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Echeveria sotoi (ser. *Gibbiflorae*, Crassulaceae), a new species from coastal Michoacán, Mexico

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Abstract

E. sotoi (ser. *Gibbiflorae*, Crassulaceae) is described as a new species endemic to the coast of Michoacán, Mexico. It is morphologically similar to *E. gibbiflora*, from which it differs by having a generally taller but much thinner stem, narrower and oblanceolate to oblanceolate-obovate leaves without purplish-glaucous colourations, thinner peduncles, horizontally spreading to obliquely ascending cincinni, flowers with frequently longer corollas but usually shorter sepals, and narrower nectary scales. The species was assessed as Critically Endangered (CR) following the IUCN criteria. A distribution map is provided for the species of *E.* ser. *Gibbiflorae* native to Michoacán.

Key words: Aquila, biogeography, comparative morphology, microendemic species, Pacific Lowlands, taxonomy

Resumen

Se describe *E. sotoi* (ser. *Gibbiflorae*, Crassulaceae) como una nueva especie endémica de la costa de Michoacán, México. Es morfológicamente similar a *E. gibbiflora*, de la cual difiere por tener un tallo generalmente más alto pero mucho más delgado, hojas más angostas y oblanceoladas a oblanceolado-obovadas sin coloraciones glauco-purpúreas, pedúnculos más delgados, cincinos horizontalmente extendidos a oblicuamente ascendentes, flores con corolas frecuentemente más largas pero sépalos usualmente más cortos y nectarios más angostos. La especie fue evaluada como En Peligro Crítico (CR) siguiendo los criterios de la UICN. Se provee un mapa de distribución para las especies de *E.* ser. *Gibbiflorae* nativas de Michoacán.

Palabras clave: Aquila, biogeografía, especie microendémica, morfología comparativa, taxonomía, Tierras Bajas del Pacífico

Introduction

The genus *Echeveria* de Candolle (1828: 401) (Crassulaceae), with about 170 species, consists of perennial plants with fibrous roots or, to a lesser extent, tuberous roots; short or long stems, either simple or much-branched; succulent, simple, and sessile leaves spirally arranged in a rosette; lateral inflorescences (a cincinnus, racemes, spikes, or panicles); and brightly coloured tubular corollas (Reyes-Santiago *et al*. 2011b). The geographic distribution of the genus is restricted to the American continent, ranging from the Southern United States to Northern Argentina, with its main centre of diversity in Mexico (represented by approximately 83% of the genus diversity) (de la Cruz-López *et al*. 2019b). The elevational range reported for *Echeveria* ranges from 180 m to about 4010 m (Reyes-Santiago *et al*. 2011b), but most of the species grow at medium to high elevations on light-shaded rocky sites (Kimnach 2003).

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While the infrageneric classification of *Echeveria* is highly artificial due to the high homoplasy of morphological characters (de la Cruz-López 2019), the genus has traditionally been divided into 17 series (Kimnach 2003). However, three genera were proposed recently: *Chazaroa* A.Vázquez, Padilla-Lepe & Rosales in Vázquez-García *et al*. (2023b: 38), *Jeronimoa* A.Vázquez, Islas & Rosales in Vázquez-García *et al*. (2023a: 51) & *Quetzalcoatlia* A.Vázquez, Padilla-Lepe & Rosales in Vázquez-García *et al*. (2023b: 38). One of the few monophyletic series of *Echeveria* so far is *E*. ser. *Gibbiflorae* (Baker 1869: lacking page numbers) Berger (1930: 474) (Carrillo-Reyes *et al*. 2009; de la Cruz-López *et al*. 2019b; Vázquez-Cotero *et al*. 2017). With 39 species, it represents one of the largest series of the genus along with *E*. ser. *Nudae* Walther (1958: 46) and *E*. ser. *Racemosae* (Baker 1869: lacking page numbers) Berger (1930: 472) (de la Cruz-López *et al*. 2021, Rosales-Martínez & Hernández-Campos 2023). Species of *E*. ser. *Gibbiflorae* are distributed from northern Sinaloa, Mexico, to Guatemala. They possess short or medium-height stems, glabrous and medium to large leaves, and mostly paniculate inflorescences with several cincinni (Kimnach 2003). Due to the appearance of their leaves, they are known in Mexico as "orejas de burro" (donkey ears).

The state of Michoacán harbours at least seven species of *E*. ser. *Gibbiflorae*, four of which are considered narrow endemic: *E*. *coruana* I.García, D.Valentín & Costea in García-Ruiz *et al*. (2016: 3), known only from the Malpaís de San Andrés Corú; *E*. *michihuacana* de la Cruz-López *et al*. (2019a: 26) from the eastern part of Michoacán; *E*. *pistioides* García-Ruiz *et al*. (2016: 966) from south of Morelia; and *E*. *purhepecha* García-Ruiz (2011: 63) from the Nuevo San Juan Parangaricutiro area. The three remaining species display a broader distribution range: *E*. *fulgens* Lemaire (1845: 8), with two varieties, is known from Estado de México, Michoacán, and Morelos (de la Cruz-López *et al*. 2019a); *E*. *gibbiflora* de Candolle (1828: 401) from Mexico City, Estado de México, Michoacán, and Morelos (Uhl 2002); and *E*. *subrigida* (Robinson & Seaton 1893: 105) Rose in Britton & Rose (1903: 10) from Guanajuato, Hidalgo, Estado de México, Michoacán, Querétaro, and San Luis Potosí (Pérez-Calix 2008).

In January 2022, we received photographs taken by Gerardo Soto and Adeodato Suárez to identify different plant species inhabiting the rocky outcrops of a mountain near Huahua, coastal Michoacán. Among the agaves, bromeliads, cacti, and orchids that appeared in such photographs, there was an unfamiliar succulent of the stonecrop family (Crassulaceae) with dried inflorescences. Upon further conversations with Gerardo Soto, the plant proved to be a member of the genus *Echeveria* known to him since 2013. This population raised our interest in conducting additional research since there was no previous record of an *Echeveria* in this geographical area. After examination of morphological characters in living specimens, a field trip observing the surrounding habitat, and careful revision of relevant literature, it became evident that we were in the presence of a novelty within *E*. ser. *Gibbiflorae*. Here, the new species is described 10 years after its discovery.

Material and methods

The new species was collected from coastal Michoacán in March 2022 by Gerardo Soto, and six living plants were brought to a greenhouse in Guadalajara, Jalisco, for study. Two of these specimens flowered in December 2022, and their morphological features were examined and photographed. Additionally, a field trip was carried out in January 2023 to collect herbarium specimens, as well as to understand the phenological traits and phenotypic variation of the species without the influence of cultivation conditions. Measurements of vegetative and reproductive traits were recorded from 13 specimens in the type locality.

The most similar species were determined by consulting descriptions of *Echeveria* taxa in the relevant literature (Kimnach 2003, Pilbeam 2008, Walther 1972), focusing on the species of *E*. ser. *Gibbiflorae sensu* Kimnach (2003). Subsequently, the new species was contrasted with its most similar species using quantitative and qualitative features.

Morphological characterization of *E*. *gibbiflora* and *E*. *longiflora* Walther (1959b: 101) was carried out using the *Echeveria* monograph by Walther (1972), and further information was incorporated from personal observations. For *E*. *gibbiflora*, notes from 12 wild plants were taken during a visit to the Reserva Ecológica del Pedregal de San Ángel, Mexico City, in December 2022. For *E*. *longiflora*, the holotype at CAS herbarium was examined and pictures of living plants were seen in Walther (1959b) and Pilbeam (2008).

The SimpleMappr software (Shorthouse 2010) was employed to generate a map with records of the new species and the other relevant taxa of *E*. ser. *Gibbiflorae*, including those distributed in the state of Michoacán. Geographical data was obtained from collections available at the National Herbarium of Mexico (MEXU) and ARIZ, BRU, CM, CIMI, GH, HNT, IBUG, IEB, LL, MICH, MIN, MO, NMC, NY, RSA, SD herbaria (SEINet 2023), excluding specimens that

could not be reliably identified. The template of biogeographic provinces of Mexico *sensu* Morrone *et al*. (2017) was included using Photoshop 23.5.1.

GeoCAT (Bachman *et al*. 2011) was used to calculate the Extent of Occurrence (EOO) and Area of Occupancy (AOO) of the new species. The IUCN Red List Categories and Criteria (IUCN 2022) were followed to assign it to a risk category.

Results

The morphological examination of the new species revealed that it belongs to *E*. ser. *Gibbiflorae* based on its caulescent habit, glabrous leaves of large size, and paniculate inflorescences. Moreover, comparative morphology (Table 1) and biogeographical information (Fig. 1) showed important differences between *E*. *sotoi* and similar species.

TABLE 1. Comparison among *Echeveria sotoi*, *E*. *gibbiflora*, *E*. *longiflora* and *E*. *rulfiana*.

	E. sotoi	***E. gibbiflora***	***E. longiflora***	***E. rulfiana***
Stem thickness (cm)	2.0–2.5	2.5–5.0	1.5–2.5	2.0–2.5
Leaf width (cm)	3.0–8.0	8.0–18.0	6.0–10.0	2.0–4.0
Leaf shape	Oblanceolate to oblanceolate-obovate	Broadly obovate-orbicular	Obovate-orbicular	Oblanceolate
Leaf color	Light green to purplish-green or orangish-pink	Glaucous-green with tendency to show reddish coloration in the whole leaf	Vetiver-green, more or less glaucous, tinged light vinaceous-drab	Green to purplish-green
Peduncle thickness (cm)	0.9–1.1	1.5–2.0	0.8–0.9	0.5–1.0
Number of cincinni per inflorescence	(3–) 8–14	6–18	2–3	4–11
Cincinnus orientation	Horizontally spreading to obliquely ascending	Pendulous	Pendulous	Pendulous
Sepal orientation	Usually obliquely ascending	Spreading to ascending	Widely spreading to slightly recurved	Spreading to reflexed
Corolla length (cm)	1.2–1.9	1.2–1.6	1.9–2.2	1.7–2.0
Petal color	Salmon-pink to reddish-pink, with yellow or orange colorations	Glaucous-pink to reddish-pink, sometimes with yellow or orange colorations	Pale vinaceous-lilac at base, old-rose above with bloom, lacking any trace of yellow or orange coloration	Orangish-pink, sometimes with yellow or orange colorations
Nectary scale width (cm)	0.2	0.3	0.3	0.3
Nectary scale color	Whitish	Whitish	Straw-yellow	Yellowish
Appendages	Absent	Absent	Absent	Present
Geological substrate	Limestone	Volcanic	Unknown	Igneous
Source of information	This work	This work, Walther (1972)	This work, Walther (1972)	Jimeno-Sevilla *et al*. (2015)

Similarities between the new species and *E*. *gibbiflora* were the large leaves, tall inflorescences, numerous cincinni, pink corolla, and whitish nectary scales. However, in mature specimens of *E*. *sotoi*, the stem was thinner, the leaves had an oblanceolate to oblanceolate-obovate shape and did not have purplish-glaucous colourations, the peduncle of the inflorescence was less robust, cincinni were horizontally spreading to obliquely ascending instead of being pendulous, and nectary scales did not exceed 2 mm in width.

Among the characteristics shared by *E. sotoi* and *E. longiflora,* there were the evident stem, peduncle thickness, and pinkish flowers. Nevertheless, plants of the new species had oblanceolate to oblanceolate-obovate leaves without glaucous colourations, numerous cincinni which are horizontally spreading to obliquely ascending, usually obliquely ascending sepals, a shorter corolla with yellow or orange colourations, and narrower whitish nectary scales.

Furthermore, *E. sotoi* is a microendemic species known only from limestone outcrops in coastal Michoacán. Of the currently known species of *E.* ser. *Gibbiflorae* in Michoacán, *E. sotoi* is the only species distributed within the Pacific Lowlands biogeographic, growing in thorn forests at low elevations (350–500 m). The other species, including *E. gibbiflora*, are confined to the pine-oak forests of the Trans-Mexican Volcanic Belt, some of them with partly overlapping distribution ranges.

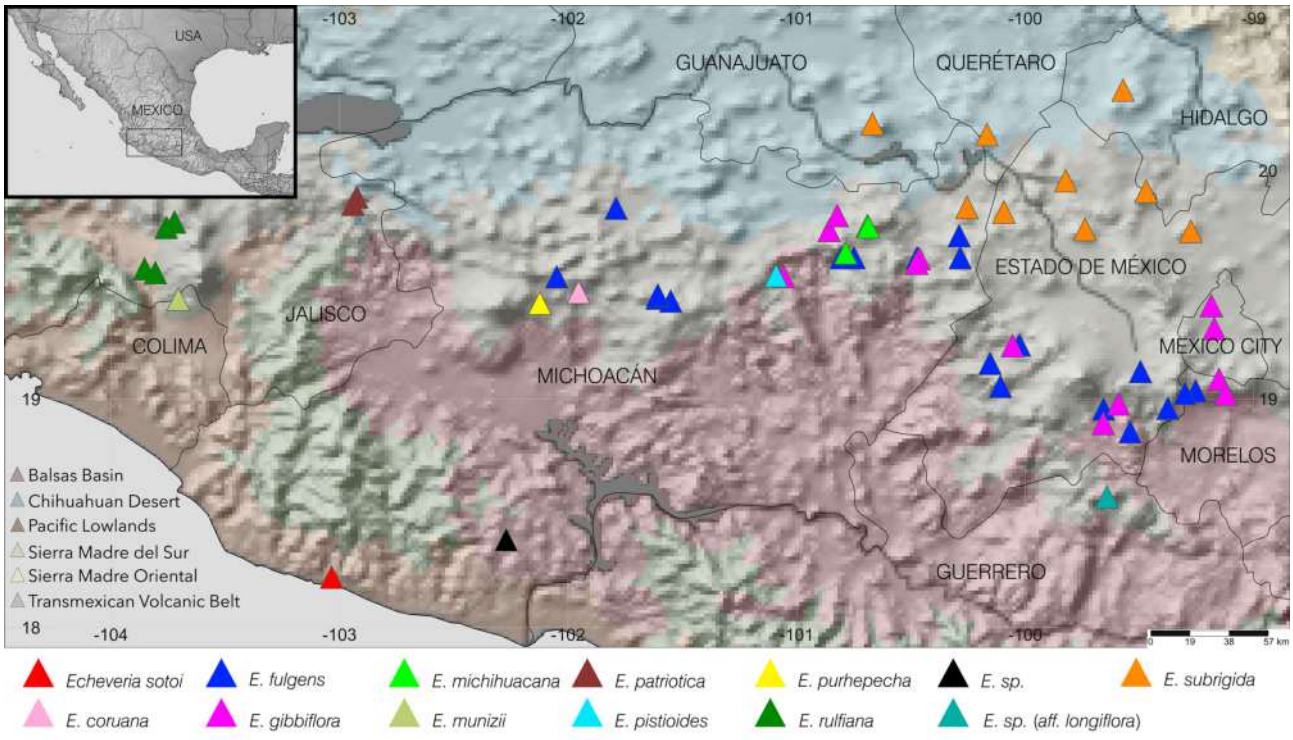

FIGURE 1. Map with records of some species of *E.* ser. *Gibbiflorae*, including those distributed in the state of Michoacán and those similar to *E. sotoi*.

Discussion

Echeveria sotoi fits well with the traditional circumscription of the monophyletic *E.* ser. *Gibbiflorae* (Carrillo-Reyes *et al*. 2009; de la Cruz-López *et al*. 2019b; Vázquez-Cotero *et al*. 2017), defined by the short to medium-height stems, glabrous leaves of medium to large size, and paniculate inflorescences (Kimnach 2003). The free styles with reddish or purplish colourations are associated with this series and may represent a synapomorphy (de la Cruz-López *et al*. 2019a, Reyes-Santiago *et al*. 2019). It has been suggested that some members of *E.* ser. *Gibbiflorae* are part of a separate series, *E.* ser *Retusae* Walther (1959a: 3), based on their smaller size and inflorescences with fewer branches (Walther 1972), but phylogenetic evidence shows that they do not form a natural group (de la Cruz-López *et al*. 2019b). Instead, two main clades with geographical support were identified within *E.* ser. *Gibbiflorae*. The new species seems to be related to the group comprising northwestern species, which tend to have large flowers (1.5 cm or more), long styles, reddish or yellowish nectary scales, and, in some cases, appendages on the inner side of the petals. In contrast, the second group consists of southwestern species with usually smaller flowers, shorter styles, and typically whitish nectary scales.

The morphological similarities among *E. sotoi*, *E. gibbiflora*, and *E. longiflora* suggest that they are putative close relatives. However, molecular information on *E. sotoi* is currently lacking, and the variability of *E. gibbiflora* and *E. longiflora* requires a broader understanding. On the one hand, it is well known that *E. gibbiflora* shows a high phenetic polymorphism, with numerous variants differing in the leaf colour, leaf margins, and some floral characters

(Kimnach 2003, Walther 1972); this states may be related to environmental conditions, such as water availability, type of soil, sun exposure, etc. On the other hand, *E. longiflora* was described from cultivated material originally collected from Guerrero but without a definite locality (Walther 1959b). Plants from Taxco and Ixcateopan de Cuauhtémoc, northern Guerrero, which have been ascribed to *E. longiflora*, possibly do not correspond to that species since they are hexaploid with $n = 81$ (Palomino *et al*. 2021), whereas a clone of the original collection of *E. longiflora* was a diploid with $n = 27$ (Uhl 2002). Despite this, the three taxa differ in several aspects (Table 1).

Another species that is similar to *E. sotoi* is mentioned in Pilbeam (2008) under the name *Echeveria* 'Juntas'. The accompanying photographs show a plant with oblanceolate, reddish leaves and salmon-pink flowers, which was discovered near Uruapan in Michoacán (Balsas Basin biogeographic province); *E. sotoi* stands apart with shorter sepals and cincinni that are not pendulous when fully developed. Although the unidentified plant appears to be an as-yet-undescribed species, further study is required to reveal its true identity. *E. sotoi* is also similar, at least in vegetative characteristics, to *E. rulfiana* Jimeno-Sevilla *et al*. (2015: 72), a species endemic to southern Jalisco. Both have long stems and oblanceolate leaves of similar colour, but they can be easily differentiated because *E. sotoi* lacks appendages on the inner side of the petals, suggesting that these species are not closely related.

The isolation of *E. sotoi* from the other species of *E.* ser. *Gibbiflorae* in Michoacán is likely a result of the geographic and climatic barriers imposed by the Sierra Madre del Sur and the Balsas Basin, which may play an important role in limiting the distribution of each species to a single biogeographic province. In this scenario, *E. sotoi* could have arisen as a result of allopatric speciation. The outcrops where the plants grow are exposed to continuous moisture from the nearby Pacific Ocean and strong air currents, indicating that the species occupies a highly specialized ecological niche. Furthermore, the fact that *E. sotoi* grows at low elevations (350–500 m) differentiates it from *E. gibbiflora* (above 1800 m) and most of the echeverias, which show a preference for altitudes of 1500 meters or higher (Etter & Kristen 2013). Some of the few echeverias that grow at similar or lower elevations than *E. sotoi* are the following: *E. laui* Moran & Meyrán-García (1976: 59) at 500 m (Moran & Meyrán-García 1976), *E. juliana* Reyes-Santiago *et al*. (2012: 52) at 350 m (Etter & Kristen 2013), *E. diffractens* Kimnach & Lau (1981: 6) at 300 m (Kimnach & Lau 1981), and *E. pallida* Walther (1938: 14) at 180 m (Reyes-Santiago *et al*. 2011b).

The discovery of *E. sotoi* contributes to the endemism of species of the Crassulaceae family in the state of Michoacán, represented by four species of *E.* ser *Gibbiflorae* (*E. coruana*, *E. michihuacana*, *E. pistioides*, and *E. purhepecha*), *Chazaroa calycosa* (Moran 1967: 14) A.Vázquez & Padilla-Lepe in Vázquez-García *et al*. (2023b: 38), *Quetzalcoatlia kristenii* (Etter *et al*. 2022: 140) A.Vázquez & Rosales in Vázquez-García *et al*. (2023b: 39), *Q. pentandra* (Moran 1971: 255) A.Vázquez & Rosales in Vázquez-García *et al*. (2023b: 39), *Pachyphytum machucae* García-Ruiz *et al*. (1999: 10), *Pachyphytum rzedowskii* García-Ruiz *et al*. (2022: 148), *Sedum moniliforme* García-Ruiz & Costea (2015: 81), and *Thompsonella garcia-mendozae* Carrillo-Reyes & Pérez-Calix (2006: 320).

Finally, *E. sotoi* increases the number of species in *E.* ser. *Gibbiflorae* to 40, taking into account that *E. guerrerensis* J.Reyes, O.González & Brachet in Reyes-Santiago *et al*. (2011a: 78) and *E. uxorum* Jimeno-Sevilla & Cházaro in Jimeno-Sevilla *et al*. (2012: 140) were recovered in this series in a recent phylogenetic study (de la Cruz-López *et al*. 2019b), and that *E. gudeliana* Véliz-Pérez & García-Mendoza (2011: 2) fits better here than in *E.* ser *Pruinosae* Walther (1959a: 2) based on morphological characters. It is noteworthy that many of these species (11 species) were described in just the last 10 years: *E. marianae* García-Ruiz & Costea (2014: 36), *E. cerrograndensis* A.Vázquez & Nieves in Nieves-Hernández *et al*. (2014: 248), *E. munizii* Padilla-Lepe & A.Vázquez in Vázquez-García *et al*. (2014: 166), *E. rulfiana*, *E. triquiana* J.Reyes & Brachet in Reyes-Santiago *et al*. (2015: 87), *E. coruana*, *E. pistioides*, *E. michihuacana*, *E. sonianevadensis* A.Vázquez, Jimeno-Sevilla & I.García in Jimeno-Sevilla *et al*. (2019: 159), *E. xochipalensis* Reyes-Santiago *et al*. (2019: 15), and *E. kristenii* L.E.Cruz-López & J.Reyes in de la Cruz-López *et al*. (2021: 375). In this context, it is expected that many new species will continue to be discovered with the intensification of botanical exploration in Mexico and the use of molecular tools.

Taxonomy

Echeveria sotoi Rosales & Quirarte *sp. nov*. Figs. 2–4.

Type:—MEXICO. Michoacán: municipio de Aquila, macizo rocoso ca. 5 km al NE de Pichilinguillo, sobre el camino a Santiaguillo, 470 m, 14 January 2023, *J. Quirarte & G. Soto 1* (holotype: IBUG!; isotype: MEXU!).

Diagnosis:—*Echeveria sotoi* is similar to *E. gibbiflora* (Fig. 5) in the tall inflorescences with numerous cincinni and pinkish flowers; however, the former differs by having a stem thickness of 2.0–2.5 cm (2.5–5.0 cm), a leaf width of 3.0–8.0 cm (vs. 8.0–18.0 cm),

oblanceolate to oblanceolate-obovate leaves (vs. broadly obovate-orbicular), light green to purplish-green or orangish-pink leaves (vs. glaucous-green with tendency to show reddish colouration in the whole leaf), a peduncle thickness of 0.9–1.1 cm (vs. 1.5–2.0 cm), horizontally spreading to obliquely ascending cincinni (vs. pendulous), a nectary scale width of 0.2 cm (vs. 0.3 cm), and a preference for limestone soils (vs. volcanic soils). Also, *E. sotoi* resembles *E. longiflora* in the evident stem, peduncle thickness, and pinkish flowers; nevertheless, it differs from the latter by having oblanceolate to oblanceolate-obovate leaves (vs. obovate-orbicular), light green to purplish-green or orangish-pink leaves (vs. vetiver-green, more or less glaucous, tinged light vinaceous-drab), (3–) 8–14 cincinni per inflorescence (vs. 2–3), horizontally spreading to obliquely ascending cincinni (vs. pendulous), usually horizontally spreading to obliquely ascending sepals (vs. widely spreading to slightly recurved), a corolla length of 1.2–1.9 cm (vs. 1.9–2.2 cm), a corolla with yellow or orange colourations (lacking any trace of yellow or orange colouration), a nectary scale width of 0.2 cm (vs. 0.3 cm), and whitish nectary scales (vs. straw-yellow).

Description:—Plants perennial, glabrous, succulent, caulescent, solitary or sometimes offsetting, rupicolous, up to 170.0 cm tall with inflorescence. Roots fibrous, somewhat thickened with age. Stems simple to very rarely branched, 15.0–65.0 cm long, 2.0–2.5 cm in diameter, erect to sometimes curved or inclined, grayish-brown, olive-green to reddish distally, bumpy, with scars of the fallen leaves 0.9–1.1 cm wide, sometimes with old peduncle segments attached. Rosettes terminal, 15.0–40.0 cm in diameter, lax. Leaves spirally arranged, 12–20 per rosette, 8.0–25.0 cm long, 3.0–8.0 cm at the widest point, oblanceolate to oblanceolate-obovate, pseudo-petiolate, rounded at the apex, provided with a small mucro, more or less horizontally spreading to ascending, light green to purplish-green or orangish-pink, smooth, the abaxial surface keeled, the adaxial surface canaliculate to the base. Margins entire to undulate or crenulate, reddish, sometimes slightly hyaline. Inflorescences lateral panicles, 1–2 per rosette, mostly 60.0–140.0 cm long. Peduncles 0.9–1.1 cm thick at the base, erect, pale yellowish-green to pinkish. Bracts 3.0–15.0 cm, oblanceolate, green to purplish. Cincinni (3–) 8–14 per inflorescence, 5.0–20.0 cm long, straight to somewhat curved, horizontally spreading to obliquely ascending, pink to greyish-purple. Flowers 4–17 per cincinnus. Pedicels 0.4–0.9 cm long, 0.2–0.3 cm in diameter, thickened at the apex, nearly straight to slightly curved. Calyx 1.7–2.1 cm in diameter, discoid. Sepals very unequal, 0.5–1.0 cm long, 0.2–0.4 cm at the widest point, triangular-lanceolate, rounded at the apex, usually obliquely ascending, reddish-green to pinkish, sometimes pruinose, the abaxial surface concave, the adaxial surface flattish to concave. Corolla 1.2–1.9 cm long, 0.7–1.2 cm wide, tubular, onion-shaped to conoid in bud, cylindrical-pentagonal at anthesis. Petals 0.5–0.6 cm at the widest point, fused at the base, lanceolate, dorsally keeled, salmon-pink to reddish-pink on the outer surface, with yellow or orange colourations, orangish-white to pinkish on the inner surface. Nectary scales 0.2 cm wide, reniform, whitish. Stamens 10, 5 episepalous, 5 epipetalous. Filaments 0.7–0.9 cm long in episepalous stamens, 0.4–0.6 cm long in epipetalous stamens, erect, whitish to yellowish. Anthers 0.2 cm long, pale yellow or beige. Gynoecium 1.1–1.4 cm long, 0.5–0.6 cm at the widest point near the base, pyriform. Carpels 5, free. Ovaries whitish-green to pale yellowish. Styles dark red to purplish-red, sometimes greenish proximally. Stigmas translucent yellow. Fruits follicles, brownish. Seeds inconspicuous, reddish-brown.

Distribution and ecology:—Current records of *Echeveria sotoi* indicate that this is a narrow endemic species, confined to a mountain near the town of Huahua (municipality of Aquila, coastal Michoacán), within the Pacific Lowlands biogeographic province (Morrone *et al*. 2017). Here, the species grows on two limestone outcrops at elevations between 350–500 m. The dominant vegetation is thorn forest, including the following species: *Adenophyllum aurantium* (Linnaeus 1753: 877) Strother (1986: 376), *Agave kristenii* A.Vázquez & Cházaro in Vázquez-García *et al*. (2013: 326), *Bursera denticulata* McVaugh & Rzedowski (1965: 365), *Cephalocereus nudus* Dawson (1948: 12), *Cyrtopodium macrobulbon* (Lexarza 1825: 42) Romero-González & Carnevali (1999: 331), *Hechtia michoacana* Burt-Utley *et al*. (2011: 5), *Mammillaria beiselii* Diers (1979: 60), species of *Tillandsia* Linnaeus (1753: 286), and others. In this specialized habitat, *E. sotoi* uses the rock crevices or roots of associated species for germination and benefits from its proximity to the Pacific Ocean (4–6 km as the crow flies), which provides optimal moisture conditions for the growth of plantlets.

Phenology:—The plants start developing their inflorescences in summer, usually around July. They are in full bloom during late fall and early winter, from late November to mid-January. Fruits and seeds complete their ripening process between mid-January and mid-March.

Eponymy:—The authors are honoured to name this species after Mr. Gerardo Soto Mendoza (Aquila, Michoacán) (Fig. 4), a passionate nature lover who discovered this species back in 2013. He was kind enough to provide us with plants for study and cultivation and guide one of us (Jaime Quirarte) to their natural habitat. Moreover, he has contributed to the knowledge and protection of biodiversity in the Sierra-Costa region of Michoacán, documenting the natural history of various animals (especially jaguars and other felines) and collecting seeds for the Comisión Nacional Forestal (CONAFOR).

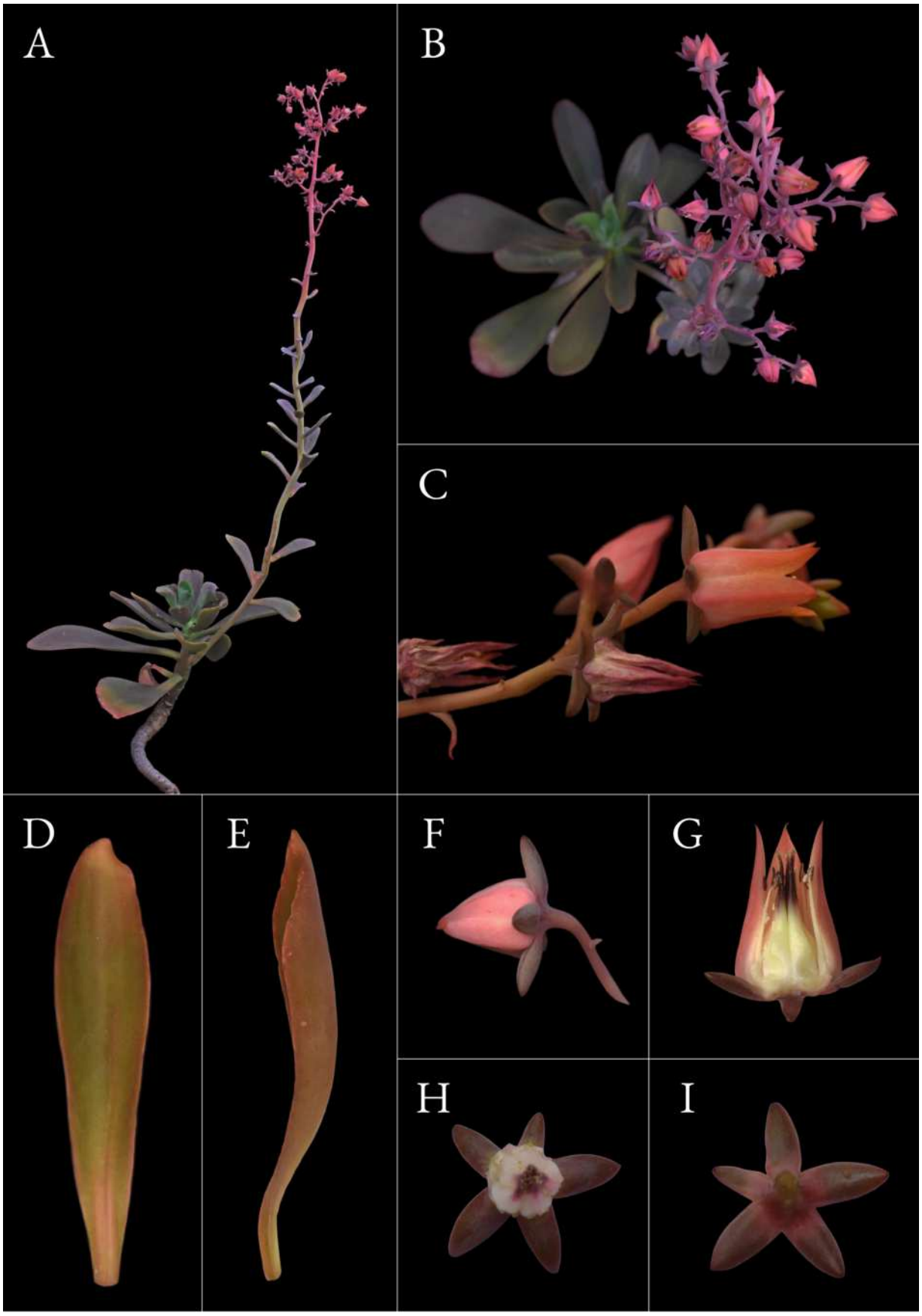

FIGURE 2. *Echeveria sotoi*. A, B. Plant with inflorescence; C. Distal portion of a cincinnus; D, E. Leaf; F. Flower bud; G. Flower dissection; H. Calyx, nectary scales, and gynoecium; I. Calyx. Photographs: Jaime Quirarte.

FIGURE 3. *Echeveria sotoi* in habitat. A. Plant with infrutescence; B. Plant with various branches; C. Plant with inclined stem; D. Plants with simple stems. E. Habitat. F. Panicle. Photographs: Jaime Quirarte.

FIGURE 4. Gerardo Soto and *Echeveria sotoi* in calcareous xerophilous scrub with *Cephalocereus nudus*, *Bursera denticulata*, and *Agave kristenii*. Photograph: Jaime Quirarte.

FIGURE 5. *Echeveria gibbiflora* in Mexico City. A. Mature rosette; B. Large population in volcanic outcrops; C. Pendulous cincinnus; D. Plant with developing inflorescence. Photographs: A and D by Daniel Vite, B by Javier Mera and C by Julio Segundo.

Conservation status:—*Echeveria sotoi* grows on rocky outcrops along a dirt road, which makes it susceptible to over-collection. Additionally, climate change and natural disasters such as landslides could have a severe impact on the ecological niche of the species. As calculated using GeoCAT (Bachman *et al*. 2011), *E. sotoi* has an Extent of Occurrence (EOO) of 0.0 km^2 and an Area of Occupancy (AOO) of 8.0 km^2 (using 2 km cell width). Based on this information, the species should be categorized as Critically Endangered following the criteria B1ab (i,ii,v) + B2ab(i,ii,v) of the IUCN (2022).

Additional specimens examined:—MEXICO. Michoacán: municipio de Aquila, Risco Chino, 5 km al N de Huahua, sobre afloramientos de caliza, 380 m, 27 January 2023, *S. Rosales 9* (IBUG!); municipio de Aquila, 10 km al S de La Parota, sobre la brecha de Playa El Zapote a Santiaguillo, 450 m, 28 January 2023, *S. Rosales 10* (MEXU!).

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