June 2022.

Preliminary conservation assessment:—According to the IUCN Red List criterion B2 (AOO < 10 km²), and conditions ab(iii) (IUCN 2022), the species could be considered Critically Endangered (CR). Additionally, due to its rarity and narrow distribution (condition a), this species experiences a continuing decline observed and projected in area and quality of habitat (condition b(iii)), because of the increase in plant hunting. This species is so far endemic to the western portion of the Sierra de Amula, Jalisco, Mexico, known only from one location, the type locality, where it has been registered from a single population. The species spatial dispersion tends to be gregarious in groups from 30 to 50 individuals, and some solitary plants; the total population size is estimated to be 300 individuals. It must be a target for conservation and research efforts. The first successful step in the recovery of this species started on June 24, 2022, through the first germination trial of about 100 seeds, and a second germination trial started in June 2023, the plants are growing fine at the University of Guadalajara's greenhouse at Zapopan, Jalisco.

Additional specimens examined:—MEXICO. Jalisco: Municipality of El Grullo, Sierra de Amula, cultivated at Zapopan, 3 June 2022 (fl), *J. Antonio Vázquez-García 10266* (IBUG!).

Quetzalcoatlia itzicuaroensis A. Vázquez, Padilla-Lepe & I. García *sp. nov.* (Figs. 1–3 & 7–15).

Type:—MEXICO. Michoacán: municipality of Los Reyes, Chorros del Varal, 12.5 km SW of Los Reyes de Salgado (cultivated by *Jesús Padilla-Lepe*), 13 April 2022 (fl & fr) *J. Antonio Vázquez-García 10290* (holotype IBUG!; isotype CIMI!).

Diagnosis:—*Quetzalcoatlia itzicuaroensis* is similar to *Q. pentandra* in rosette size and color pattern of the flowers but it differs from the latter in having a serpentine herbaceous pendant habit vs. erect (possibly decumbent) and suffrutescent; much longer full-sized stems up to 48 vs. <15 cm; basal leaves up to 3.8 vs. up to 6.4 cm long, adaxial surface usually concave rarely flattish vs. usually

flattish to convex, rarely slightly concave; leaf apex mostly acute vs. mostly obtuse or rounded or truncated; shorter inflorescences 12.9–16.4(–18) vs. 20.0–35.0 cm; more numerous branches per full-size inflorescence 4–7 (vs. 3); smaller corolla, 14.0–16.2 vs. 17.9–18.0 mm in diameter; shorter but wider petal segments, 5.9–6.1 × 3.0–3.4 vs. 6.9–7.0 × 1.7–1.75 mm; longer and wider corolla tube, 4.5–4.6 × 5.7 vs. 3.0–3.5 × 4.0 mm.



FIGURE 7. *Quetzalcoatlia itzicuaroensis*. Cultivated by J. Padilla-Lepe; Photograph by A. Vázquez-García, April 2022.

Description:—**Plants** herbaceous, perennial, 9.0–55.0 cm tall, caulescent, sinuously pendant, cespitose, glabrous; stems 6.0–48.0 × 0.3–0.6 cm, prostrate to sinuously pendant, smooth, brownish to green; leaf scars 1.6–2.5 × 1.1–1.5, bumped, centrally whitish, the outline pinkish to brownish; rosettes terminal, 3.0–7.0 × 6.4–8.4 cm in diameter, compact, with 12–34 leaves. **Leaves** 1.9–2.9(–3.8) × 1.0–1.5 cm, 2.0–3.0 mm thick at the base, mostly obovate, the basal ones obovate and up to 3.8 cm long; adaxially usually concave, rarely flattish and abaxially convex, keeled at

mid vein; the margins entire and rounded; glabrous, glaucous greenish to grayish or pinkish, when green, the margins and or tips often pinkish; the base cuneate; the stalk-like, basal portion 3–4 mm wide; the apex mostly acute, rarely obtuse or rounded or truncated; apical mucro 1.5–2.0 × 1.5–1.6 mm. **Inflorescences** 1–3(–4), shorter than wider, 12.9–16.4(–18) × 18.0–18.6 cm, 12–34 flowers on 4–7 secondary axes (branches), rarely opposite, each branch spaced 2.0–3.0 cm; primary axis 2.0–3.5 mm thick at the base, 1.0–1.5 mm thick above, straight, bluish-gray to pinkish; basal bracts on primary axis deciduous, 4–9, 7.0–9.0 × 4.0–6.0 mm, lenticular, lanceolate, gray; branches 5.6–9.7 × 1.1–1.2 mm, zigzagged, with 2–14 flowers, with 2–8 flowers on basal branches, with each pedicel spaced 8.0–16.1 mm, bracteoles 3–7, 1.1–2.1 × 2.0–2.1 mm, narrowly ovoid, glaucous-grayish; pedicels 1.0–2.0 × 0.11–0.12 cm, glaucous grayish; flower buds 6.4 × 5.3 mm, ovoid, the sepal lobes glaucous greenish, the corolla penta-costate with each petal keeled, glaucous yellowish, glabrous. **Flowers** 14.0–16.2 mm in diameter; calyx fused 1.4–1.5 × 2.6–2.7 mm; calyx lobes 2.4–2.5 × 0.9–1.3 mm; corolla tube 4.5–4.6 × 5.7 mm; corolla lobes 5.9–6.1 × 3.0–3.4 mm, triangular, subequal, longitudinally shallowly furrowed, proximally greenish, the base of corolla lobes sparsely dark red spotted, distally with transverse v-shaped red stripes or solid dark-red on upper $\frac{1}{2}$ – $\frac{2}{3}$; nectaries 0.8 × 0.9 mm, the apex rounded, bright yellow; stamens 5, erect at early stage of anthesis, later reflexed, red to pink; filaments 6.8–6.9 × 0.1–0.7 mm, the base mostly with short red lines, distally dark red, whitish to pale green below; anthers 0.4 × 0.3 mm, broadly ovoid, beige; gynoecium 4.0 × 4.1 mm, mostly the lower half yellowish to whitish, the distal 5–10% pinkish, the style purplish; carpels 6.1–6.3 × 1.0–1.3 mm, cylindroid and acuminate, abaxially obtuse to rounded, yellow to distally pinkish; styles 1.1–1.2 × 0.1–0.5 mm long; stigmas 0.3–0.4 mm. **Fruits** 4.9–5.6 × 1.2–1.5 mm, oblongoid, costate; carpels obtuse, proximally yellowish to distally pinkish; seeds 0.37–0.49 × 0.09–0.17 mm long, yellowish brown.

Distribution, habitat, and phenology:—*Quetzalcoatlita itzicuaroensis* is known only from some subpopulations at the type locality, in Los Reyes municipality, in the Michoacán state. It is located in the middle part of the Tepalcatepec river basin, at an elevation that ranges between 800–1000 m. The vegetation is tropical deciduous and semideciduous forest, growing on rocky slopes shaded in the north aspect, together with *Agave garciaruii* A. Vázquez, Hernández-Vera & Padilla-Lepe, *Anthurium halmoorei* Croat, *Astrolepis sinuata* (Lag. ex Sw.) D.M. Benham & Windham, *Euphorbia* sp., *Hechtia purhepecha* I. García, Espejo & López-Ferr. and *Tillandsia capitata* Griseb. (García-Ruiz *et al.* 2014, García-Ruiz & Lott 2015, Hernández-Vera *et al.* 2019). It flowers in early March to April, fruiting from May to June.

Etymology:—The specific epithet refers to the name of the location of this species, at the Itzicuaro river canyon, where the spectacular waterfalls Chorros del Varal are located, at Los Reyes, Michoacán.

Notes:—In 1990, the species was first collected at Chorros del Varal by Ignacio García Ruiz. Miguel Cházaro revisited the area and thought that it was the second wild location of *Graptopetalum pentandrum*. Despite its great variability, a close comparison allowed us to conclude that the populations of this locality should be described as a new species. This species is often sold at nurseries as *Graptopetalum pentandrum*.

Preliminary conservation assessment:—Following IUCN Red List criteria B1ab(iii) (IUCN 2022) the species was assessed as Critically Endangered: the EOO is less than 100 km² (criterion B1); AOO <10 km² (B2); only known from a single location (condition a); and an inferred decline of quality of habitat (condition b(iii)) through recreation and increasing water demands for irrigation. The species is propagated at University of Guadalajara-Zapopan.

Additional specimens examined:—MEXICO. Michoacán: Los Reyes municipality, Chorros del Varal, 26 April 1990, *I. García et al.* 3173 (CIMI); same locality, in front of the falls, 5 April 1993, *H. Díaz-Barriga* 7384 (IEB!); same location, *Acevedo* 1723 (XAL!); same location, cultivated at Jiquilpan, the source from Chorros del Varal, Municipio de Los Reyes, Michoacán, 1550 m, 15 April 1996, *I. García* 3984 (CIMI!); Barranca de Los Chorros del Varal, municipio de Los Reyes, Michoacán, río arriba del puente hacia El Salto, 900–940 m, 24 March 2004, *I. García & A. Linares* 6431 (CIMI!, IEB!); Barranca Chorros del Varal, hasta la parte más baja, municipio de Peribán, Michoacán, 820–850 m, 11 May 2004, *I. García & A. Linares* 6500 (CIMI!, IEB!); Barranca Chorros del Varal, municipio de Los Reyes-Peribán, Michoacán, 900–1000 m, 14 April 2005, *I. García & H. Cortez* 7065 (CIMI!, IEB!); Barranca Chorros del Varal, a orilla del río Apupátaro, municipio de Los Reyes, Michoacán, 900–1000 m, 06 April 2006, *I. García* 7433 (CIMI!, IEB!); 12.5 km al SW de Los Reyes de Salgado, 12 July 1998, *P. Carrillo R. & M. Cházaro* B. 319 (IEB!).

Quetzalcoatlita kristenii (Etter, A. Vázquez & Rosales) A. Vázquez & Rosales, *Boletín Nakari* 34(2): 39 (2023) (Figs. 1–3 & 16).

≡ *Graptopetalum kristenii* Etter, A. Vázquez & Rosales, *Phytotaxa* 555 (2): 140 (2022).

Type:—MEXICO. Michoacán: municipality of Coalcomán, SW of San Acamitán, shady cliffs along Coalcomán river in tropical deciduous forest, 20 March 2013, *J. Etter & M. Kristen* 3764 (holotype IBUG!, isotype CIMI!).

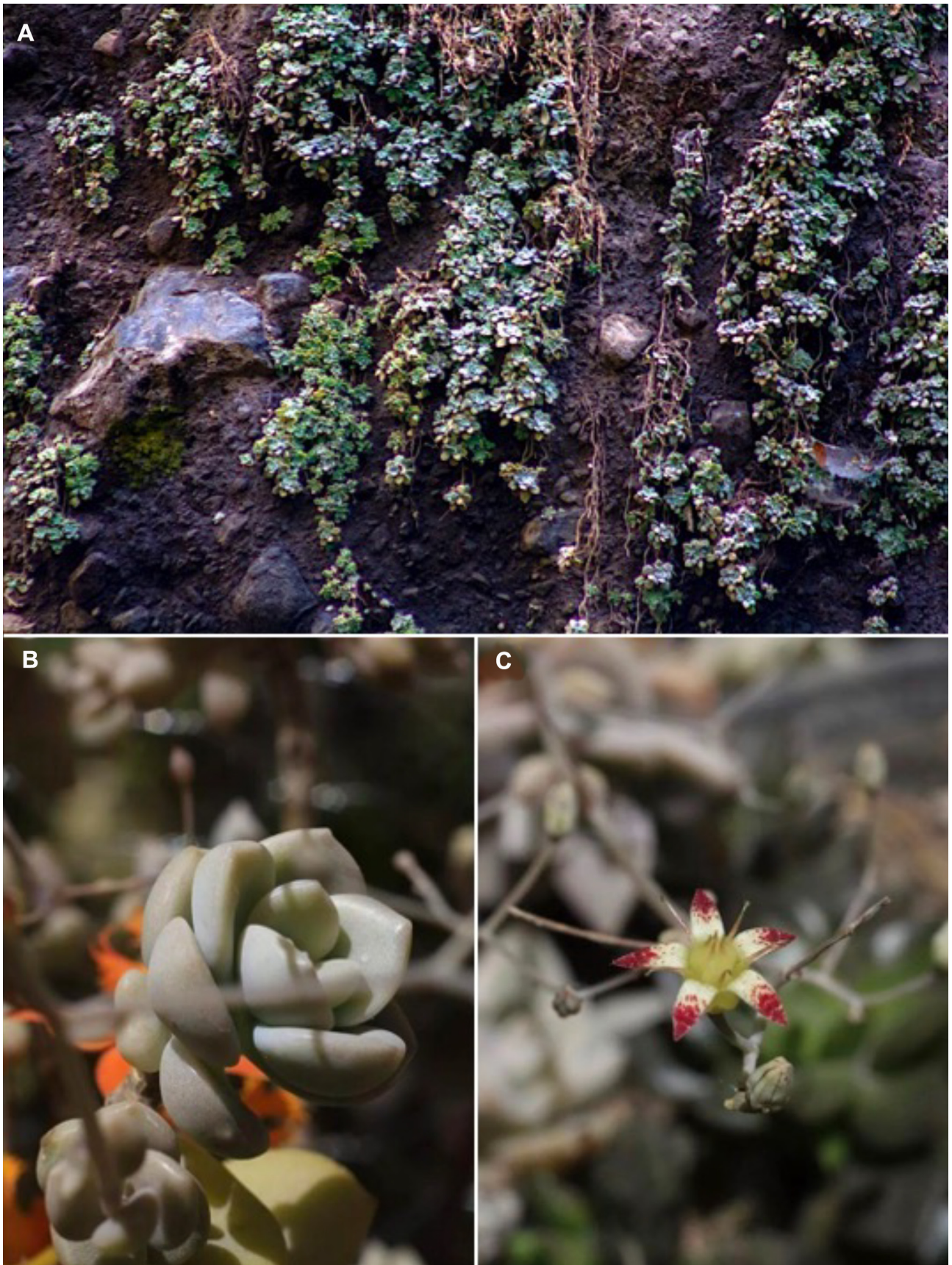


FIGURE 8. *Quetzalcoatlia itzicuaroensis*. Photographs: A by Omar Rentería (<https://www.naturalista.mx/photos/175856162>), January 2022, B–C by J. Padilla-Lepe, April 2022.



FIGURE 9. *Quetzalcoatlia itzicuaruensis*. Photographs: J. Padilla-Lepe, December.

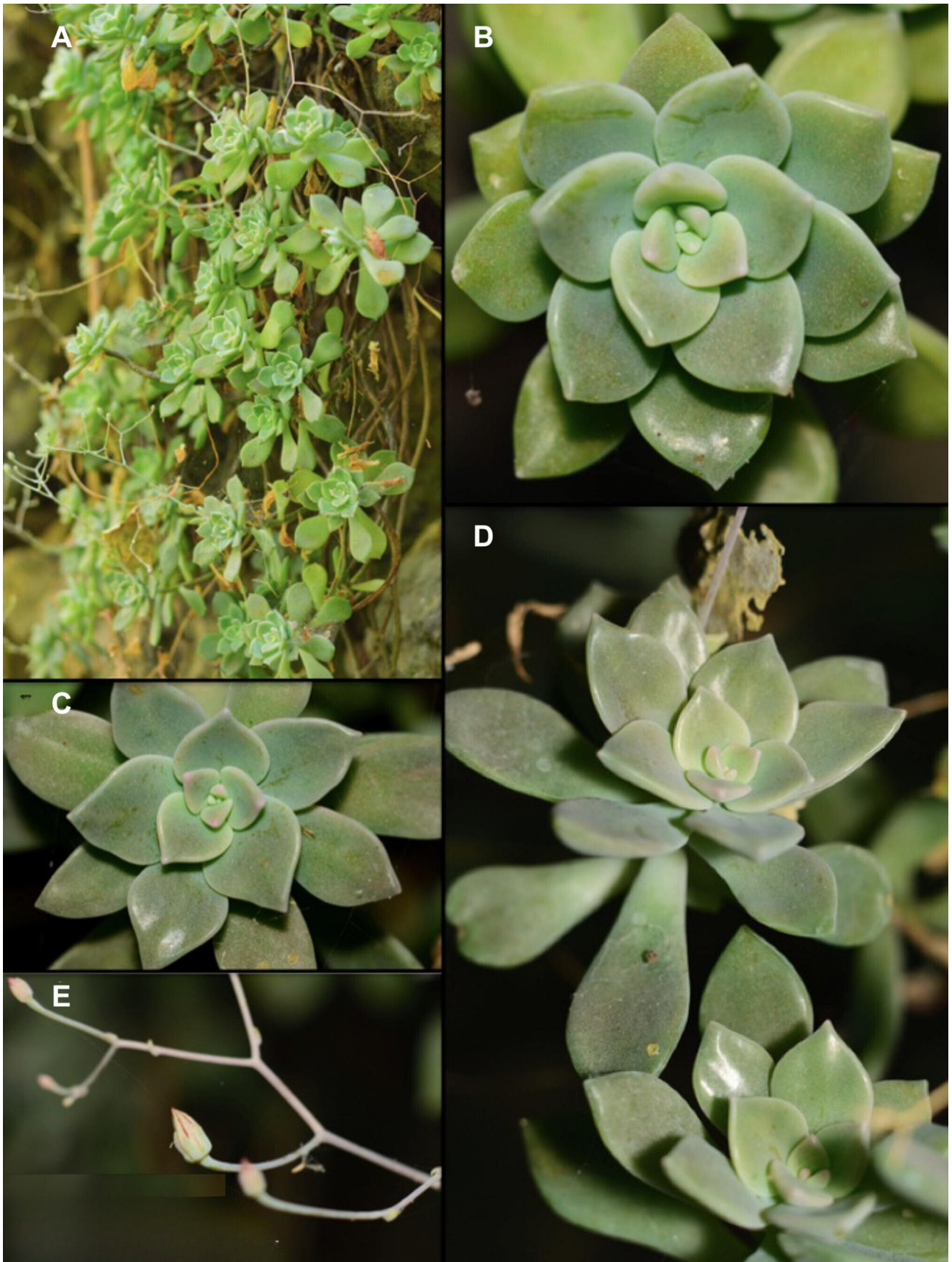


FIGURE 10. *Quetzalcoatlita itzicuaroensis*. Photographs by R. Arredondo-T., May 2019: <https://www.naturalista.mx/photos/>: 33774644, 33774695, 33774702, 33774717, 33774740 & 33774745).

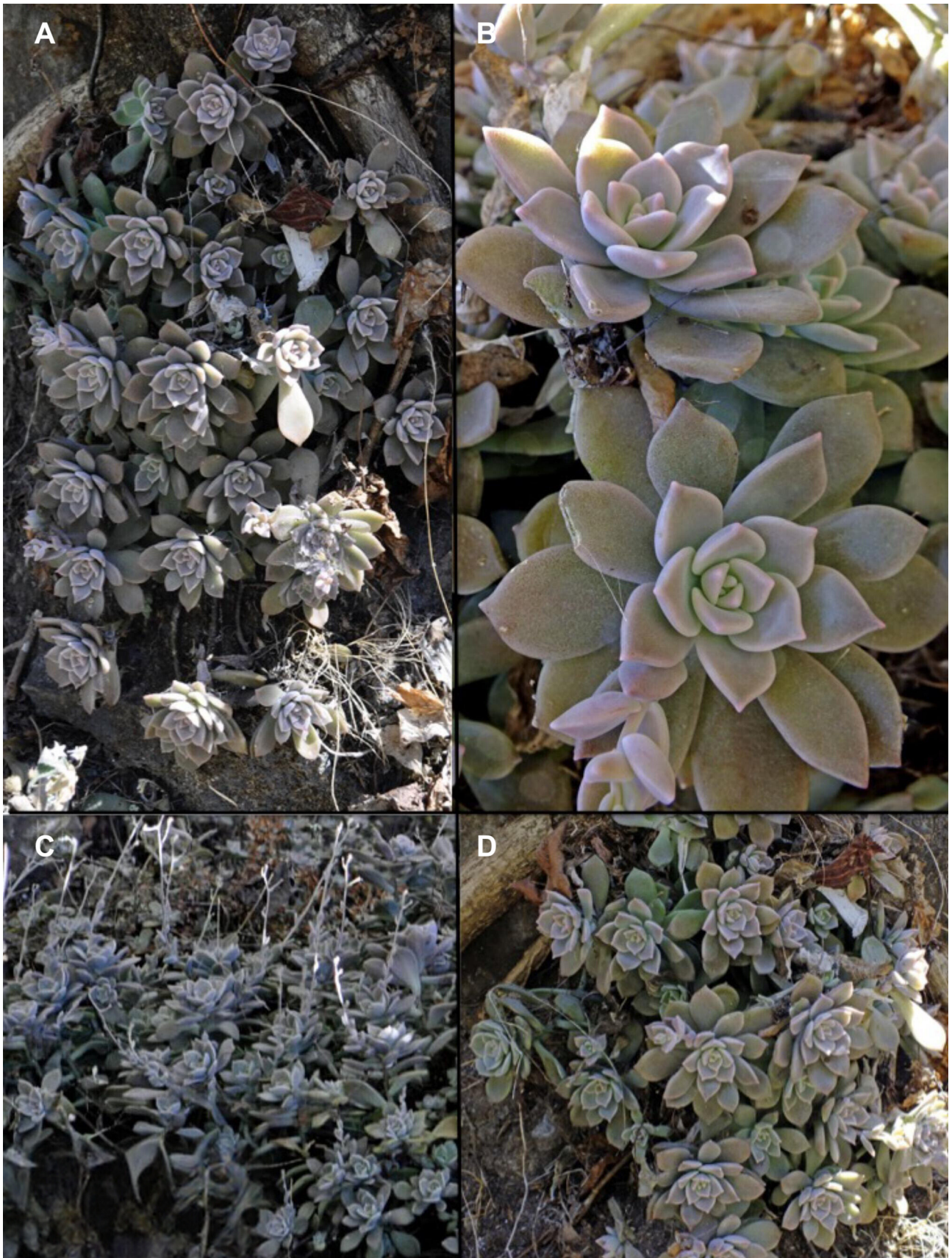


FIGURE 11. *Quetzalcoatlia itzicuaroensis*. Chorros del Varal waterfalls, S of Apupátaro river, © M. Costea, I. García-Ruiz & G. Costea, Feb. 2013 (www.phytoimages.siu.edu).



FIGURE 12. *Quetzalcoatlia itzicuaruensis*. Photographs by M. Cházaro-Basáñez, Nov. 1995.

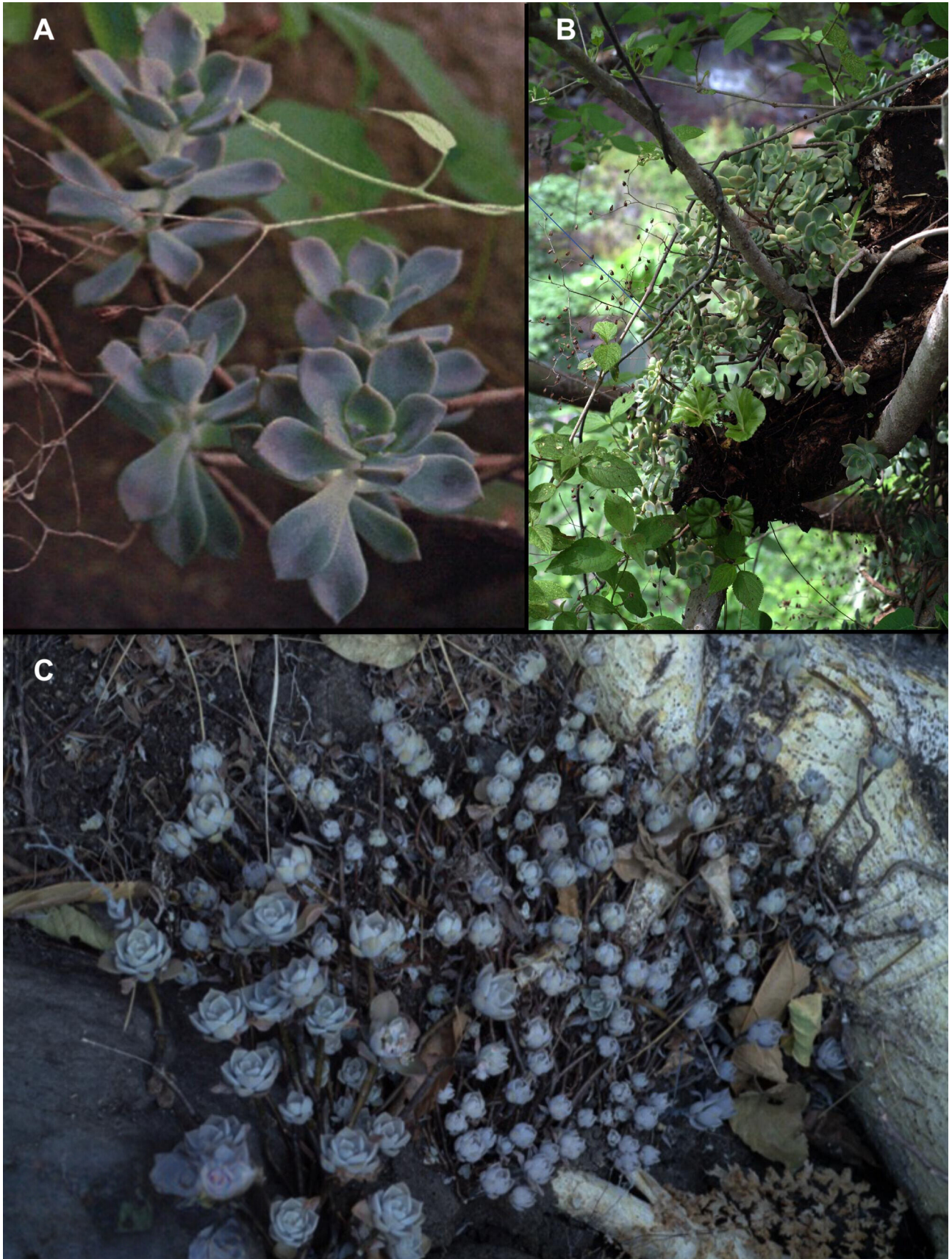


FIGURE 13. *Quetzalcoatlia itzicuarioensis*. Photographs: J. Etter & M. Kristen (No. 919), Mar 2005.

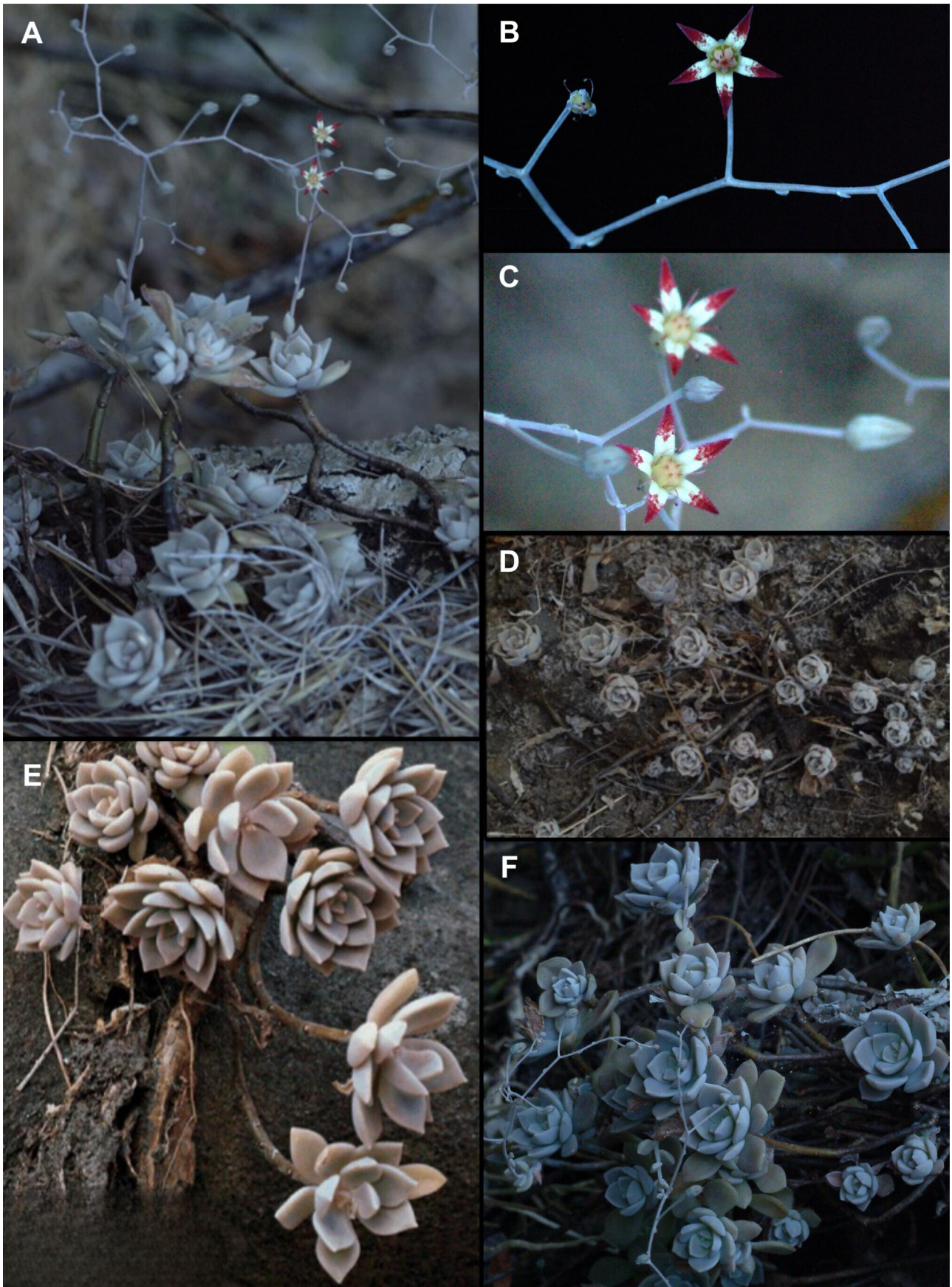


FIGURE 14. *Quetzalcoatlia itzicuaroensis*. Photographs: J. Etter & M. Kristen (No. 919). Mar 2005.

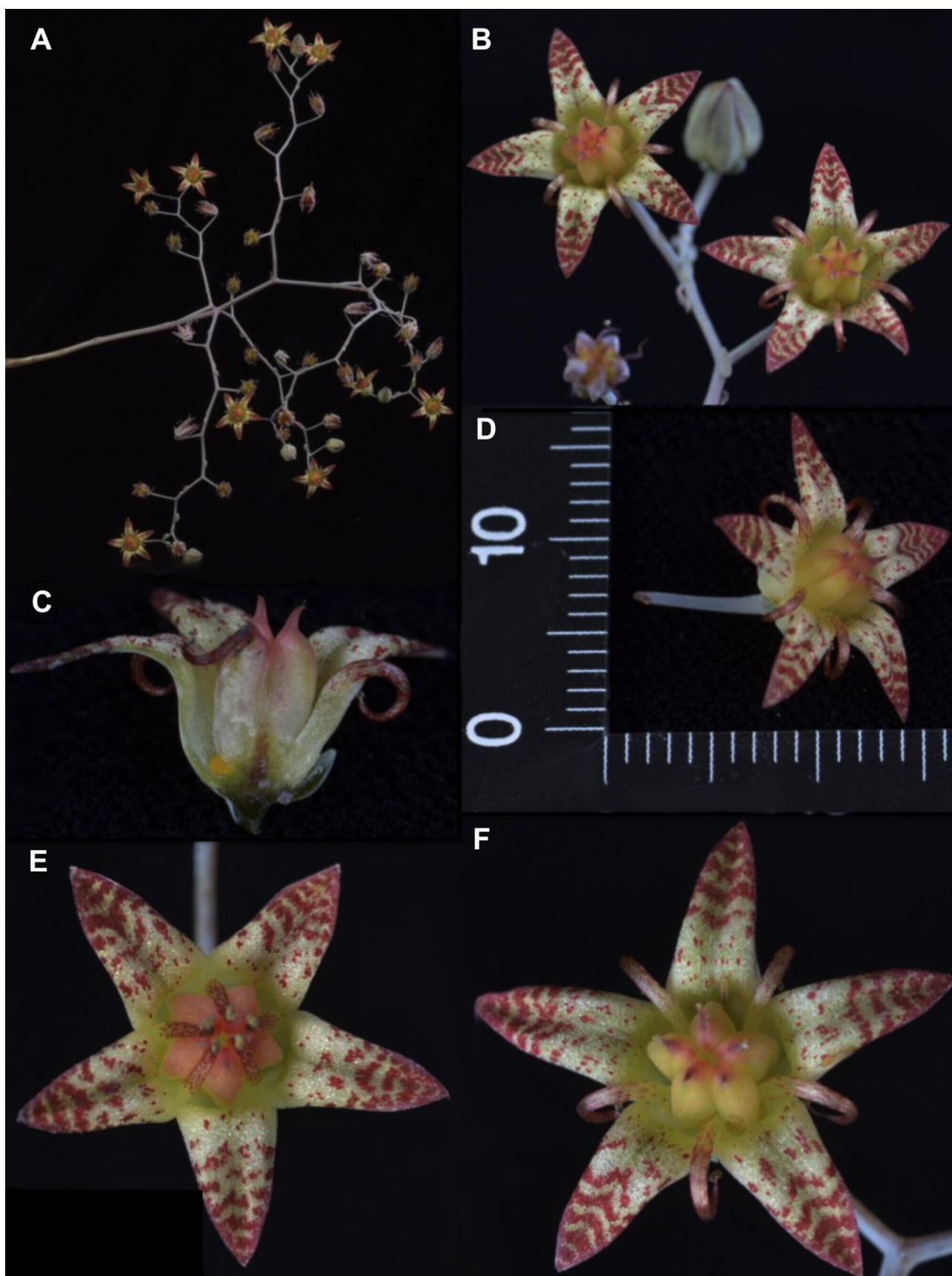


FIGURE 15. *Quetzalcoatlia itzicuaroensis*. Photographs: J. Etter & M. Kristen (No. 1089). Apr. 2022.

Description:—**Plants** herbaceous, perennial, 8.0–30.0 cm tall without inflorescence, caulescent, pendant, cespitose-ramose, sometimes forming dense groups, branching basally and from the leaf axils; stems 4.0–22.0 × 0.25–0.35 cm at

the base, erect at first, later decumbent to pendant, surface smooth, green-brownish to grayish, pinkish to green-glaucous from a short segment below the rosette upwards; leaf scars prominent, 1.0–1.5 mm in diam., circular, green-brownish, the tips grayish; rosettes terminal (2.3–)4.0–8.0 × (2.8–)3.5–5.0 cm, with somewhat scattered leaves but compact to the apex, with 15–30 leaves. **Leaves** 1.4–2.7(–3.2) × 0.7–1.3 cm, 4.0–4.5 mm thick, the thickest part near the middle, broadly oblong, straight to sometimes incurved, shortly acuminate, greenish to glaucous-pinkish, sometimes with a different darker pinkish to purplish tonality toward the apex, somewhat pruinose, papillose; the margins entire, rounded; the base obtuse to truncate, the stalk-like, basal portion 12.0–13.0 mm wide; the apex acute, usually inclined upwards, adaxially slightly concave, abaxially convex; apical mucro 1.0–2.0 × 1–1.5 mm. **Inflorescences** as paniculate cymes, 18.0–28.0 × 10.0–11.1 cm, the fertile portion 6–7 mm long; (10–)15–24 flowers on 2–4 primary branches; primary axis 2.5–3.5 mm thick at the base, 1.0–1.2 mm thick above, gray-bluish to pinkish; bracts on primary axis 1.0–1.3 × 0.4–0.7 cm, those below the branches 0.2–0.4 × 0.1–0.2 cm, gradually smaller upwards to 0.4–0.7 × 0.2–0.4 cm; oblong-obovate or lanceolate to elliptic; the basal primary branches 2.0–6.0 cm, somewhat zig-zag shaped, the basal usually simple, with 1–4 flowers, the rest mostly bifurcate, with 1–7 flowers each; bracteoles 1.1–1.5 × 0.7–0.8 mm irregularly scattered, lanceolate to elliptic, obtuse at the base, acute at the apex, glabrous, grayish to pinkish; pedicels 0.6–1.1 × .06–0.1 cm, the same color as the primary axis or dark reddish; flower buds ovoid, obtuse at the base, acute at the apex, the corolla pentacostate, whitish to pinkish toward the apex, calyx reaching to *ca.* $\frac{1}{3}$ of its length, glaucous green. **Flowers** 12.5–15.5 mm in diameter; calyx fused 0.5–0.6 × 2.7–3.6 mm; calyx lobes 1.5–1.8 × 1.3–1.4 mm, triangular, glaucous-greenish; corolla tube 2.4–2.9 × 4.1–4.5 mm; corolla lobes 5, subequal, 4.9–6.2 × 2.2–2.6 mm at the widest part (near the middle), triangular, shortly acuminate, bending back, white with conspicuous red stains along, with a shallow middle-groove along; proximally white-pinkish, to distally reddish-wine; nectaries 0.7 × 0.7 mm, bright yellow; stamens 5; erect at first, later curving outside, white-pinkish, filaments 3.9–4.1 × 0.1–0.4 mm, anthers ellipsoid 0.5–0.6 × 0.2–0.4 mm white or blackish; gynoecium 6.7–6.8 × 3.7–3.8 mm, protruding from the corolla 2.3 mm, creamish-yellow to yellow-greenish, obovate, carpels 5.0–6.1 mm, abaxially obtuse to rounded, pale yellowish to pale greenish, the tips reddish; styles 1.3–1.4 × 0.3–0.4 mm long, reddish; stigmas 0.1–0.2 mm in diam., pale pink. **Fruits** 5.4–5.6 × 1.2–1.4 mm; seeds 0.41–0.49 × 0.15–0.18 mm.

Notes:—*Quetzalcoatlia kristenii* is similar to *Q. itzicuarioensis*, but it differs from the latter in rosette diameter, 3.4–5.0 cm vs. 6.0–8.0 cm; leaf broadly oblong vs. obovate; basal branch with fewer flowers than in the rest of branches vs. with an overlapping number of flowers concerning the rest of branches; flower diameter 12.5–13.5 vs. 17.0–19.0 mm; petal width 2.2–2.6 mm vs. 1.7–1.8 mm; petal widest part near the base vs. near the middle; and petal color pattern white with conspicuous red spots along vs. white to yellowish, with a rhomboid dark red spot in the upper half of the petal.

Distribution, habitat, and phenology:—So far, *Quetzalcoatlia kristenii* is known only from a single population in the Sierra de Coalcomán, Michoacán. It grows in tropical deciduous forest on rocky vertical slopes along a small portion of the Río Coalcomán, at an elevation between 700–800 m, with *Agave andreae* Sahagún & A. Vázquez, *Anthurium halmoorei* Croat, *Philodendron warszewiczii* K. Koch & C.D. Bouché, *Bursera* spp., *Epidendrum ciliare* L., *Oncidium leleui* R. Jiménez & Soto-Arenas; *Mammillaria* sp., *Opuntia* sp., *Selenicereus murrillii* Britton & Rose, *Pittocaulon hintonii* H. Rob. & Brettell, *Pseudobombax* sp., and *Tillandsia* spp. The development of the inflorescence starts to be evident during the first two months of the year. The flower anthesis occurs between early March and early April, fruiting in May.

Etymology:—The specific epithet honors Martin Kristen, an outstanding explorer, horticulturist, and expert in succulent plants, whose work contributed to the discovery of some new species of Asparagaceae and Crassulaceae, including the one described here.

Preliminary conservation assessment:—We assessed the new species as Critically Endangered (CR) based on the IUCN Red List criteria B1ab(iii) (IUCN 2022). The species is known from a single population (condition a) within an area of less than 10 km². The EOO is 10 km² (criterion B1) and the AOO is 4.0 km². There is a continuing decline observed in the extent and quality of its habitat (condition b(iii)). A population reduction is expected due to deforestation for agriculture and climate change, which could cause more severe natural disasters and alter the microclimate of this fragile habitat.

Quetzalcoatlia latipetala A. Vázquez, I. García & Rosales *sp. nov.* (Figs. 1–3 & 17–18).

Type:—MEXICO. Michoacán: municipality of Aguililla, at the waterfall of El Salto, 4 km north of Aguililla, Sierra de Coalcomán, 1200 m, May 1973, *Alfred Lau* 49 (holotype HNT!).

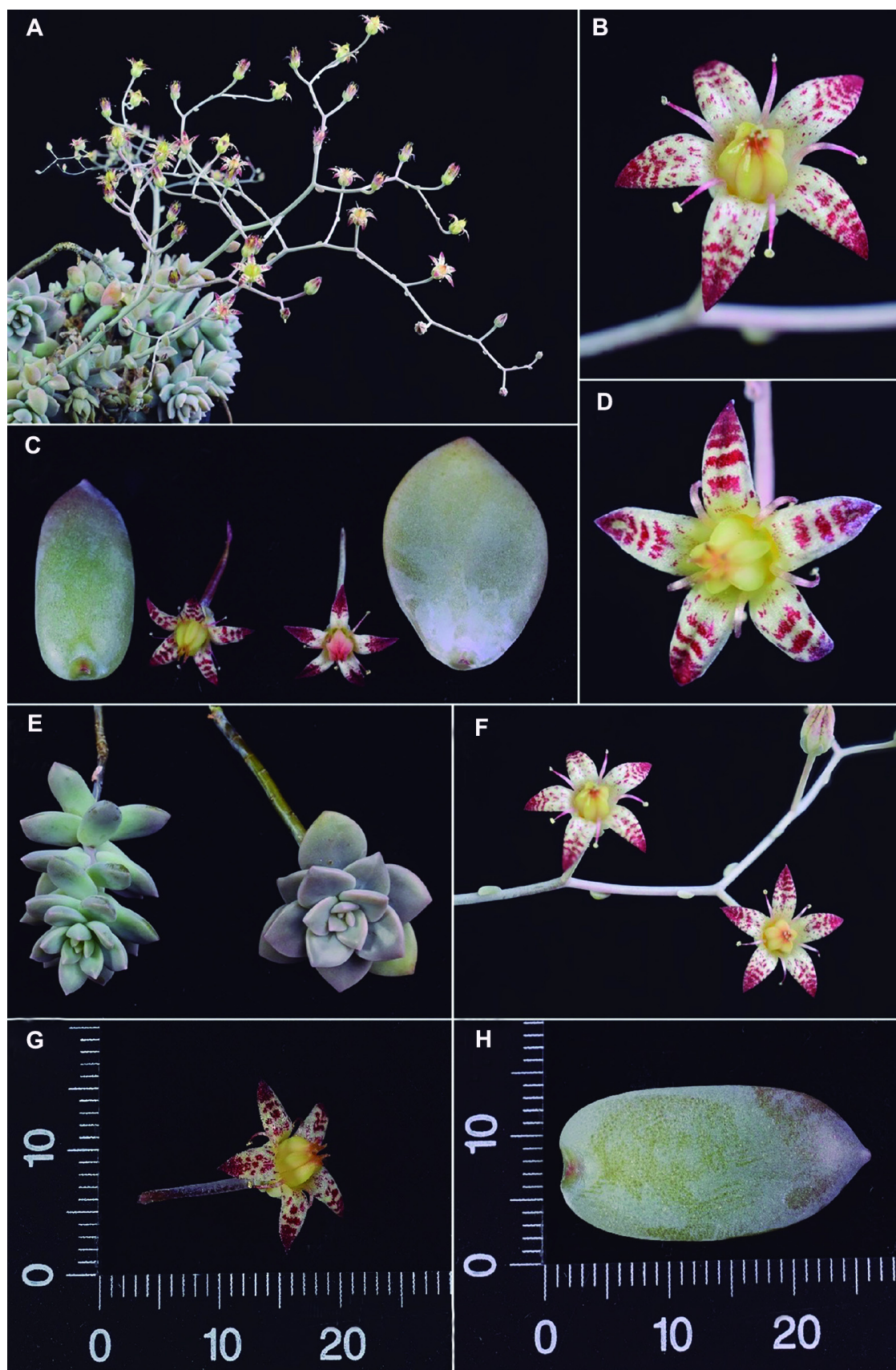


FIGURE 16. *Quetzalcoatlia kristenii* (Pinzán, municipality of Coalcomán). A. Habit, rosettes and inflorescence. B, D. Flowers at anthesis. C. Leaf and flower variability. E. Rosettes. F. Section of inflorescence. G. Flower size. H. Leaf size. Photographs: J. Etter & M. Kristen, Mar. 2013.

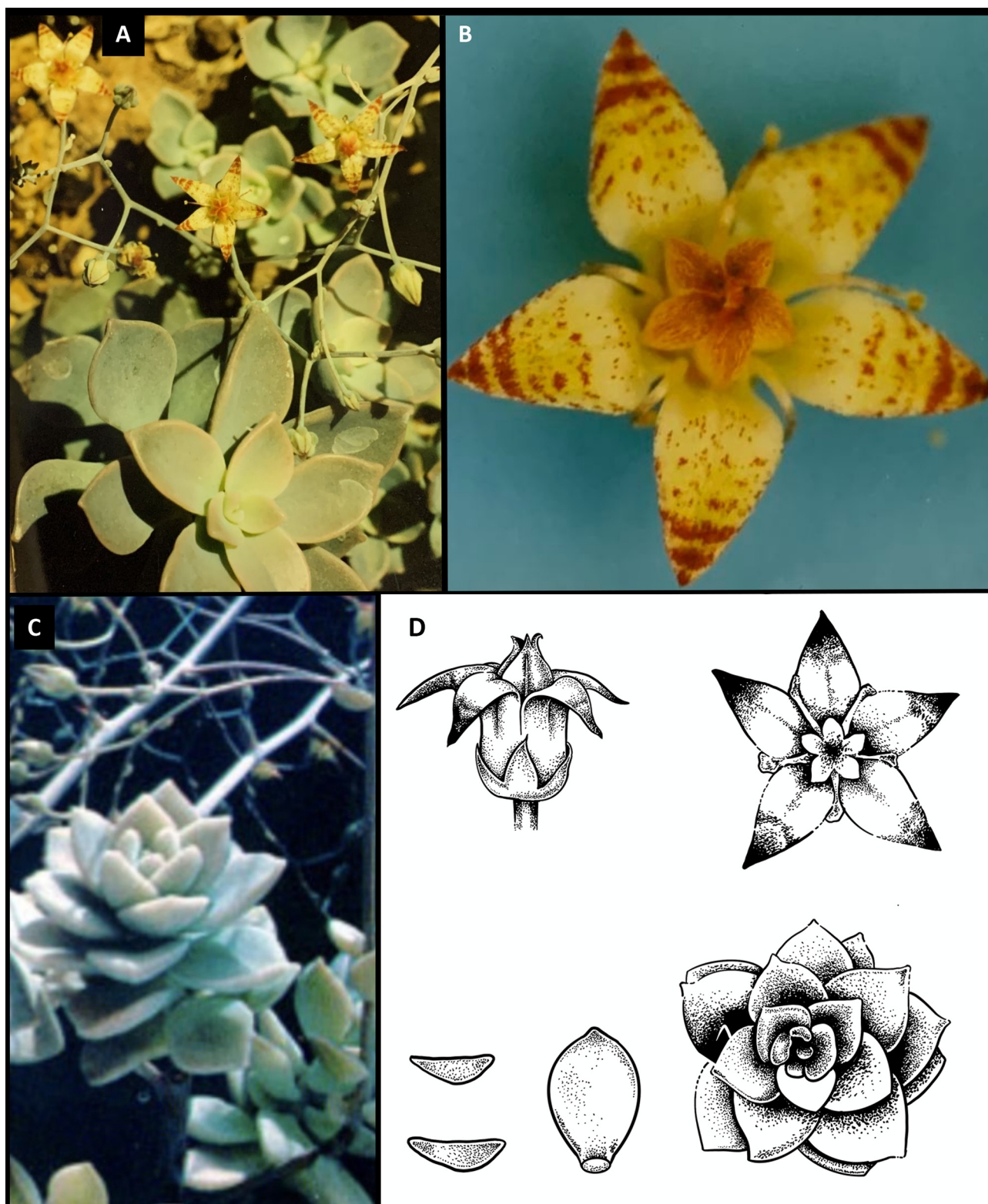


FIGURE 17. *Quetzalcoatlia latipetala* from El Salto, Aguililla, Michoacán. Photographs A & B by I García-Ruiz; C reproduced from Kimmach (1987); D redrawn by Daniel Barba from Kimmach (1987).

Diagnosis:—*Quetzalcoatlia latipetala* is similar to *Q. pentandra*, as they overlap in rosette size and share basal thickened bracts, but it differs from the latter in having shorter habit 15.0–16.0 vs. 19.0–24.0 cm, stouter vs. slender stems; leaves mostly concave, upward and abruptly attenuate vs. convex to flat, reflexed and gradually attenuated; leaves yellowish to bluish green, slightly pinkish at the margin vs. blue-glaucous to tinged with lavender; basal bracts $1.6\text{--}2.3 \times 1.0\text{--}1.2$ cm long, ovoid, acute at the apex vs. 3.5×1.5 cm long, lenticular and obtuse at the apex; more numerous flowers per full-sized inflorescence 23–27 vs. 31–36; shorter pedicels 0.8–1.7 vs. 1.8–2.3 cm; wider flowers 20.0–21.0 vs. 17.9–18.0 mm; larger corolla lobes, $8.0\text{--}8.1 \times 4.5\text{--}4.6$ mm, distally

less reddened, banded and spotted at the lower half vs. $6.9\text{--}7.0 \times 1.7\text{--}1.75$ mm, distally solid rusty reddish and mostly none spotted at the lower half.

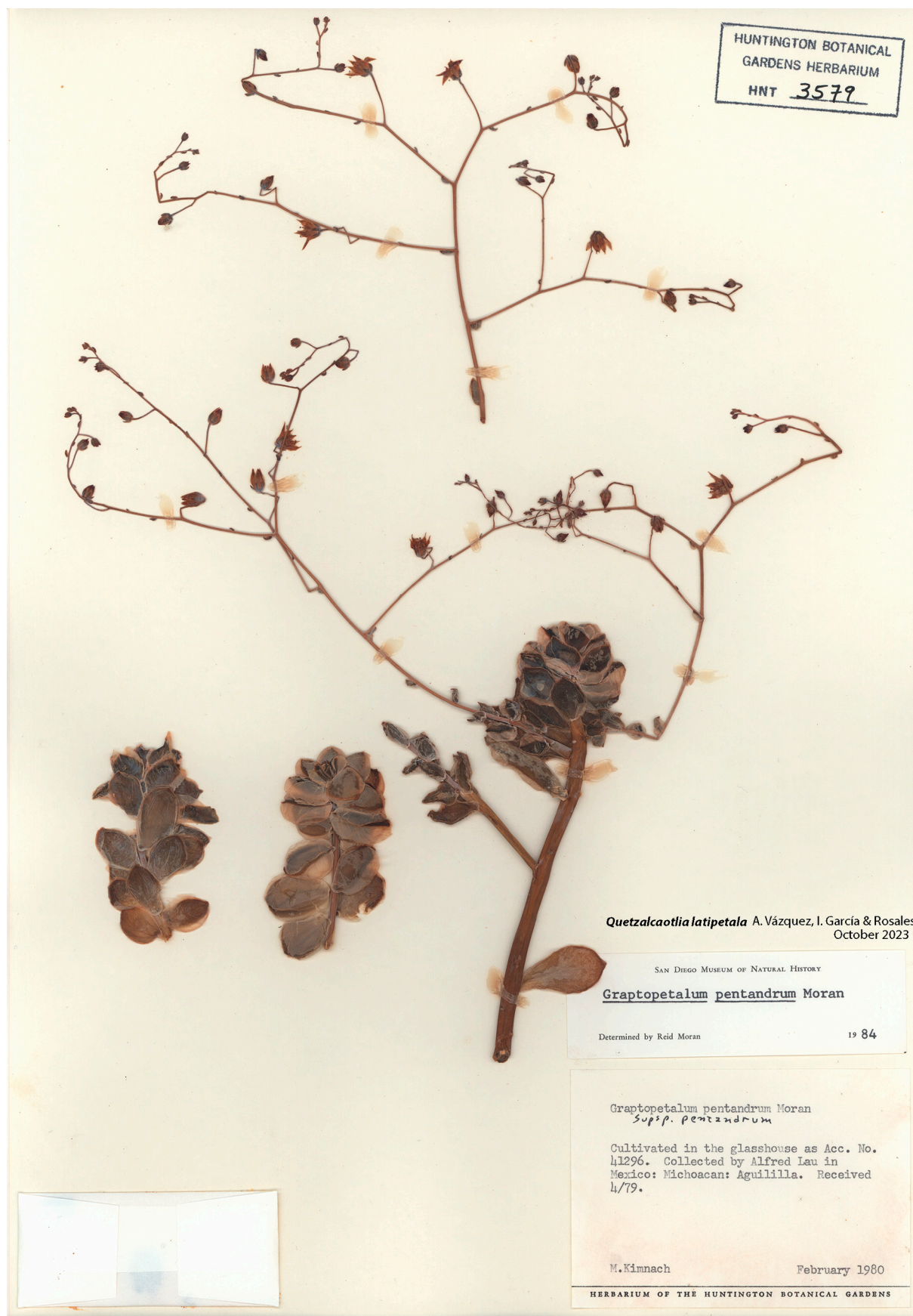


FIGURE 18. *Quetzalcoatlia latipetala*. Clonotype from Lau 49, accession HBG-41296, from El Salto, Aguililla, Michoacán, Apr. 1979, Kinnach s.n. (HNT).

Description:—**Plants** herbaceous, perennial, 15.0–16.0 cm tall, excluding inflorescence, erect to decumbent, ramose with lateral branches below the rosette; stems 8.4–9.5 × 0.5–0.6 cm, smooth with brown scars; leaf scars 1.2–1.4 × 0.9–1.2 mm, flat, broadly elliptic to subcircular and brown; rosettes terminal, 3.2–3.8 × 5.8–6.8 cm with 17–18 leaves. **Leaves** 2.1–3.1 × 1.2–1.6 cm, 2.2–2.3 mm thick at the base, obovate to broadly obovate, to broadly ellipsoid, adaxially concave, abaxially convex, yellowish to bluish green, the margins slightly pinkish; the base cuneate, the stalk-like, basal portion 3.5–3.6 mm wide, the apex obtuse to acute, apiculate with a mucro *ca.* 1.0–1.5 × 0.8–3.3 mm. **Inflorescences** up to 3, 13.0–21.3 × 16.0–24.0 cm, the fertile portion 8.0–13 cm long, with 23–27 flowers on 3–4 secondary axes (branches), each branch spaced 2.1–2.6 cm; primary axis 2.9–3.1 mm thick at the base, 1.1–1.2 mm thick above, straight and perpendicular to the stems, brown; bracts 8–10, proximal ones 9.0–9.2 × 6.6–6.8 mm, obovate and obtuse, the basal bracts ovoid; branches 9.3–11.6 cm, simple, zigzagged or straight, brownish, with 5–8 flowers, the basal branches bearing 5–8 flowers and nearly perpendicular to primary axes, proximal pedicels spaced 2.4–3.4 mm; bracteoles 7–10, distal ones 1.7–32.1 × 1.1–1.3 mm, narrowly oblongoid acute at the apex, grayish dull green; pedicels 0.8–1.7 × 0.11–0.13 cm, distally ticker, pale brownish when dried; flower buds 4.7–4.9 × 5.4–5.6 mm, ovoid, the sepals covering $\frac{2}{3}$ of the corolla, the calyx glaucous to grayish dull green, glabrous, the corolla yellowish. **Flowers** 20.0–21.0 mm in diam.; calyx fused 0.4–0.6 × 4.4–4.5 mm; calyx lobes 5, 3.7–3.9 × 1.3–1.7 mm, dull greenish, distally darker; corolla tubes 2.9–3.1 × 4.0–4.1 mm; corolla lobes 5, 8.0–8.1 × 4.5–4.6 mm, triangular, creamy white to greenish at the base, rusty reddish at the distal third, faintly red banded or dotted; stamens 5, erect at early stage of anthesis, later reflexed; filaments 5.3–5.4 × 0.5 mm, proximally yellowish at the base, reddish at the distal $\frac{2}{3}$; nectaries unknown; stamens 5, erect in the early stage of anthesis, later reflexed; anthers subglobose 0.8 mm in diam., yellowish to pale brown; gynoecium 8.8–9.0 × 5.1–5.5 mm, mostly yellowish the lower half, reddish the distal 5–10%, the carpels 9.1–9.2 × 2.0–2.3 mm, keel at right angle, abaxially pinkish at the middle, reddish at the apex; styles 1.1–1.2 × 0.1–0.5 mm, dark red; stigmas 0.3–0.4 mm. **Fruits** 9.1–9.2 × 0.5–0.6 mm, obovoid, dark brown, the apex of carpels with a persistent beak, arched-out; seeds 0.48–0.52 × 0.24–0.36 mm, narrowly oblong, beige.

Distribution, habitat, and phenology:—*Quetzalcoatlia latipetala* is known only from some subpopulations at the type locality, in the waterfall of El Salto, Aguililla, Michoacán, in tropical deciduous forest, at an elevation of approximately 1200 m, growing with *Mammillaria knippeliana* Quehl and *Mammillaria xaltiangensis* var. *aguilensis* Repp. It flowers from early March to April, fruiting in June.

Etymology:—The specific epithet “*latipetala*” refers to its broad petals, the broadest and largest among *Quetzalcoatlia*.

Notes:—The species was first collected by Alfred Lau in May 1973, who thought he had discovered the first wild population of *Graptopetalum pentandrum*. In the late 1990’s, the species was again collected and photographed by Ignacio García, which allowed us to describe this distinctive new species, half a century after its discovery. Gametic chromosome number: $n=32$ (Kinnach 1987). It has some potential as an ornamental.

Preliminary Conservation Assessment:—Following the IUCN Red List criteria B1ab(iii) (IUCN 2022) this species was assessed as Critically Endangered (CR): The EOO is less than 100 km² (B1); The AOO < 10 km² (B2); this species is only known from a single location (condition a); and we inferred a decline of quality of its habitat (condition b(iii)) through land use change, recreation and increasing water demands for irrigation. This species is being reproduced at HNT.

Additional specimens examined:—MEXICO. Michoacán: Municipality Aguililla, at the waterfall of El Salto, approx. 8.5 km north straight line of Aguililla, east side of Sierra de Coalcomám, 795 m, 20 April 1998, cultivated at Jiquilpan, *I. García*, 5130-Bis (CIMI!); same locality, 10 April 1999, cultivated at Jiquilpan, *I. García* 5592 (CIMI!).

Quetzalcoatlia pentandra (Moran) A. Vázquez & Rosales, *Boletín Nakari* 34(2): 39 (2023) (Figs. 1–3 & 19).

≡ *Graptopetalum pentandrum* Moran, *Cactus and Succulent Journal* (Los Angeles) 43: 255, Figs. 1–4 (1971).

Type:—Cultivated. MEXICO. Jalisco: Obtained in a small nursery in Guadalajara, January 1970. by *F. Boutin* & *M. Kinnach* 2922 (holotype SD!, isotypes HNT!, MEXU!, US!). Native source unknown, grown at the Huntington Botanical Gardens, no. 25082; pressed by *R. Moran*, 12 April 1971.

Diagnostic characters:—*Quetzalcoatlia pentandra* is unique in the genus by having elongate and slender inflorescence, branches, and pedicels. Its full-sized rosettes “are reminiscent of *Pachyphytum* [*Graptopetalum*] *amethystinum*” (Rose 1905: 11) Walther (1931: 12) in having obovate to broadly oblanceolate leaves, each contracted at the base to a narrow attachment, and the lavender shading of the leaves, but differs from the latter in having thinner stems and leaves, which usually are relatively wider.



FIGURE 19. *Quetzalcoatlia pentandra*. A. Inflorescence. B. Flower at male phase. C–D. Rosettes. Photographs from TYPE material, reproduced from Moran (1971).

Description (from protologue):—Suffrutex erect, decumbent, 19.0–24.0 cm tall, caulescent; stems up to 5.0–15.0 × 0.3–0.6 cm, at first erect, rather woody and strong, smooth, dull green but heavily glaucous; leaf scars 1.5–2.0 mm wide, 1.0 mm high, with a single vascular bundle scar, bumped and tan; rosettes 3.0–9.0 × 6.0–8.0 cm wide, irregular, lax, of ca 15–36 rather scattered leaves, with internodes to 1.5 cm long, distally more crowded. **Leaves** 3.0–4.0(–5.5) × 1.5–2.3 cm × 1.5–2.3 cm, 5.0–8.0 mm thick, mostly obovate and obtuse to rounded, the lower ones sometimes broadly oblanceolate and somewhat reflexed, adaxially flattened, abaxially rounded, at first blue-glaucous, somewhat tinged with lavender, deciduous after withering; margins obtuse; base 6.0 mm wide and 5.0 mm thick, cuneate, contracted to a narrow attachment; apex mostly obtuse, or rounded or truncated, submucronate. **Inflorescences** 20.0–35.0 cm long; flowers per full-sized inflorescence 31–36, on 3 alternate secondary axes (branches), each branch spaced 2.3–3.0 cm; primary branches, primary axis arising 2.0–8.0 cm below the stem apex, supra-axillary, 2.5–3.0 mm thick at the base, slender, spreading, with 14–17 leaves in the 8.0–15.0 cm below the inflorescence but mostly crowded at or near the base; basal bracts *ca.* 1.0–1.5 cm long, nearly as wide, 5.0–6.0 mm thick, or the lower to 35.0 mm long and 15.0 mm wide, mostly lenticular, obtuse, spreading perpendicular to the stem, turning gradually into much smaller and relatively narrower bracts above; branches 3–4, simple or bifurcate, 10.0–15.0 cm long and less than 1.0 mm thick, each with 3–11 flowers; The basal branch with 3–11 flowers; pedicels mostly 1.8–2.3 cm long, 1/3 thick, slightly thicker above. **Flowers** pentamerous, 10.0–11.0 mm long unopened, 17.9–18.1 mm in diameter, erect; calyx 4.0–4.5 × 4.5–5.0 mm, cup-shaped, glaucous, the disk 3.0–3.5 mm wide; calyx lobes nearly equal, 3.5–4.0 × 1.5 mm, 0.5 mm thick, narrowly ovate, subacute, appressed to the corolla; corolla yellowish white marked with dark red; corolla tube 3.0–3.5 × 4.0 mm, proximally yellowish-white; corolla lobes *ca.* 6.9–7.0 × 1.7–1.75 mm, triangular, acute, ventrally low-papillose and almost solid dark red in the distal half, with a transversal-stripe below but adaxially with only scattered uncolored cells, mostly near the margins; nectaries bright yellow, 0.4 × 0.9 mm, 0.3 mm thick, truncate above, the secretory face ± normal to the floral axis, obtusely lunate; stamens 5, antesealous, at first erect, in age reflexed between the petals; filaments 8.0 mm long from the corolla base, 0.3 mm wide and 0.5 mm thick, adnate 3.0 mm to the corolla and less than 0.5 mm to the intercarpellary tissue, greenish, red-marked in upper half; anthers 1.0 × 0.7 mm, red, dehiscent while filaments still erect; gynoecium 7.0–7.5 mm high, 3.5 mm thick above, 2.0 mm thick at the base, greenish somewhat marked with red above; carpels erect, obtuse and keeled, connate 2.5 mm, slightly separated above, keeled, tapering abruptly to styles barely 1.0 mm long; ovules *ca.* 70, *ca.* 0.6 × 0.2 mm thick, cylindric. **Fruits** and seeds unknown.

Distribution, habitat, and phenology:—Only known from the type material of cultivated source. It flowers in April, fruiting in May.

Etymology:—Its specific epithet refers to the five stamens of its flowers.

Notes: In 1970, Frederick Boutin and Myron Kimnach found in a small nursery in Guadalajara, Mexico an unfamiliar *Echeveria*-like species of unknown origin (Boutin & Kimnach 2022), which was then grown at the Huntington Botanical Garden (no. 25082) and collected in flower in April 1971 by Reid Moran and also by Myron Kimnach, and described by Reid Moran as a new species.

In plants of the Huntington Botanical Gardens, the stems are short and mostly erect. Some are semidecumbent but perhaps partly because of the way they were transplanted. However, they will likely be decumbent in age. Leaves are variable in shape. The upper leaves are obovate, about 3.0–4.0(–5) × 2.0 cm; the lower ones are broadly oblanceolate. After losing the lower leaves, those remaining are more uniformly obovate: the longer ones perhaps occur only on young meristems. Several authors have included within this species concept two additional populations from the state of Michoacán (Aguililla, Sierra de Coalcomán and Chorros del Varal, Los Reyes) (Kinnach 1987, Thiede 2003, Cházaro-Basáñez *et al.* 2004, Acevedo-Rosas *et al.* 2018). However, we argue, based on numerous quantitative and qualitative characters in their flower and rosette morphology, that the two populations represent distinct taxa and we describe them here as two new species: *Q. latipetala* and *Q. itzicuarioensis*, respectively. Gametic chromosome number: *n*=32 (Kinnach 1987).

Preliminary conservation assessment:—Since this species has not been confirmed in the wild since its discovery over half a century ago (1970), there is no appropriate data on abundance or distribution. For this reason, this species was assessed as Data Deficient (DD). Its clonotype is reported to exist at HNT.

Quetzalcoatlía rosanevadoensis (A. Vázquez & Acev.-Rosas) A. Vázquez & Rosales, *Boletín Nakari* 34(2): 39 (2023) (Figs. 1–3 & 20).

≡ *Graptopetalum rosanevadoense* A. Vázquez & Acev.-Rosas, *Phytotaxa* 496(2): 162 (2021).

Type:—MEXICO. Jalisco: municipality of Zapotitlán de Vadillo, Nevado de Colima volcano, Cuenca del Río Alseseca, Los Lavaderos, 4 km E of Telcruz, on a vertical sandy slope of NW exposure, 1400 m, 7 May 2005 (fl), J. Antonio Vázquez-García 7990, with M. Cházaro, N. Contreras & R. Murguía (holotype IBUG!, isotypes MO!, NY!).

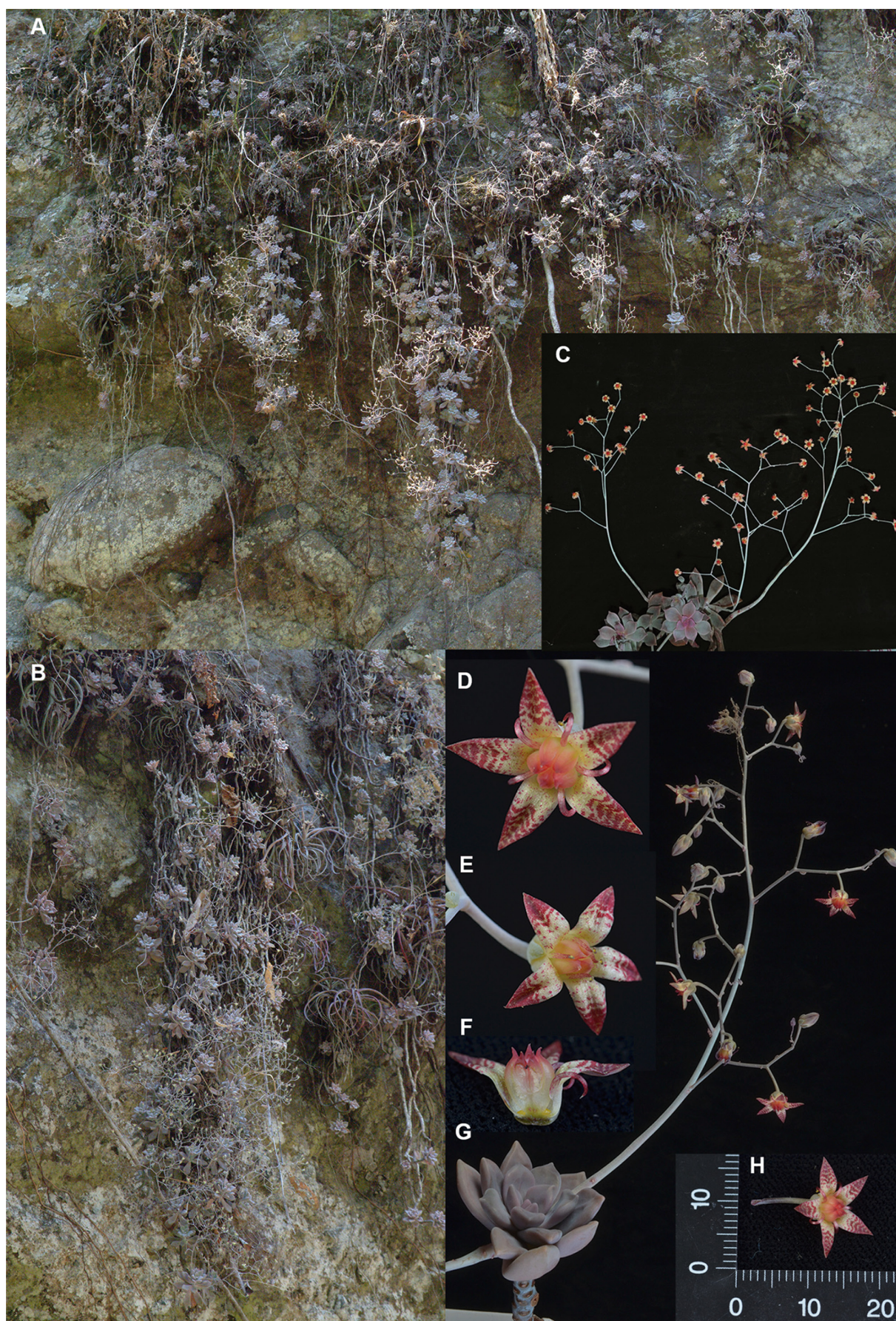


FIGURE 20. *Quetzalcoatlia rosanevadoensis*, from Lavaderos, Zapotitlán de Vadillo, Jalisco. A–B. Habitat and habit. C. Rosettes and inflorescences. D. Flower at anthesis. E. Flower at male phase. F. Flower cross-section. G. Rosette and inflorescence. H. Flower size. Photographs by J. Etter & M. Kristen.

Description:—**Plants** suffrutex, perennial, 40.0–96.0 cm tall, caulescent, ramose; stems 0.7–0.8 cm diam., decumbent, pendulous, smooth; rosettes terminal, 4.0–5.0 × 10.0–16.0 cm, sparse, with 31–47 leaves. **Leaves** (1.5–)3.0–4.0(–7.6) × (1.4–)1.6–1.8(–1.9) cm, (4.0–)5.0–7.0(–8.0) mm thick, oblong–obovate, obtuse to rounded, inner surface slightly concave, glaucous to brownish green, pinkish when young; base cuneate; apex sometimes with a short mucro. **Inflorescence** (9.8–)10.5–20.3(–60.0) cm long; primary axis 1.5–4.0 mm thick at the base, 1.0 mm thick at the top; bracts 23–29, ovoid, the lowest 1.9–3.1 cm long, the uppermost 2.0–3.0 mm long, soon deciduous; branches 5–6, 2.4–4.3 cm long, simple or bifurcate, with 2–4 flowers each; Number of flowers per full-sized inflorescence 14–34; pedicels 0.3–1.4 cm long; flower buds 3.0 × 3.0 mm. **Flowers** 14.9–15.1 mm in diameter; calyx lobes 5, 3.0 mm long, distinct, appressed; corolla tube 2.9–3.1 mm; corolla lobes 5, 5.4–5.5 × 2.9–3.0 mm, proximally creamy-white to yellowish-green, distally red-wine, forming horizontal bands below the apex; nectaries 0.5 × 1.0 mm, truncate; stamens 5, alternate to the petals, at first erect, later completely recurved; filaments white with the apical half dotted with red or pinkish red; gynoecium *ca.* 0.5 mm long, obovate, yellow-green; abaxial carpels obtuse to rounded, entirely red; styles 0.9 mm, orange, red-orange or dark red apically. **Fruits** 5.3–5.9 × 1.4–1.6 mm; seeds 0.35–0.42 × 0.15–0.19 mm.

Notes:—It is similar to *Quetzalcoatlia superba* in sharing a non-caespitose and ramose habit, similar stem length, and oblong obovate leaves, but it differs from the latter in having a stem surface smooth vs. squamose, stem diameter 0.7–0.8 vs. 1.0–1.2 cm, leaves per rosettes 31–47 vs. 12–28, leaf color glaucous to brownish green, pinkish when young vs. grey-blue to pink-violet, inflorescence length 9.8–27.5 vs. 30.0–40.0 cm, and branches per inflorescence 5–6 vs. 12–15. It is also similar to *Q. pentandra* in stem length with smooth surface and color pattern of petals, but it differs from the latter in having a none caespitose-ramose habit vs. caespitose-ramose, rosette diameter 10.0–16.0 vs. 6.0–8.0 cm, stem diameter 0.7–0.8 vs. 0.3–0.6 cm, leaves 31–47 vs. 12–20, leaf color glaucous to brownish green, pinkish when young vs. blue-green to white blue, branches per panicle 5–6 vs. 3–4.

Distribution, habitat, and phenology:—*Quetzalcoatlia rosanevadoensis* is known only from two subpopulations almost contiguous to the type locality, on the western slopes of the Nevado de Colima, found in creeks of tributaries of the Alseseca river, at 1400 m on shallow sandy soils, on vertical slopes of protected ravines with a tropical dry forest surrounded by oak forest on the adjacent hills. It flowers in May and perhaps in November as we were told by local inhabitants, presumably fruiting in June.

Etymology:—The specific epithet honors Ing. Rosa Murguía Araiza, an energetic and enthusiastic silviculturist and conservation activist, from Zapotitlán de Vadillo, Jalisco, on the SW slopes of Nevado de Colima, where she discovered this species while going with her mother to wash their clothes at Los Lavaderos, in the Alseseca river basin.

Notes:—The hanging rosettes are called “*chonguitos*”. Smashed leaves are used for eye cleaning, rosettes are collected and grown in the backyards as ornamentals, and the leaves are often eaten by birds (especially sparrows) while in flower pots. Plants of this species are sold as “*Graptopetalum acevedoi*”, a *nomen nudum*, because Antonio Vázquez initially meant to name it so. However, at last, Raúl Acevedo-Rosas proposed to name it after its discoverer and the volcano where it was found.

Preliminary conservation assessment:—*Quetzalcoatlia rosanevadoensis* was assessed as Critically Endangered (CR) using the IUCN guidelines (IUCN 2022). Population reduction is expected due to the high humidity requirements of this species. Its association with protected shady creeks in an area with a marked dry season makes it vulnerable to climate change. Criterion B2ab(iii): A very narrow distribution is usually the case for species of *Quetzalcoatlia*. The area of occupancy (AOO) is less than 10 km² (criterion B2) where only two nearly contiguous subpopulations are known from a single location (condition a). There is a continuing decline observed in the extent and quality of its habitat (condition b(iii)). Criterion C2a(i): The population size is very small, with less than 50 mature individuals, and is expected to decline.

Additional specimens examined:—MEXICO. Jalisco: Las Goteras, Los González, Ejido de Zapotitlán de Vadillo, 15 May 2005, *R. Murguía-A. 21* (IBUG); Punta del Plan, Municipio de Zapotitlán de Vadillo, 15 May 2005, *R. Murguía-A. 27* (IBUG); Bajada del Borrego, Municipio de Zapotitlán de Vadillo, 15 May 2005, *R. Murguía-A. 32* (IBUG).

Quetzalcoatlia santanamichelii A. Vázquez, Cuevas & B. Gut. *sp. nov.* (Figs. 1–3 & 21).

Type:—MEXICO. Jalisco: municipality of Casimiro Castillo (La Resolana), La Calera, Reserva de la Biosfera Sierra de Manantlán, 11–12 km SSW de Autlán, bosque tropical subcaducifolio con *Brosimum*, *Hura*, *Lonchocarpus*, 23 May 2023 (fl & fr), *J. Antonio Vázquez-García 10264 w/ Byron Gutiérrez, J. Padilla Lepe y Adrián Jiménez* (holotype IBUG!, isotype ZEA!).



FIGURE 21. *Quetzalcoatlia santanamichelii*, from Casimiro Castillo, western side of Sierra de Manantlán Biosphere Reserve, Jalisco. Photographs A, C–D & F. by D. Figueroa-S., B by A. Vázquez-García, May 2023, and E. by J. Padilla Lepe, May 2022.

Diagnosis:—*Quetzalcoatlia santanamichelii* is similar to *Q. superba* in having a ramose habit, plant size, and oblanceolate leaves, but it differs from the latter in having narrower stems, 0.6–0.9 (vs. 1.0–1.2 cm); stem surface smooth vs squamose; leaves pinkish–grayish green vs. gray–bluish to pink–violet); shorter inflorescences 12.0–21.1 (vs. 30.0–40.0 cm); less numerous branches per full-size inflorescence 4–8 (vs. 12–15); less numerous flowers per branch 1–5 (vs. 8–15); less numerous flowers per basal branch 1–3 (vs. 8–12); less numerous flowers per full-size inflorescence (10–) 15–27 (vs. 57–121); smaller flower diameter 8.5–11.0 (vs. 15.0–16.0 mm); smaller corolla lobes 3.9–4.0 × 1.9–2.0 (vs. 5.5–6.0 × 2.0–2.7 cm); abaxial carpels yellowish, reddish only toward the apex (vs. entirely red); shorter fruits 4.75–5.25 (5.3–5.9 mm) and larger seeds 0.52–0.64 × 0.23–0.29 (vs. 0.35–0.42 × 0.15–0.19 mm).

Description:—**Plants** suffrutex, perennial, 10.0–88.0 cm tall without inflorescence, ramose, entirely glabrous, branching basally; roots fibrous; stems first erect, later decumbent to pendulous, 7.0–85.0 × 0.6–0.9 cm, 0.7–1.3 cm thick below the rosette, surface smooth, brownish green in the base, pinkish and slightly pruinose between the leaves, to with oval pale-green leaf scars, raised somewhat 1.0 mm long, 2.0–3.0 mm wide; rosettes almost flat, 2.8–3.0(–6.5) × 4.8–6.5(–12.5) cm, 17–26 leaves. **Leaves** 2.1–3.8(–6.5) × 1.2–1.9 cm, 3.0–5.0 mm thick, oblanceolate-spatulate, base cuneate, adaxially almost flat to slightly convex, abaxially slightly convex, sometimes diffusely keeled, entire margin, apex obtuse-rounded, rarely acute, mucronate, mucro 2.0–3.0 mm long, 2.0–3.0 mm wide, the apical ones slightly ascending, the older ones slightly reflex, pinkish–grayish green, epidermis lemon green beneath a light layer of wax. **Inflorescences** 1–3 per rosette, lateral, paniculate, 12.0–21.1 cm long, 2.0–4.0 mm wide in the base, 8.0–10.7 cm of the peduncle from the base to the first primary branch, (10–)15–27 flowers per full-sized inflorescence, whitish green; bracts 7.0–9.0 × 9.0–13.0 mm long, 4.0–6.0 mm wide, elliptic-lanceolate, primary branches 4–8, with 1–5 flowers, the basal branch with 1–3 flowers; pedicels 0.4–1.0 cm long, same color as the peduncle. **Flowers** pentamerous, 8.5–11.0 mm in diameter; sepals subequal, 1.9–2.0 mm long, lanceolate, same color as the leaves; petals subequal 5.8–6.0 mm, forming a 3.0–4.0 mm long tube, the lobes 3.9–4.0 × 1.9–2.0 mm at the widest part near to the center, elliptic, apex subacute, whitish–pale yellow with red spots forming diffuse horizontal stripes but present more densely at the apex, orange-yellow near to the base; nectaries reniform, 1.0 mm wide, orange-yellow; stamens 5, antesealous, 3.0–4.0 mm, erect at first, later curving outside, pale yellow in the basal third, the rest reddish, base adnate to corolla tube; anthers rounded, reddish; gynoecium protruding from the corolla, 4.0 × 3.0 mm, orange-yellow, obovate; styles 1.0 mm long, erect, reddened; abaxial carpels rounded, yellowish, reddish toward the apex and the pistil. **Fruits** polyfollicular, 4.75–5.25 × 1.5–1.52 mm, with dorsal dehiscence, ascendant, pale brown; seeds inconspicuous, 0.52–0.64 × 0.23–0.29 mm, brown.

Distribution, habitat, and phenology:—It is only known from La Calera, Casimiro Castillo, in Jalisco, western Mexico. It grows on nearly vertical and loose rocky slopes, in tropical subdeciduous forests with *Brosimum alicastrum* Sw. (“capomo”), *Trophis mexicana* (Liebm.) Bureau, *Trichilia americana* (Sessé & Moc.) T.D. Penn., *Sideroxylon capiri* (A. DC.) Pittier, *Apoplanesia paniculata* C. Presl, *Lysiloma acapulcense* (Kunth) Benth., *Ipomoea bracteata* Cav., *Nopalea karwinskiana* (Salm-Dyck) K. Schum., *Peperomia* sp., *Philodendron* sp. and *Anthurium halmoorei* Croat (“muchacha”). It flowers from March to May, and fruits from May to June.

Preliminary conservation assessment:—This species is so far endemic to the western portion of the Sierra de Manantlán Biosphere Reserve (SMBR), Jalisco, Mexico, known only from one location, the type locality, where it has been registered from a single population, the species spatial dispersion tends to be gregarious in groups from 10 to 30 individuals, and some solitary plants, the total population size is estimated to be *ca.* 250 individuals. It must be a target for conservation and research efforts. This location is inside SMBR, in the lowlands of the buffer zone. Even though the area is legally protected, being right on the vertical walls of Highway 80 (Autlán-Barra de Navidad), it is suffering to severe disturbance from landslides and is vulnerable to plant hunters. According to the IUCN Red List criterion B2 (AOO < 10 km²), and conditions ab(iii) (IUCN 2022), the species could be considered Critically Endangered (CR). Additionally, due to its rarity and narrow distribution (condition a), this species experiences a continuing decline observed and projected in the quality of habitat (condition b(iii)), because of the increase in deforestation due to landslides and plant hunting. The authors made an unsuccessful germination trial in June 2022. The first successful step in the recovery of this species started on June 20, 2023, through the second germination trial of about 25 seeds, the plants are growing fine at the University of Guadalajara’s greenhouse at Zapopan, Jalisco.

Etymology:—The species name honors its discoverer, botanist Francisco Javier Santana Michel (1958–2015), whom collected for the first time this plant in 1995 at La Calera, La Resolana. Santana Michel was an agrostologist, outstanding plant explorer, and collector. He described new species of *Aristolochia* and grasses, and several of his collections resulted in scientific novelties.

Notes:—A couple of visits to La Calera (including cliff escalating by Dante Figueroa) in late Spring of 2022, failed to secure flowers. A year after we came back to the same spot and the cliff escalator Byron Gutiérrez, found minimal

flowering to none but one flower, however sufficient to complete our description as a new species. The pendulous habit of its compact blueish-green rosettes makes it a valuable ornamental plant for gardening.

Additional specimens examined:—MEXICO. Jalisco: municipality Casimiro Castillo (La Resolana), La Calera, Reserva de la Biosfera Sierra de Manantlán, 11–12 km SSW de Autlán, 800 m, 10 March 1995 (fl), *F. J. Santana et al.* 7120 (ZEA!). Same locality, 786 m, 24 May 2022, *G. Nieves-Hernández et al.*, recorded as *J. Antonio Vázquez-García* 10192 (IBUG!, ZEA!). Same locality, 795 m, 31 May 2022, *V. Shalisko et al.*, recorded as *J. Antonio Vázquez-García* 10193 (IBUG!, ZEA!).

Quetzalcoatlia superba (Acev.-Rosas) A. Vázquez & Rosales, *Boletín Nakari* 34(2): 39 (2023) (Figs. 1–3 & 22).

=*Graptopetalum pentandrum* subsp. *superbum* Kimnach, *Cact. Succ. J. (Los Angeles)* 59: 142 (1987).

≡*Graptopetalum superbum* (Kimmach) Acev.-Rosas, *Novon* 13(4): 380 (2003).

Type:—Cultivated. MEXICO. Jalisco: municipality La Barca, near Guadalajara, the native locality unknown, *Aviña s.n.*, HNT acc. no. 49307 (holotype HNT!, sheet #6392; isotypes BH!, MEXU!, US).

Description:—**Plants** suffrutex, ramose, perennial, 40.0–80.0 cm, branching basally, entirely glabrous; stems 1.0–1.2 cm thick near base, 0.5–1.0 cm thick near apex, squamose, suberect to semidecumbent, prominently marked with leaf-scars, at first nearly white-glaucous, later strongly violet-glaucous except for a dark olive-green area within 4.0 mm of each leaf-scar; leaf-scars *ca.* 4.0 mm wide and 2.0–3.0 mm high, elliptical, tan; rosettes 4.0–4.5 × 9.0–14.0 cm, 12–20 leaves per rosette. **Leaves** 4.0–5.5 (6.4) × 2.0–2.5 cm, 1.5–2.0 cm from apex, 4.0–7.0 mm wide at base, 5.0–7.0 mm thick at thickest part *ca.* 5.0 mm from apex, *ca.* 4.0 mm thick, *ca.* 1.0 cm from base, thickening again near base to 5.0–6.0 mm, ovate-oblong when young, later oblong-obovate, the upper surface nearly flat to slightly convex, or somewhat concave along basal half, the lower surface more or less strongly convex, obtusely keeled along whole length, with an obscure obtuse spur near point of attachment, the more apical ones in a dense, nearly flat rosette, the lower ones separated 5.0–8.0 mm at base, the youngest slightly ascending, the older ones spreading to slightly reflexed, soon deciduous, heavily glaucous with dark purplish bloom in winter, less purplish in summer, the epidermis amber-gray beneath wax; margin acute along basal half, more obtuse toward apex; apical mucro 1.0–1.5 mm long and wide, deltoid. **Inflorescences** up to 3 to a stem, emerging laterally *ca.* 6.0–8.0 cm below stem-apex, 30.0–40.0 cm long and *ca.* 2.0–3.0 mm wide at base or middle, erect or ascending-horizontal, diffuse and much-extended, pyramidal or oblong in outline, peduncle 7.0–12.0 cm long, *ca.* 5.0 mm thick, glaucous like the stem, rachis 1.0–3.0 mm thick; bracts lacking on basal 2.0–3.0 cm of peduncle, *ca.* 10 above, similar to leaves but smaller; number of flowers per full-sized inflorescence 57–121; branches 12–15, *ca.* 2.0–4.0 cm apart, the lower ones usually divaricately once-branched, the upper usually unbranched, the rachis *ca.* 1 mm thick along basal half and *ca.* 0.5 mm thick above, with 5–9 flowers; pedicels 1.0–1.4 cm long, *ca.* 0.75 mm thick, ascending and straight, or horizontal and becoming erect just below calyx, 1.5–3.0 cm apart. **Flowers** 15–16 mm; calyx disc *ca.* 3.0 mm wide; calyx lobes appressed to corolla lobes, 3–4 mm long, *ca.* 1.0 mm wide at middle, narrowly lanceolate, subacute, glaucous and colored like leaves; corolla *ca.* 9.0 mm long when unopened, 15.0–16.0 mm wide when expanded; corolla tube 2.9–3.1 mm, corolla lobes 5(–6) mm long, 2.0–2.75 mm wide, triangular, acute, the upper surface grooved longitudinally, minutely papillose along depression, sharply keeled on the lower side, the upper surface greenish yellow, the apical millimeter reddish brown, the next 2.0 mm with 2–3 crossbands and scattered dots of same color; nectaries *ca.* 0.5 mm high and 1.0 mm wide, truncate; stamens 5(–6), 6.0–7.0 mm long, *ca.* 0.5 mm wide, antesepalous, at first erect, later reflexed between the corolla lobes, greenish yellow, the apical half red-dotted; gynoecium *ca.* 7.0 × 3.5 mm thick, obovoid, greenish yellow, reddened apically; styles less than 1.0 mm long. **Fruits** 5.3–5.9 × 1.4–1.6 mm; seeds 0.35–0.42 × 0.15–0.19 mm.

Notes:—Similar to *Quetzalcoatlia pentandra*, the stems are 0.8–1.2 cm thick, rosette 6.0–8.0 cm wide, leaves 4.0–6.0 cm long, 2.0–2.5 cm wide, gray-purple, primary axis 30–40 cm long, stamens 5 (rarely 6). *Quetzalcoatlia superba* is distinguished from *Q. pentandra* by its larger size, the squamous surface of the stem, the pink-violet color of the rosette, leaves oblong-obovate, and a profusely branched inflorescence (see Table 1). Gametic chromosome number: *n* = 64 (Kimmach 1987).

Relationships:—Molecular and morphological cladistic analyses indicate that three species of *Quetzalcoatlia* (treated as *Graptopetalum*): *Q. glassii*, *Q. itzicuaroensis*, and *Q. superba* are closely related and belong to a strongly supported clade occurring in the area of Nueva Galicia in western Mexico (Acevedo-Rosas *et al.* 2004a, 2004b). Among the characters they share are stamens in a single whorl (haplostemonous flowers) instead of ten in two whorls, as in the genus *Graptopetalum*. Among Crassulaceae, only certain genera of Sedoideae and all the representatives in the Crassuloideae include haplostemonous species, all of which are from the Old World (Berger, 1930).

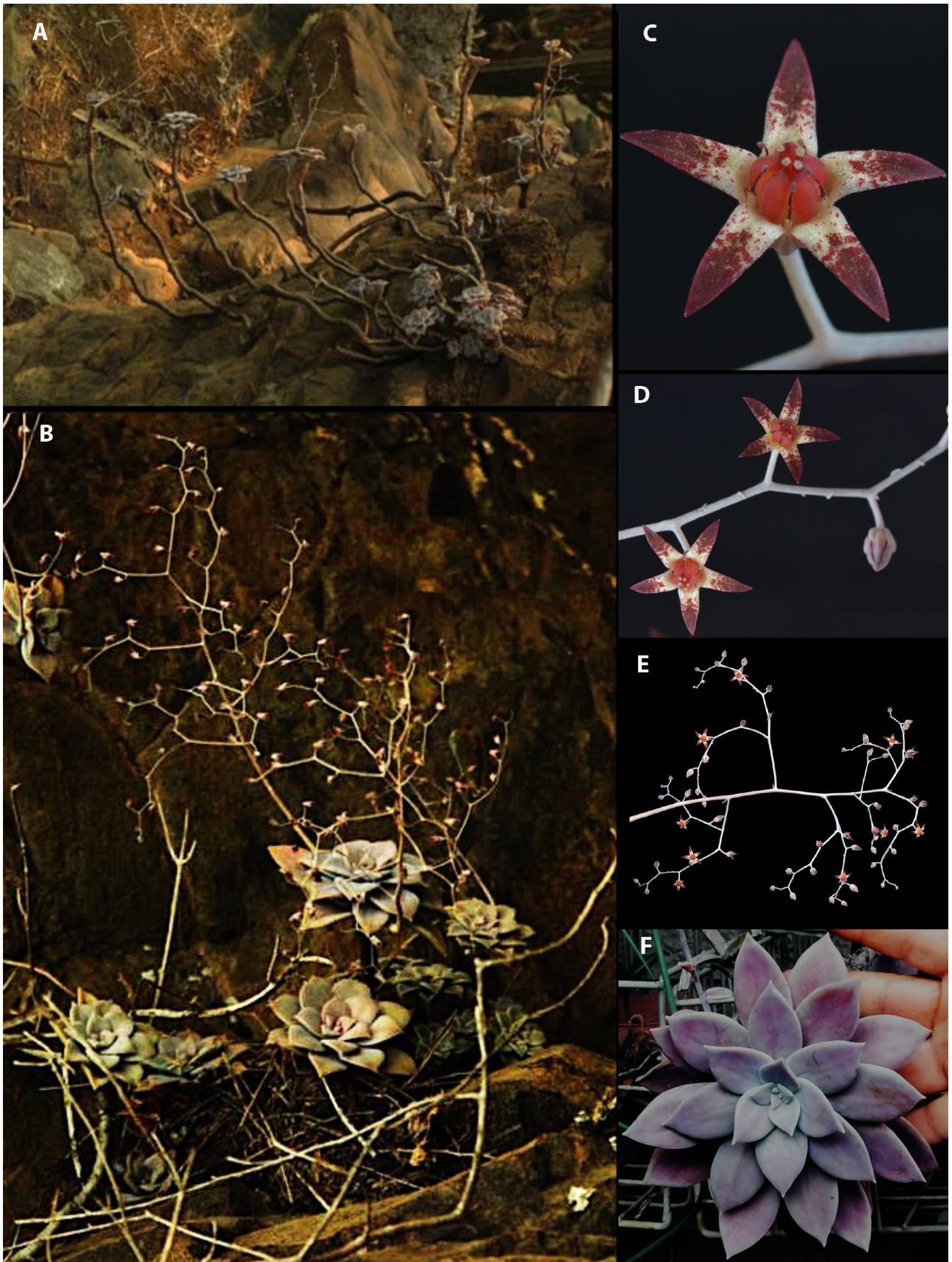


FIGURE 22. *Quetzalcoatlina superba*, from Los Corrales, Juchitlán, Jalisco. Photographs: A–E by J. Etter & M. Kristen; F. by A. Vázquez-García (cult.).

Distribution, habitat, and phenology:—Endemic to the ravine of the Juchitlán river, growing at 1200 m a.s.l in tropical dry forest with *Agave angustifolia* Haw., *Aleuritopteris farinosa* (Forssk.) Fée, *Bursera* sp., *Spondias mombin* L., *Stenocereus* sp., *Tabebuia rosea* (Bertol.) DC. and *Tillandsia capitata* Griseb. It flowers from April to May and fruits in June.

Etymology:—The specific epithet means very beautiful, due to the purplish color of its large rosettes.

Notes:—In 1985, Ricardo Ornelas and Agustín Flores from Universidad de Guadalajara found this species at Los Corrales, Juchitlán; however, it was at a sterile stage and no herbarium specimen was kept. Luis Aviña, a physician of La Barca city, state of Jalisco, bought a *Graptopetalum* plant from an unknown locality and it was sent to the Huntington Botanical Garden, and upon flowering it was named as *Graptopetalum pentandrum* subsp. *superbum* by Myron Kimnach (1987). In May 1990 Flores, Cházaro, Servando Carvajal, and Antonio Machuca returned to Los Corrales and found in flower the first wild population of *Graptopetalum pentandrum* subsp. *superbum* (Cházaro-Basáñez & Flores 1992), which now corresponds to *Quetzalcoatlia superba*.

Preliminary conservation assessment:—Following the IUCN Red List criteria B1ab(iii) (IUCN 2022), the species was assessed as Critically Endangered (CR). The EOO is less than 100 km² (criterion B1); the AOO is < 10 km² (B2); this species is only known from a single location (condition a); and we inferred a decline in the quality of its habitat (condition b(iii)) through land use change and over-collecting. This species is being reproduced in private collections.

Additional specimens examined:—MEXICO. Jalisco: municipality Juchitlán, Cañada rocosa cerca de Los Corrales, al E de Juchitlán, 1200 m, *M. Cházaro-Basáñez et al.* 6929 (IBUG!); Barranquilla, 1 km al N de Los Corrales camino a Los Guajes, 13 May 1990, *M. Cházaro B. et al.* 6215 (ENCB!, IEB!, MEXU!, MO!, MICH!, XAL!, WIS!); Cerca de Los Corrales, Juchitlán-Los Guajes, 12 May 1991, *M. Cházaro-Basáñez, et al.* 6647 (XAL!); Same locality, 3 May 1992, *M. Cházaro-Basáñez et al.* 6926 (XAL!); Cultivada de planta de Jalisco, 20 March 1997, *I. García & J.A. Machuca* 4622 (CIMI!); Cultivada Guadalajara, 10 April 1999, *I. García* 5590 (CIMI!).

Quetzalcoatlia trujilloi (A. Vázquez & Rosales) A. Vázquez & Rosales, *Boletín Nakari* 34(2): 39 (2023) (Figs. 1–3 & 23).

≡ *Graptopetalum trujilloi* A. Vázquez & Rosales, *Phytotaxa* 532(3): 282 (2022).

Type:—MEXICO. Jalisco: municipality of San Gabriel, 4 km N of San Gabriel, 1390 m, 7 September 2008, *J. Antonio Vázquez-García* 8835, with *J. Trujillo, J. Etter, M. Kristen & M. Cházaro* (holotype IBUG!, isotypes CIMI!, ZEA!).

Description:—**Plants** suffrutex, perennial, 15.0–35.0(–41) cm tall without inflorescence, caulescent, ramose, branching basally; stems 8.0–27.0 × 0.6–0.8 cm, decumbent to pendant, surface smooth, brownish, at the base; leaf scars 1.0–2.0 mm in diameter, oval to circular, bumped and dark greenish, the tip soon dries; rosettes terminal, 7.0–8.0 × 9.0–11.0(–12.0) cm, with 15–32(–52) leaves. **Leaves** 4.0–7.5 × 2.3–2.8 cm, 6.0–9.0 mm thick, obovate to oblanceolate, glabrous, adaxially slightly concave, abaxially convex, glaucous greenish to pinkish; margins entire and rounded, convolute toward the apex; the base cuneate, the stalk-like, basal portion 5.0–6.0 mm wide, the apex acute, in right angle or obtuse; apical mucro 1.0–3 × 1.0–3.0 mm, the tips yellowish to pinkish. **Inflorescences** 15.0–32.0 × 0.7–11.9 cm, oblongoid dense, 30–50 flowers on 7–10 simple or bifurcate branches, each branch spaced 2.0–3.4 cm with 3–7 flowers, the basal branch with 3–6 flowers; the fertile portion 24.0–25.0 cm along the primary axis; primary axis 2.0–3.0 mm thick at the base, distally 1.0 mm thick, gray-bluish to pinkish, mean flower density per 10 cm of the primary axis 17–20; bracts on primary axis soon deciduous, 10–13, 1.0–3.0 × 0.9–1.0 mm, lanceolate to elliptic; panicle branches 2.0–6.0 × 0.1.5–0.2 cm, simple or bifurcate, with 3–6 flowers each, 3–5 in the basal branch; bracteoles 1.7–1.8 × 0.9–1.3 mm, lanceolate, glaucous greenish; pedicels 0.9–1.1 × 0.07–0.09 cm long; flower buds 6.4–6.5 × 5.3–5.4 mm. **Flowers** 12.9–13.1 mm in diameter; calyx fused 0.4–0.5 mm × 1.4–1.5 mm; calyx lobes 2.3–2.0 × 1.2–1.3 mm; corolla tube 3.7–3.8 × 3.0–3.4 mm; corolla lobes 4.9–5.2 × 2.7–2.8 mm, triangular, subequal, proximally greenish to distally red and striped, longitudinally with a shallow groove; nectaries 0.7 × 0.9 mm, bright yellow; stamens (4–)5, erect in the early stage of anthesis, later reflexed; filaments 7.2–7.4 × 0.2–0.5 mm, greenish to distally red; anthers 0.4 × 0.2 mm, ellipsoid, beige, becoming blackish; gynoecium 7.2–7.3 × 3.2–3.3 mm, carpels 7.0–7.1 × 1.1–1.3 mm, carpels obtuse, abaxially greenish to pinkish; styles 1.1–1.2 × 0.3–0.4 mm; stigmas 0.1–0.2 mm. **Fruits** costate oblongoid, 7.4–7.6 × 3.2–3.4 mm; oblongoid; seeds unknown.

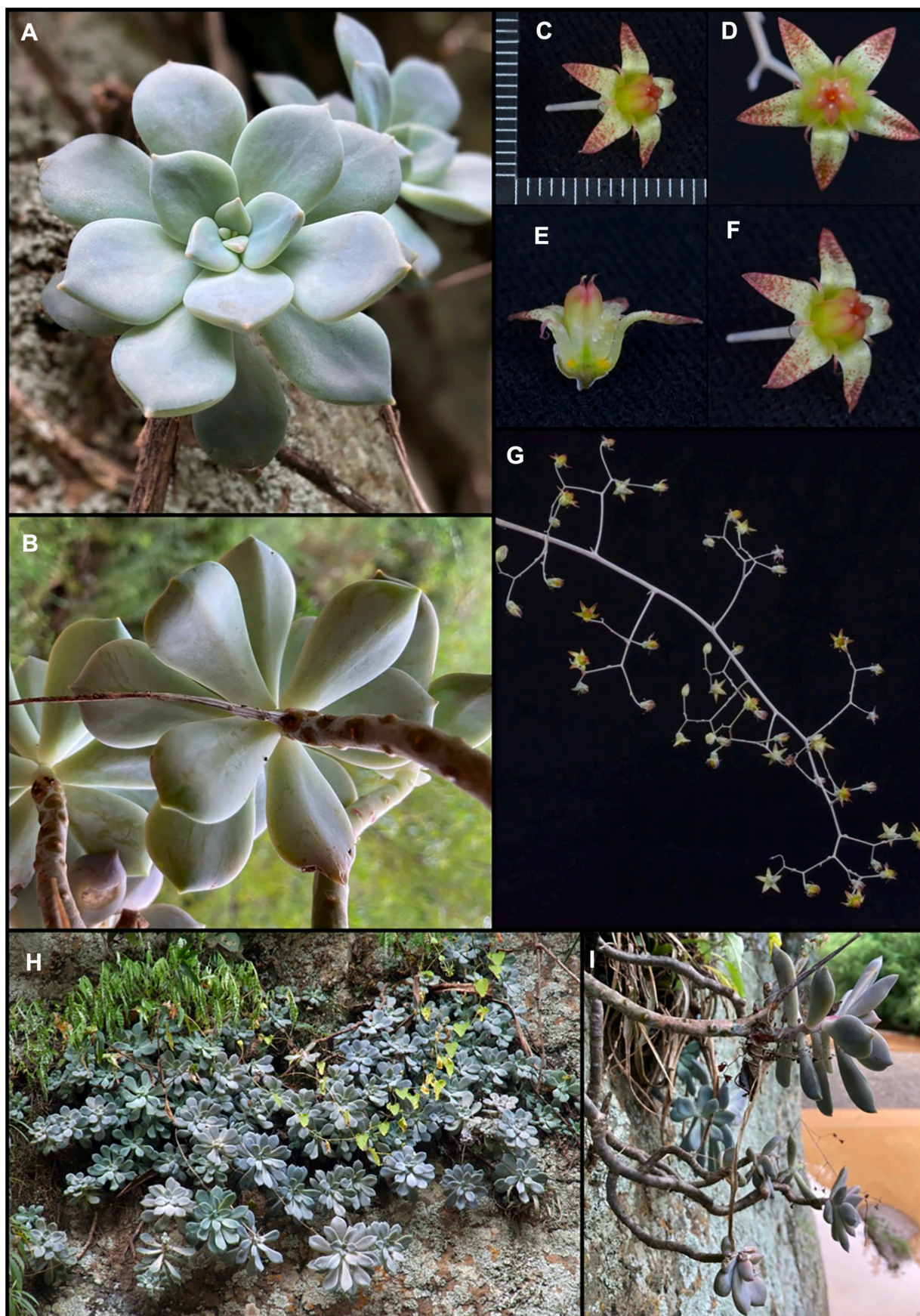


FIGURE 23. *Quetzalcoatlía trujilloi*, from Sierra de Tapalpa, San Gabriel, Jalisco. Photographs: A–B & I by Santiago Rosales, C by A. Vázquez-García, D–H by J. Etter & M. Kristen.

Notes:—*Quetzalcoatlia trujilloi* is similar to *Q. rosanevadoensis* in sharing a ramose habit, smooth stem surface, and stem diameter, but it differs from the latter in having a smaller habit 15.0–35.0(–41.0) vs. 40.0–87.0 cm, more numerous branches per inflorescence 7–10 vs. 5–6, larger mean flower density per 10.0 cm of the scape 17–20 vs. 6–9, fewer flowers per basal branch 3–5 vs. 6–7, smaller flower diameter 12.9–13.1 vs. 14.9–15.1, petals greenish with transversal inconspicuous red stripes vs. yellowish with transversal conspicuous red stripes, petal width 2.7–2.8 vs. 2.9–3.0 mm, filaments greenish to distally red vs. red and carpels abaxially obtuse vs. rounded. It is also similar to *Q. superba* in sharing a ramose habit, similar rosette diameter and similar mean flower density per 10.0 cm of the scape, but it differs from the latter in having a smaller habit 15.0–35.0 (–41.0) vs. 40.0–80.0 cm, stem surface smooth vs. squamous, smaller stem diameter 6.0–8.0 vs. 10.0–12.0 mm, less numerous branches per inflorescence 7–10 vs. 12–15, and smaller flower diameter 12.9–13.1 vs. 15.0–16.0 mm. In September 2008, J. A. Vázquez-García and collaborators visited San Gabriel municipality, Jalisco, and collected plants of a *Quetzalcoatlia* species (at that time identified as *Graptopetalum*) which later bloomed in Zapopan, Jalisco, these populations were revisited by Santiago Rosales in 2021 to confirm that this population actually belongs to an undescribed species. *Quetzalcoatlia trujilloi* is under cultivation mostly in private collections.

Distribution, habitat, and phenology:—*Graptopetalum trujilloi* is known only from populations at the type locality, on vertical slopes of the southern region of Jalisco, north of San Gabriel, in tropical deciduous forest, at an elevation of approximately 1390–1410 m, with *Agave pedunculifera* Trel., *Astroleps sinuata* (Lag. ex Sw.) D.M. Benham & Windham, *Dioscorea* sp., *Euphorbia* sp., *Peperomia* sp., *Sedum chazaroi* P. Carrillo & J.A. Lomelí and *Tillandsia* sp. It flowers in early March and sets fruit in early June.

Etymology:—The specific epithet honors Jesús Trujillo, an outstanding explorer of the Gran Barranca de Guadalupe and expert in succulent cultivation who contributed to the discovery of this species.

Preliminary conservation assessment:—Following the IUCN Red List criteria B1ab(iii) (IUCN (2022)), the species was assessed as Critically Endangered (CR). The EOO is less than 100 km²; (criterion B1); the AOO is < 10 km² (B2); this species is only known from a single location (condition a); and we inferred a decline in the quality of its habitat (condition b(iii)) through land use change and over-collecting.

Additional specimens examined:—MEXICO. Jalisco: San Gabriel municipality, 4 km north of San Gabriel, 1410 m, 27 June 2021 (sterile), *S. Rosales et al. 1* (IBUG), same location, 27 June 2021 (infructescence), *S. Rosales et al. 2* (IBUG).

Discussion

Species diversity:—A revision of Crassulaceae of Jalisco (Cházaro and Thiede 1995) reported only two haplostemonous taxa of *Quetzalcoatlia* (treated as *Graptopetalum*). Since then, the number of haplostemonous species for this genus has increased five-fold, with five species occurring in the state of Jalisco, three in the state of Michoacán, and one in the state of Colima, all, so far, confined to western Mexico.

Comparative morphology:—Relevant differences of our population samples from all other species in *Quetzalcoatlia* are illustrated, deserving to be considered as four new taxa: *Q. grulloensis*, *Q. itzicuarioensis*, *Q. latipetala*, and *Q. santanamichelii*. The four taxa morphologically belong to a group characterized by having typically a distinctive morphological character, a single whorl of stamens (haplostemonous, five alternate stamens to the petals) instead of two whorls (10 stamens), common in the family Crassulaceae. *Q. glassii*, *Q. kristenii*, and *Q. pentandra* are considered the closest morphological taxa to *Q. latipetala* and *Q. itzicuarioensis* (Table 1), while *Q. superba* is considered the morphologically closest species to *Q. grulloensis* and *Q. santanamichelii*.

Phylogeny and geographic structure:—Morphological and molecular data of *Quetzalcoatlia* (at that time treated as *Graptopetalum*) display a well-supported subclade within the Clade IV (*Cremnophila* + *Echeveria* + *Reidmorania* + *Sedum*) (de la Cruz-López *et al.* 2019), which corresponds to a strong geographic structure. Nine haplostemonous species inhabit western Mexico: five are confined to southern Jalisco, one to Colima, and three to Michoacán. Furthermore, the group of species having haplostemonous flowers, as a synapomorphic character, previously treated as *Graptopetalum*, is a well-supported clade (Acevedo-Rosas *et al.* 2004a, 2004b). However, the inclusion of the newly described taxa in the phylogenetic analysis is needed to test the monophyly of *Quetzalcoatlia*. Phylogenetic analyses (Mort *et al.* 2001, Mayuzumi & Ohba 2004) indicate that haplostemony is an exclusive feature of the “Crassula clade” and the “Telephium clade”. But these ten haplostemonous species of *Quetzalcoatlia* (six of them previously treated as *Graptopetalum*) seem to demonstrate that this character independently arose more than twice in the family, i.e., in the

African *Crassula* Linnaeus (1753: 282), the Asian *Sinocrassula* Berger (1930: 462), and the American *Quetzalcoatlia* and *Sedum* (Acre clade). However, the evolutionary process that gave rise to haplostemony within the family remains uncertain and needs to be investigated.

Ecological speciation:—A remarkable diversification in a short distance (within a radius of *ca.* 100 km) is documented for *Quetzalcoatlia* within western Mexico (Jalisco, Colima, and Michoacán), displaying a pattern of allopatric radiation. The confluence of four biogeographic provinces sensu Morrone *et al.* (2017) and various geologic substrates (igneous, limestone, and gypsum), coupled with a 1000 m long elevational gradient, contrasting rainfall regimes (380–1500 mm of MAP), and restricted seed and pollen dispersal capabilities may have interacted to generate multiple selective pressures allowing an extraordinary speciation process.

Geographic distribution:—Four of the species: *Q. grulloensis*, *Q. rosanevadoensis*, *Q. superba*, and *Q. trujilloi*, were confined to the Jaliscan side of the more recent physiographic region Transmexican Volcanic Belt, and *Q. santanmichelii* is confined to the tropical portion of the older physiographic region Sierra Madre del Sur. In contrast, *Q. glassii* is restricted to Cordillera Costera of Colima side, in low elevation foothills of the Sierra Madre del Sur; while *Q. itzicuarioensis*, occurred in the Tarascan province, Michoacán, and *Q. kristenii* and *Q. latipetala* occurred in the Sierra de Coalcomán, Sierra Madre del Sur, Michoacán (Fig. 1). The geographically closest species to *Q. itzicuarioensis*, from Los Reyes, is *Q. latipetala*, from Aguililla, the two inhabiting the high Tepalcatepec Balsas basin. All nine species are separated by topographic barriers, each immersed in deep ravines, along a single watershed, three of the new species thrive near waterfalls of touristic relevance and may be threatened by over-collecting.

Floristic relationships:—It is remarkable that most of the species of *Quetzalcoatlia* share a habitat with different species of *Agave*: *Q. grulloensis* with *A. stringens* (sect. *Rigidae*), *Q. glassii* growing with *Agave colimana* (sect. *Littaea*) and *A. pablocarrilloi* (sect. *Marmoratae*), *Q. kristenii* with *A. andreae* (sect. *Marmoratae*), *Q. superba* with *A. angustifolia* (sect. *Rigidae*), *Q. trujilloi* with *A. martaelenae* (sect. *Inermes*), *Q. rosanevadoensis* with *A. attenuata* (sect. *Inermes*), *Q. itzicuarioensis* with *A. garciaruzii* (sect. *Heteracanthae*), and *Q. santanamichelii* with no species of *Agave* (Table 2).

TABLE 2. Differences in floristic composition among communities with different species of *Quetzalcoatlia*. x= presence of the species.

	<i>Q. glassii</i>	<i>Q. kristenii</i>	<i>Q. santanamichelii</i>	<i>Q. itzicuarioensis</i>	<i>Q. grulloensis</i>	<i>Q. latipetala</i>	<i>Q. superba</i>	<i>Q. trujilloi</i>	<i>Q. rosanevadoensis</i>
<i>Agave andreae</i>		X							
<i>Agave angustifolia</i>							X		
<i>Agave attenuata</i>									X
<i>Agave colimana</i>	X								
<i>Agave garciaruzii</i>				X					
<i>Agave martaelenae</i>								X	
<i>Agave pablocarrilloi</i>	X								
<i>Agave</i> sp.			X						
<i>Agave stringens</i>					X				
<i>Anthurium halmoorei</i>			X	X					
<i>Apoplanesia paniculata</i>			X						
<i>Astrolepis sinuata</i>				X					
<i>Astrolepis sinuata</i>								X	
<i>Brossimum alicastrum</i>			X						
<i>Bursera arborea</i>	X			X			X		
<i>Bursera schlechtendalii</i>	X								
<i>Bursera</i> sp.		X					X		X
<i>Bursera</i> spp.	X					X			
<i>Calliandra caeciliae</i>					X				

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TABLE 2. (Continued)

	<i>Q. glassii</i>	<i>Q. kristenii</i>	<i>Q. santanamichelii</i>	<i>Q. itzicuaroensis</i>	<i>Q. grulloensis</i>	<i>Q. latipetala</i>	<i>Q. superba</i>	<i>Q. trujilloi</i>	<i>Q. rosanevadoensis</i>
<i>Ceiba aesculifolia</i>	X						X		
<i>Cephalocereus alensis</i>					X				
<i>Cheilanthes farinosa</i>							X		
<i>Clusia</i> sp.	X								
<i>Combretum farinosum</i>						X			
<i>Comocladia engleriana</i>	X			X					
<i>Dioscorea</i> sp.								X	
<i>Dioscorea</i> ssp.									X
<i>Epidendrum ciliare</i>		X							
<i>Euphorbia</i> sp.				X				X	
<i>Ficus cotinifolia</i>	X								
<i>Ficus</i> sp.					X				X
<i>Ficus</i> spp.							X		
<i>Graptopetalum fruticosum</i>									X
<i>Hechtia laevis</i>	X								
<i>Hechtia purepecha</i>				X					
<i>Heliocarpus</i> sp.	X			X					
<i>Ipomoea bracteata</i>			X						
<i>Lonchocarpus</i>			X						
<i>Lysiloma acapulcensis</i>	X		X	X	X		X		
<i>Lysiloma microphyllum</i>						X			
<i>Lysiloma</i> sp.									X
<i>Mammillaria knippeliana</i>						X			
<i>Mammillaria</i> sp.		X							
<i>Mammillaria xaltiangensis</i> var. <i>aguilensis</i>						X			
<i>Matelea cyclophylla</i>	X								
<i>Montanoa</i> ssp.									X
<i>Neobuxbaumia mezcalensis</i>	X								
<i>Nopalea karwinskiana</i>			X						
<i>Oncidium leleui</i>		X							
<i>Oncidium</i> sp.					X				
<i>Opuntia</i> sp.		X							
<i>Pachycereus pecten-aboriginum</i>					X				
<i>Pedilanthus calcaratus</i>	X								

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TABLE 2. (Continued)

	<i>Q. glassii</i>	<i>Q. kristenii</i>	<i>Q. santanamichelii</i>	<i>Q. itzicuarioensis</i>	<i>Q. grulloensis</i>	<i>Q. latipetala</i>	<i>Q. superba</i>	<i>Q. trujilloi</i>	<i>Q. rosanevadoensis</i>
<i>Peperomia</i> sp.			X					X	
<i>Philodendron</i> sp.			X						
<i>Philodendron warszewiczii</i>		X							
<i>Pinguicula colimensis</i>	X								
<i>Piper</i> sp.									X
<i>Pithecoctenium echinatum</i>									X
<i>Pittocaulon filare</i>	X								
<i>Pittocaulon hintonii</i>		X							
<i>Plumeria rubra</i>	X				X				
<i>Pseudobombax ellipticum</i>	X	X				X			
<i>Pseudobombax palmeri</i>					X				
<i>Quercus</i> sp.									X
<i>Sedum hemsleyanum</i>						X			
<i>Sedum</i> sp.								X	
<i>Selenicereous murillii</i>		X							
<i>Senecio praecox</i>	X								
<i>Sideroxylon capiri</i>			X						
<i>Spondias mombin</i>							X		
<i>Stenocereus</i> sp.							X		
<i>Tabebuia rosea</i>							X		
<i>Tillandsia achyrostachys</i>								X	
<i>Tillandsia capitata</i>				X	X		X		
<i>Tillandsia</i> sp.									X
<i>Trichilia</i> sp.			X						
<i>Trophis racemosa</i>			X						

Remarks

Geographic distribution:—According to the biogeographic provinces proposed by Morrone *et al.* (2017), two species, *Quetzalcoatlina rosanevadoensis* and *Q. trujilloi*, occur in the Transmexican Volcanic Belt province; four, *Q. glassii*, *Q. grulloensis*, *Q. santanamichelii*, and *Q. superba*, in the Pacific Lowlands; one, *Q. kristenii*, in the Sierra Madre del Sur province; two, *Q. latipetala* and *Q. itzicuarioensis* in the Balsas Basin province; and one, *Q. pentandra*, is only known from cultivated material. Five of the species, *Q. glassii*, *Q. grulloensis*, *Q. rosanevadoensis*, *Q. superba*, and *Q. trujilloi*, occur in a single watershed, that of the Armería river, each on a particular micro watershed; two, *Q. latipetala* and *Q. itzicuarioensis*, in the Tepalcatepec Balsas watershed; one, *Q. santanamichelii* in the Río Purificación watershed; and one, *Q. kristenii*, in the Coalcomán watershed. Most of the species inhabit elevations ranging from 900 to 1400 m (Table 3), and have a 700–1000 mm, mean average precipitation (MAP), except *Q. glassii*, *Q. latipetala*, and *Q. santanamichelii* which thrived at 380, 600, and 1500 mm MAP, respectively. Most species of *Quetzalcoatlina* (eight out of ten) were microendemic to a particular micro watershed (Hernández-López & Carrillo-Reyes 2019), and a new population from Sierra de Quila, Jalisco (Alejandra Flores pers. com.) deserves further study.

TABLE 3. Species of genus *Quetzalcoatlia* along elevation.

	300– 399	400– 499	500– 599	600– 699	700– 799	800– 899	900–999	1000– 1099	1100– 1199	1200– 1299	1300– 1399	1400– 1499	1500– 1599
<i>Q. glassii</i>	x	x											
<i>Q. kristenii</i>				x	x	x							
<i>Q. santanamichelii</i>					x	x							
<i>Q. itzicuarioensis</i>						x	x	x					
<i>Q. grulloensis</i>							x	x					
<i>Q. latipetala</i>										x			
<i>Q. superba</i>										x			
<i>Q. trujilloi</i>											x	x	
<i>Q. rosanevadoensis</i>												x	

Habitat:—All the species inhabit rocky substrates in the tropical dry forest, except one: *Q. santanamichelii* from tropical subdeciduous forests. However, six taxa grow on igneous substrate: *Quetzalcoatlia grulloensis*, *Q. itzicuarioensis*, *Q. rosanevadoensis*, *Q. santanamichelii*, *Q. superba*, and *Q. trujilloi*; two on limestone: *Q. latipetala* and *Q. kristenii*; and one on gypsum: *Q. glassii*.

Phenology:—All the species had a flowering peak in spring (Table 4). *Quetzalcoatlia itzicuarioensis* had the longest flowering period, one period from January to May with a peak in April and a sporadic flowering period in November, followed by *Q. glassii*, *Q. latipetala*, and *Q. kristenii*, *Q. grulloensis*, *Q. santanamichelii* flowering during five, three or two months. Three taxa, *Q. pentandra*, *Q. superba*, and *Q. trujilloi*, flowered within a single month (April, May, and March, respectively). *Q. rosanevadoensis* is reported to have a disjunct flowering period (May and November). Fruiting and seeding have not been observed and most species, they either lose their flowers before fruiting or do not produce any seeds.

TABLE 4. Flowering phenology of species of genus *Quetzalcoatlia*.

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
<i>Q. itzicuarioensis</i>	x	x	x	x	x						x	
<i>Q. latipetala</i>		x	x	x								
<i>Q. glassii</i>		x	x	x	x							
<i>Q. trujilloi</i>			x									
<i>Q. grulloensis</i>			x									
<i>Q. kristenii</i>			x	x								
<i>Q. santanamichelii</i>			x	x	x							
<i>Q. pentandra</i>				x								
<i>Q. superba</i>					x							
<i>Q. rosanevadoensis</i>					x							

Conservation:—We assessed all (except one out of 10) haplostemonous species of *Quetzalcoatlia* as Critically Endangered, each under a particular set of threats: natural disasters (forest fires, flooding, and landslides) or anthropic pressures (mining, tourism, overcollection, deforestation, land use change, cattle raising). Criteria B1ab, B2ab (iii) implying a reduced extent of occurrence (EOO <100 km²) and/or a very restricted area of occupancy (AOO < 10 km²) was met for all *Quetzalcoatlia* species except for *Q. glassii*, which grows in more than one location. We confirmed the existence of living plants of *Quetzalcoatlia* species in ex-situ collections including HNT, IBUG, or in private collections (Table 5), three propagated in private collections, and only two conserved in research institutions (Table 5). Only two of the species, *Q. itzicuarioensis* and *Q. santanamichelli* occur in a protected area, the Chorros del Valar in Los Reyes, Michoacán, under the status of Area of Ecological Protection and the Sierra de Manantlán Biosphere Reserve (SMBR), respectively. However, in the first case, the circumstances include a lack of administration and management plans and contamination by garbage disposal from tourists and families visiting the waterfalls. The second case in the SMBR involves frequent landslides in the rainy season, forest fires, and exposure to “plant hunters” along Highway 80, Autlán-Barra de Navidad.

TABLE 5. Conservation status and habitat differences among species of *Quetzalcoatlia* in western Mexico.

	<i>Q. glassii</i>	<i>Q. grulloensis</i>	<i>Q. itzicuaroensis</i>	<i>Q. kristenii</i>	<i>Q. latipetala</i>	<i>Q. pentandra</i>	<i>Q. rosanervadoensis</i>	<i>Q. santanamichelii</i>	<i>Q. superba</i>	<i>Q. trujilloi</i>
Microbasin, subbasin, or basin	La Salada Río Armería	El Grullo Río Ayuquila Río Armería	Itzicuaro, Río Balsas	Río Balsas	Aguilla, Tepalcatepec	Unknown	Alseseca Río Armería	Río Purificación	Juchitán Río Ayuquila Río Armería	Tapalpa Río Tuxcacuesco Río Armería
Threats	Gypsum mining	Looting from tourism	Tourism	Tourism	Tourism	Unknown	Overcollected	Landslides, plant hunting	Overcollected	Flooding from deforestation and landslides
Ex-situ collections	Etter & Kristen private collection	IBUG, Etter & Kristen private collection	Cházaro private collection	Etter & Kristen private collection	None	HNT	IBUG	IBUG	IBUG	Rosales-Martínez private collection
Conservation status	Endangered	Critically Endangered	Critically Endangered	Critically Endangered	Critically Endangered	Data Deficient	Critically Endangered	Critically Endangered	Critically Endangered	Critically Endangered
Physiography	Cordillera Costera, Colima	Sierra de Amula, Jalisco	Neovolcanic Tarascan Subprovince, Michoacán	Sierra Madre del Sur, Michoacán	Sierra Madre del Sur, Michoacán	Unknown	Nevado de Colima Low valleys in southwest Jalisco	Sierra Madre del Sur, Sierra de Manantlán, Jalisco	Sierra de Amula, Jalisco	Sierra de Tapalpa, SE, low valleys
Elevation (m)	410	1057 (987)	1280	920	1200		1400	798	1200	1400
MAP (mm)	380	851	922	1018	800–1200		700	1451	852	819
Average annual t °C										
Min	23.3	12.0	16.5	21.0	10	Native locality unknown	16.7	14	11.1	20
Mean	31.7	24.1	24.0	23.2	27		17.5	25.2	22.3	21
Max	33.0	31.0	31.8	26.2	30		33.1	36.2	33.6	27
Substrate	Gypsum	Igneous/Basaltic	Igneous	Limestone	Limestone	Unknown	Igneous	Igneous	Igneous	Igneous
Vegetation	Tropical dry forest	Tropical dry forest	Tropical dry forest	Tropical dry forest	Tropical dry forest	Known only from cultivation	Tropical dry forest, surrounded by oak forest	Tropical subdeciduous forest	Tropical dry forest	Tropical dry forest

Conclusions

A small-scale pattern of high allopatric speciation (morphological radiation) was unveiled, and five of the ten haplostemonous species diversified along an elevational gradient including ravines with permanent stream tributaries within a single watershed, the Armería River.

The four new haplostemonous species of *Quetzalcoatlia*, are sufficiently distinct from other haplostemonous species and two are endemic to Michoacán (in the Balsas Basin biogeographic province), and two are endemic to Jalisco (one confined to the Sierra de Amula and the other to western Sierra de Manantlán). The four new species were assessed as critically endangered.

We hypothesize that *Q. pentandra* should still exist in the wild. Currently, only a few individuals survive ex-situ in nurseries and botanical gardens.

Quetzalcoatlia itzicuarioensis, previously treated as *Q. pentandra*, was already confirmed to belong to the well-supported subclade including two other haplostemonous species while further molecular analysis is needed to include type material of *Q. grulloensis*, *Q. latipetala*, *Q. kristenii*, *Q. pentandra* s.s. (cultivated at HNT), *Q. trujilloi* and *Q. rosanevadoensis*, *Q. santanamichelii*; however, biogeographic and evolutionary processes giving rise to haplostemony and allopatric morphological radiation deserve further attention, particularly using the molecular evidence.

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