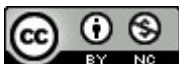


A new endemic species of *Nolana* (Solanaceae-Nolaneae) from near Iquique, Chile

Una nueva especie endémica de *Nolana* (Solanaceae-Nolaneae) cerca de Iquique, Chile



Abstract

In connection with studies on the fog oasis or *lomas* formations at Alto Patache near Iquique, Chile, the first author encountered several *Nolana* species, including one new to science described here, *N. patachensis* J. Hepp & M. O. Dillon (Solanaceae-Nolaneae). The new species is diagnosed, described, illustrated with photographs, and compared to nearest geographic neighbors in northern Chile. To an aid in recognition, a key to *Nolana* species reported from region of Tarapacá is provided. Putative relationships between the various *Nolana* species encountered at the type locality are discussed. Conservation efforts at the type locality are highlighted, including its unique environmental conditions, biota and potential threats.

Keywords: *Nolana*, Nolaneae, endemics, *lomas* formations, new species, region of Tarapacá, Chile, conservation, Solanaceae.

Resumen

En relación a los estudios sobre el oasis de niebla o las formaciones de lomas en Alto Patache cerca de Iquique, Chile, el primer autor recolectó varias especies de *Nolana*, incluida una nueva especie para la ciencia que aquí se describe, *N. patachensis* J. Hepp & M. O. Dillon (Solanaceae-Nolaneae). Además de la descripción, se realiza la diagnosis, se ilustra con fotografías y se compara con las especies vecinas más cercanas del norte de Chile. Para ayudar al reconocimiento, se proporciona una clave para las especies de *Nolana* reportadas para la región de Tarapacá. También se discuten las relaciones putativas entre las diversas especies de *Nolana* encontradas en la localidad del tipo; así mismo, se resaltan los esfuerzos de conservación en la localidad tipo, incluyendo sus condiciones ambientales únicas, biota y amenazas potenciales.

Palabras clave: *Nolana*, Nolaneae, endémicas, formaciones de lomas, especie nueva, región de Tarapacá, Chile, conservación, Solanaceae.

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Introduction

Nolana L. ex L.f. (Solanaceae-Nolaneae) is a genus consisting of 90 species, including the one described here (Dillon, 2005, 2016). With the addition of this species, it brings the total number to 48 Chilean species, including 45 endemic species, and three species with disjunct distributions ranging from southern Peru (i.e., *Nolana adansonii* (Roem. & Schult.) I. M. Johnst., *N. gracillima* (I. M. Johnst.) I. M. Johnst., and *N. lycioides* I. M. Johnst.). Of this number, twelve *Nolana* species have been verified from Región de Tarapacá (see Table 1).

In Chile, greatest species diversity in *Nolana* is confined to near-ocean localities termed *lomas* formations, between 50-800 m elevation and along the foot of the Coastal

Cordillera, usually within 20 kms of the Pacific Ocean (Rundel *et al.*, 1991; Dillon & Hoffmann, 1997). Only a few species are distributed above 2000 m and/or at a distances of 50-500 kms inland from the coast, e.g., *Nolana leptophylla* (Miers) I. M. Johnst., *N. sessiliflora* Phil., and *N. villosa* (Phil.) I. M. Johnst.

Most Chilean species are narrow endemics, with small, restricted geographic ranges and specific ecological requirements, but a few species have larger geographic distributions and occupy several vegetation formations (Dillon, 2005).

Materials and methods

Descriptions were made from dried herbarium specimens deposited in SGO. All acronyms follow those in Index

Herbariorum (<http://sweetgum.nybg.org/science/ih/>). Conservation status was assigned using IUCN criteria (2017) combined with field observations and geographic distribution based on herbarium specimens. Scanning electron microscopy (SEM) was used to examine the structure of the mericarps. Samples were mounted on aluminium SEM stubs and sputter coated with a platinum-gold alloy, using a Quorum Sputter Coater Q150T. Mericarps were examined and photographed using a HITACHI S-4700 SEM at an accelerating voltage of 2.0 kV and working distance of 12.0 mm. Images were saved as TIFF (Tagged Image File Format). Sample were photographed using a stereoscopic magnifying glass.

We utilize the “morphological cluster” concept in recognition of species in *Nolana* (see Mallet, 1995), defined as “assemblages of individuals with morphological features in common and separate from other assemblages by correlated morphological discontinuities in a number of features”. In addition to the diagnoses provided for the new species, specific characters useful in recognition of species are detailed in the **Key to Species of Región de Tarapacá, Chile**.

Taxonomic treatment

Nolana patachensis J. Hepp & M. O. Dillon, **sp. nov.** (Figs. 1, 2, 3, 4, 5)

TYPE: CHILE. **Región de Tarapacá:** Prov. Iquique, Alto Punta Patache, 20°49'S, 70°09'W, 1-XI-1997, W. Sielfeld 32 (holotype: SGO-143057).

Diagnosis

Nolana patachensis is most similar to *N. onoana*, sharing similar leaf and floral morphology (Fig. 7C); however, it differs from the latter species in its spreading, prostrate

habit, and erect, terete leaves. Further, its elliptic or oval mericarps with (1-)2-3(-4) seeds and finely bullate surfaces (Fig. 5A) are essentially unique within its congeners in northern Chile. The mericarps in *N. patachensis* also differ from mericarps found in *N. onoana* which are round or spherical, with a finely reticulate or alveolate surfaces. Other annual, tap-rooted species, e.g., *N. aplocaryoides*, have with much wider leaves with long, villous trichomes (Fig. 7A), and round or spherical mericarps; and *N. gracillima* with glabrescent to pilose pubescence leaves, shorter corollas (Fig. 7B), and pyriform mericarps.

Description

Taprooted annual **herbs** to 50 cm in diameter, 10-20 cm tall, basally-branched; stems branched, prostrate to decumbent, to 15 cm long, densely stipitate-glandular. **Leaves** alternate, sessile, the blades linear-oblong, 10-20 mm long, 3-4 mm wide, terete, erect or perpendicular orientation, succulent, densely pubescence with stout, stipitate-glandular trichomes, entire, apically rounded, the bases rounded. **Inflorescences** of solitary flowers in upper leaf axils; pedicels cylindrical, densely pubescent, 2-7 (-10) mm long. **Flowers** 5-merous; calyx narrowly campanulate, 5-7 mm wide at anthesis, densely covered with stipitate-glandular trichomes, 5-lobed, the tube ca. 3-5 mm long, ca. 5 mm wide, the lobes lanceolate, unequal, 2-3 mm long, ca. 1 mm wide, the apices obtuse or rounded; corollas zygomorphic, infundibuliform, 18-24 mm long, 8-12 mm wide at anthesis, distally lavender to light blue, the throat clear, externally and internally glabrous, the lobes obtuse; stamens 5, included, the filaments inserted on lower third of corolla, unequal, 3 long, 2 short, anthers dithecal, purple, the thecae ca. 1.2 mm long, ca. 1 mm wide, glabrous; ovary glabrous, basal

nectary ca. 1 mm wide, the carpels 5, the style included, the stigma green. **Fruits** mericarps, 5, 1-seriate, oval to elliptic, black, 2-3 mm long, 1.5-2 mm wide, adaxial surfaces minutely bullate; seeds (1-)2-3(-4) per mericarp.

Phenology: Annual, tap-rooted annual that responds to sufficient moisture for germination and flowering during november, 1997, and more recently november-december, 2015.

Etymology: The species epithet is the latinisation of the geographic locality of the type collection, Alto Patache fog oasis or *lomas* formation located in Región of Tarapacá of northern Chile. As with many place names, the origins remain obscure, but it may have its origins in *Puquina*, a language distantly related to *Quechua*. In any event, it is not associated directly with either *Quechua* or *Aymara*. Further details on the locality are to be found below.

Distribution and ecology: *Nolana patachensis* has been recorded from two adjacent localities in Región de Tarapacá (Fig. 6), Alto Patache fog oasis or *lomas* formation (20°48'S, 70°09'W) and Alto Punta Lobos (21°02'W, 70°09'W). Both of these localities exhibit southwest oriented slopes that are constantly exposed to fog (Muñoz-Schick *et al.*, 2001; Calderón *et al.*, 2010; Osses *et al.*, 2017). Alto Patache fog oasis has been recognized as a priority area for conservation and is currently protected in a concession granted by the Ministry of National Assets for 25 years (since 2007) to Pontificia Universidad Católica de Chile, through the Atacama Desert Center. Its isolation has provided conditions for development of a particular biota. For example, it is the only known locality for *Santessonia cervicornis* (Follmann) Follmann (an endemic Critically Endangered lichen

species; Vargas *et al.*, 2017) and several other lichens common to the Atacama Desert. The vascular flora at Alto Patache has been estimated at approximately 42 species of vascular plants (Pliscoff *et al.*, 2017), including one of the few populations of *Alstroemeria lutea* Muñoz-Schick (Muñoz-Schick, 2000). The arthropod fauna includes two endemic Coleoptera, *Scotobius patachensis* and *Scotobius larraini* (Sagredo *et al.*, 2002), and two bees, *Penapis larraini* (Hymenoptera: Halictidae: Rophitinae) (Packer, 2012) and *Neofidelia submersa* (Hymenoptera: Apoidea: Megachilidae) (Dumesh & Packer, 2013). Lastly, this locality has been implicated in the first record of a noctuid moth, *Hemieuxoa polymorpha* Forbes, for Chile, when adults were collected at Alto Patache in 1999 (Angulo & Olivares, 2005). Alto Punta Lobos is located approximately 25 kms south of Alto Patache, and like that formation, it has a compliment of perhaps 20 endemics in a flora of ca. 40 species (Muñoz-Schick *et al.*, 2001).

Putative relationships: *Nolana patachensis* is distinctive among its congeners in Chile with a combination of characters not encountered in any other described species. While DNA results are not available for this species, overall morphological similarity suggests relationships with *Nolana onoana*, a member of Clade G (Dillon *et al.*, 2009).

Clade G is a strictly Chilean clade including *Nolana aplocaryoides* as the sister taxon to the remainder of the clade (Dillon *et al.*, 2009). This group is represented by small to large shrubs and annuals, all with small leaves, (1-)10-20(-40) mm long and (1-)2-5(-7) mm wide, all with smaller corollas when contrasted with those in Clade B (e.g., *N. jaffuelii*) and some members with only white or yellowish corollas. The leaf pubescence is extremely variable from glabrous to densely canescent with stellate or dendritic,

or arachnoid, stipitate, or simple trichomes, and rarely with superficial salt glands.

Conservation status: Critically Endangered (CR); overall distribution at two localities, each with <10 km² (CR) and perhaps <250 individuals. See IUCN (2017) for explanation of measurements. The threats to these habitats are posed by ever-expanding human pressure from mining and other industrial processes that can contaminate these fragile environments. Efforts at studying, protecting and preserving the region are underway.

Additional specimens examined: CHILE. Región de Tarapacá: Prov. Iquique, Alto Patache, *E. Belmonte* 97770 (CONC-143484), Alto Punta Patache, 20°49'W, 70°09'W, 800 m, 8-XI-1997, *R. Pinto s.n.* (SGO-142975); Alto Punta Lobos, 21°02'S, 70°09'W, 800 m, 17 Jan 1998, *R. Pinto s.n.* (SGO-142976).

A series of *Nolana* collections from further south of the currently known range of *N. patachensis* need to be evaluated in the light of recent discoveries; these are from Región de Antofagasta, Prov. Tocopilla, camino a Mina Mantos de La Luna, *M. Quezada & E. Ruiz* 16 (CONC-121070), *M. Quezada & E. Ruiz* 17 (CONC-121207), and *M. Quezada & E. Ruiz* 19 (CONC-121076; SGO-127878). Another collection that should be scrutinized further; Prov. Tocopilla, Quebrada Mamilla, *F. Schlegel* 7693 (CONC-115627).

Notes: When herbarium material of this plant was first encountered by MOD in 2009, the type sheet had been determined as *Nolana aplocaryoides*, another tap-rooted annual species typically recorded further to the south. That species has different leaves and pubescence, but with similar corollas (Fig. 7A). At that time, MOD determined the sheets as *N. gracillima*, a species originally

described from southern Peru (Fig. 7B) but with populations reaching northern Chile. In 2018, MOD examined photographs of living plants with flowers taken by JH on a field trip to Alto Patache in 2015, after the abundant August rains in the sector (Figs. 2, 3), MOD recognized the plants as distinct, and convinced that the taxon was new to science. While close to *N. onoana* (Fig. 7C) in its floral morphology, that species has a very different growth habit and its leaves are more sulcate on the abaxial surfaces, but most distinctive are the differences in the mericarps.

Key to *Nolana* species recorded from Region of Tarapacá, Chile.

| | | |
|---|--|-----------------------|
| 1 | Annual, tap-rooted herbs. | 2 |
| | Perennial herbs, subshrubs or shrubs. | 6 |
| 2 | Leaves clearly petiolate, the bases auriculate, occasionally connate, the blades cordiform, rarely reniform or elliptic, glabrous, the surfaces with salt glands, attracting atmospheric moisture and causing the look and feel of oil | <i>N. adansonii</i> |
| - | Leaves, if petiolate, without auriculate bases nor connate, the blades spathulate to oblanceolate, variously pubescent, but never oily | 3 |
| 3 | Basal leaves with entire blades, the flowering shoots with sessile oval to ovate bracts subtending flowers, the corollas 30-40 mm wide; mericarps more than 20, 3-seriate | <i>N. jaffuelii</i> |
| - | Basal leaves lacking, the cauline leaves linear-lanceolate to linear-spathulate, the corollas less than 10 mm wide; mericarps 2-5, 1-seriate | 4 |
| 4 | Leaves linear-spathulate, the blades 7-30 mm long, apically acute, the calyx 8-10 mm long, the mericarps 2-5, 2 largest, ca. 3 mm long. | <i>N. tarapacana</i> |
| - | Leaves linear to linear-lanceolate, the blades 8-25 mm long, apically obtuse to rounded, the calyx 3-6 mm long, the mericarps typically 2-5, the largest 1.5-2 mm long. | 5 |
| 5 | Leaves 8-25 mm long, finely pilose to glabrescent, the mericarps pyriform, 1.5-2 mm long | <i>N. gracillima</i> |
| - | Leaves 10-20 mm long, densely stipitate-glandular pubescent, the mericarps oval to elliptic, 2-3 mm long. | <i>N. patachensis</i> |
| 6 | Leaves clavate to globular-obovate, the corollas 6-9 mm long | 7 |
| - | Leaves oblong to linear-lanceolate to linear-spathulate. | 8 |
| 7 | Leaves broadly clavate to globular-obovate, 5-10 mm long, densely pubescent with stellate or dendritic trichomes, the corollas suburceolate, white to yellowish. | <i>N. peruviana</i> |
| - | Leaves clavate to globular, 1-5 mm long, densely pubescent with arachnoid-tomentose pubescence, the corollas hypocrateriformis, white or rarely bluish | <i>N. sedifolia</i> |
| 8 | Leaves narrowly linear-spathulate to linear-lanceolate, 20-30 mm long, 10-20 mm wide | 9 |
| - | Leaves 10 mm long or less, linear-oblong to oblong, 1-4 mm wide. | 10 |
| 9 | Leaves narrowly linear-spathulate, conspicuously shaggy villous, the corollas lavender with deep purple guides in the throat. | <i>N. intonsa</i> |
| - | Leaves linear-lanceolate to linear-spathulate, 10-25 mm long, ca. 1 mm wide, stipitate-glandular, the corollas blue, obvious guides absent. | <i>N. lycioides</i> |

| | | |
|----|---|-------------------------|
| 10 | Leaves linear-oblong, 4-5 mm long, ca. 1 mm wide, hispidulous with capitate-glandular trichomes, 3-4(-5) mericarps | <i>N. leptophylla</i> |
| - | Leaves linear or oblong, 2-10 mm long, pubescence of elongate trichomes, not of capitate-glandular trichomes. | 11 |
| 11 | Leaves oblong, 2-6 mm long, 0.7-1.5 mm wide, oblong, tomentose to villous with flaccid-elongate trichomes, mericarps 5. | <i>N. tocopillensis</i> |
| - | Leaves linear, 10 mm long, 3-4 mm wide, pubescent with simple trichomes, mericarps 2(-3). | <i>N. foliosa</i> |

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Contribution of the authors

J. H.: Fieldwork, redaction of the text, taxonomic determination of the species, review and approval of the final text. M. O. D.: Redaction of the text, evaluation

methodology, fieldwork, taxonomic determination of the species, review and approval of the final text.

Conflicts of interests

The authors declare not to have conflicts of interests.

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Fig. 1. *Nolana patachensis* J. Hepp & M. O. Dillon. Holotype: W. Siefeld 32 (SGO-143057). Colección Museo Nacional de Historia Natural, Chile (SGO)

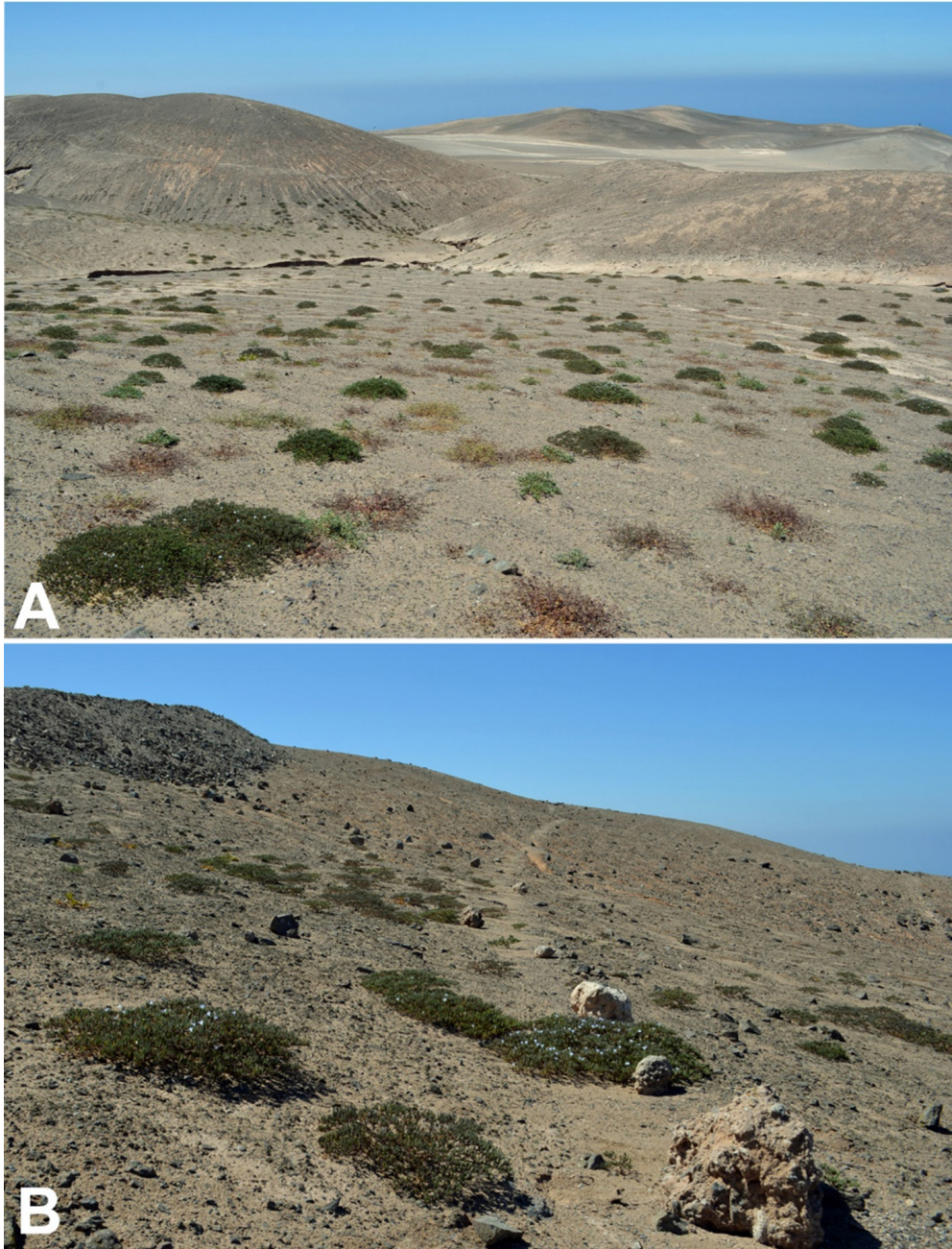


Fig. 2. *Nolana patachensis* habitats. A. Individuals of *N. patachensis* growing together with *N. jaffuelii*, *N. intonsa* and *Cristaria molinae* in December 2015, at the hills and inner plateau of Alto Patache oasis, which in dry years are devoid of plants; B. Prostrate growth habit of *N. patachensis*.



Fig. 3. *Nolana patachensis*. A. Close-up of flowers showing light blue color on the edge of the corolla; B. Lepidoptera (Family Hesperidae - Skippers) pollinating the flowers available in the oasis with rains, December 2015. It is possible to see the trichomes on the erect leaves.

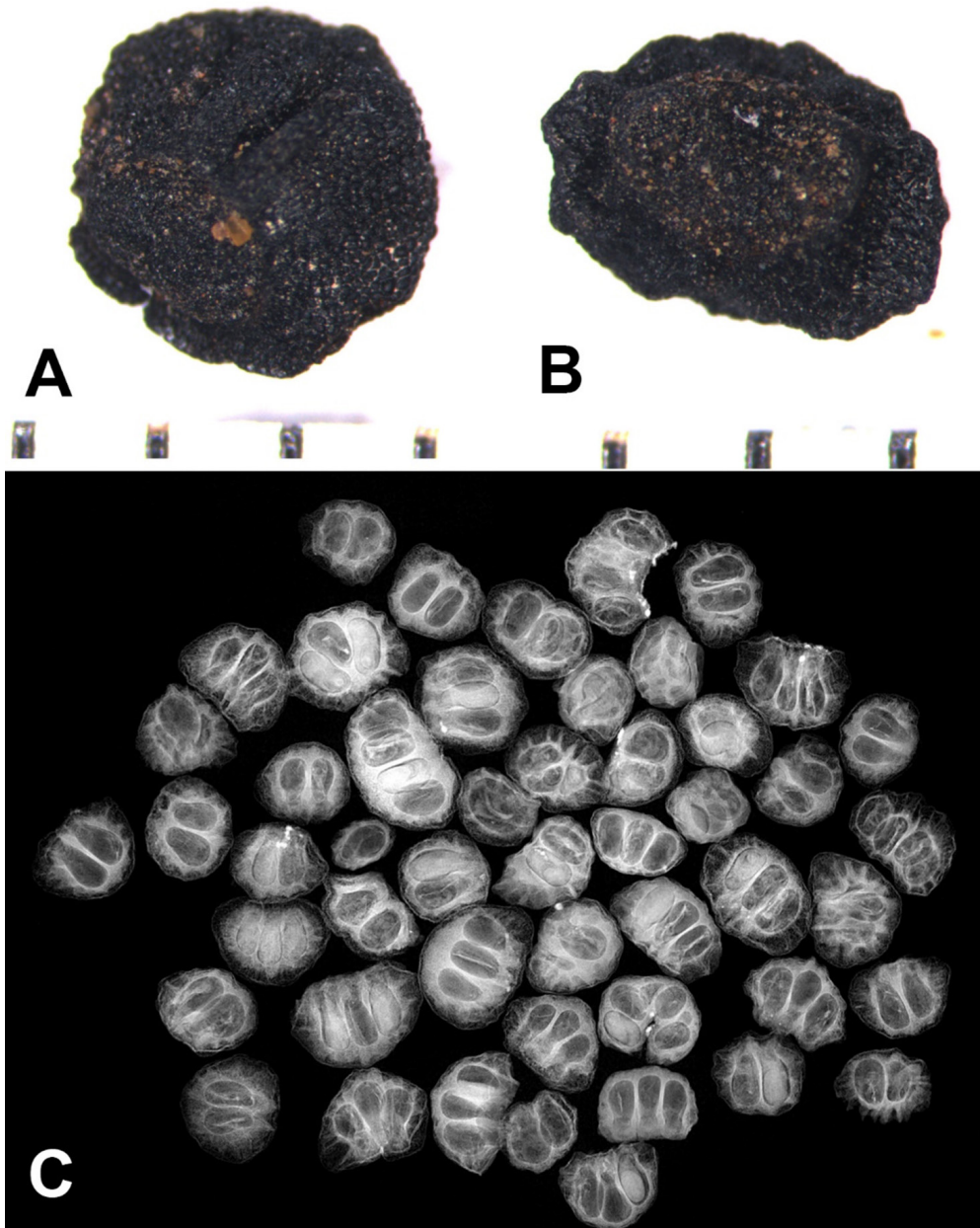


Fig. 4. *Nolana patachensis* mericarps. A. Abaxial view with stereoscopic magnifying glass images, scale marks = 1 mm; B. Adaxial view with stereoscopic magnifying glass images, scale marks = 1 mm; C. X-ray photograph showing internal seed chambers within each mericarp.

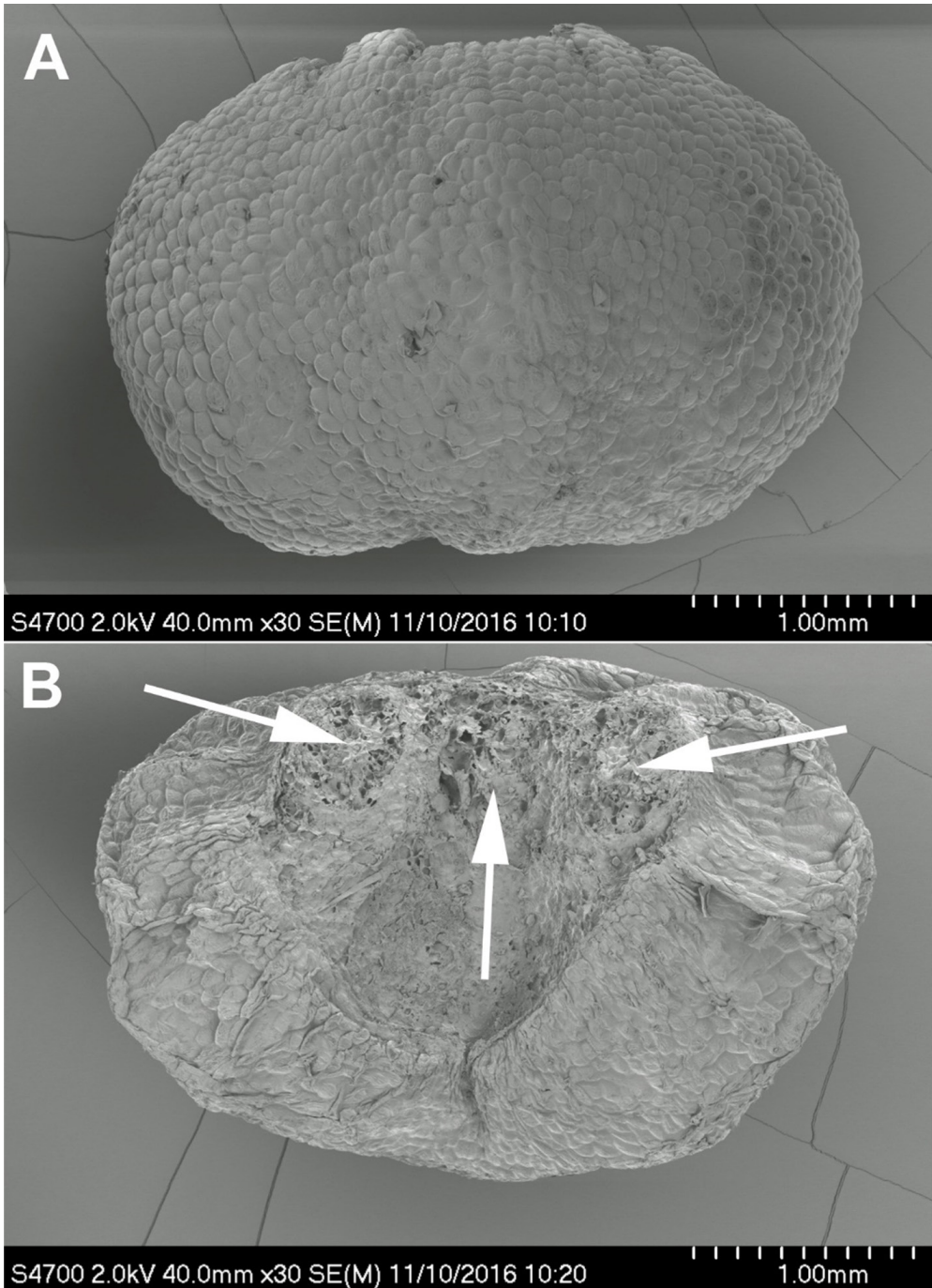


Fig. 5. *Nolana patachensis* mericarp. A. SEM of adaxial mericarp surface; B. SEM of abaxial mericarp surface, the arrows indicates the position of the funicular scars where the radicle appears during germination.

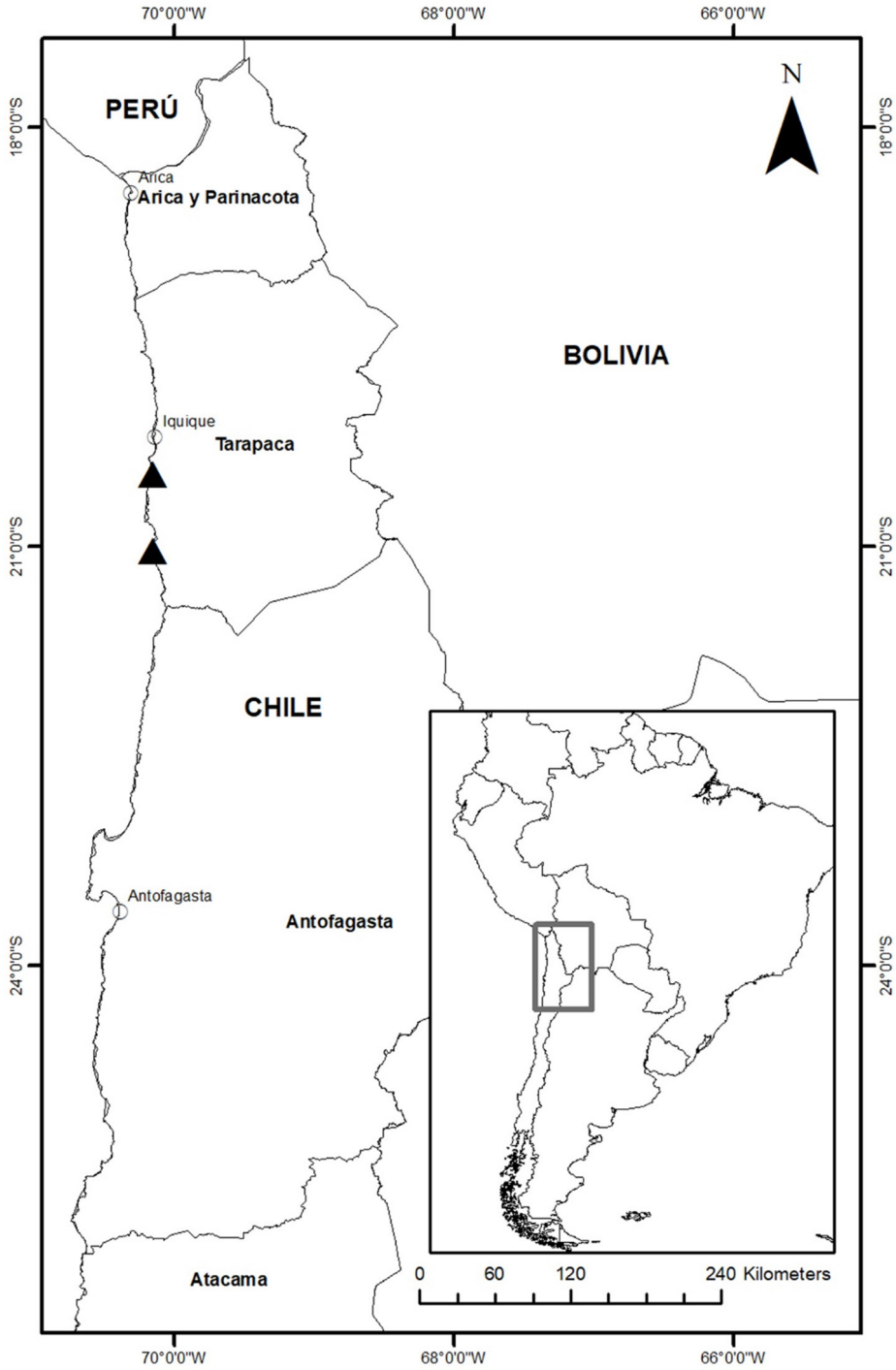


Fig. 6. Distribution of *Nolana patachensis*.

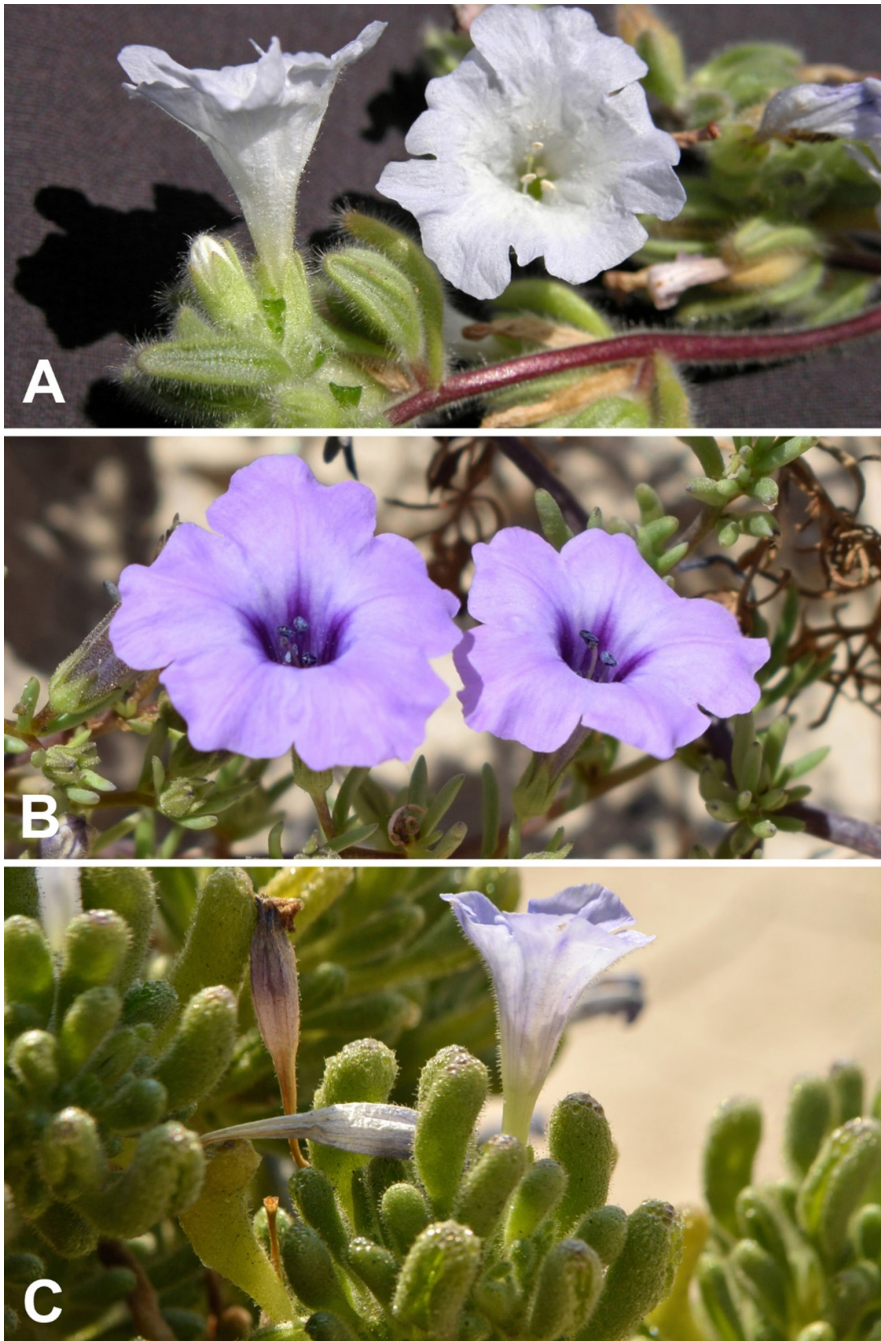


Fig. 7. *Nolana* species compared with *N. patachensis*. A. *N. aplocaryoides*, close-up of leaves and flowers illustrating villose pubescence. Voucher: Dillon 9055 (F); B. *N. gracillima*, close-up of flowers illustrating its dark nectar guides. Voucher: Quipuscoa et al. 6728 (F); C. *N. onoana*, close-up of leaves and flowers. Voucher: Dillon 9050 (F).

Table 1.

Alphabetical list of *Nolana* species recorded from Región Tarapaca, Chile, distribution and phylogenetic position as suggested by membership in clades (adapted from Dillon *et al.*, 2009).

| | Species & Authority | Distribution | Clade |
|----|---|---------------------|--------------|
| 1 | <i>N. adansonii</i> (Roem. & Schult.) I. M. Johnst. | Chile-Peru | F |
| 2 | <i>N. foliosa</i> (Phil.) I. M. Johnst. | Chile | E |
| 3 | <i>N. gracillima</i> (I. M. Johnst.) I. M. Johnst. | Chile-Peru | E |
| 4 | <i>N. intonsa</i> I. M. Johnst. | Chile | F |
| 5 | <i>N. jaffuelii</i> I. M. Johnst. | Chile | B |
| 6 | <i>N. leptophylla</i> (Miers) I. M. Johnst. | Chile | G |
| 7 | <i>N. lycioides</i> I. M. Johnst. | Chile-Peru | D |
| 8 | <i>N. patachensis</i> J. Hepp & M. O. Dillon | Chile | G |
| 9 | <i>N. peruviana</i> (Gaudich.) I. M. Johnst. | Chile | G |
| 10 | <i>N. sedifolia</i> Poepp. | Chile | G |
| 11 | <i>N. tarapacana</i> (Phil.) I. M. Johnst. | Chile | E |
| 12 | <i>N. tocopillensis</i> (I. M. Johnst.) I. M. Johnst. | Chile | G |