



## *Pachyphytum rogeliocardenasii* (Crassulaceae), a new species from northwestern Querétaro, Mexico

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### Abstract

*Pachyphytum* (Crassulaceae) is a genus of perennial plants with ca. 20 species endemic to central Mexico. *Pachyphytum rogeliocardenasii* is described here as a new species. It is compared to *P. garciae*, which is morphologically similar. The new species is endemic to the northwestern region of the state of Querétaro where it was found on limestone walls. It is assigned the category of endangered (EN).

**Key Words:** Arroyo Seco, sect. *Diostostemon*, sect. *Ixiocaulon*

### Resumen

*Pachyphytum* (Crassulaceae) es un género de plantas perennes que contiene ca. 20 especies endémicas del centro de México. Aquí se describe a *P. rogeliocardenasii* como especie nueva para la ciencia. Se compara con *P. garciae* con la que morfológicamente parece estar relacionada. La nueva especie es endémica de la región noroeste del Estado de Querétaro; habita en paredes de roca caliza; se le asigna en la categoría de En Peligro (EN).

**Palabras Clave:** Arroyo Seco secc. *Diostostemon*, secc. *Ixiocaulon*

### Introduction

*Pachyphytum* Link, Klotzsch & Otto (Klotzsch, 1841: 9) is a genus of the family Crassulaceae, comprising perennial or suffrutex herbs, generally pendant; leaves close to the stem apex, or sometimes forming a lax rosette; the blades are succulent and vary from flat and thick to terete; its inflorescence is a bracteate cincinnus; showy flowers, gamosepalous calyx, equal or unequal lobes, longer or the same size as the petals; gamopetalous corolla, each petal has two marginal appendages on the inner side (Thiede 2003, Pérez-Calix 2008).

Systematic studies reveal that *Pachyphytum* is related to *Echeveria* De Candolle (1828: 401), based on morphological evidence (Berger 1930, Moran 1963, 1965, 1968, Walther 1972, Thiede 2003), as well as molecular phylogenetic studies of Crassulaceae (Ham & Hart 1995, Carrillo-Reyes *et al.* 2009). Morphologically, the plants assigned to *Pachyphytum* are different from those grouped in *Echeveria*, which have a pair of appendages (scales) on the inner surface of each petal that are considered folds of the margins of the petals (Leinfellner 1954). Additionally, the petals of *Echeveria* are imbricated at the base, whereas in *Pachyphytum* they are imbricated in the apical portion, at least in bud, but not during anthesis, and narrow in the middle (Walther 1931, Moran 1965).

According to Moran (1968, 1971), *Pachyphytum* is subdivided into three sections based on morphological characters: *Diostostemon* Salm-Dyck (1854: 265) Walther (1931), *Ixiocaulon* Moran (1968: 41), and *Pachyphytum* Moran (1968: 39). Thiede (2003) only recognizes the first and third sections. The genus *Pachyphytum* comprises ca. 20 species, endemic to central Mexico, from southern Tamaulipas to San Luis Potosí, Guanajuato, Querétaro, Hidalgo, and Michoacán, as well as to the Central-Western region, up to northern Jalisco. They grow mainly on rocks (Pérez-

Calix 2008). For the state of Querétaro, Pérez-Calix (2008) reports *Pachyphytum compactum* Rose (1911: 301), *P. garciae* Pérez-Calix & Glass (1999: 4), *P. glutinicaule* Moran (1963: 37) and *P. viride* Walther (1937: 210).

In an exploration carried out by the second author in the northwest region of the state of Querétaro, Mexico, a species of *Pachyphytum* was collected that could not be identified with the specialized literature in the group (Meyrán & Chávez 2003, Thiede 2003, Pérez-Calix 2008). Hence, it is described here as a new species to science. It is compared with *P. garciae*, to which it is morphologically similar, and its conservation status is proposed.

## Material & Methods

The Santa María de Cocos region and adjacent canyons, where the population of the new *Pachyphytum* species was collected, were explored with the objective of collecting samples to document the morphological variation of the species, its phenology and habitat, as well as looking for additional populations. The morphological description of the species was prepared based on collections from the field. Because the plants are succulent, the process of herborization alters the shape and size of their organs. To avoid this problem the data were taken from living organisms, which were later herborized and deposited in the herbaria IEB, MEXU, and QMEX. Observations of small structures were performed using a Leica M80 stereo microscope. The conservation status of the species was determined on the basis of the criteria of the IUCN (2012).

## Taxonomy

*Pachyphytum rogeliocardenasii* E. Pérez-Calix & R. Torres, *sp. nov.*, Fig. 1; Fig. 2 A–D.

**Type**.—MEXICO. Querétaro: municipio Arroyo Seco, cerca de 2.9 km al sur de Santa María de Cocos, 800 m elevation, 21°18'24.64" N, 99°38'26.54" O, 3 November 2015, E. Pérez 6616 (holotype IEB!, isotypes MEXU!, QMEX!).

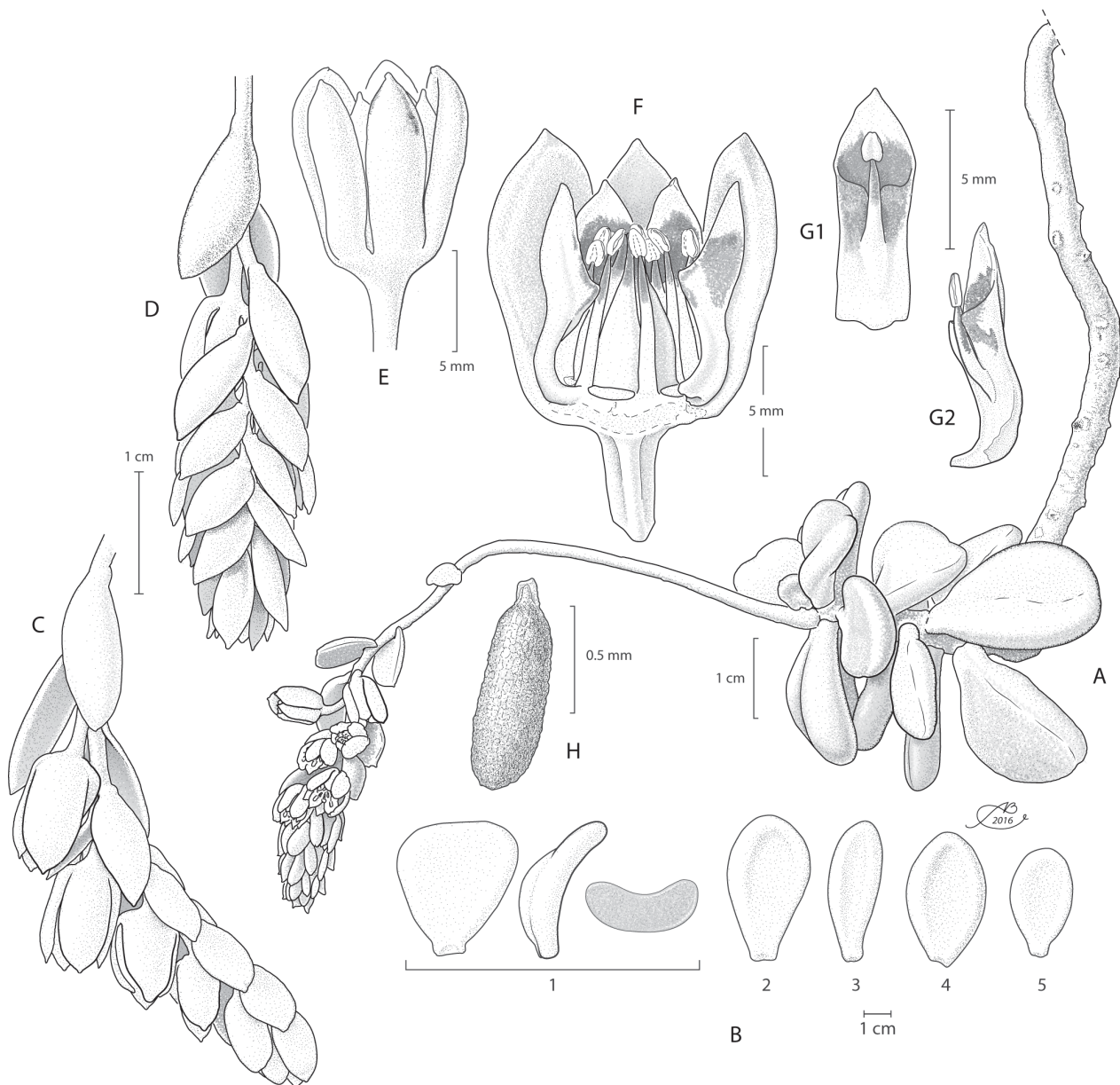
*Pachyphytum rogeliocardenasii* is morphologically similar to *P. garciae*, which differs in that its leaves are up to 1.3 cm longer and 0.5 cm wider; the bracts of the peduncle are 6–7.5 mm longer and 2–3.5 wider; calyx lobes are also larger and corolla lobes are white with an abaxial red spot in the middle.

Suffrutex herb, succulent, pendant, decumbent, glaucous, glabrous; stems often unbranched or branched from near the base, 60 cm long or less, up to 0.6 cm thick. Leaves sessile, arranged in a spiral at the apex of the stem, in lax rosettes, laminas narrowly to widely elliptic or obovate, (2.5–)3.2–5.8 cm long, (1.5–)1.8–2.8 cm wide, (0.4–)0.6–10 mm thick, transversely elliptic in cross-section, apex rounded or obtuse, margin entire, succulent, green, slightly pruinose, glabrous. Inflorescence axillary, near the apex of the branches; peduncle 9–23 cm long until the first flower, pink, pruinose; bracts elliptical to oblong-elliptical, 12–18 mm × 6–10 mm, obtuse at the apex, cuneate-attenuate at the base, flat, green, pink with age; flower bracts subimbricate in young cincinnus, ovate, obovate, oblong, elliptical, to oblong-elliptical, 8.5–16 mm × 5–9 mm. Flowers on a turbinate pedicel, 3–7 mm × 1.5–2 mm, pruinose. Calyx 5-lobate, lobes unequal, the largest oblong, 9.5–13 mm × 4.2–6 mm; the smaller oblong, 8–10 mm × 2.5–3.5 mm, apex acute, mucronate. Corolla gamopetalous, 5-lobate, lobes oblong, 7–9 mm × 2.5–3 mm, apex acute, yellowish-white with an abaxial red spot in the middle; scales red. Stamens 10, 5 antipetalous, 2.5–4 mm long, 5 antisepalous, 5–6.5 mm long. Nectaries narrow, transversely elliptical, ca. 0.5 mm long, yellowish. Ovary ca. 6 mm, style ca. 2 mm long. The fruit a follicle, ca. 8 mm long, seeds numerous, narrowly obovoid.

**Distribution and habitat**.—*Pachyphytum rogeliocardenasii* is endemic to the northwest region of Querétaro, near the border with Guanajuato where one population that lives on vertical walls of limestone sedimentary rock has been recorded in the canyon of the Atarjea river. The climate of the region is subhumid, semi-warm (sensu García 1973). The vegetation corresponds to the deciduous tropical forest (sensu Zamudio *et al.* 1992). Some of its elements are *Celtis iguanaea* and various representatives of Leguminosae. The walls where the plant grows are also habitat by populations of *Agave sp.*, *Hechtia sp.*, *Echeveria sp.* and *Sedum corynephyllum*.

**Additional material examined (paratypes)**.—MEXICO. Querétaro: municipio Arroyo Seco, Cañon de Atarjea, sobre paredes en el lecho del río, 3 km al SW de Santa María de Cocos, 800 m elevation, 21°18'24.64" N, 99°38'26.54" O, 24 May 2015, R. Torres C. 17902, A. Zaldívar & V. Salinas (IEB!, MEXU!, QMEX!); cerca de 2.9 km al SW de Santa María de Cocos, 800 m elevation, 21°18'24.64" N, 99°38'26.54" O, 16 June 2015, E. Pérez 6605 (IEB!).

**Phenology**.—The new species is suffrutex and perennial, so it can be seen with the leaves arranged near the apex of the hanging stems throughout the year. It has been registered flowering in November and eventually in June.



**FIGURE 1.** *Pachyphytum rogeliocardenasii* E. Pérez-Calix & R. Torres, *sp. nov.* **A)** Habit; **B)** Variation of the foliar lamina and cross section of the leaf blade; **C)** Cincinnus lateral view; **D)** Cincinnus adaxial view; **E)** Flower; **F)** Flower dissection; **G1)** Petal abaxial view; **G2)** Petal lateral view; **H)** Seed. (**A–H** based on *E. Pérez 6616*, IEB)

**Conservation status:**—*Pachyphytum rogeliocardenasii* is assigned in the category of Endangered, based on the proposal of the International Union for Conservation of Nature, under the Criterion B, sub-criteria 1a and 2a; and Criterion C, sub-criteria 2a (EN B1a+2a; C2a) (IUCN, 2012). It is estimated that the only known population has less than 1000 mature individuals and its area of occupation is very small (ca. 150 m<sup>2</sup>).

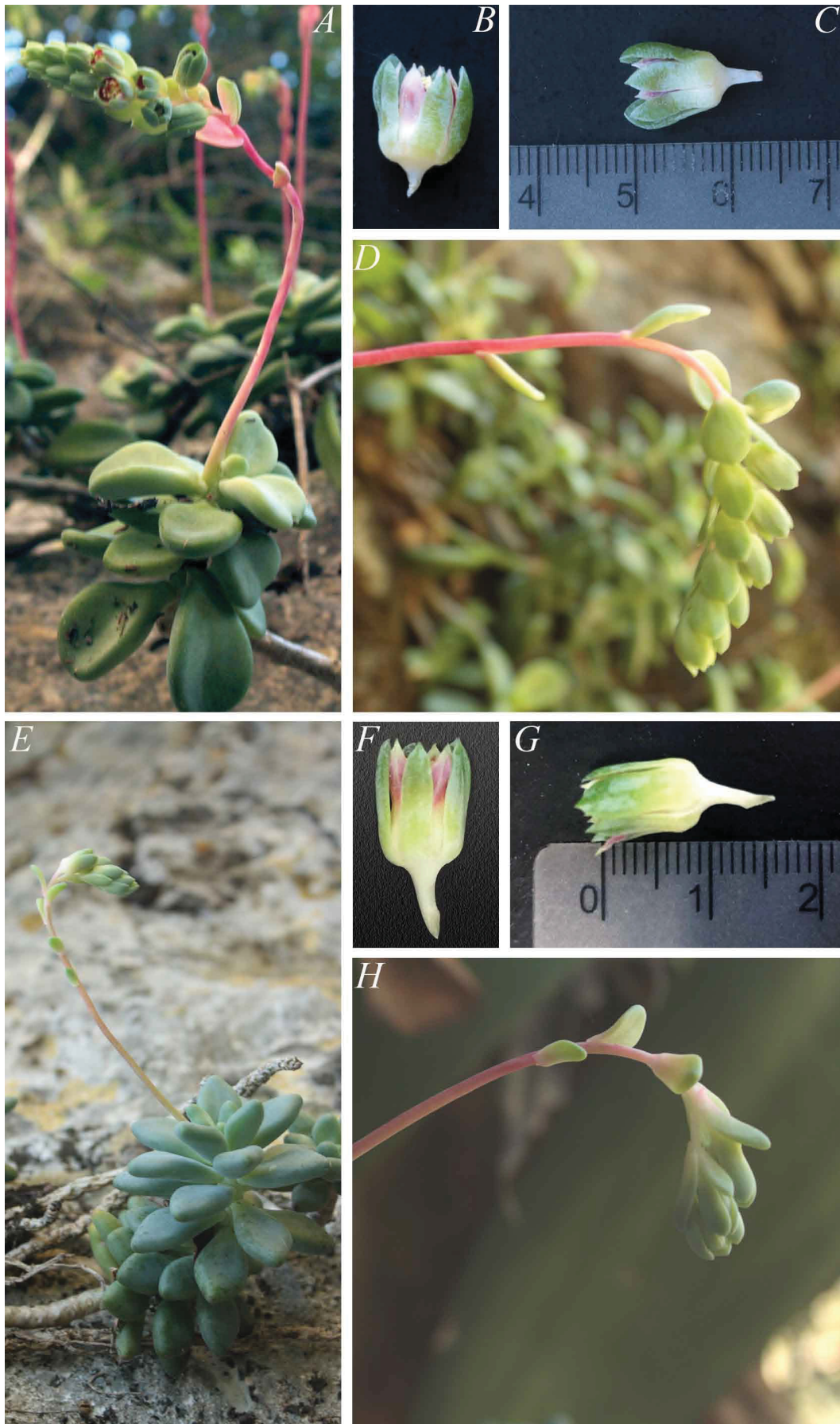
**Etymology:**—The specific epithet is dedicated to the memory of Rogelio Mariano Cárdenas-Soriano (Cautla, Morelos, 1961 - Pátzcuaro, Michoacán, 2010). Rogelio worked as a scientific illustrator in the Bajío Regional Center of the Institute of Ecology, A.C., from 1995 until his death, and elaborated a series of illustrations, published in the fascicles of *Flora del Bajío* and of adjacent regions; he also drew new taxa for science, which were published in various specialized journals in botany.

**Discussion:**—Morphologically, *Pachyphytum rogeliocardenasii* is classified in Section *Pachyphytum* (sensu Moran 1968, 1971) because it possesses the following set of characters:

—The bracts are narrowly imbricate in the young cincinnus, long and bidentate at the base.

—The calyx exceeds the corolla, the segments of the first whorl are unequal between them, and the longer ones are imbricated before and after anthesis.





**FIGURE 2.** *Pachyphytum rogelioardenasii*: A) habit; B) petal color; C) calyx lobes; D) inflorescence peduncle and floral bracts. *P. garciae*: E) habit; F) petal color; G) calyx lobes; H) inflorescence peduncle and flowers bracts.

—The white petals are spotted deep red on the inner side of the width of the petal, almost completely covering the scales, forming together with the pistil and filaments a conspicuous red center on the flower.

—Short pedicels (2–8 mm).

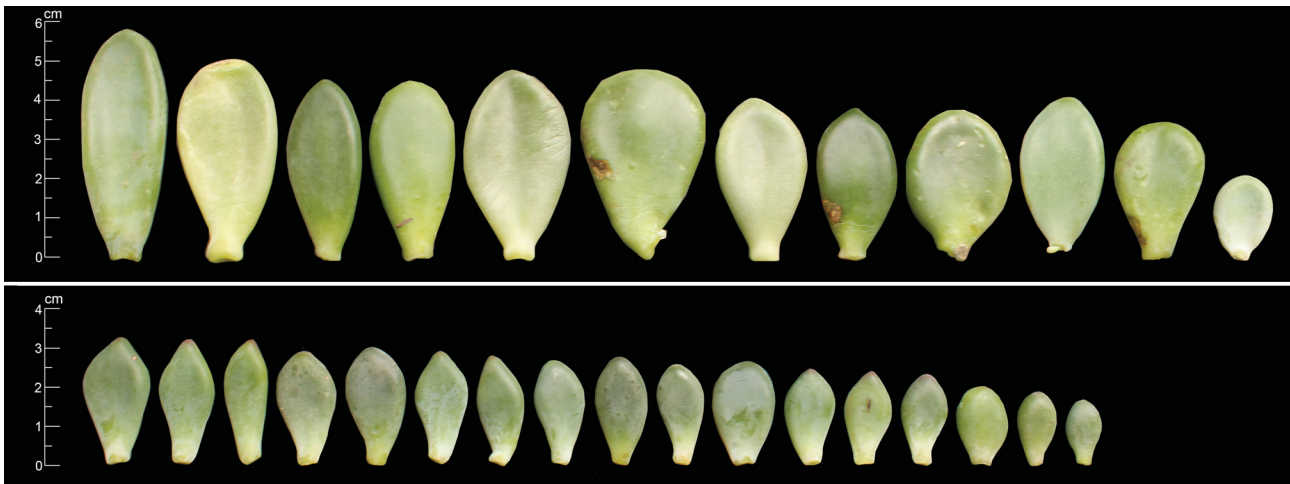
—The basal leaf blades are elliptic to obovate and less than 2–5 times wider than thick.

*Pachyphytum rogeliocardenasii* is morphologically similar to *P. garciae*. It differs from the latter species by the leaves being up to 1.3 cm longer and 0.5 cm wider (Fig. 3), peduncle bracts 6–7.5 mm longer and 2–4.5 mm wider and similarly, the calyx lobes are also longer and wider. Finally, the lobes of the corolla in *P. rogeliocardenasii* are white abaxially and with an abaxial red spot in the middle, unlike those of *P. garciae*, which are light pink abaxially and spotted reddish (Table 1).

The classification of *Pachyphytum garciae* in any of the sections in which *Pachyphytum* is subdivided (Pérez-Calix & Glass 1999, Thiede 2003) is uncertain. Nevertheless, this species, like *P. rogeliocardenasii*, shows a great similarity with the section *Pachyphytum*. A molecular phylogenetic study is required to unravel the systematics of this group.

**TABLE 1.** Comparison of the new species *Pachyphytum rogeliocardenasii* with *P. garciae*.

Characters	<i>Pachyphytum rogeliocardenasii</i>	<i>Pachyphytum garciae</i>
Leaves		
Shape	narrowly to widely elliptic, obovate	obtrullate, elliptic, elliptic-oblongate, obovate a obovate-spatulate
Length (cm)	(2.5)3.2–5.8	1.5–4.5
Width (cm)	(1.5)1.8–2.8	0.8–2(2.3)
Thickness (mm)	(0.4)0.6–1.0	0.5–0.7
Peduncle bracts		
Shape	elliptic, oblong–elliptic	obovate to elliptic
Length (mm)	12–18	6–11.5
Width (mm)	6–10	4–6.5
Flower bracts		
Shape	ovate, obovate, oblong-elliptic	obovate to elliptic
Length (mm)	8.5–16	7–11
Width (mm)	5–9	4–6.5
Arrangement in the young cincinnus	imbricate	subimbricate
Calyx lobes		
Large lobes; shape	oblong	oblong
Length (mm)	9.5–13	8–9.5
Width (mm)	4.2–6	4.5–5.5
Short lobes; shape	narrowly oblong	oblong
Length (mm)	8–10	6–6.5
Width (mm)	2.5–3.5	2–2.5
Corolla lobes		
Length (mm)	7–9	7.5–8
Width (mm)	2.5–3	2.5–3
Color	yellowish-white with abaxial red spot in the middle	light pink with abaxial reddish spot, cream color at the base
Appendage	red	reddish
Stamens		
Antipetalous (mm)	2.5–4	4–5
Antisepalous (mm)	5–6.5	5.5–6.5



**FIGURE 3.** Leaf shape and size variation of: A) *Pachyphytum rogeliocardenasii*; B) *Pachyphytum garciae*.

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## Literature Cited

- Berger, A. (1930) Crassulaceae. In: Engler, A. & Prantl, K. (Eds.) *Die Natürlichen Pflanzenfamilien*, ed. 2. 18a, Verlag Wilhelm Engelmann, Leipzig, pp. 352–458.
- Carrillo-Reyes, P., Sosa, V. & Mort, M.E. (2009) Molecular phylogeny of the *Acre* clade (Crassulaceae): dealing with the lack of definitions for *Echeveria* and *Sedum*. *Molecular Phylogenetics and Evolution* 53: 267–276.  
<https://doi.org/10.1016/j.ympev.2009.05.022>
- De Candolle, A.P. (1828) Crassulaceae. In: De Candolle, A.P. (Ed.) *Prodromus systematics naturalis regni vegetabilis III*. Treutel et Würtz, Paris, p. 401.
- García, E. (1973) *Modificaciones al sistema de clasificación climática de Köppen*. 2ª edición Instituto de Geografía. Universidad Nacional Autónoma de México, México, D.F., 246 pp.
- Ham, R.H.J. & Hart, H. (1995) Phylogenetic relationships in the Crassulaceae inferred from chloroplast DNA variation. In: Hart, H. & Eggli, U. (Eds.) *Evolution and systematics of the Crassulaceae*. Backhuys Publishers, Leiden, pp. 16–29.
- IUCN (2012) *IUCN Red List Categories and Criteria: Version 3.1*. Second edition. Gland, Switzerland and Cambridge, UK, iv + 32 pp.
- Klotzsch, J.F. (1841) Einer neuen mexikanischen Pflanze *Pachyphytum bracteosum*. In: Otto, F. & Dietrich, A.G. (Eds.) *Allgemeine Gartenzeitung* 9 (2): 9.
- Leinfellner, W. (1954) Beiträge zur kronblattmorphologie. III. Die kronblätter der Gattung *Pachyphytum*. *Österreichische Botanische Zeitschrift* 101: 586–591.  
<https://doi.org/10.1007/BF01284373>
- Meyrán, G.J. & Chávez, L.L. (2003) *Las Crassuláceas de México*. Sociedad Mexicana de Cactología, A.C., México, D.F., 234 pp.
- Moran, R. (1963) *Pachyphytum brevifolium* Rose and *P. glutinicaule*, a new species from Hidalgo, Mexico. *Cactus and Succulent Journal* 35: 35–41.
- Moran, R. (1965) *Pachyphytum coeruleum* Meyrán. *Natural Cacti & Succulent Journal* 20: 37–38.
- Moran, R. (1968) New subgeneric groups in *Echeveria* and *Pachyphytum*. *Cactus and Succulent Journal of America* 40: 36–42.
- Moran, R. (1971) *Pachyphytum fittkaui*, a new species from Guanajuato, Mexico. *Cactus and Succulent Journal* 43: 26–32.
- Pérez-Calix, E. (2008) *Crassulaceae. Fascículo 156. Flora del Bajío y regiones adyacentes*. Instituto de Ecología, A. C., Centro regional del Bajío, Pátzcuaro, Michoacán, 141 pp.

- Pérez-Calix, E. & Glass, C. (1999) *Pachyphytum brevifolium* Rose (Crassulaceae) a un siglo de su descubrimiento y *Pachyphytum garciae*, una especie nueva del centro de México. *Acta Botanica Mexicana* 48: 1–10.  
<https://doi.org/10.21829/abm48.1999.829>
- Rose, J.N. (1911) Studies of Mexican and Central American plants -No 7. *Contributions United States Natural Herbarium* 13: 291–312.
- Salm-Dyck (1854) Beschreibung einer neuen mexikanischen Pflanze *Diotostemon hookeri*. In: Otto, F. & Dietrich, A.G. (Eds.) *Allgemeine Gartenzeitung* 22(34): 265.
- Thiede, J. (2003) *Pachyphytum*. In: Egli, U. (Ed.) *Crassulaceae. Illustrated handbook of succulent plants*. Springer, Berlin, pp. 190–195.
- Walther, E. (1931) Genus *Pachyphytum*. *Journal of the Cactus and Succulent Society of America* 3: 9–13.
- Walther, E. (1937) *Pachyphytum viride*, a new species. *Cactus and Succulent Journal* 8: 210–211.
- Walther, E. (1972) *Echeveria*. California Academy of Sciences, San Francisco, 426 pp.
- Zamudio, S., Rzedowski, J., Carranza, E. & Calderón, G. (1992) *La vegetación del Estado de Querétaro, panorama preliminar*. Instituto de Ecología, Centro Regional del Bajío. Pátzcuaro, 92 pp.