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Sedum dormiens (Crassulaceae, Sempervivoideae, Sedeae): a new species from the Sierra de Manantlán, Mexico

RAMÓN CUEVAS-GUZMÁN^{1*}, EMMANUEL PÉREZ-CALIX² & PABLO CARRILLO-REYES³

¹ Herbario ZEA, Departamento de Ecología y Recursos Naturales, Universidad de Guadalajara, Av. Independencia Nacional 151, Autlán de Navarro 48900, Jalisco, México.

✉ rcuevas@cucsur.udg.mx; <https://orcid.org/0000-0002-4980-8989>

² Instituto de Ecología, A.C., Centro Regional del Bajío. Red de Diversidad Biológica del Occidente Mexicano, Avenida Lázaro Cárdenas 253, 61600 Pátzcuaro, Michoacán, México.

✉ emmanuel.perezcalix@inecol.mx; <https://orcid.org/0000-0002-6195-19722>

³ Herbario IBUG, Instituto de Botánica, Departamento de Botánica y Zoología, Universidad de Guadalajara, Camino Ramón Padilla Sánchez 2100, Las Agujas, Nextipac, Zapopan 45110, Jalisco, México.

✉ pcarreyes@gmail.com; <https://orcid.org/0000-0001-9278-0208>

*Author for correspondence: ✉ rcuevas@cucsur.udg.mx

Abstract

Sedum dormiens (Crassulaceae) from the Sierra de Manantlán in Jalisco, Mexico, is described. The distinctive characters of the species are its chamaephytic nature, capillary roots, formation of large colonies, tetramerous flowers with white petals, dormant terminal and lateral buds in the mother plant and connate fruits of $\frac{1}{2}$ – $\frac{3}{4}$ its length. The habitat and morphology of the species is illustrated and its relationships with close species presented. Its conservation status was categorized as Endangered (EN).

Keywords: Capillary roots, dormant buds, endemism, Jalisco, *S. quadripetalum*, tetramerous

Resumen

Se describe *Sedum dormiens* (Crassulaceae) de la Sierra de Manantlán, Jalisco, México. Los caracteres distintivos de la especie son el ser caméfitas, tener raíces capilares, la formación de colonias grandes, las flores tetrámeras de pétalos blancos, las yemas terminales y laterales persistentes en la planta madre y latentes, frutos connados $\frac{1}{2}$ – $\frac{3}{4}$ de su longitud. Se ilustra el hábitat y la morfología de la especie y se discuten sus relaciones con las especies más cercanas. Su estado de conservación fue evaluado como En Peligro (EN).

Palabras clave: Endemismo, Jalisco, raíces capilares, *S. quadripetalum*, tetrámero, yemas latentes

Introduction

Crassulaceae is a family with 34–35 genera and 1400–1500 species. Mexico is a center of diversity for the family, with ca. 325–330 species (Thiede & Egli 2007; Carrillo-Reyes *et al.* 2009). Six subfamilies were recognized within the family (Berger 1930), but recent molecular studies suggest that there should only be three: Crassuloideae, Kalanchoideae and Sempervivoideae (Thiede & Egli 2007). Sempervivoideae has been subdivided into five tribes, with the largest being Sedeae, featuring 640 species. This tribe includes the *Acre* and *Leucosedum* clades, both with species of *Sedum*, so the latter is recognized as a polyphyletic genus, being his taxonomy problematic and controversial (‘t Hart & Nyfferler 1995; Mort *et al.* 2002; Carrillo-Reyes *et al.* 2009). Molecular studies in the Sedeae tribe have suggested the need to split the genus *Sedum* (Nikulin & Gontcharov 2017), making the respective taxonomic adjustments in some cases (Gallo 2017). In a broad sense, *Sedum* includes 420 species in the subg. *Gormaniana* (Clausen 1942: 28) and subg. *Sedum* (Linnaeus 1753: 430), of which 170 are recorded in America (Thiede & Egli 2007).

Sedum Linnaeus (1753: 430), known as stonecrops, is a group of importance as ornamental and medicinal plants (Stephenson 1994). There are around 133 *Sedum* species in Mexico, 110 (83 %) of which are endemic (Aragón-Parada *et al.* 2019) and the country is considered a center of diversity for the genus (Pérez-Calix 2008; Carrillo-Reyes *et al.* 2009) and, new species are expected to be found as the findings of recent years suggest (García-Ruiz & Costea 2015; Reyes-Santiago *et al.* 2015; Pérez-Calix 2016; Reyes-Santiago *et al.* 2017). *Sedum* species are distributed mainly in fast-draining rocky environments and most present a preference for elevations above the tree line (Stephenson 1994), almost always in places where lichens and mosses are present (Thiede & Egli 2007). The genus has been recorded in Mexico as areas of high species richness of *Sedum* in the Trans-Mexican Volcanic Belt (Clausen 1959) and the Sierra Madre del Sur (Aragón-Parada *et al.* 2019). The latter is a physiographic region to which the Sierra de Manantlán belongs and is where collection of the species proposed here as new was made, since its characters do not match those of the known species. The species has previously been referred to as *Sedum* sp. 1 in Vázquez-García *et al.* (1995) and as *Sedum* sp. nov. 1., in Aragón-Parada *et al.* (2019).

TABLE 1. Morphological differences among *Sedum* species and some additional information regarding their phenology and distribution. Information about the species was obtained from the literature (Clausen 1959, 1977, Stephenson 1994, Meyran-García & López-Chávez 2003, Naturalista 2021, for *S. dormiens*, this study).

Characters	<i>S. dormiens</i>	<i>S. grandipetalum</i>	<i>S. quadripetalum</i>
Primary root	Capillary	Capillary	Tuberous
Leaf dimensions (mm)	6–7 × 1.8–2.5 × 1	12–23 × 4–5	15–20 × 5–7.5
Leaf bases	Spurred	Amplexicaulous and spurred	
Inflorescences	Cymes with 2–3 cincinni	Cymes with 2–3 cincinni	Cincinni
Flowers	4–merous	5–merous	4–merous
Sepal outlines	Elliptic to elliptic-oblong	Lanceolate or oblong	elliptic
Sepal dimensions (mm)	2.7–4 × 1.2–1.5 × 0.6–0.7	4–6 × 1.4–2.8	2.4–3.6
Sepal bases	Spurred	Spurred	Spurred
Petal outlines	Linear to elliptic-lanceolate	Elliptic to elliptic-lanceolate	Ovate
Petal colors	White with pink to reddish bases	Light yellow	Pale pink spotted with red
Petal dimensions (mm)	4–5 × 1.5	5.8–9.4 × 2.5–4.3	2.8–3.3
Nectary color	Red	White or yellowish	Red
Nectary dimensions (mm)	0.6–0.8 × 0.2	0.2–0.7 × 0.5–1.1	1.2–1.4 × 1–1.2
Seed dimensions (mm)	0.7–1	0.9–0.3	0.5–0.6
Flowering	September to November	November to May	August to September
Fruiting	October to November	January to June	October
Distribution	Jalisco	Jalisco	Durango

Material and methods

The species was described based on specimens available in the ZEA Herbarium of the University of Guadalajara. Vegetative and reproductive structures were carefully revised under a stereoscopic microscope using the protocol recommended in Radford *et al.* (1974) and Stearn (2004) in order to produce the description. The relevant literature was reviewed, including taxonomic keys for the family, genera and species (Berger 1930; Fröderström 1935; Clausen 1959; Stephenson 1994; Cházaro-Basáñez & Thiede 1995; Meyrán-García & López-Chávez 2003; Thiede & Eggl 2007; Pérez-Calix 2008), as well as that of recently described species for Mexico (García-Ruiz & Costea 2015; Reyes-Santiago *et al.* 2015; Pérez-Calix 2016; Reyes-Santiago *et al.* 2017). Photographs of type specimens were reviewed in the Tropicos (2020) (www.tropicos.org) and JSTOR (2020) (<http://plants.jstor.org>) databases of species that could be related to the new *Sedum* species proposed here as a new species. Measurements and photographs of the vegetative and floral structures were taken using hydrated plant material and a Zeiss Stemi 2000–C microscope connected to an AxioCam ICc 1 camera and AxioVision SE64 (Rel. 4.9.1) software. Photographs of the species in the field were taken with a Canon EOS M3 camera. Habitat and phenology data of the new species were obtained from herbarium specimen labels and fieldwork, while information for related species was taken from the labels of type images and Naturalista (2021, observation 18724880).

Results

Sedum dormiens is a chamaephyte species of short size with capillary roots but without woody stems that forms dense colonies of plants. The species presents reticulate-papillate and elliptic-oblong leaves, inflorescence cymes 2-3 cincinni and reticulate-papillate, the flowers are tetramerous and with white petals, while the seeds are reticulate-papillate. *Sedum dormiens* presents aerial winter buds protected by dry leaves that resemble scarious scales, which pass the dry winter season in a dormant state and do not separate from the mother plant until new roots are emitted and new individuals are generated. Something similar has been observed in some European-Asian species of *Hylotelephium* and *Petrosedum*.

Sedum grandipetalum Fröd. (Fröderström 1935: 52-53), a sympatric species with *S. dormiens*, produces conical buds of flat leaves that are imbricated on the stems after flowering, passing the winter in this condition, reason for which it is compared with *S. dormiens*, while *S. quadripetalum* Clausen (1977: 213) is compared with *S. dormiens* for its tetramerous flowers and its way of reproduction.

Sedum dormiens produces seeds that remain in physiologically dormant during the cold and dry season, and germinate in the following warm and wet season, the resulting seedlings produce only vegetative growth with dormant aerial buds in the first year, which will produce plants that flower in the second wet season. This reproductive behavior of *S. dormiens* is similar to that of biennial species of *Sedum*. Differences among *S. dormiens*, *S. grandipetalum* and *S. quadripetalum* are presented in table 1.

Discussion:—By being a chamaephyte of short size and lacking woody stems, *Sedum dormiens* would be included in the Latin American species of subg. *Sedum*, in the Mexican non-woody species group (Stephenson 1994). Through its capillary roots, reticulate-papillate and elliptic-oblong leaves, inflorescence cymes 2-3 cincinni and reticulate-papillate seeds, *Sedum dormiens* would be included in the clade *Acre* subg. *Sedum* (Thiede & Eggl 2007). *Sedum dormiens* presents dormant aerial winter buds, something similar has also been observed in the European-Asian species *Hylotelephium viviparum* (Maximowicz 1883: 137) H. Ohba (1977: 54), *H. verticillatum* (Linnaeus 1753: 430) H. Ohba (1977: 54), *Petrosedum amplexicaule* (De Candolle 1808: 12) Velayos (1989: 584) and *P. pruinatum* Link ex Brotero (1805: 209) Grulich (1984: 41), but it is otherwise unknown among New World species of *Sedum*. *Hylotelephium viviparum* and *H. verticillatum* form adventitious buds in the upper leaf axils, which fall at the base of the parents and remain there until the next growing season when they generate new individuals (Stephenson 1994). In *S. dormiens*, the buds do not fall to the ground; they are aerial and do not separate from the mother plant until new roots are emitted and new individuals are generated. On the other hand, *Petrosedum amplexicaule* and *P. pruinatum* produce sterile shoots that could be short (in the former) or form stolons (in the latter) with summer-dormant buds (‘t Hart & Eggl, 2003). Plants grow in dense reticulate mats as with *S. dormiens*; however, these species have yellow, mostly polymerous (5–10–merous) flowers, while *S. dormiens* has tetramerous white flowers. *Sedum grandipetalum* Fröd. (Fröderström 1935: 52-53), which is recorded from the Sierra de Manantlán and has been found to be sympatric

with *S. dormiens*, produces conical buds of flat leaves that are imbricated on the stems after flowering, passing the winter in this condition, and presenting an elongation in the next growing season, arching and falling to form new individuals (Stephenson 1994). A condition such as that of *S. grandipetalum* could be one route leading to dormant and protected aerial buds with scarious and resistant scales, such as those of *S. dormiens*. *Sedum dormiens* differs from *S. grandipetalum* by the following characters: the flowers are tetramerous and white and there is no foliar dimorphism between sterile and flowering branches, whereas in *S. grandipetalum* the flowers are yellow and pentamerous, the leaves of the vegetative stems are different from those of the flower stems. The reproductive behavior of *S. dormiens* of produce seeds until the second year, after seeds germinate, is similar with the biennial species group of *Sedum*, with the difference that in biennial species the plant produces a rosette of basal leaves in the first year, passing the winter in this condition and the next summer it produces new vegetal material that bears fruits and seeds and then dies (Clausen, 1977), while *S. dormiens*, the plant passes the winter condition as an aerial latent buds and the next summer it generates new individual that fructify and produce aerial dormant buds again. This behavior has been considered as a response to a climatic situation with a wet season in summer and lower temperatures in winter (Clausen, 1977).

The formation of dormant aerial buds in *Sedum dormiens* is an adaptation that had not been recorded in *Sedum* species from the American continent. Research is required to help know the origin of this adaptation and how it is related to the European-Asian species that show similar adaptations. Molecular studies are also required to establish the possible phylogenetic relationships of *S. dormiens* with other species of *Sedum*.

Taxonomy

Sedum dormiens Cuevas, Pérez-Calix & P. Carrillo, *sp. nov.* (Fig. 1, 2)

Type:—MEXICO. Jalisco state: Municipio de Cuautitlán de García Barragán, Cerro Las Capillas, in rocky areas within the *Pinus durangensis* forest, 2800 m a.s.l., 1st Nov 2009 (fl, fr), Cuevas, Cuevas & Medina 9882 (holotype: ZEA! Isotypes IEB, IBUG).

Diagnosis:—*Sedum dormiens* resemble most to *Sedum quadripetalum* with which it shares tetramerous flowers, but in the latter the roots are tuberous, the leaves are bigger (15–20 × 5–7.5 mm) and the nectaries are greenish-yellow, whereas in *S. dormiens* the roots are capillary, the leaves smaller (6–7 × 1.8–2.5 mm) and the nectaries are red. In *S. quadripetalum*, the winter leaves form basal rosettes and the species is biennial, while in *S. dormiens*, dormant aerial buds are formed and the species is chamaephytic.

Chamaephytic herb, rupicolous, 4–10 cm tall, sometimes prostrate with branches of up to 15 cm in length. It forms dense colonies from a few to hundreds of m² in area. Plants turn reddish during flowering and fruiting. Stems with long, almost leafless, stolons ending in compact sterile shoots forming winter-dormant buds protected by scarious scales, stems from the previous season reddish-brown and hollow, while those of the current season are solid, with a spongy pith, both covered with a strong, transparent epidermis. Lower leaves are alternate, upper leaves are opposite-crossed or sub-opposed, linear-elliptic to slightly spatulate, glabrous, reticulate and sometimes papillose, 6–7 × 1.8–2.5 × 1 mm, with spur of 0.5–1 mm in length, concave ventrally and convex dorsally. Inflorescences are cymes of 2–3 cincinni, each cincinnus with 1–4 flowers. Stems are papillose. Pedicels of 1 mm in length, white-pink. Flowers are 4 (5)–merous, 9–10 mm in diameter; sepals of equal size in each flower, fleshy, glabrous, elliptic to elliptic-oblong, 2.7–4 × 1.2–1.5 × 0.6–0.7 mm, base spurred; petals cruciform, linear to elliptic-lanceolate, 4–5 × 1.5 mm, acute, with the midrib dorsally keeled and very strong, white with pink to reddish bases; stamens 8, 4 epipetalous and 4 alternipetalous, 3.5–4 mm long, pinkish to reddish basally, anthers reddish, 0.5 × 0.3 mm, epipetalous stamens open later; nectaries are oblong, red, 0.6–0.8 × 0.2 mm, rounded at the apices; carpels are 4 mm in length, divergent, connated ventrally ½–¾ in length, beaks of 0.5–0.7 mm in length; 2–6 ovules per carpel, cylindrical, 0.6–0.8 × 0.2–0.25 mm. The fruit is ventrally dehiscent, 4–4.5 mm in length, each carpel with 2–4 seeds. Seeds are cylindrical or claviform, 0.7–1 mm in length, reticulate-papillate, reddish-brown.

Habitat, distribution, and phenology:—*Sedum dormiens* is a rupicolous species which appears to be dead in the cold, dry season of the year (December to early June), but in June, when the atmospheric humidity increases, even without precipitation, a reaction occurs in *S. dormiens*; the buds lose their dormancy and generate aerial adventitious roots with new individuals that anchor themselves to the ground and form broad *Sedum* colonies (field observation). This event seems to be concomitant with the response of mosses to increased atmospheric humidity and with which *S. dormiens* coexists. *Sedum dormiens* is only known from three localities in western Mexico, located between 2400 to 2860 m a.s.l. in elevation, in the highest parts of the Sierra de Manantlán. It grows in volcanic rock and open areas

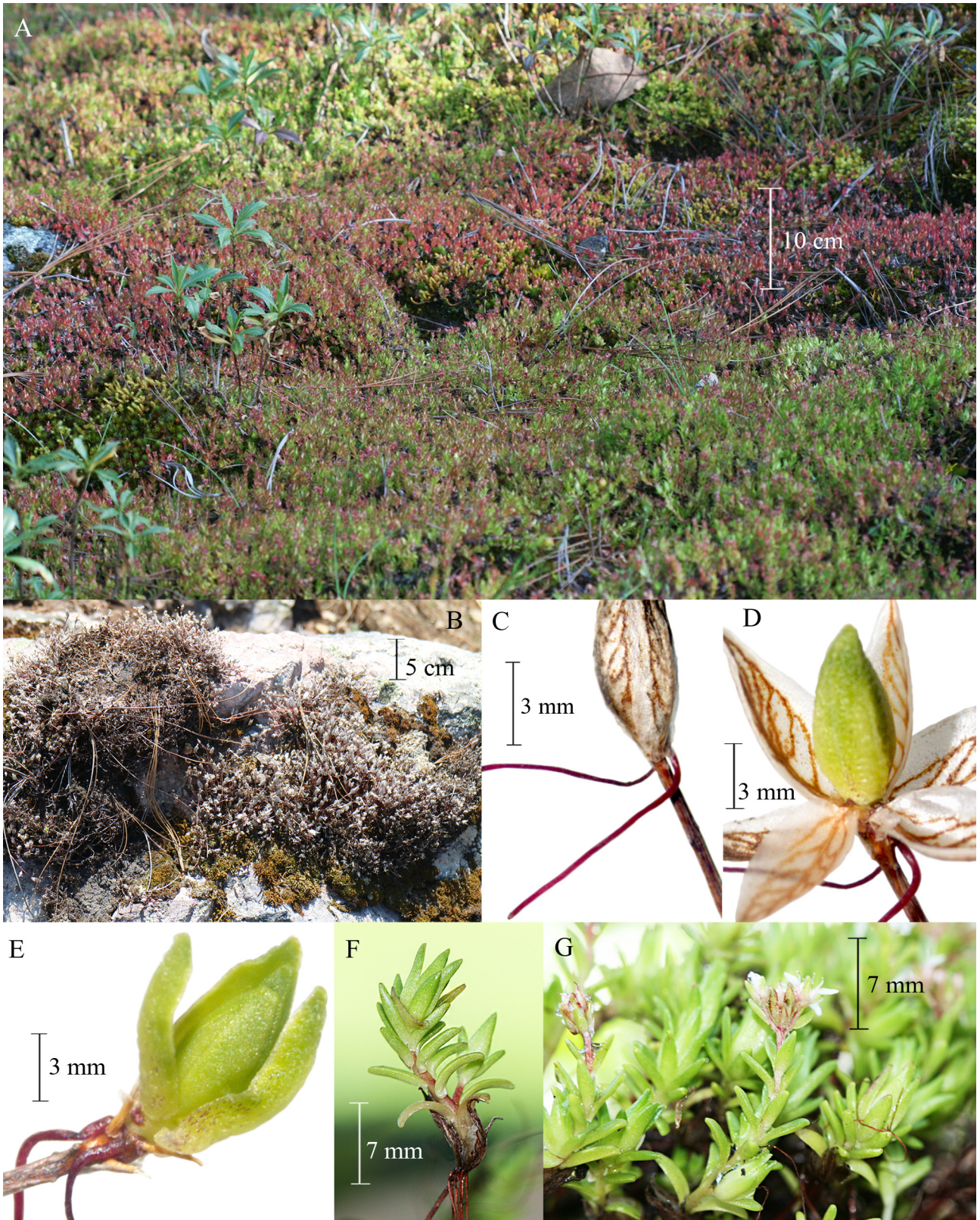


FIGURE 1. A. *Sedum dormiens* colony; B. Individuals with dormant aerial buds; C. Buds beginning growth with aerial roots; D. Roots, scarios scales and bud; E. Bud in growths; F. Clone with adventitious roots; G. Individual flowering.

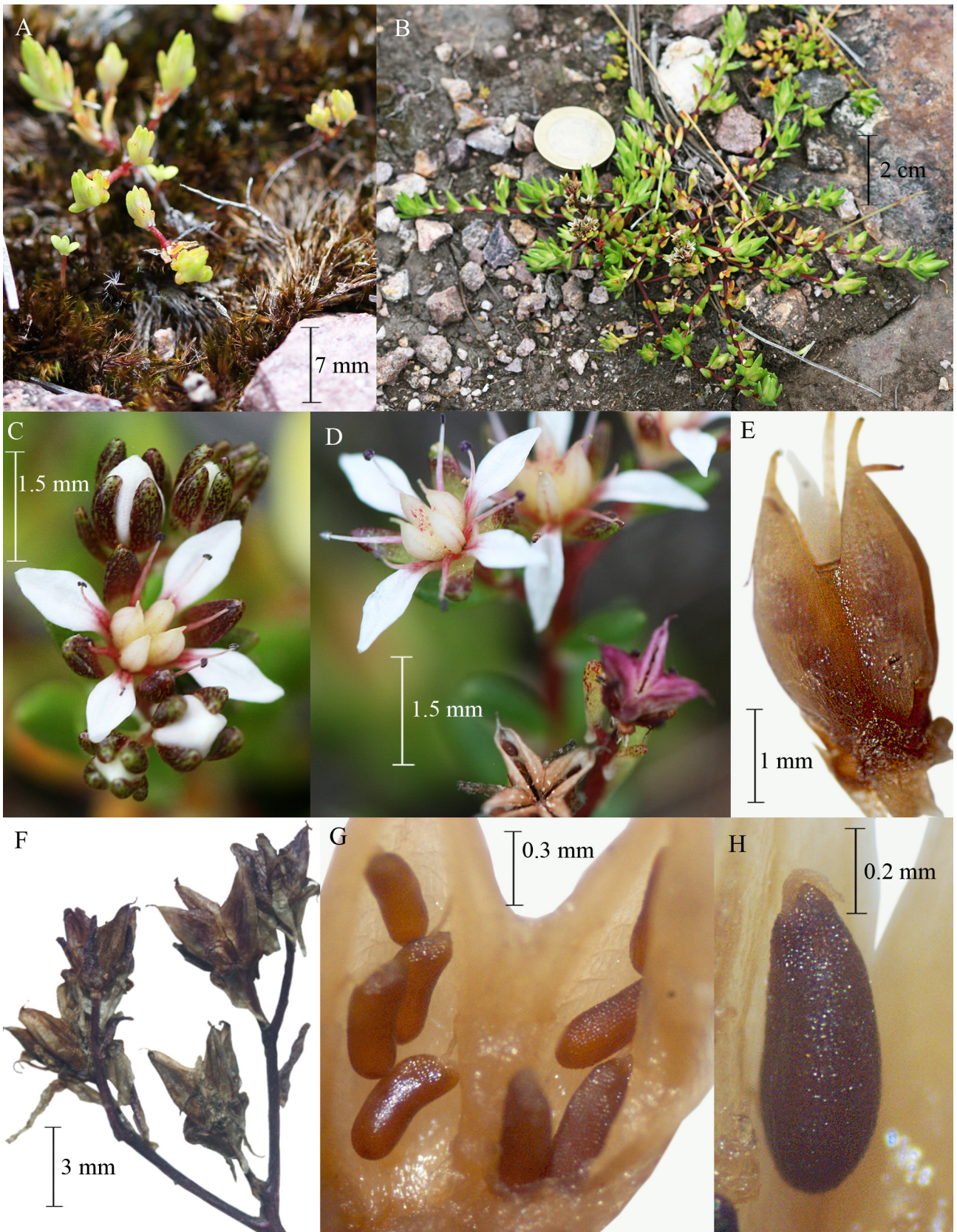


FIGURE 2. A. New individual by sexual reproduction; B. Prostrate individual; C. Flower buds and flower in anthesis. E. Flower in anthesis and fruits; F. Connate fruits; G. Infructescence; H. Carpels with seeds; I. Seed.

in *Pinus durangensis* Martínez (1942: 23) forest, coexisting with *Arbutus occidentalis* McVaugh & Rosatti (1978: 303–304), *Agave manantlanicola* Cuevas & Santana-Mich. (2012: 330), *Agrostis novogaliciana* McVaugh (1983: 41–42), *Arbutus xalapensis* Kunth (1819: 279–280), *Castilleja albobarbata* Iltis & G.L. Nesom (2003: 1343–1346), *Castilleja macvaughii* Holmgren (1976: 203–204), *Comarostaphylis discolor* (Hook.) Diggs subsp. *manantlanensis* Diggs (1988: 205), *Disocactus speciosus* (Cav.) Barthlott, (1991: 87), *Lopezia miniata* Lag. ex DC. (De Candolle 1813: 121), *Microspermum debile* Bentham (1840: 64), *Muhlenbergia dumosa* Scribner ex Vasey (1892: 71), *Pedicularis glabra* McVaugh & Mellich. (1975: 58–60), *Quercus laurina* Bonpl. (von Humboldt & Bonpland 1809: 32), *Sedum jaliscanum* S. Watson (1890: 148), *Sisyrinchium schaffneri* S. Watson (1883: 160), *Tagetes filifolia* Lagasca (1816) and *Weldenia candida* Schult. f. (1829: 3), among other species.

Flowering of *S. dormiens* occurs from September to November, while fruiting has been observed in October and November.

Etymology:—The name of the species alludes to the presence of dormant aerial buds protected by strong scarious scales, which maintain perennity during the dry and cold season of the year.

Conservation Status:—According to the categories and criteria of the IUCN Red List (IUCN 2012), *Sedum dormiens* is assigned a preliminary status of “Endangered” EN (B2a). Its known and estimated geographical distribution is less than 500 km² in area, and it has been recorded from only three localities.

Additional specimens examined (paratypes):—MEXICO. Jalisco: Municipio de Cuautitlán de García Barragán: Cerro Las Capillas, 2800 m a.s.l., 7th Jan 1980 (st), *Iltis, Schatz, Sorensen & Matekaitis 2414* (WIS, MEXU); Top of sharp crest of the Sierra de Manantlán, Oriental just E of “Cerro Las Capillas”, along from road to “Cerro La Cumbre” to “Los Jardines”, 19 km due SSE of El Chante, 19°33'15"N; 104°09'W, 2800–2860 m a.s.l., 10th Oct 1980 (fl), *Iltis & Guzmán 3216* (WIS); 35 km to the southeast of Autlán, between San Miguel and El Rincón de Manantlán, 2400 m a.s.l., 4th Sep 1981 (fl), *Vázquez-García & Nieves-Hernández 471* (IBUG); Cerro Capulín, 19°33'N; 104°09'W, 2750 m a.s.l., 9th Mar 1987 (st), *Iltis, Benz, Vázquez & Cházaro 29392* (WIS); los Picachos del Pozanco, 19°32'54.3" N; 104°07'49.6" W, 2830 m a.s.l., 1st Nov 2009 (fl, fr), *Cuevas, Cuevas & Balcázar 9910* (ZEA); 1st Nov 2009 (fl, fr), *Cuevas, Cuevas & Balcázar 9917* (ZEA); Cerro Las Capillas, 0589169 and 2162369 Datum WGS84, 2846 m a.s.l., 9th Oct 2012 (fl, fr), *Cuevas, Carrillo-Reyes & Pérez-Calix 10936* (ZEA, IEB, IBUG).

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