



***Oenothera resicum* (Onagraceae), a new species and the first record of the family from the Revillagigedo Archipelago, Mexico**

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Abstract

Oenothera resicum (Onagraceae) is here described and illustrated. This is the first record of the Onagraceae family in the Revillagigedo Archipelago, Mexican Pacific. The new species, presently known only from Isla Clarión, has characteristic features of species of subsect. *Raimannia*, from which can be differentiated by its perennial habit, glabrescent large fruits, glabrous sepals, conspicuously dentated leaves, stigma surrounded by the anthers at anthesis, basal rosette absent, and its particular ecological habitat. The species description, ecological information, habitat and conservation assessment are also discussed. Additionally, a key for the species of subsect. *Raimannia* distributed in Mexico is provided.

Keywords: Insular floras, Island endemics, *Raimannia*

Resumen

Oenothera resicum (Onagraceae) se ilustra y describe. Este es el primer miembro de la familia Onagraceae en ser registrado en el Archipiélago de Revillagigedo, Pacífico Mexicano. Esta nueva especie, registrada en la actualidad solamente en Isla Clarión, tiene rasgos característicos de las especies de la subsect. *Raimannia*, dentro de la cual puede ser diferenciada por su hábito perenne, frutos de gran tamaño casi glabros, sépalos glabros, hojas conspicuamente serradas, estigma rodeado por las anteras en la antesis, ausencia de roseta basal y su particular hábitat. Se presentan notas y discusión sobre la descripción de la especie, información ecológica, hábitat y su estado de conservación. Además, se proporciona una clave para las especies de la subsect. *Raimannia* distribuidas en México.

Palabras clave: Endémicos insulares, flora insular, *Raimannia*

Introduction

The Revillagigedo Archipelago is a group of four volcanic islands: Socorro, Clarión, San Benedicto and Roca Partida, located in the eastern Pacific Ocean, several hundred kilometers off the southwestern coast of Mexico. Due to its remoteness and the complex geological processes that have shaped landscapes and biota, the area depicts several examples of allopatric speciation. A rare new species of *Oenothera* Linnaeus (1753: 346), family Onagraceae was found on Clarión island, the furthest Mexican insular territory, barely 20 km² in surface and located almost 690 km away from the nearest continental point, the southern tip of the Baja California Peninsula. The last formal flora of the Revillagigedo Archipelago (Levin & Moran 1989) includes a list for Clarión based on intensive collections made in April 1925 (Johnston 1931), which included 41 taxa; but no members from the Onagraceae were considered in the list. Three strictly endemic taxa were pointed out occurring in Clarión: *Ipomoea halierca* I.M. Johnston (1931: 85), *Physalis clarionensis* Waterfall (1967: 326–327), and *Aristida tenuifolia* Hitchcock (1931:296). The relevance of this finding has both taxonomic and floristic implications, as this is the first record for the family in the entire archipelago, which increases the specific richness of endemics on Clarión Island.

The species under discussion presents some features common in sect. *Oenothera*: a multi-stemmed perennial habit with long decumbent to weakly ascending stems, forming a terminal cauline rosette (Figures 2E, 2F, 4A); flowers with yellow petals (Figures 2C, 2E), with a red mark near the base at anthesis; stigma with 4 linear lobes; fruits are cylindrical capsules attenuate at the apex (Figures 2A, 2F). Likewise, the presented species has characteristic traits of the subsect. *Raimannia* (Rose ex Britton & A. Brown, 1913: 596) W. Dietrich (1977: 612), such as a curved hypanthium when the floral buds are fully developed (Figure 2B); and the petals apically truncate (Figures 2D, 2F).

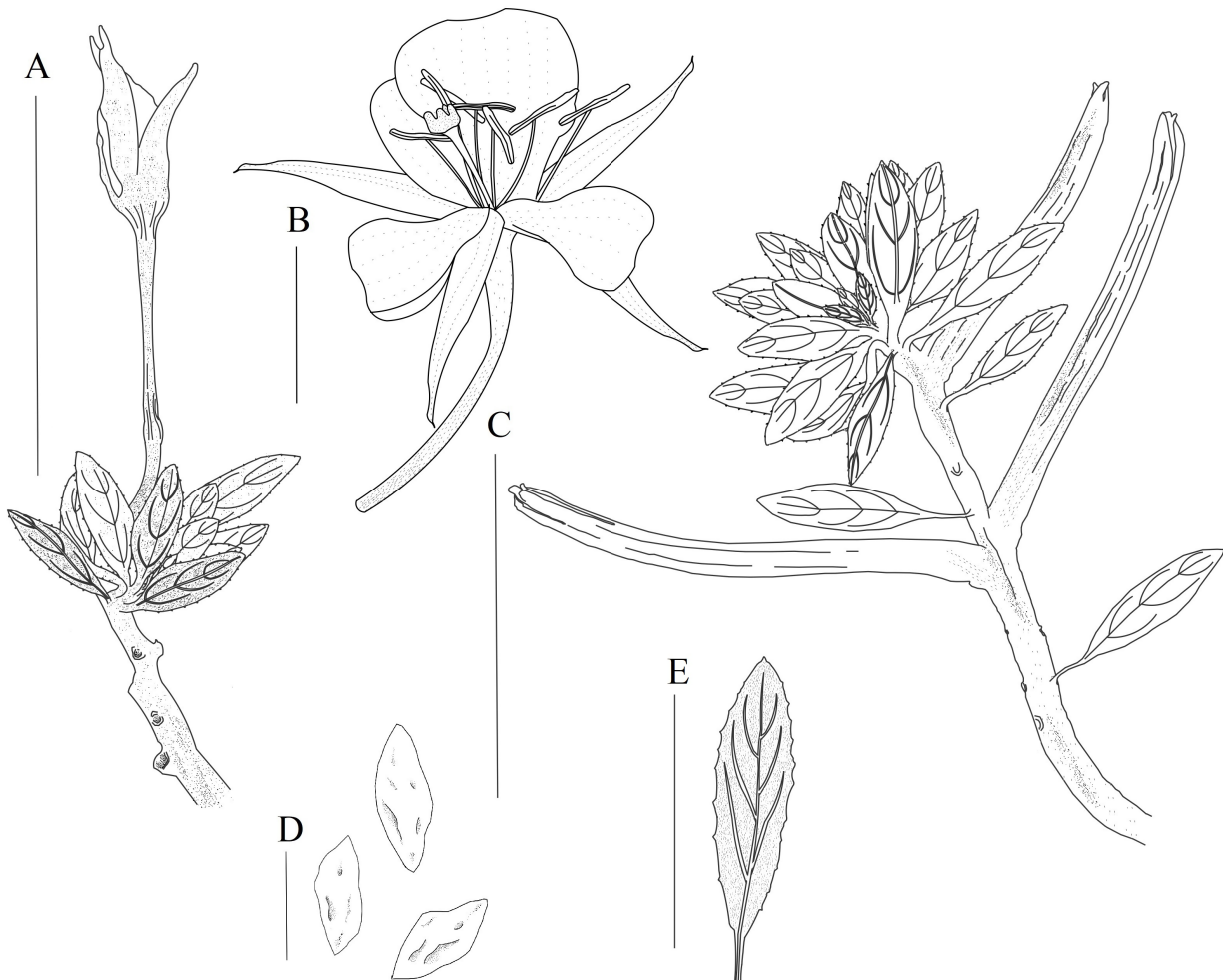


FIGURE 1. *Oenothera resicum*. A. Floral bud (scale: 5cm). B. Flower (2 cm). C. Branch with capsules (5 cm). D. Seeds (1 mm). E. Leaf (3 cm). Drawn by E. Benavides.

According to Dietrich & Wagner (1988) and Wagner et al. (2007) subsect. *Raimannia* contains six species (seven taxa) distributed in North America, primarily in southcentral United States, with four species extending into Mexico down to Tamaulipas, *Oenothera grandis* Smyth (1899: 160) and *Oenothera laciniata* Hill (1767: t. 10); Campeche, *Oenothera drummondii* Hooker (1834: 3361) subsp. *drummondii*; and at the southern tip of Baja California peninsula, *Oenothera drummondii* subsp. *thalassaphila* (Brandege, 1922:185) W. Dietrich & W.L. Wagner (1987: 150) (Figure 3). A combination of characteristics are used for the separation of species within this section, as there is no single morphological feature that can differentiate them. Therefore, the four taxa of the subsection distributed in Mexico serves here as reference material for the delimitation of the new species.

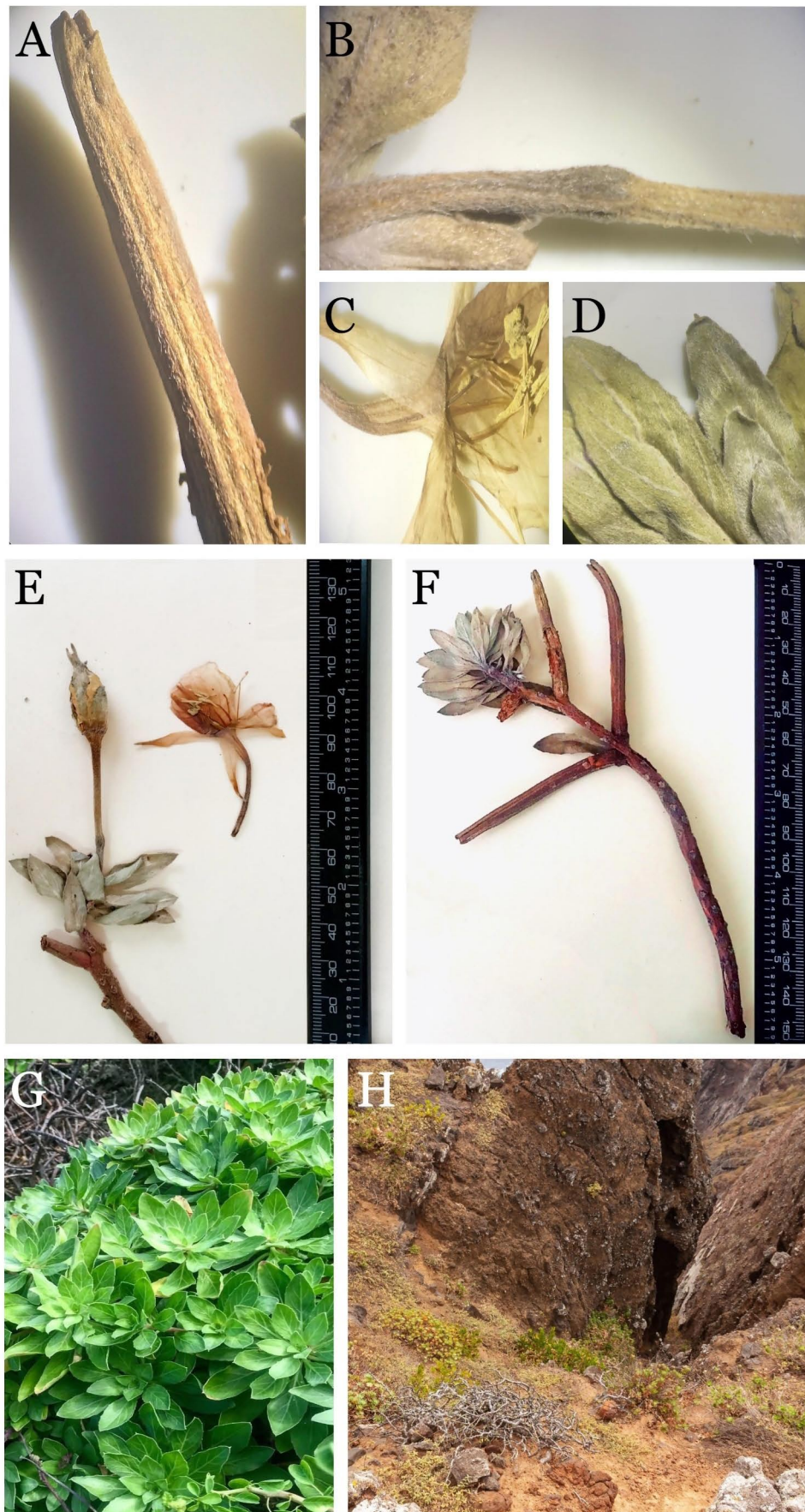


FIGURE 2. Relevant distinctive morphological and ecological characters of *Oenothera resicum*. A. Cylindric capsule attenuate at the tip. B. Curved hypanthium. C. Anthers and pollen grains in contact with the stigma. D. Leaf details (pubescence and margin). E. Floral bud and flower dimensions. F. Lateral branch with capsules and cauline rosette. G. Vegetative stage. H. Habitat. (A–D are magnified x 1.5).

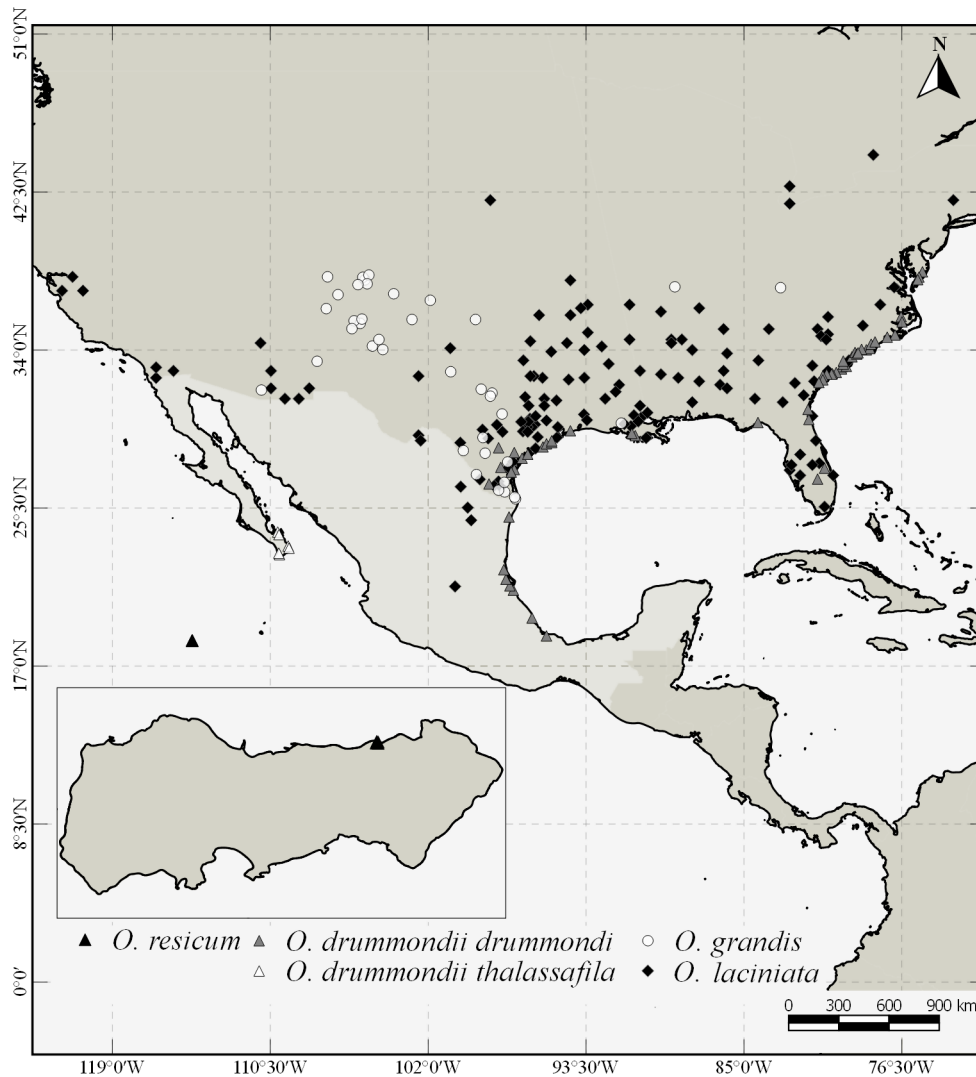


FIGURE 3. Distributional range of the species from subject *Raimannia* present in Mexico (occurrence data obtained from GBIF database, 2019), including *Oenothera resicum* type locality.

Materials and methods

The species description is based on the type material collected by the first and second author in May 2018, and a subsequent visit to the type location during November 2018. This allowed for the study of the species habit before and after the rain season, and additional collections of reproductive material to study juvenile growth and polymorphism. Taxonomy and comparisons were derived from studying four of its most closely affiliated taxa *O. drummondii* subsp. *thalassaphila*, *O. drummondii* subsp. *drummondii*, *O. grandis* and *O. laciniata*. Field observations, voucher revision of the family at HCIB and IBUG collections (acronyms follow Thiers 2019), and existing literature (Munz, 1935, Raven *et al.* 1979, Stubbe & Raven 1979, Dietrich & Wagner 1988, Wagner *et al.* 2007) were used to support the field material and the recognition of the new species. The conservation status was assessed using the IUCN (2017) criteria based on population size, health of mature individuals and habitat availability.

Results

Oenothera resicum Benavides, Kuethe, Ortiz-Alcaráz & León de la Luz, *sp. nov.* (Figure 1.)

Oenothera resicum differs from *O. drummondii* subsp. *thalassaphila* by its glabrous sepals (vs. densely villous pubescent), larger and glabrescent fruits (vs. smaller strigillose fruits) and its rocky habitat (vs. sandy); from *O. drummondii* subsp. *drummondii*, *O. laciniata* and *O. grandis* it differs by the perennial shrubby habit (vs. annual herb), and the absence of glandular indumentum on the flower (vs. floral indumentum present).

Type:—MEXICO. Revillagigedo Archipelago, Isla Clarión, the cliffs in the north just west of Cerro Tortuga, 200m, 018°22'0.80"N, -114°42'9.90"W, 30 May 2018, fr. *E. Benavides & J.R. Kuethe 23* (holotype HCIB!; isotypes MEXU!, SD!).

Ascending to procumbent subshrubs, perennial, mature individuals forming taproots; stems simple or with lateral branches up to 50 cm, reddish, strigose to glabrescent, terminal rosettes containing smaller leaves; basal rosette absent. Leaves elliptic, cuneate at base, mucronate at apices, short-petiolate to almost sessile, margins conspicuously dentate, strigillose; terminal rosette leaves 0.5–3 × 0.3–1 cm; cauline leaves 2–6 × 1–1.5 cm; bracts 2.5 × 0.4 cm, deciduous. Flowers solitary, axillary; sepals 1.9–2.5 × 0.43–0.46 cm, green to yellowish, glabrous, sepal tips 0.3 mm long; petals 4, yellow, fading into red near the base at anthesis, obovate, 1.6–2.2 × 1.3–1.8 cm; floral tube 2.5–3 cm, strigillose to sparsely strigose; stigma with 4 linear lobes, 2 mm long, surrounded by the anthers at anthesis; stamens 8, filaments 20 mm, anthers 6–8 mm. Four celled capsule 5.5–8 cm long, 4.5–6 mm in diameter, attenuate at the tip, strigose to glabrescent, dehiscent. Seeds 0.8–1.2 mm, ellipsoid, with pitted testa. Apparently self-compatible. Chromosome number unknown.

Etymology:—Derived from the Latin words “*resicum*”, “*risicum*” or “*riscus*” which means “*cliff*” or “*reef*”. The epithet was chosen in reference to its natural habitat, which is at the top of a cliff; also, for its reference to the anglicization of the word “*risk*”, alluding to its critically endangered state of conservation and the instability of its habitat. Thus, the specific epithet “*resicum*”, alludes to both the habitat of the species (a cliff) and its conservation priority (at risk).

Distribution and habitat:—Apparently, the natural habitat of *O. resicum* is limited to a single outcrop on top of the northern cliffs on Isla Clarión (Figure 2H). This outcrop is marked by a distinctively different geochemical composition which is largely enriched in magnesium oxide and glaucophane (Mg, Na), opposed to the more ferric enrichment seen on the outcrops elsewhere on the island. The sole occurrence of *O. resicum* on this single outcrop marks a very strong preference to this particular soil-type, and arguably may be important in considering conservation under cultivation.

Phenology:—Semi-deciduous, losing some of their cauline leaves during the dry season, but keeping the terminal rosettes. This species was found with one flower senescing, flower buds and mature capsules during the first collection in May 2018; however, no open flowers were observed. During the second collection in November 2018, no new flower buds were present. The time of anthesis is currently unknown. Flowering probably extends from late spring till summer, with fruiting occurring simultaneously. It is observed in the closely related species that flowers are often self-compatible. For this species it is likely to be the case, since the stigma is at the same level of the anthers and there is evidence of pollen grains on this structure (Figure 2C).

Conservation status:—Given the limited size and location of the outcrop where the species occurs above crumbling cliffs, it is highly likely that much of its original habitat has been lost due to coastal erosion, with the present outcrop being the mere remnant of a larger deposit, with its present area of occupancy limited to less than 50 m², and with a recorded population of less than 10 mature individuals. The location is at ca. 200 m elevation above a vertical cliffside and the present crevices forming suggest that this outcrop, too, will soon succumb to coastal erosion which is likely to mark the extinction of this species in the wild. Altogether, the high specificity, rarity and low stability of its habitat scales this species as critically endangered (CR), according to IUCN conservation criteria A2, B2ab (i, ii, iii) (IUCN 2017). Its permanence will only be guaranteed with conservation efforts *ex-situ* (i.e. botanical gardens, conservatories or scientific collections).

TABLE 1. Distinctive morphological characters between the species from *Oenothera* sect. *Oenothera* subsect. *Raimannia*, found on mainland Mexico, and *O. resicium* from Isla Clarión (derived from Munz, 1935 and Dietrich & Wagner, 1988).

	<i>O. resicium</i>	<i>O. drummondii</i> subsp. <i>thalassaphila</i>	<i>O. drummondii</i> subsp. <i>drummondii</i>	<i>O. grandis</i>	<i>O. laciniata</i>
Habit	Perennial subshrub	Perennial subshrub	Annual herb	Annual Herb	Annual Herb
Basal rosette	Absent	Absent	Absent	Present	Present
Stem pubescence	Sparsely strigose to subglabrous	Strigillose	Strigillose to villous	Strigillose and sparsely villous	Sparsely to moderately strigillose and villous
Glandular puberulent hairs	Absent	Absent	Present	Present	Present
Cauline leaves	2–6 cm, elliptic, strigillose, margins conspicuously dentate	1–4.5cm, oblong lanceolate to oblanceolate, strigillose, margins entire to coarsely dentate	1–8 cm, oblanceolate to obovate, densely villous, margins entire to remotely sinuate- dentate	3–10 cm, narrowly obovate or oblanceolate to narrowly elliptic, sparsely strigillose, margins lobate or dentate	2–10 cm, oblong lanceolate to oblanceolate, strigillose and villous, margins deeply dentate to lobate
Floral tube	2.5–3 cm, sparsely strigose pubescence	2–3.5cm, strigillose	2.5–5 cm, strigillose to densely villous	2.5–4.5 cm, densely to sparsely villous	1.2–3.5 cm, densely to sparsely villous or strigillose, red flushed
Sepals	1.9–2.5 cm, glabrous	1.3–2.5cm, strigillose, occasionally red dotted	2–3 cm, strigillose to villous	1.5–3 cm, villous, often red striped at the junction of the floral tube	0.5–1 cm, strigillose, occasionally red flushed with a marginal red stripe
Petal length	1.6–2 cm	2–3.5cm	2.5–4.5cm	2.5–4 cm	0.5–2.2 cm
Anthers	6–8 mm	5–12mm	5–12mm	4–11 mm	2–6 mm
Stigma	Surrounded by the anthers at anthesis	Elevated above the anthers at anthesis	Elevated above the anthers at anthesis	Elevated above the anthers at anthesis	Surrounded by the anthers at anthesis
Capsule	5.5–8 cm, sparsely strigose to glabrescent	2–4cm, strigillose	2.5–5.5 cm, strigillose to villous	2.5–5 cm, strigillose and villous	2–5 cm, strigose
Seeds	0.8–1.2 mm, pitted	1.5–2 mm, smooth	1.1–1.7 mm	0.8–1.5 mm	0.9–1.8 mm
Habitat	Rocky	Sandy coastal	Sandy coastal	Sandy/Rocky	Sandy/disturbed

Discussion

A combination of morphological features allowed to define the new species *Oenothera resicum* within sect. *Oenothera*, subsect. *Raimannia*. The diagnostic traits for its taxonomic placement in sect. *Oenothera* include a multi-stemmed perennial habit with long decumbent to weakly ascending stems, the presence of a terminal cauline rosette, 4-merous flowers with yellow petals; stigma with 4 linear lobes, and cylindrical capsules attenuate at the apex; for subsect. *Raimannia* the relevant traits include a curved hypanthium when the floral buds are fully developed, and the apex of the petals being truncated.

Given the number of shared traits and the proximity in its distributional range, apparently the most closely related species is *O. drummondii* subsp. *thalassaphila* (figure 3, table 1), from which it is distinguished by glabrescent and larger fruits, glabrous sepals, stigma surrounded by the anthers at anthesis, larger conspicuously serrated leaves and its specific habitat preferences. The separation of the new taxon from the other species of subsect. *Raimannia* depends on an array of contrasting traits, although the most evident morphological feature that clearly differentiates it, is the size of the fruit, which is the largest of the subsection (figure 2A, 2F). More detailed differences between *Oenothera resicum* and the four taxa analyzed are presented in table 1.

So far, subsect. *Raimannia* is defined based on the genome and plastome relationships, inferred by outcrossing experiments paired with morphological studies (Dietrich & Wagner, 1988). Further analyses to study the reproductive biology of *Oenothera resicum* are needed, both to solve the relationships between the other presumably closely related species, and due to its critically endangered status, as its permanence will only be guaranteed with conservation efforts *ex-situ*.

It should be noted that the phylogenetic relationships within all *Oenothera* genus continue unsolved, and the group remains paraphyletic. The molecular analysis performed by Levin et al. (2004) showed some monophyletic lineages that correspond to traditional sections or groups of sections within *Oenothera*, but only one species of the subsect. *Raimannia* (*O. laciniata*) was considered for this analysis, therefore, the monophyly of the subsection has not been tested. The development of a solid phylogenetic framework will provide support for biogeographical studies on diversification in subsect. *Raimannia* and other *Oenothera* groups (i.e. Katinas et al. 2004, Evans et al. 2009). This is of particular relevance as a family Onagraceae has represented an important model for studying plant evolution.

Key for the species of *Oenothera* Sect. *Oenothera* subsect. *Raimannia* distributed in Mexico

1. Annual Herb; floral glandular hairs present3
- Perennial subshrub; floral glandular hairs absent2
2. Sepals 1.3–2.5 cm, densely villous; fruits 2–4cm, densely villous; sandy habitat *O. drummondii* subsp. *thalassaphila*
- Sepals 1.9–2.5cm, glabrous; fruits 6–8cm, scattered strigose to glabrous; rocky habitat *O. resicum*
3. Basal rosette present; leaf margin dentate to lobate4
- Basal rosette absent; leaf margin entire to remotely shallowly dentate *O. drummondii* subsp. *drummondii*
4. Petals 0.5–2.2 cm long; stigma surrounded by the anthers at anthesis *O. laciniata*
- Petals 2.5–4 cm long; stigma elevated above the anther at anthesis *O. grandis*

Acknowledgements

This work is part of the inter-institutional project “Integral ecological restoration of the Revillagigedo Archipelago” implemented by *Grupo de Ecología y conservación de Islas* (GECI), in collaboration with the Secretariat of Environment and Natural Resources (SEMARNAT), the National Commission of Natural Protected Areas (CONANP), the Ministry of the Interior and the Secretariat of the Navy (SEMAR). We appreciate the support of these institutions, in particular the logistical support of the SEMAR. We also appreciate the financial support of the WWF-Carlos Slim Foundation Alliance, The David and Lucile Packard Foundation, Marisla Foundation and The Mohamed bin Zayed Species Conservation Fund. Special thanks to the staff of the HCIB herbarium, Alfonso Medel-Narváez and Reymundo Domínguez-Cadena, who contributed valuable information. Special thanks to Carolina Gámez and David Colby for their support in the field. The collection was made under the Scientific Collection License granted to GECI by the Directorate General of Wildlife (DGVS), No. SGPA / DGVS / 003135/18.

Literature cited

- Brandegee, T.S. (1922) *Plantae Mexicanae Purpusianae*. *University of California Publications in Botany* 10 (2): 181–188.
- Britton, N.L. & Brown, A. (1913) Onagraceae. *An illustrated flora of the Northern United States, Canada and the British Possessions* 2: 596–597.
- Dietrich, W. (1977) The South American species of *Oenothera* sect. *Oenothera* (*Raimannia*, *Renneria*; Onagraceae). *Annals of the Missouri Botanical Garden* 64 (3): 425–626.
<https://doi.org/10.2307/2395257>
- Dietrich, W. & Wagner, W.L. (1987) New taxa of *Oenothera* L. sect. *Oenothera* (Onagraceae). *Annals of the Missouri Botanical Garden* 74 (1): 144–150.
<https://doi.org/10.2307/2399272>
- Dietrich, W. & Wagner, W.L. (1988) Systematics of *Oenothera* Section *Oenothera* Subsection *Raimannia* and Subsection *Nutantigemma* (Onagraceae). *Systematic Botany Monographs* 24: 1–91.
<https://doi.org/10.2307/25027713>
- Dietrich, W., Wagner, W.L. & Raven, P.H. (1997) Systematics of *Oenothera* Section *Oenothera* Subsection *Oenothera* (Onagraceae). *Systematic Botany Monographs* 50: 12–34.
<https://doi.org/10.2307/25027870>
- Evans, M.E.K., Smith, S.A., Flynn, R.S. & Donoghue, M.J. (2009) Climate, Niche Evolution, and Diversification of the “Bird Cage” Evening Primroses (*Oenothera*, Sections *Anogra* and *Kleinia*). *The American Naturalist* 173 (2): 225–240.
<https://doi.org/10.1086/595757>
- GBIF (2019) GBIF Home Page. Available from: <https://www.gbif.org> (accessed 25 March 2019)
- Hill, J. (1767) “Laciniata”. *The Vegetable System. Or, the internal structure and the life of plants; their parts, and nourishment, explained; their classes, orders, genera, and species, ascertained, and described; in a method altogether new: comprehending an artificial index and a natural system* 12 (Appendix): 64, pl. 10.
- Hitchcock, A.S. (1935) New Species of Grasses from the Galapagos and the Revillagigedo islands. *Proceedings of the California Academy of Sciences Series 4*, 21 (24): 295–300.
- Hooker, W.J. (1834) *Oenothera drummondii*, Mr. Drummond’s evening-primrose. *Botanical Magazine* 61: pl. 3290–3373.
- IUCN (2017) *Guidelines for using the Red list Categories and Criteria*. Version 13. Prepared by the Standards and Petition subcommittee. Available from: <http://www.iucnredlist.org/documents/RedListGuidelines.pdf> (accessed 9 September 2019)
- Johnston, I.M. (1931) The Flora of the Revillagigedo Islands. *Proceedings of the California Academy of Sciences, Series 4*, 20: 9–104.
- Katinas, L., Crisci, J., Wagner, W.L. & Hoch, P.C. (2004) The geographical radiation of tribes Epilobieae, Gongylocarpeae, and Onagreae (Onagraceae) in North America, based on parsimony analysis of endemism and track compatibility analysis. *Annals of the Missouri Botanical Garden* 91: 159–185.
- Levin, G.A. & Moran, R.V. (1989) The vascular flora of Isla Socorro, Mexico. *San Diego Society of Natural History, Memoir* 16: 1–71.
- Levin, R.A., Wagner, W.L., Hoch, P.C., Hahn, W.J., Rodriguez, A., Baum, D.A., Katinas, L., Zimmer, E.A. & Sytsma, K.J. (2004) Paraphyly in Tribe Onagreae: Insights into Phylogenetic Relationships of Onagraceae Based on Nuclear and Chloroplast Sequence Data. *Systematic Botany* 29 (1): 147–164.
<https://doi.org/10.1600/036364404772974293>
- Linnaeus, C. (1753) *Species plantarum* 1: 346.
- Munz, P.A. (1935) Studies in Onagraceae. IX. The Subgenus *Raimannia*. *American Journal of Botany* 22 (7): 645–663.
<https://doi.org/10.1002/j.1537-2197.1935.tb05052.x>
- Raven, P.H., Dietrich, W. & Stubbe, W. (1979) An outline of the systematics of *Oenothera* subsect. *Euoenothera* (Onagraceae). *Systematic Botany* 4 (3): 242–252.
<https://doi.org/10.2307/2418422>
- Smyth, B.B. (1889) Additions to the flora of Kansas. *Transactions of the Annual Meetings of the Kansas Academy of Science* 12: 105–119.
<https://doi.org/10.2307/3623784>
- Stubbe, W. & Raven, P.H. (1979) A genetic contribution to the taxonomy of *Oenothera* sect. *Oenothera* (including subsections *Euoenothera*, *Emersonia*, *Raimannia* and *Munzia*). *Plant Systematics and Evolution* 133 (1–2): 39–59.
<https://doi.org/10.1007/BF00985878>
- Thiers, B. (2019) *Index Herbariorum: A global directory of public herbaria and associated staff*. New York Botanical Gardens Virtual Herbarium. Available from: <http://sweetgum.nybg.org/ih/> (accessed April 2019)
- Wagner, W.L., Hoch, P.C. & Raven, P.H. (2007) Revised classification of the Onagraceae. *Systematic Botany Monographs* 83: 1–204.
- Waterfall, U.T. (1967) *Physalis* in Mexico, Central America and the West Indies. *Rhodora* 69 (779): 326–327.