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Graptopetalum rosanevadoensis (Crassulaceae): A new haplostemonous species from the Nevado de Colima, Jalisco, Mexico

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Abstract

Graptopetalum rosanevadoensis (subgenus *Glassia*, Crassulaceae), a new haplostemonous species from Jalisco, Mexico, is described and illustrated. Its closest morphological species are *G. superbum* and *G. pentandrum*. It differs from both in having a much larger rosette with more numerous leaves and in terms of its number of branches per panicle and its stem diameter, which is intermediate between the two species. Now, subgenus *Glassia* includes four allopatric haplostemonous species, all confined to western-central México: *G. glassii*, *G. pentandrum*, *G. rosanevadoensis* and *G. superbum*. A key to species of *Graptopetalum*, subgenus *Glassia* is provided. According to IUCN criteria, the species was assessed as critically endangered (CR).

Resumen

Graptopetalum rosanevadoensis (subgénero *Glassia*, Crassulaceae), una nueva especie haplostémona del Nevado de Colima, Jalisco, México es descrita e ilustrada. Sus especies más cercanas morfológicamente son *G. superbum* y *G. pentadrum*. Difiere de ambas por sus rosetas de mayor tamaño y con mayor número de hojas, y en la cantidad de ramas por panícula y en el diámetro del tallo que es intermedio entre las dos especies. Ahora, el subgénero *Glassia* incluye cuatro especies haplostémonas alopátricas, todas confinadas al occidente-centro de México. Se proporciona una clave para las especies haplostémonas de *Graptopetalum*. Según los criterios de la UICN, la especie se evaluó como en peligro crítico (CR).

Keywords: succulent plants, taxonomy, western Mexico

Introduction

Graptopetalum Rose (1911: 296) includes 20 species ranging from Arizona in the southern USA to Oaxaca, México (Meyrán-García & López-Chávez 2003, Acevedo-Rosas & Cházaro-Basáñez 2003, Thiede & Eggl 2007, Vega-Aviña *et al.* 2020), six of them occur in western-central Mexico, not including Michoacán state (Acevedo-Rosas *et al.* 2018): *G. amethystinum* (Rose 1905: 11) Walther (1931: 73) from west of Bolaños, Jalisco rediscovered by Cházaro & Flores (1999); *G. fruticosum* Moran in Moran & Uhl (1968: 152) from the southwest of Puerto los Mazos, Sierra de Perote, southern and central part of the state of Jalisco (Lomeli-Sención 1988); *G. glassii* Acevedo-Rosas & Cházaro-Basáñez (2003: 378), from Ixtlahuacán, Colima (Fig. 1; Cházaro-Basáñez & Acevedo-Rosas 2008); *G. marginatum* Kimmach & Moran (2002: 74) from Mirador del Águila, Nayarit (Cházaro-Basáñez *et al.* 2012); *G. pachyphyllum* Rose (1922: 45) from Ojuelos, Jalisco (Cházaro-Basáñez & Thiede 1995); and *G. superbum* (Kimmach 1987: 142) Acev.-Rosas in

Acevedo-Rosas & Cházaro-Basáñez (2003: 380) from Juchitlán, Jalisco (Fig. 1; Cházaro-Basáñez & Flores 1992). Whereas *G. pentandrum* Moran (1971: 56) is from El Salto, a waterfall 4 km north Aguililla, Michoacán (Kimmach, 1987) and from the waterfall of Los Chorros del Varal, 20 km SW of Los Reyes, Michoacán (Fig. 1; Cházaro-Basáñez *et al.*, 2004).

Graptopetalum comprises succulent perennial herbs or small shrubs with acaulescent to caulescent rosettes and lateral few-flowered inflorescences; the flowers are frequently characterized by a fetid odor, the petals are connate from the base up to the middle of their length, forming a tube, white or somewhat pale yellowish or pale greenish and show nearly always a series of red, wine red or dark purple dots in horizontal bands; the stamens are usually 10, in two whorls, initially erect and recurved after anthesis (Meyrán-García & López-Chávez 2003), but sometimes bearing only 5 stamens on a single whorl (haplostemony or pentandry), a rare trait shared among *G. glassii*, *G. pentandrum*, and *G. superbum*, forming a group of closely related species (Acevedo-Rosas *et al.* 2003) which was informally separated as the *Graptopetalum pentandrum* group (Thiede 2003) and formalized as *Graptopetalum* Subg. *Glassia* Byalt (2012: 79); this feature is shared with some old world genera such as *Sedum* Linnaeus (1753: 430) (subfamily Sempervivoideae, tribe Sedeae Fries (1835: 97) *et t* Hart in Hart & Egli (1995) and *Sinocrassula* Berger (1930: 462) (subfamily Sempervivoideae, tribe Telephieae Bartling (1825: 157).

In July of 2004, Rosa Murguía-Araiza, a student of agronomy engineering from the Universidad de Guadalajara, collected a few living plants locally called “chonguitos” near her hometown village, Telcruz. Her mother then grew them in her backyard. One of those plants bloomed in May 2005 at Vázquez-García’s greenhouse. We readily realized that it did not match any of the few well known haplostemonous species of *Graptopetalum*, albeit *G. superbum* was the most similar mainly for the size and diameter of the rosette and having oblong-obovate leaves.

The aim of this work is to determine the systematic position and the taxonomic status of the plants found near Telcruz village, Zapotitlán de Vadillo in Southern Jalisco, and to propose the conservation status since the population has a restricted distribution area and it is having a human impact strongly perturbing its habitat.

Material and methods

Several field trips were carried out to the region of Colima volcano where the species grows. The field trips were planned monthly at each season to observe as many characters as possible. Soon thereafter, we visited the area searching for additional populations, to gain a better understanding of its variability.

The identity of the genus was successfully confirmed using the keys to Mexican Crassulaceae by Meyrán-García & López-Chávez (2003) and we adopted the Cronquist’s morphological species concept (Cronquist 1978). Specimens of *Graptopetalum* spp. were examined at IBUG herbarium. The morphological analyses were carried out using fresh material and herbarium specimens. All seven quantitative measurements and the four qualitative observations (Table 1) were made in fresh, and fine observations of leaf and stem texture and measurements of reproductive structures such as style length were made with the aid of a stereomicroscope.

Major characters of the plants from Telcruz, Zapotitlán de Vadillo, were contrasted against the single morphologically closest species *Graptopetalum superbum* and also against the other two geographically close species, *G. pentandrum* and *G. glassii*, occurring in Western México too (Acevedo-Rosas *et al.* 2018) (Table 1).

The morphological comparison was based on the protologues and on the descriptions, including dichotomic keys, of all four known haplostemonous species of *Graptopetalum*. We studied specimens of this genus deposited at IBUG, IEB, XAL and ZEA. Habitat and phenology were obtained from herbarium specimen labels, fieldwork and local inhabitants.

The Protologue of *G. superbum* and its synonym *G. pentandrum* subsp. *superbum* was consulted at the Biodiversity Heritage Library Database (2019) (<https://www.biodiversitylibrary.org/>) (Kimmach 1987). High-resolution images of the type material of *G. superbum* and of other pentandrous species of *Graptopetalum* were examined at the both Tropicos (2019) database (<https://www.tropicos.org/>) and JSTOR Global Plants website (2019) (<http://plants.jstor.org>).

The distribution map was generated uploading GPS data on a Google Earth image 2020 (<https://earth.google.com/web/search/Jalisco,+M%C3%A9xico/@19.79972419,-103.55786066,1711.57016764a,555911.93043195d,35y,0h,0t,0r/data=CigiJgokCd31N0SXIjRAEdvln0SXIjTAGXqFVJkuh0XAIIdooSm73FGLA>) and the use of vectorial data from INEGI 2020 (<http://en.www.inegi.org.mx/app/mapa/espacioydatos/>) to draw the state borders.

TABLE 1. Characters distinguishing *Graptopetalum rosanevadoensis* sp. nov. from its closest morphological species.

	<i>G. rosanevadoensis</i>	<i>G. superbum</i>	<i>G. pentandrum</i>	<i>G. glassii</i>
Plant	Ramose	Ramose	Caespitose-ramose	Caespitose
Plant size (cm)	40.0–87.0	40.0–80.0	40.0	16.0–20.0
Rosette diameter (cm)	10.0–16.0	9.0–11.0	6.0–8.0	2.0–4.0
Number of leaves per rosette	31–47	12–28	15–35	30–40
Stem surface	Smooth	Squamous	Smooth	Smooth
Stem diameter (cm)	0.7–0.8	1.0–1.2	0.3–0.6	0.3–0.5
Leaf length (cm)	1.5–5.9	4.0–5.5	2.0–4.0	1.3–2.0
Leaf form	Oblong-obovate	Oblong-obovate	Obovate	Oblanceolate
Leaf color	Glaucous to brownish green, pinkish when young	Gray-bluish to pink-violet	Blue-greenish to white-bluish	Blue-greenish to white-greenish
Inflorescence length (cm)	9.8–27.5	30.0–40.0	20.0–35.0	6.0–12.0
Number of branches per inflorescence	5–6	12–15	3–4	1–2

The conservation status was assessed using the IUCN Red List Criteria (IUCN 2019) and the GeoCAT cloud software tool (Kew 2019). The Extent of Occurrence (minimum convex polygon, EOO) and the Area of Occupancy (grid cell area with occupancy, AOO) of each taxon were delimited from georeferenced records obtained from specimens at the IBUG herbarium, the GBIF, Tropicos.org, REMIB-CONABIO, REBIOMEX database and field data. AOO was based on the IUCN default cell width of 2 km. Field observations of habitat conditions and abundance and the trend of global warming were also taken in to the account.

Results

The comparison between the species from the Volcán de Colima area, near Telcruz, Zapotitlán, Jalisco, with the other known closest related species carry us out to decide that is a new one within the genus *Graptopetalum* Subg. *Glassia*, because the morphological differences.

Graptopetalum sp. shares with from its morphologically closest species, *G. superbum*, similar habit, plant size, rosette diameter, leaf length and form, but it differs from the latter in the number of leaves per rosette, stem surface, stem diameter, leaf color, inflorescence length and number of branches per inflorescence (Table 1). It shares with *G. pentandrum* a similar plant size, number of leaves per rosette, stem surface, leaf and inflorescence length, but it differs from the latter in habit, rosette diameter, stem diameter, leaf form and color and number of branches per inflorescence. It shares with *Graptopetalum glassii* a similar or overlapping features, such as habit, habit, number of leaves per rosette, stem surface and diameter, leaf length and color, but it differs from the latter in plant size, rosette diameter, leaf form, inflorescence length and number of branches per inflorescence.

The newly described species was assessed as critically endangered (CR). Criterion A3 (EOO). Population reduction is projected 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 B2. The area of occupancy (AOO) is less than 10 km² where only two nearly contiguous populations are known from a single location. A very narrow distribution is usually the case for species of *Graptopetalum*. Criterion C2(a)(i). The population size is very small, with less than 50 mature individuals and is expected to decline. Criterion E. The population is expected to decrease by about 50% within three generations (100 years).

Discussion

Morphological analysis showed a clear distinction of our samples from all other compared species, deserving to be treated as a new species: *G. rosanevadensis* sp. nov.

Graptopetalum rosanevadensis belongs to a very small subgroup within the genus that is defined as a monophyletic group for having a distinctive character, a single whorl of stamens (haplostemonous, 5 alternate stamens to the petals) instead of two whorls (10 stamens) typical of the family Crassulaceae. *Graptopetalum superbum*, *G. pentandrum* and *G. glassii* are considered as the closest morphological species to *Graptopetalum rosanevadensis* (Tab. 1). According to Acevedo-Rosas *et al.* (2004a, 2004b), using morphological and molecular data, this group displays a moderate to well-supported subclade within the genus and a strong geographic structure in the phylogeny, thus geographic distribution is a better indicator of phylogenetic relationships than habit or flower morphology, all four haplostemonous species inhabit western Mexico: two are confined to southern Jalisco, one to Colima and one to Michoacán. Furthermore, the group, having haplostemonous flowers as a synapomorphic character, is defined as monophyletic within *Graptopetalum* (Acevedo-Rosas *et al.* 2004a, 2004b). Phylogenetic analyses (Mort *et al.* 2001, Mayuzumi and Ohba 2004) indicate that haplostemony is an exclusive feature of the “Crassula clade” and the “Telephium clade”. But these four haplostemonous species of *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* and the American *Graptopetalum* (Acre clade). However, the evolutionary process that gave rise to haplostemony within the family remains uncertain and needs to be investigated.

Even though that all four known haplostemonous species of *Graptopetalum* are endemic to southwestern México, within an area of 100 km of radius, where they display a small-scale pattern of allopatric speciation. Two of the species: *G. rosanevadensis* and *G. superbum* were confined to the Jaliscan side of the more recent physiographic region Trans-Mexican Volcanic Belt. In contrast, *G. glassii* was restricted to the Coliman side of the older physiographic region Sierra Madre del Sur; and *G. pentandrum*, occurred in the two mentioned physiographic regions, the two locations are in the state of Michoacán (Fig. 1). The geographically closest species (62 km apart) are *G. glassii* and *G. rosanevadoensis*, the former growing on gypsic soils at 500 m in elevation and the latter on volcanic sandstone at 1400 m in elevation, the two separated in distinct physiographic provinces and by the topographic barrier imposed by the slopes of both the calcareous massif of Cerro Grande and by the numerous volcanic ridges of the steep slopes of Volcán de Colima.

Conclusions

1. A new haplostemonous and narrow endemic species of *Graptopetalum* was discovered in the steep slopes of Volcán de Colima, Jalisco, México; 2. The morphological analysis help determine that the specimen collected in Telcruz, Zapotitlán de Vadillo is a new species that we named *Graptopetalum rosanevadoensis*. 3. *Graptopetalum rosanevadoensis*, as a novelty, with its uncommon synapomorphic haplostemony, is expected to be part of the well-supported subclade including all other haplostemonous species; 4. Biogeographic and evolutionary processes giving rise to haplostemony deserve further attention; 5. A small-scale pattern of allopatric speciation was unveiled for all four haplostemonous endemic species of *Graptopetalum* in Western Mexico; and 6. Using IUCN criteria, the species was assessed as critically endangered.

Taxonomic treatment

Graptopetalum rosanevadoensis A. Vázquez & Acev.-Rosas sp. nov. (Figs. 1–4).

Diagnosis:—It is similar to *Graptopetalum superbum* 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, 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, and branches per inflorescence 5–6 vs. 12–15. It is also similar to *G. pentandrum* in stem length with smooth surface and color pattern of petals, but it differs from the latter in having a habit none caespitose ramose vs. caespitose-ramose, rosette diameter 10.0–16.0 vs. 6.0–8

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.

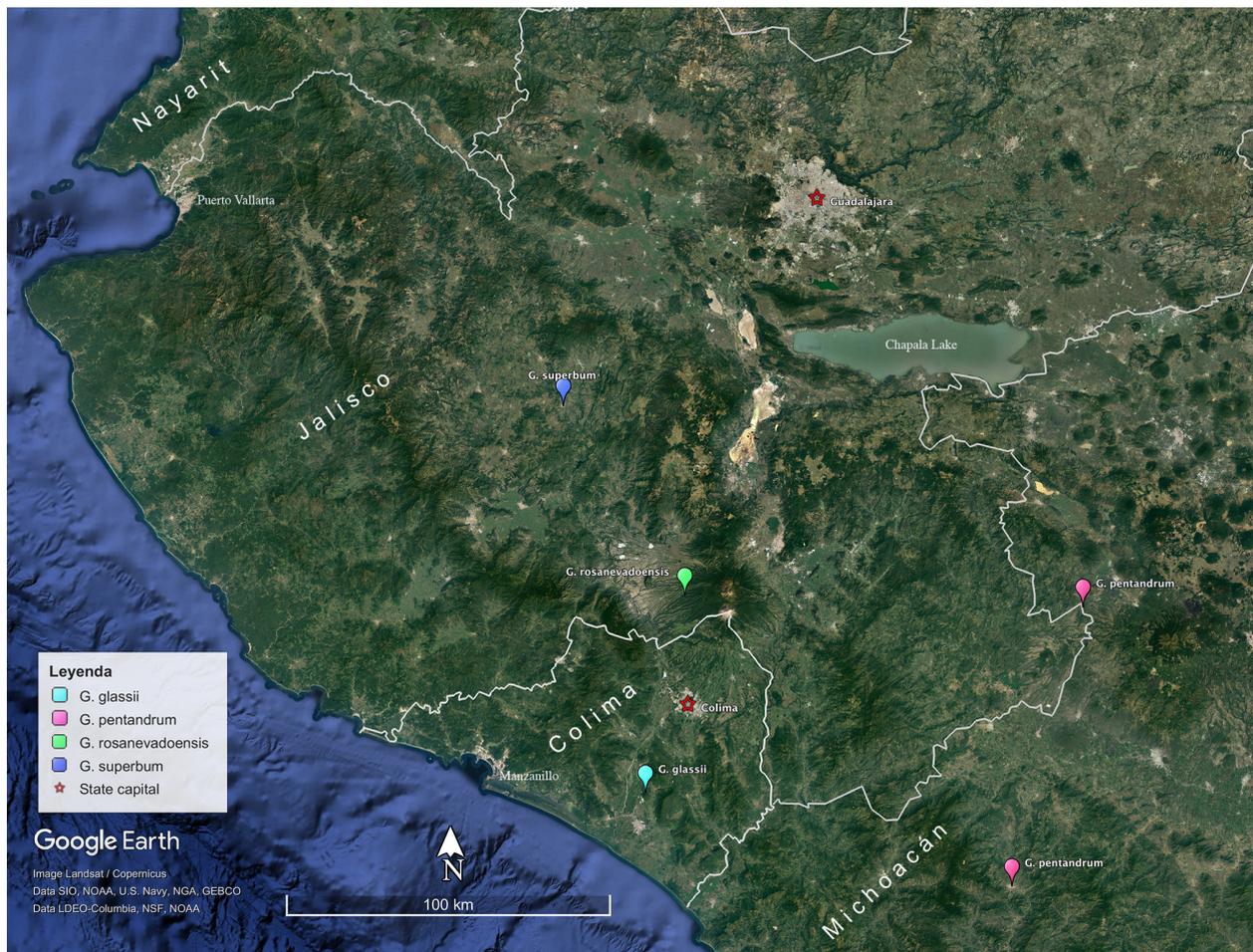


FIGURE 1. Distribution map for the haplostemonous species of *Graptopetalum*.

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

Plant perennial, ramose, a sparse terminal rosette 10.0–16.0 cm diam.; stems 40.0–87.0 cm tall, decumbent, pendulous, smooth, 7.0–8.0 mm diam.; leaves 31–47, (1.5–) 3.0–4.0 (–5.9) × (1.4–) 1.6–1.8 (–1.9) cm, (4.0–)5.0–7.0 (–8.0) mm thick, inner surface slightly concave, oblong–obovate, obtuse to rounded, sometimes with a short apical mucro, cuneate at the base, glaucous to brownish green, pinkish when young; scape 1.5–4.0 mm thick at the base, 1 mm thick at the top; panicle (9.8–) 10.5–20.3 (–27.5) cm long, 5–6 branches per inflorescence; bracts 23–29, ovoid, the lowest 1.9–3.1 cm long, the uppermost bracts 2.0–3.0 mm long, soon deciduous; panicle branches 2.4–4.3 cm long, simple or bifurcate, with 2–4 flowers each; pedicels 3.0–14.0 mm long; flower buds 3.0 × 3.0 mm; sepals 5, 3.0 mm long, distinct, appressed; petals 5, pale yellowish-green or pale yellowish, with red to wine red dots, these forming horizontal bands across the petals, mainly at the apex; nectary scales [wanting]; 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 cm long, obovate, yellow green, style 0.9 mm, orange, red-orange or dark red apically.

Distribution, habitat and phenology:—*Graptopetalum rosanevadoensis* is known only from several large populations (10–20 individuals each) at and near the type locality, on the western slopes of the Nevado de Colima, found in various 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. Flowering in May and perhaps in November as we were told by local inhabitants.

Eponymy and Ethnobotany:—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. The hanging rosettes are called “chonguitos”. Smashed leaves are used

for eye cleaning, rosettes are collected and grown in the backyards as ornamentals, the leaves are often eaten by birds (especially sparrows) while in flower pots.

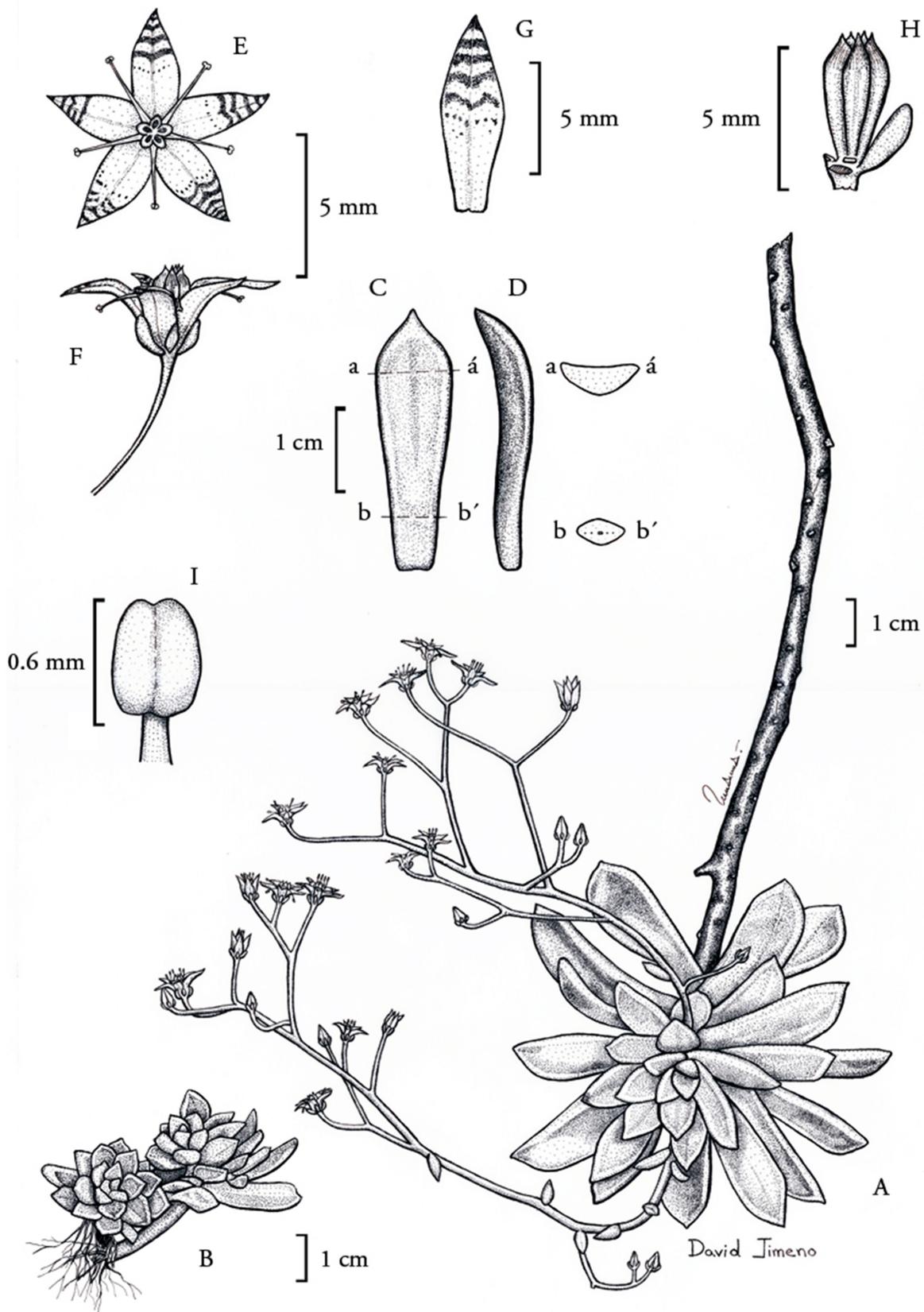


FIGURE 2. *Graptopetalum rosanevadoensis*. A. Habit in perspective, the focal point, on terminal inflorescence, appearing larger than it is. B. Vegetative growth. C. Leaf in ventral view. D. Leaf in lateral view (a–a', b–b', cross-sections of the leaf). E. Front view of the flower. F. Lateral view of the flower and pedicel. G. Petal detail. H. Gynoecium with nectary scale. I. Anther detail (drawn from the holotype by David Jimeno).



FIGURE 3. *Graptopetalum rosanevadoensis*, grown from type collection at Jesús Trujillo's home (in Guadalajara; photo: April 11, 2012).

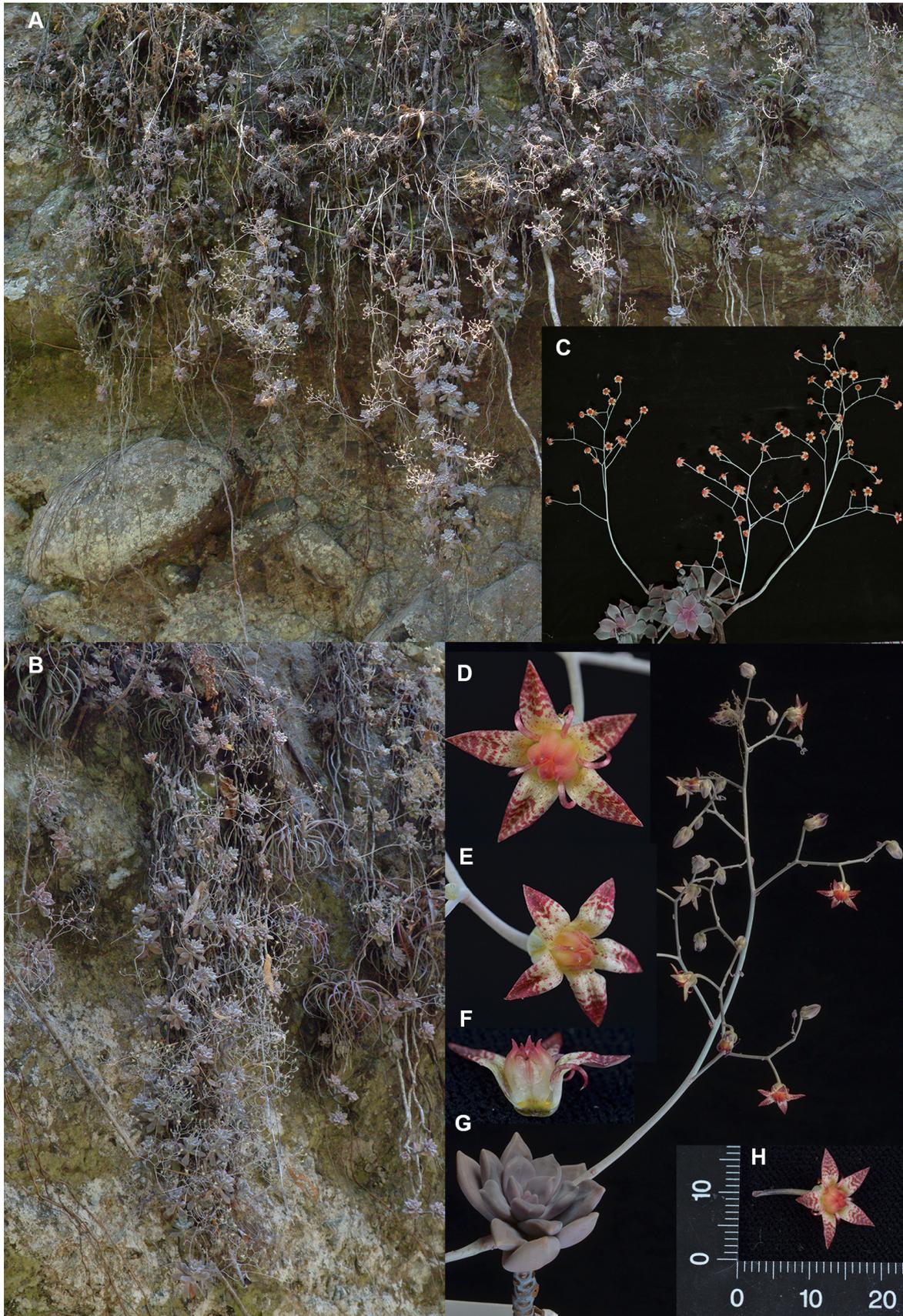


FIGURE 4. *Graptopetalum rosanevadoensis*. A–B. Inverted J-shaped hanging habit of rosettes [at the type locality, photo: May 15, 2005]. C. Rosettes and inflorescence (upper view). D. Flower after anthesis. E. Flower at anthesis. F. Lateral view of a dissected flower. G. Rosette and inflorescence, lateral view. C–H from cultivated plants (grown from the type collection, photo: April 10, 2012). Flower dimensions in mm.

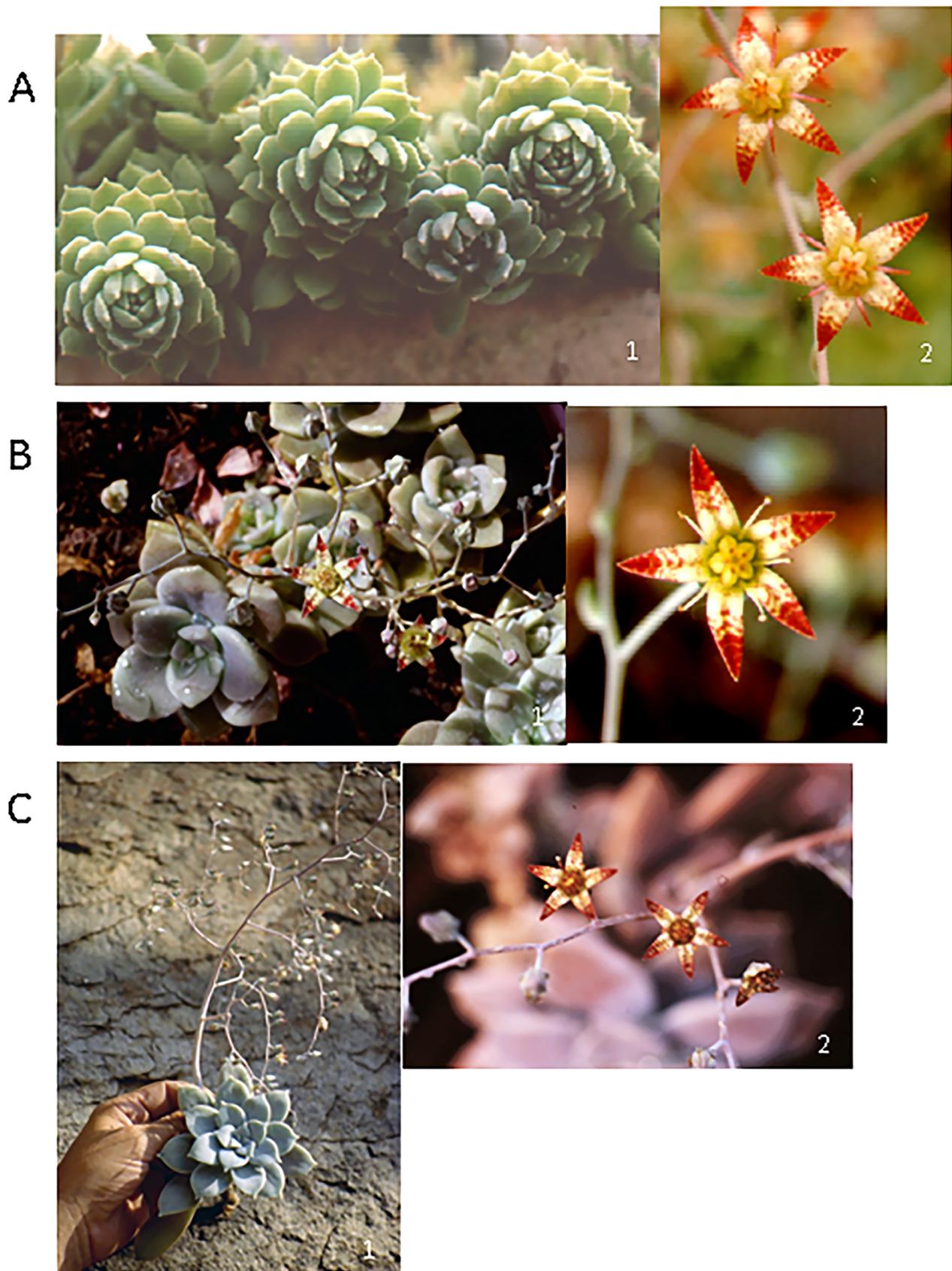


FIGURE 5. *Graptopetalum rosanevadoensis* closest morphological species. A. *G. glassii*. Notice the compact, recurved-leaved greenish habit with many rosettes. B. *G. pentandrum*. Notice the loosely branched habit with few, large flat grayish leaves. C. *G. superbum*. Notice the flat, heart-shaped gray-bluish leaves. Photos: R. Acevedo-Rosas (A, B2 and C2); M. Cházaro-Basáñez (B1 and C1).

Additional specimens examined:—MÉXICO. 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).

Key to the species of Haplostemonous *Graptopetalum*

- 1. Plants with rosettes less than 6 cm diameter, oblanceolate leaves and less of 2 cm long *G. glassii*
- Plants with rosettes more than 6 cm diameter, obovate to oblong-obovate leaves and more of 2 cm long 2
- 2. Rosettes less than 8 cm diameter, obovate leaves and until 4 cm long *G. pentandrum*
- Rosettes more than 8 cm diameter, oblong-obovate leaves and more than 5 cm long 3
- 3. Inflorescence branches 6 or less, inflorescence length until 27.5 cm *G. rosanevadoensis*
- Inflorescence branches 12 or more, inflorescence length until 40 cm *G. superbum*

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References

- Acevedo-Rosas, R., Cameron, K., Sosa, V. & Pell, S. (2004a) A molecular phylogenetic study of *Graptopetalum* (Crassulaceae) based on ETS, ITS, *rpl16*, and *trnL-F* nucleotide sequences. *American Journal of Botany* 91: 1099–1104.
<https://doi.org/10.3732/ajb.91.7.1099>
- Acevedo-Rosas, R. & Cházaro-Basáñez, M. (2003) A new species and a nomenclature change in *Graptopetalum* (Crassulaceae). *Novon* 13: 377–380.
<https://doi.org/10.2307/3393365>
- Acevedo-Rosas, R., Cházaro-Basáñez, M. de J., Jimeno-Sevilla, H.D. & Zuno-Delgadillo, O. (2018) Crassulaceae from Western-Central Mexico. *Cactus and Succulent Journal* 90: 146–151.
<https://doi.org/10.2985/015.090.0201>
- Acevedo-Rosas, R., Sosa, V. & Lorea, F.G. (2004b) Phylogenetic relationships and morphological patterns in *Graptopetalum* (Crassulaceae). *Brittonia* 56: 185–194.
[https://doi.org/10.1663/0007-196X\(2004\)056\[0185:PRAMPI\]2.0.CO;2](https://doi.org/10.1663/0007-196X(2004)056[0185:PRAMPI]2.0.CO;2)
- Bartling, F.G. (1825) [1826?] Ueber den Bau und die Verwandtschaften der Alsineen. *Beiträge zur Botanik* 3: 133–206.
- Berg, A. (1930) Crassulaceae. In: Engler, A., Prantl, K. *Die natürlichen Pflanzenfamilien* 2, W. Engelmann, Leipzig, pp. 352–483.
- Byalt, V. V. [Бялт, В. В.] (2012) Новая система рода *Graptopetalum* Rose (Crassulaceae) [A new system of the genus *Graptopetalum* Rose (Crassulaceae)]. *Новости систематики высших растений [Novitates Systematicae Plantarum Vascularium]* 43: 70–83.
- Cházaro-Basáñez, M. de J. & Acevedo-Rosas, R. (2008) *Graptopetalum glassii*, recently described from Colima, Mexico. *Cactus and Succulents Journal* (US) 80: 202–203.
[https://doi.org/10.2985/0007-9367\(2008\)80\[202:GG\]2.0.CO;2](https://doi.org/10.2985/0007-9367(2008)80[202:GG]2.0.CO;2)
- Cházaro-Basáñez, M. de J., Acevedo-Rosas, R. & Machuca-Núñez, J.A. (2012) On *Graptopetalum marginatum* (Crassulaceae). *Cactus and Succulents Journal* (US) 84: 155–158.
<https://doi.org/10.2985/0007-9367-84.3.155>
- Cházaro-Basáñez, M. de J. & Flores, A. (1992) *Graptopetalum pentandrum* subsp. *superbum* Kimnach, from the wild. *Cactus and Succulents Journal* (US) 64: 187–189.
- Cházaro-Basáñez, M. de J. & Flores, A. (1999) *Graptopetalum amethystinum* (Rose) Walther, rediscovered! *International Cactus Adventures* 43: 9–12.
- Cházaro-Basáñez, M. de J., García-Ruiz, I., Flores-Macías A. & Machuca-Núñez, J.A. (2004) In Situ: *Graptopetalum pentandrum* Moran. *International Cactus Adventures* 61: 12–17.
- Cházaro-Basáñez, M. de J. & Thiede, J. (1995) Floristic and phytogeographic studies on the Crassulaceae of Jalisco (Mexico). In: T'Hart,

- H. & Egli, U. (Eds.) *Evolution and systematics on the Crassulaceae*. Backhuys Publishers, Leiden, The Netherlands, pp. 89–123.
- Cronquist, A. (1978) Once again, what is a species? *Beltsville Symposia in Agricultural Research* 2: 3–20.
- Fries, E.M. 1835. *Corpus florum provincialium Sueciae. I. Floram scanicam*. Palmblad, Serell & C., Uppsala, pp. 394.
<https://doi.org/10.5962/bhl.title.47083>
- IUCN Standards and Petitions Committee (2019) Guidelines for using the IUCN Red List Categories and Criteria. Version 14. Prepared by the Standards and Petitions Committee. Downloadable from [<http://www.iucnredlist.org/documents/RedListGuidelines.pdf>]
- KEW Royal Botanic Gardens (2019) GeoCAT Geospatial Conservation Assessment Tool. IUCN, Kew Royal Botanic Garden, Vibrant, Cordis, European Union & NERC.
- Kimmach, M. (1987) A new succulent from Mexico: *Graptopetalum pentandrum* subsp. *superbum*. *Cactus & Succulent Journal of America* 59: 140–143.
- Kimmach, M. & Moran, R. (2002) *Graptopetalum marginatum*, a new species from Nayarit, Mexico. *Cactus & Succulent Journal of America* 74: 196–198.
- Linnaeus, C. (1753) *Species Plantarum*, Laurentius Salvius, Stockholm, 560 pp.
- Lomeli-Sención, J.A. (1988) *Graptopetalum fruticosum* (Crassulaceae), en el sur de Jalisco. *Cactáceas y Suculentas Mexicanas* 33: 89–91.
- Mayuzumi, S. & Ohba H. (2004) The phylogenetic position of eastern Asia Sedoideae (Crassulaceae) inferred from chloroplast and nuclear DNA sequences. *Systematic Botany* 29: 587–598.
<https://doi.org/10.1600/0363644041744329>
- Meyrán-García, J. & López-Chávez L. (2003) *Las crasuláceas de México*. Sociedad Mexicana de Cactología, A.C. México, D.F. 292 pp.
- Moran, R. (1971) *Graptopetalum pentandrum* a new species of Mexico. *Cactus and Succulent Journal (US)* 43: 255–258.
- Moran, R. & Uhl, Ch. (1968) *Graptopetalum fruticosum*, a new species from Jalisco, Mexico. *Cactus and Succulents Journal (US)* 40: 152–156.
- Mort, M.E., Soltis, D.E., Soltis P.S., Francisco-Ortega, J. & Santos-Guerra, A. (2001) Phylogenetic relationships and evolution of Crassulaceae inferred from *matK* sequence data. *American Journal of Botany* 88: 76–91.
<https://doi.org/10.2307/2657129>
- Rose, J.N. (1905) *Pachyphytum amethystinum*. *North American Flora* 22: 11.
- Rose, J.N. (1911) *Graptopetalum*, a new genus, Crassulaceae. *Studies of Mexican and Central American Plants-No. 7, Contributions from the United States National Herbarium* 13: 296.
- Rose, J.N. (1922) *Graptopetalum pachyphyllum*: thick leaved *Graptopetalum*. *Addisonia* 7: 45–46.
- Thiede, J. (2003) *Graptopetalum*. In: Egli, U. (Ed.) *Illustrated handbook of succulent plants, Vol. VI, Crassulaceae*. Springer, Berlin, Heidelberg, pp. 128–134.
<https://doi.org/10.2307/2657129>
- Thiede, J. & Egli, U. (2007) Crassulaceae. In: Kubitzki, K. (Ed.) *Flowering Plants: Eudicots, The families and genera of vascular plants, vol. 9, 9*. Springer, Berlin, Heidelberg, pp. 83–118.
https://doi.org/10.1007/978-3-540-32219-1_12
- t'Hart, H. & Egli, U. (1995) *Evolution and systematics of the Crassulaceae*. Backhuys Publishers, Leiden, 192 pp.
- Vega Aviña, R., Delgado Vargas, F. & Pío León, J.F. (2020) *Graptopetalum sinaloensis* (Crassulaceae), una nueva especie de Sinaloa, México. *Acta Botanica Mexicana* 127: e1550.
<https://doi.org/10.21829/abm127.2020.1550>
- Walther, E. (1931) *Graptopetalum amethystinum* (Rose) Walther, New combination. *Cactus & Succulent Journal of America* 3: 73–75.