



## *Graptopetalum kristenii* (subg. *Glassia*, Crassulaceae), a new haplostemonous species from Michoacán, Mexico

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### Abstract

A new haplostemonous species of *Graptopetalum* (subg. *Glassia*, Crassulaceae) from the Sierra de Coalcomán, Michoacán, is described and illustrated. It differs from its morphologically closest species, *G. pentandrum*, by having a smaller rosette diameter, broadly oblong leaves, its basal inflorescence branch with fewer flowers than in the rest of branches, a smaller flower diameter, wider petals, and its petal color pattern. It was assessed as Critically Endangered (CR) following the IUCN criteria. A key to the haplostemonous species of *Graptopetalum* (subg. *Glassia*) is provided.

**Keywords:** endemic, *Graptopetalum pentandrum*, Sierra de Coalcomán, stamens, Western Mexico

### Resumen

Se describe e ilustra una nueva especie haplostémona de *Graptopetalum* (subg. *Glassia*, Crassulaceae) de la Sierra de Coalcomán, Michoacán. Difiere de su especie morfológicamente más cercana, *G. pentandrum*, por tener un diámetro de roseta menor, hojas anchamente oblongas, su rama basal de la inflorescencia con menos flores que en el resto de las ramas, un diámetro de flor menor, pétalos más anchos, y su patrón de color del pétalo. Fue evaluada como En Peligro Crítico (CR) siguiendo los criterios de UICN. Proporcionamos una clave para las especies haplostémonas de *Graptopetalum*.

**Palabras clave:** endémica, estambres, *Graptopetalum pentandrum*, Occidente de México, Sierra de Coalcomán

### Introduction

*Graptopetalum* Rose (1911: 296) is a genus of rosette plants within the Crassulaceae family, currently comprising 20 species from semi-arid environments in Arizona, USA, to Oaxaca, Mexico (Acevedo-Rosas & Cházaro-Basáñez 2003, Thiede 2003, Thiede & Eggl 2007, Vega-Aviña *et al.* 2020, Vázquez-García *et al.* 2021). It is almost exclusive to Mexico (Cházaro-Basáñez & Thiede 1995), where all the 20 species are found, of which 18 (90%) are endemic.

Vegetatively, the members of this genus are usually very different from each other. Within the Crassulaceae family, they are distinguished by having a lateral cyme or panicle with generally fetid flowers; the pale and erect petals are connate in the lower half and rotate in the apex, where they are marked with red to brown stains normally forming transversal bands. The stamens are erect at an early stage, and strongly recurved after anthesis (Uhl 1970).

*Graptopetalum* is divided into two subgenera, which are differentiated by the androecium: the number of stamens in subgenus *Graptopetalum* is 10, in two whorls (diplostemony), while in subgenus *Glassia* Byalt (2012: 79) it is 5, in a single whorl (haplostemony or pentandry) (Byalt 2012). The three species of subgenus *Glassia* studied with molecular sequence data, *G. glassii* Acevedo-Rosas & Cházaro-Basáñez (2003: 378), *G. pentandrum* Moran (1971: 56) and *G. superbum* (Kimmach 1987: 142) Acev.-Rosas in Acevedo-Rosas & Cházaro-Basáñez (2003: 380), conform a well-supported clade (Acevedo-Rosas 2004a, 2004b), and the remaining haplostemonous species are expected to form part of it.

In March 2013, during a visit to Coalcomán, Michoacán, in search of populations of *Sedum hintonii* Clausen (1943: 292), the first author and her husband inquired with the local historian about a place called ‘Pinzán’ and ‘Arroyo Chacán’, and he drew them a little map of how to get there. Following his map, they came through Ixtala, La Guayabera and Los Ocotes, from where they went to San Acamitán and down to the Río Coalcomán between El Nogal and El Guamúchil, the place supposedly called ‘Pinzán’ by the locals. Since they did not find anybody there, they could not inquire about the name of the place. Walking along the river, they went straight for the cliffs and did not find *S. hintonii* but a *Graptopetalum* species that resembled *G. pentandrum*. Since Aguililla, one of two known localities for *G. pentandrum*, is only 46 kms NNE of ‘Pinzán’ as the crow flies, they assumed that this was a new locality for the latter, but after comparing the *Graptopetalum* from ‘Pinzán’ with plants from Chorros del Varal, near Los Reyes, the second locality of *G. pentandrum*, the ‘Pinzán’ plants were much smaller and continued to stay small even when grown in the greenhouse. Once flowering, the authors unveiled that these plants belonged to a new species, which is described and illustrated here.

## Material and methods

Populations of the new *Graptopetalum* species were first discovered during a field trip carried out in March 2013 south of Coalcomán, Michoacán. Living material was brought to Santa Elena, Jalisco, where plants were cultivated and propagated in order to observe their variability. In April 2015, the specimens flowered, and their morphological characters were documented complementing them with previous field data.

A review of the haplostemonous species of the genus was carried out involving literature, herbarium specimens (at IBUG, MEXU and US), photographs, and living plants to establish a comparison of morphological characters against the morphologically closest species described. From the resulting data, additional morphological characters for *Graptopetalum glassii* and *G. pentandrum* are provided, included in Table 1.

**TABLE 1.** Morphological differences between *Graptopetalum kristenii* and its morphologically closest species.

	<i>G. kristenii</i>	<i>G. glassii</i>	<i>G. pentandrum</i>
Plant	Cespitose-ramose	Cespitose	Cespitose-ramose
Rosette diameter (cm)	3.4–5.0	2.0–4.0	6.0–8.0
Leaf length (cm)	1.4–2.7	1.3–2.0	2.0–4.0
Leaf shape	Broadly oblong	Oblanceolate	Obovate
Leaf color	Green-glaucous to blue-pinkish	Blue-greenish to white-greenish	Blue-greenish to white-bluish
Inflorescence length (cm)	19.0–28.0	6.0–12.0	10.0–35.0
Number of branches per inflorescence	3–4	1–2	3–5
Number of flowers per branch	4–7	2–3	1–12
Flower diameter (mm)	12.5–15.0	12.0–19.0	17.0–19.0
Petal width (mm)	2.2–2.6	3.5	1.7–1.8
Petal color pattern	White with conspicuous stains along	White-yellowish with dots and a red stain in the upper half	White to yellowish, with a rhomboid dark-red stain in the upper half of the petal
Number of flowers per basal branch	3–4	1–2	1–12
Number of flowers per inflorescence	15–24	3–6	6–43
Mean flower density per 10 cm of the scape	7–8	5	6–12

Based on the map of the biogeographic provinces of Mexico provided by Morrone *et al.* (2017), a distribution map of *Graptopetalum kristenii* and its morphologically closest species, *G. glassii* and *G. pentandrum*, was generated in order to gain a better understanding of ecological aspects. A point per locality was marked from *in situ* records consulted at several herbaria and NaturaLista (2019), as well as observations made by the authors.

The conservation status was assessed based on the guidelines of the IUCN Red List Criteria (IUCN 2019), using the GeoCat online tool (Bachman *et al.* 2011) to calculate the Area of Occupancy (AOO) and Extent of Occurrence (EOO).



**FIGURE 1.** Distribution map of *Graptopetalum kristenii* and its morphologically closest species (*G. glassii* and *G. pentandrum*) in Western Mexico, with overlays of biogeographic provinces (Morrone 2017).

## Results

Focussing on the habit and the pentamerous (haplostemonous) flowers of the *Graptopetalum* populations from Coalcomán (SW of San Acamitán), Michoacán, the plants were compared to those of the morphologically closest species within subg. *Glossia*, *G. pentandrum*, and it was concluded that it is a new species.

The new species showed some overlap with its morphologically closest species, *G. pentandrum*, in its habit, the length of the leaves and the inflorescences, the number of branches per inflorescence, and the number of flowers per branch, basal branch and inflorescence. However, it differed from the latter by having a smaller rosette diameter, broadly oblong leaves, a basal inflorescence branch with fewer flowers than in the rest of branches, a smaller flower diameter, wider petals, and its petal color pattern. It also showed similarities with *G. glassii*, such as the rosette diameter, leaf color, and flower diameter, but it differed from the latter by its longer and broadly oblong leaves, larger inflorescence, more branches per inflorescence, more flowers per branch, and different petal color and pattern (Table 1).

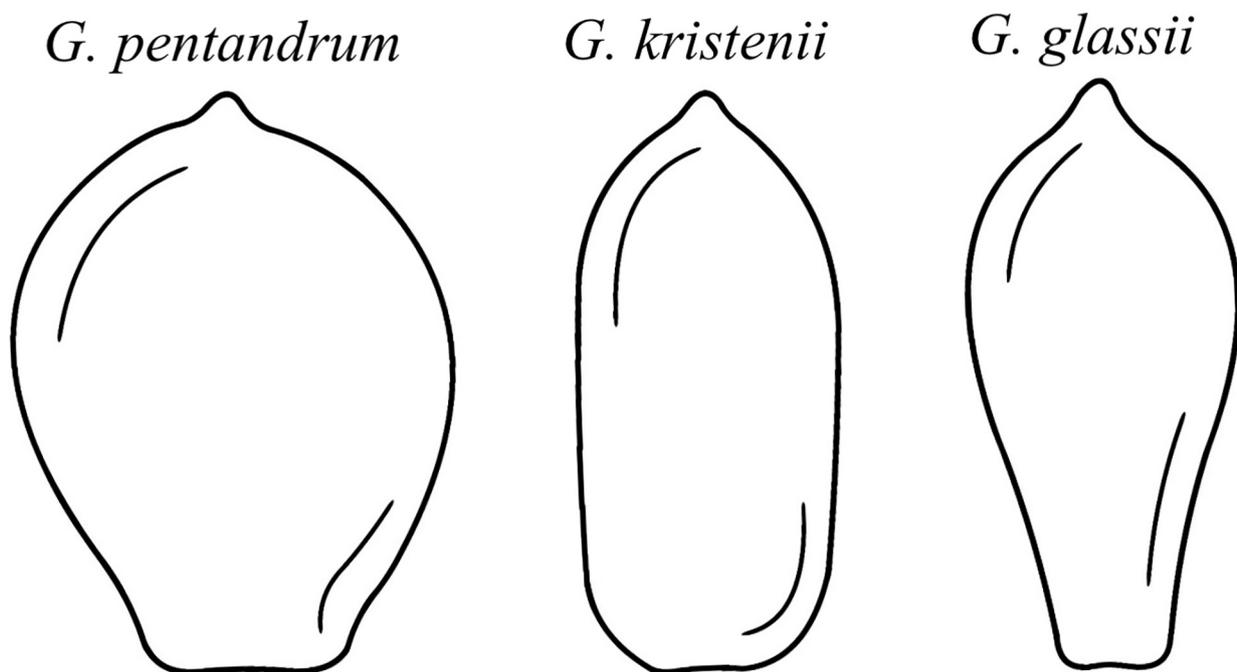
Furthermore, the new species is confined to a single biogeographic province, the Sierra Madre del Sur, where it grows at an elevational range of 700–800 m. *G. glassii* and *G. pentandrum* inhabit different biogeographic provinces, the Pacific Lowlands and the Balsas Basin, respectively (Table 2).

**TABLE 2.** Ecological differences between *Graptopetalum kristenii* and its morphologically closest species.

	<i>G. kristenii</i>	<i>G. glassii</i>	<i>G. pentandrum</i>
Biogeographic province	Sierra Madre del Sur	Pacific Lowlands	Balsas Basin
Micro watershed	Coalcomán	La Salada	Itzicuaró, Aguililla
Elevation (m)	700–800	400–500	900–1300
Latitude (°)	18.6	19.0–19.3	18.8–19.5

## Discussion

Morphologically, *Graptopetalum kristenii* belongs to *G.* subg. *Glassia*, which now includes six species characterized by having flowers with 5 stamens, in a single whorl, a synapomorphy called haplostemony. This feature arose independently more than two times in the Crassulaceae family (Vázquez-García *et al.* 2021). Phylogenetic studies (Acevedo-Rosas *et al.* 2004a, 2004b) sampling 19 species of *Graptopetalum* and 24 species from nine closely related genera of the Crassulaceae family showed that *Graptopetalum* is not monophyletic, but three studied haplostemonous species, *G. glassii*, *G. pentandrum* and *G. superbum*, conformed a moderate to well-supported clade, which was later formalized as *G.* subg. *Glassia* (Byalt 2012). Within this small group, the morphologically closest species to *G. kristenii* are *G. pentandrum* and *G. glassii*, however, the key diagnostic character for *G. kristenii* is its oblong leaf shape (Fig. 2). The three remaining species of subgenus *Glassia*, *G. rosanevadoense* A.Vázquez & Acev.-Rosas in Vázquez-García *et al.* (2021: 162), *G. superbum*, and *G. trujilloi* A.Vázquez & Rosales in Vázquez-García *et al.* (2022: 282), feature considerably larger vegetative and reproductive structures, a ramose habit, and oblong-obovate leaves (Kimmach 1987, Vázquez-García *et al.* 2021, 2022).



**FIGURE 2.** Leaf shapes of *Graptopetalum pentandrum*, *G. kristenii* and *G. glassii*.

*Graptopetalum kristenii*, with its narrow distribution, contributes to the high endemism of the Sierra de Coalcomán, since it is known only from a single population. This area is characterized by pine-oak forests, low deciduous and

medium subdeciduous forests with areas of montane cloud forest (Santiago-Alvarado *et al.* 2016). It harbors many endemic taxa, such as *Agave andreae* Sahagún & A. Vázquez in Vázquez-García *et al.* (2013: 323), *Beiselia mexicana* Forman (1987: 262), *Bia manuelii* Steinmann & Ramírez-Amezcuca (2013: 747), *Cuphea michoacana* Foster (1945: 65), *Euphorbia coalcomanensis* (Croizat 1943: 19) Steinmann (2003: 48), *Mirabilis hintoniorum* Le Duc (1992: 53), *Pinus rzedowskii* Madrigal-Sánchez & Caballero-Deloya (1969: 1), and others. Due to that, as well as for its high richness and biological integrity, the Sierra de Coalcomán is considered one of Mexico's priority regions for conservation (Arriaga *et al.* 2000). On the other hand, *Graptopetalum kristenii* becomes the second species of the genus reported for Michoacán after *G. pentandrum*, which was described from cultivated material, but later rediscovered by Alfred B. Lau near Aguquilla (Kimmach 1987), and also reported from Los Chorros del Varal (Cházaro-Basáñez *et al.* 2004). Despite the fact that *G. kristenii*, *G. pentandrum* and *G. glassii* are geographically close within a small area in the states of Colima and Michoacán, in Western Mexico, their distribution ranges fall within different biogeographic provinces (Fig. 1): *G. kristenii* inhabits the Sierra Madre del Sur, *G. pentandrum* the Balsas Basin, and *G. glassii* the Pacific Lowlands. Furthermore, *G. kristenii* is the southernmost species among subgenus *Glassia* (Fig. 1, Table 2). Each province involves different orogenic processes, implying the formation of geographic barriers and different direct and indirect gradients, which promotes small-scale allopatric speciation.

## Conclusions

1. A new species, *Graptopetalum kristenii*, was unveiled based on morphological and ecological data. 2. The new species can be easily distinguished from its morphologically closest species, *G. pentandrum* and *G. glassii*, by its broadly oblong leaves. 3. *G. kristenii* is endemic to Coalcomán, Michoacán, where it thrives on rocky outcrops within the Sierra Madre del Sur province. It is the southernmost species among subgenus *Glassia*.

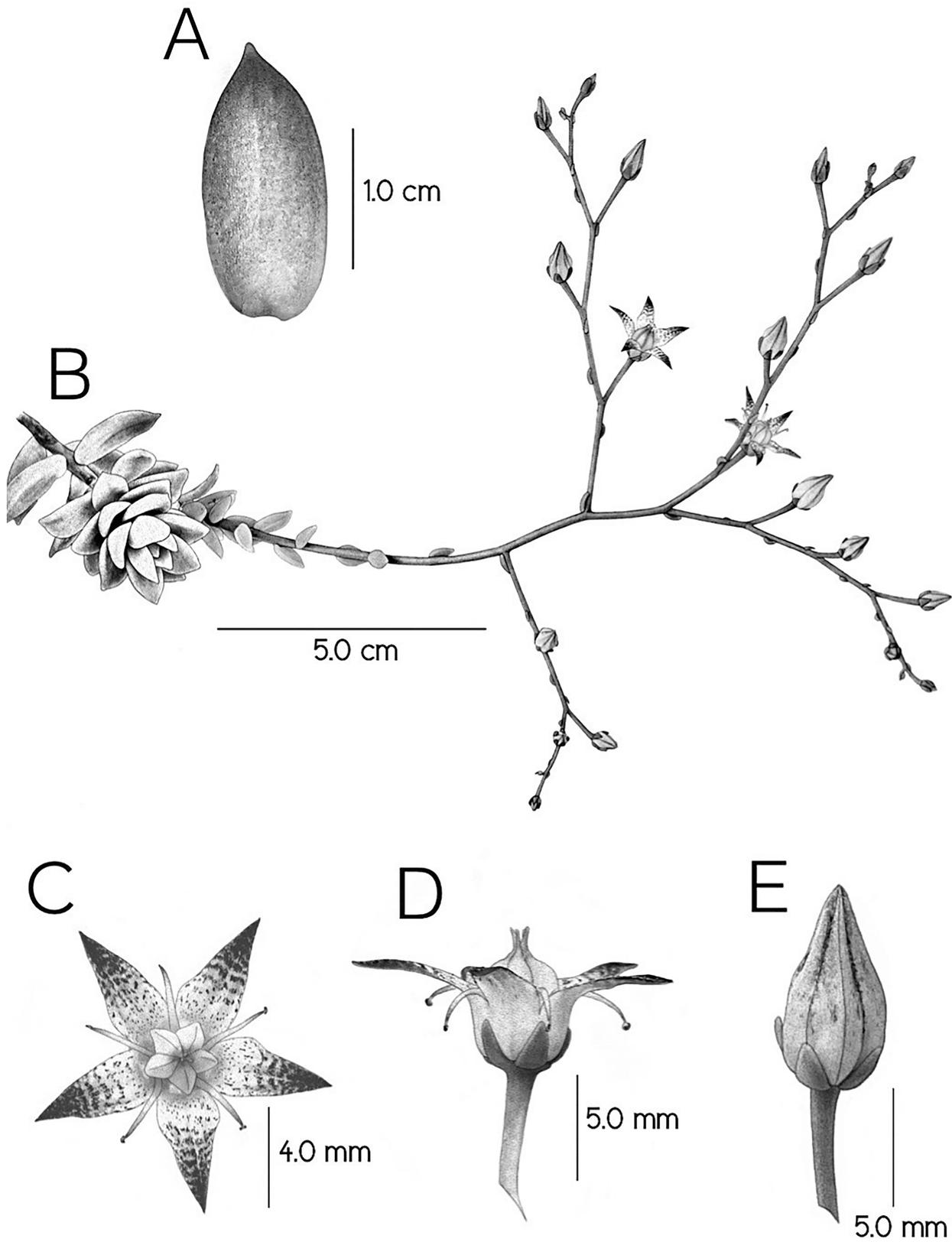
## Taxonomy

*Graptopetalum kristenii* Etter, A. Vázquez & Rosales *sp. nov.* Figs. 3–5.

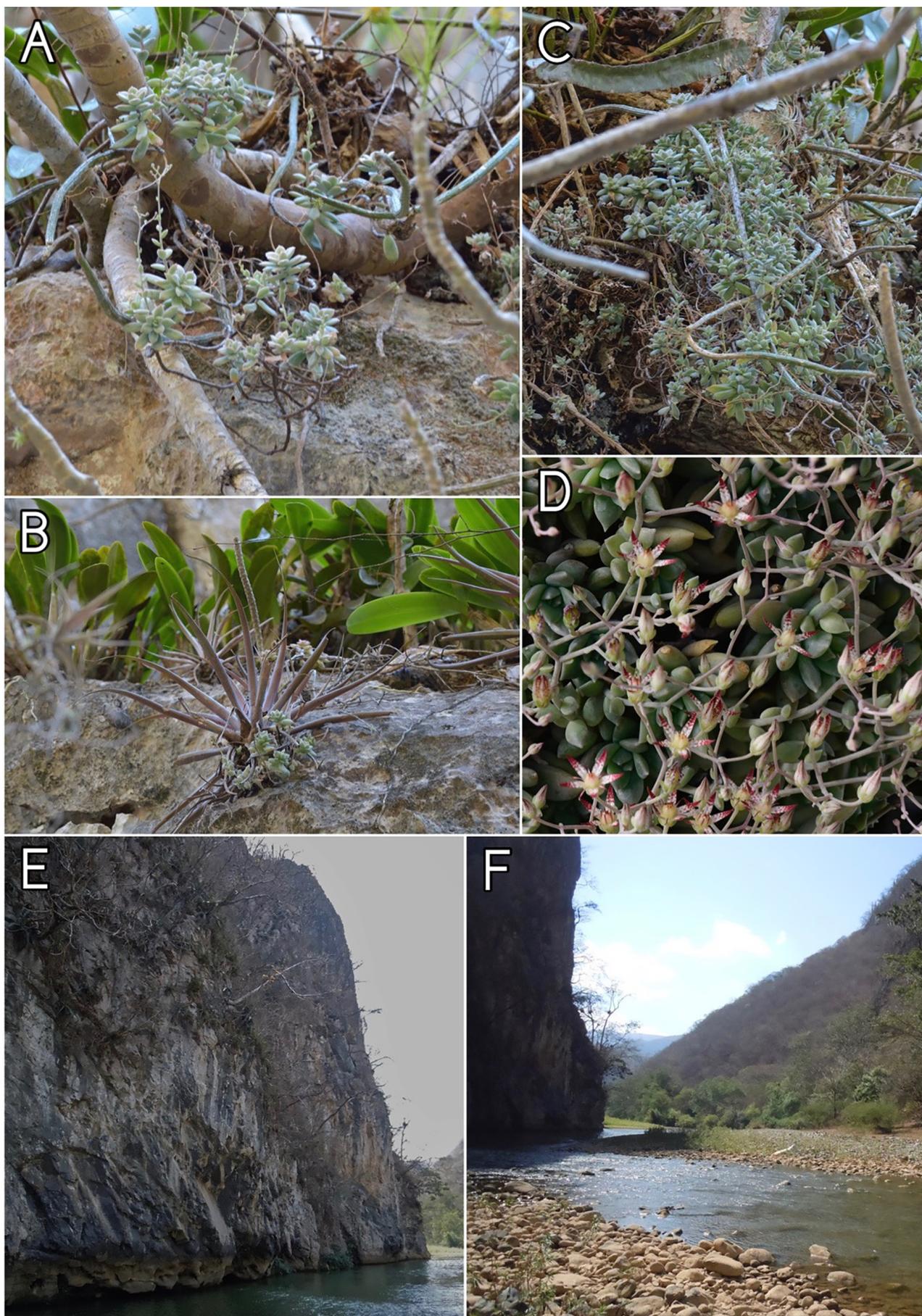
**Type:**—MEXICO. Michoacán: municipality of Coalcomán, SW of San Acamitán, shady cliffs along Río Coalcomán in tropical deciduous forest, 20 March 2013, *J. Etter & M. Kristen 3764* (Holotype IBUG!; isotype CIMI!).

**Diagnosis:**—*Graptopetalum kristenii* is similar to *G. pentandrum*, but it differs from the latter in rosette diameter 3.4–5.0 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 with respect to the rest of branches; flower diameter 12.5–15.0 vs. 17.0–19.0 mm; petal width 2.2–2.6 vs. 1.7–1.8 mm; and petal color pattern white with conspicuous red stains along vs. white to yellowish, with a rhomboid dark red stain in the upper half of the petal.

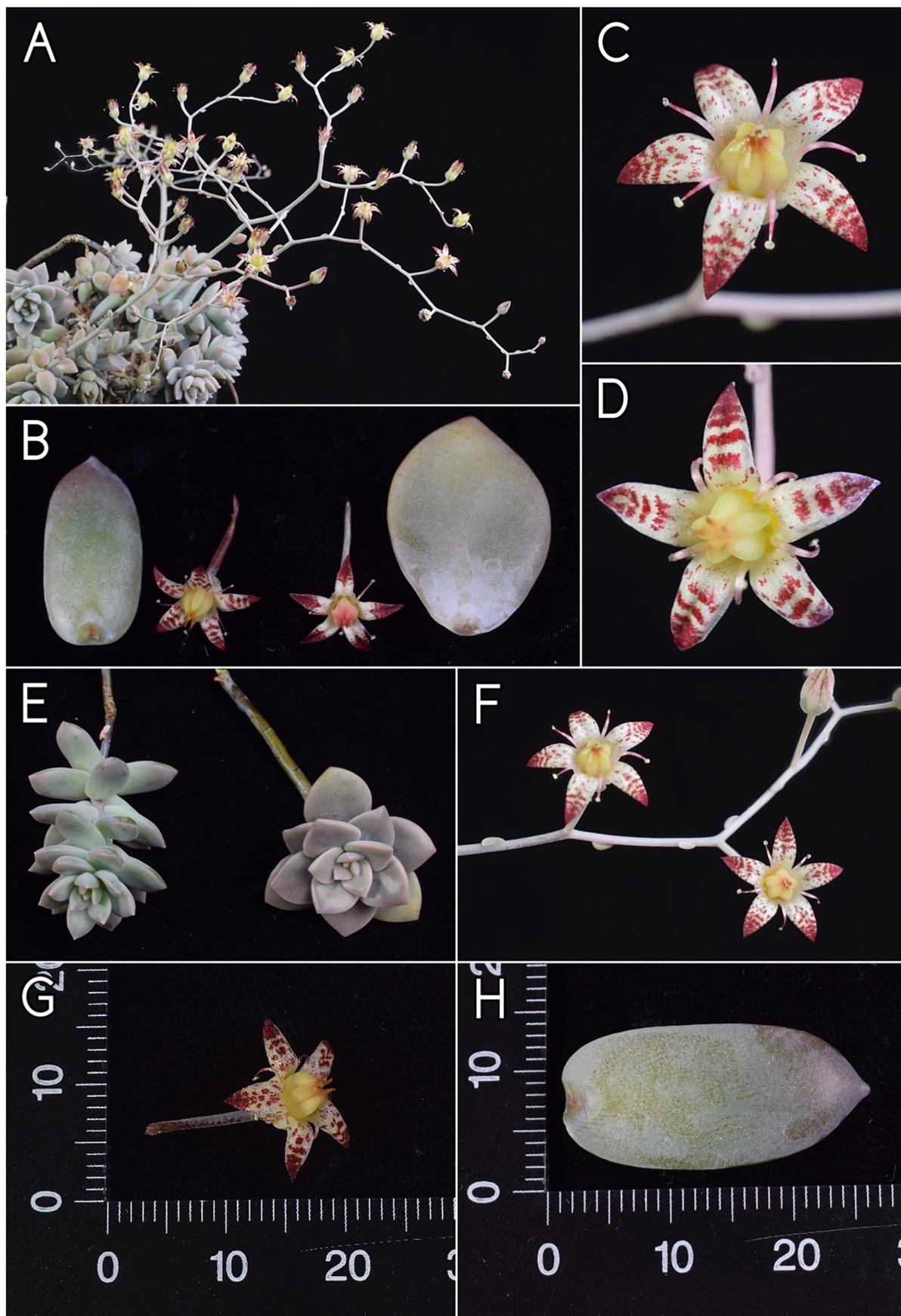
**Description:**—Plants perennial, caulescent, cespitose-ramose, sometimes forming dense groups, branching basally and rarely from the upper parts of the stem, 8.0–30.0 cm tall without scape; stems 2.5–3.5 mm in diam. at the base, erect at first, later decumbent to pendant, surface smooth, green-brownish to grayish, pinkish to green-glaucous from a short segment below the rosette upwards, with prominent, circular, green-brownish scars, 1.0–1.5 mm in diam., the tips grayish; rosettes terminal, 4.0–8.0 × 3.4–5.0 cm, sometimes with somewhat scattered leaves but compact to the apex; leaves 15–30 per rosette, 1.4–2.7 × 0.7–1.3 cm, broadly oblong, straight to sometimes incurved, shortly acuminate, base obtuse, apex with a small mucro 1–2 × 1–1.5 mm, usually inclined upwards, adaxially slightly concave, abaxially convex, 4.0–4.5 mm thick, the thickest part near the middle, greenish to glaucous-pinkish, sometimes with a different darker pinkish to purplish tonality towards the apex, somewhat pruinose, glabrous; inflorescence a paniculate cyme, 19.0–28.0 cm long; peduncle 2.0–2.5 mm thick at the base, gray-bluish to pinkish; peduncle bracts oblong-obovate or lanceolate to elliptic, the basal 10.0–13.0 × 4.0–7.0 mm, gradually smaller upwards to 4.0–7.0 × 2.0–4.0 mm, those below the branches 2.0–4.0 × 1.0–2.0 mm; fertile part with 3–4 primary branches, with 15–24 flowers per inflorescence; primary branches 2.0–6.0 cm, with irregularly scattered bractlets, somewhat zig-zag shaped, the basal usually simple, with 3–4 flowers, the rest mostly bifurcate, with 4–7 flowers each; pedicels variable in length, 6.0–11.0 mm long, same color as the peduncle or reddish; flowers pentamerous, 12.5–15.0 mm in diameter; sepals subequal, 2.4–2.7 mm long, lanceolate, same color as the leaves; petals subequal, forming a 2.4–2.9 mm long tube, the lobes 4.9–6.2 × 2.2–2.6 mm



**FIGURE 3.** *Graptopetalum kristenii*. A. Broadly oblong leaf. B. Plant with inflorescence. C–D. Flower. E. Flower bud.



**FIGURE 4.** *Graptopetalum kristenii* in habitat. A–C. Pendant rosettes growing on cliffs. D. Flowering plants. E–F. Cliffs along Río Coalcomán. Photographs by J. Etter and M. Kristen.



**FIGURE 5.** *Graptopetalum kristenii*. A. Colony showing various rosettes with inflorescence. B. Comparison between leaves and flowers of *G. kristenii* (left) and *G. pentandrum* (right). C–D. Flowers with different petal color patterns. E. Comparison between rosettes of *G. kristenii* and *G. pentandrum*. F. Branch segment with flowers and buds. G. Flower with measurements (mm). H. Leaf with measurements (mm). Photographs by J. Etter and M. Kristen.

at the widest part near the base, triangular, shortly acuminate, bending back, white with conspicuous red stains along, with a shallow middle-groove along; stamens 5, antesealous, ca. 6.0–7.0 × 0.3–0.5 mm, erect at first, later curving outside, white-pinkish, reddish in the upper half, base adnate to corolla tube; anthers rounded, white; gynoecium protruding from the corolla, ca. 6.0–7.0 × 3.5 mm, creamish-yellow to yellow-greenish, obovate, carpels abaxially obtuse; styles ca. 1 mm long, erect, reddened.

**Distribution and ecology:**—So far, *Graptopetalum 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*, *Anthurium halmoorei* Croat (1983: 301), *Bursera* spp., *Epidendrum ciliare* Linnaeus (1759: 1246), *Mammillaria* sp., *Oncidium leleui* Jiménez-Machorro & Soto-Arenas (1990: 58), *Opuntia* sp., *Philodendron warszewiczii* K.Koch & C.D.Bouché in Braun *et al.* (1855: 4), *Pittocaulon hintonii* Robinson & Brettell (1973: 452), *Pseudobombax* sp., *Selenicereus murrillii* Britton & Rose (1920: 206), *Tillandsia* spp., and others.

**Phenology:**—The development of the inflorescences starts to be evident during the first pair of months of the year. The anthesis occurs between early March and early April.

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

**Conservation status:**—We assessed the new species as critically endangered (CR) based on the criteria B1ab. The Extent of Occurrence was 10.0 km<sup>2</sup> and the Area of Occupancy was 4.0 km<sup>2</sup>. A population reduction is expected due to deforestation for agriculture and due to climate change, which could cause more severe natural disasters and alter the microclimate of this fragile habitat. Also, the species is known from a single population within an area of less than 10 km<sup>2</sup>.

#### Key to the haplostemonous species of *Graptopetalum*:

1. Rosettes 2.0–8.0 cm in diameter, cespitose .....2
- Rosettes 9.0–16.0 cm in diameter, non cespitose .....4
2. Inflorescence 6.0–12.0 cm long, 2 or less branches per inflorescence, endemic to Colima ..... *G. glassii*
- Inflorescence 19.0–35.0 cm long (rarely less), 3 or more branches per inflorescence, endemic to Michoacán .....3
3. Leaves broadly oblong, rosettes 5.0 cm or less in diameter, flowers 15.0 mm or less in diameter .....*G. kristenii*
- Leaves obovate, rosettes 6.0 cm or more in diameter, flowers 17 mm or more in diameter..... *G. pentandrum*
4. Stems more than 10.0 mm in diameter, squamose stem surface ..... *G. superbum*
- Stems less than 8.0 mm in diameter, smooth stem surface .....5
5. Plants 40.0–87.0 cm tall, inflorescence primary branches 5–7, mean flower density per 10 cm of the scape 6–14, flowers per basal branch 7–8, flower diameter 14.9–15.9 mm, petals yellowish with conspicuous transversal red stripes, petal width 2.9–3.0 mm, filaments red, carpels abaxially rounded..... *G. rosanevadoense*
- Plants 15.0–35.0 (–41.0) cm tall, inflorescence primary branches 8–10, mean flower density per 10 cm of the scape 16–20, flowers per basal branch 3–6, flower diameter 12.9–13.1 mm, petals greenish with inconspicuous transversal red stripes, petal width 2.7–2.8 mm, filaments greenish to distally red, carpels abaxially obtuse.....*G. trujilloi*

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