

A revision of *Heliotropium* sect. *Cochranea* (Heliotropiaceae)

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Summary. A revision of the *Heliotropium* L. sect. *Cochranea* (Miers) Kuntze (Heliotropiaceae) is presented and a total of 17 species is recognised. Morphology, ecology, distribution, conservation status and phenology of all species are presented. One subspecies, *Heliotropium krauseanum* Fedde subsp. *jahuayense* Luebert is described as a new taxon. Two previously recognised species names, *H. sclerocarpum* Phil. and *H. huascoense* I. M. Johnst., are placed in the synonymy of *H. chenopodiaceum* (A. DC.) Clos and *H. stenophyllum* Hook. & Arn., respectively. One epitype, one neotype and one lectotype are designated here.

Key Words. Atacama Desert, Boraginales, Chile, Peru, taxonomy.

Introduction

The family Heliotropiaceae is composed of four monophyletic genera, *Ixorhea* Fenzl (monotypic), *Myriopus* Small (c. 20 species), *Euploca* Nutt. (c. 100 species) and *Heliotropium* L. with around 300 species (Hilger & Diane 2003; Diane *et al.* in press; Luebert *et al.* 2011a). Within *Heliotropium*, four major clades can be recognised from phylogenetic analyses: (1) *Heliotropium* sect. *Heliothamnus* I. M. Johnst., composed of c. 11 species with a centre of diversity in the Andes of Ecuador and Peru (Johnston 1928b), which is sister to the remainder of *Heliotropium*; (2) Old World *Heliotropium*, including the genera *Ceballosia* G. Kunkel ex Förther, *Argusia* Boehm. and *Nogalia* Verdc., with about 100 species (Förther 1998); (3) *Heliotropium* sects *Coeloma* (DC.) I. M. Johnst., *Heliotrophytum* G. Don, *Hypsogenia* I. M. Johnst., *Plagiomeris* I. M. Johnst., *Platygyne* Benth., *Schobera* (Scop.) I. M. Johnst., *Tiaridium* (Lehm.) Griseb. and *Tournefortia* L. sect. *Tournefortia*, which is composed of c. 160 species and is broadly distributed in America, from southern United States to Patagonia, and in the Indo-Pacific region with c. 12 species (Johnston 1928b, 1930, 1935a, b; Förther 1998); (4) *Heliotropium* sect. *Cochranea* (Miers) Kuntze, with 17 species from the Peruvian and Atacama Deserts (Johnston 1928b, 1937; Weigend *et al.* 2003; Luebert & Pinto 2004; Luebert & Wen 2008). A current species-level revision is pending for all groups in *Heliotropium*, some of which have never been taxonomically treated. Section *Cochranea*, subject of this work, has not been revised since Johnston (1928b).

The first mention of a species now assigned to *Heliotropium* sect. *Cochranea* in the taxonomic literature

comes from Molina (1810) in his description of *Meladendron chilense* Molina. No type specimen has been found for this species (Förther 1998). Philippi (1864) suggested that this species corresponds to *Cordia decandra* Hook. & Arn., but most of the later authors (Reiche 1907, 1910; Johnston 1928b; Gunckel 1972; Förther 1998) placed it in the synonymy of *Heliotropium stenophyllum* Hook. & Arn. (1830, non *H. chilense* Bertero 1829 = *H. curassavicum* L.). Hooker & Arnott (1830) described *Heliotropium stenophyllum*, the first name still in use within the section. Since then new currently recognised species in *Heliotropium* sect. *Cochranea* have been described in the works of de Candolle (1845), Philippi (1860a, 1873, 1895), Miers (1868), Krause (1906), and Johnston (1928b, 1937). The most important revisionary works are those of de Candolle (1845), Clos in Gay (1849), Miers (1868), Reiche (1907, 1910) and Johnston (1928b). De Candolle (1845) assigned all members of the current *Heliotropium* sect. *Cochranea* hitherto described to the genus *Helioephytum* (Cham.) A. DC. Later Clos (in Gay 1849) transferred all Chilean *Helioephytum* sensu de Candolle (1845) back to *Heliotropium*; Miers (1868) coined the generic name *Cochranea* Miers, which was later accepted by Bentham (1876), F. Philippi (1881), Gürke (1893) and Philippi (1895). The names under *Cochranea* were again reunited in the genus *Heliotropium* in the revisions of Reiche (1907, 1910) and Johnston (1928b), who also placed numerous Miers (1868) and Philippi (1873, 1895) names in the synonymy and fixed several nomenclatural problems. The work of Johnston (1928b) is the most important revision of *Heliotropium* in South America and is still

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used today. Some additional contributions to the knowledge of *Heliotropium* sect. *Cochranea* have also been made by Philippi (1861, 1891), Fedde (1906), Johnston (1929), Macbride (1960), Förther (1998), Weigend *et al.* (2003) and Luebert & Pinto (2004). Recently, molecular phylogenetic analyses (Luebert & Wen 2008) have confirmed the monophyly of *Heliotropium* sect. *Cochranea*.

In spite of the efforts of these and other authors, there are not comprehensive and consistent descriptions of the species of *Heliotropium* sect. *Cochranea*, for Johnston (1928b) neither provided them nor attempted to do so. On the other hand, the accumulated knowledge since the last revision of Johnston (1928b) needs to be systematised, particularly regarding the distribution and systematic affinities of the species. The purpose of this paper is to provide descriptions and illustrations of the species of *Heliotropium* sect. *Cochranea* and a key for their determination. The nomenclature of the species is fully revised and their distribution is updated.

Material and Methods

Field studies were conducted in Chile between 2002 and 2011, where 177 collections of *Heliotropium* sect. *Cochranea* from different populations were made. More than 1,600 specimens of the herbaria A, B, BM, BSB, C, CONC, EIF, F, FI, G, G-DC, GH, HAL, K, M, MA, MSB, NY, SGO, ULS, US, W, WU were critically revised, most of them at CONC and SGO. All cited specimens have been seen by the author, unless otherwise indicated. Taxa in the revision are presented in a sequence that follows the phylogenetic relationships and morphological similarities of the species (Johnston 1928b; Luebert & Wen 2008; Luebert *et al.* 2011a).

All typifications were carefully revised. Published and unpublished documents were examined in order to determine the source of type specimens and to interpret their identity. Since most of the names in *Heliotropium* sect. *Cochranea* were published by R. A. Philippi, particular attention was paid to the interpretation of those specimens with respect to collector, exact locality, date of collection and distribution across herbaria, taking into account the relevant literature associated with them, including the original descriptions (Philippi 1860a, 1861, 1873, 1895), typifications (Johnston 1928b; Förther 1998) and the documentation about Philippi's specimens and collecting trips (Philippi 1886; Johnston 1929; Muñoz 1960; Muñoz-Schick 1973, 1991; Taylor & Muñoz-Schick 1994). Several names were described on the basis of specimens collected by Thomas Bridges in Chile. The localities of this collector are often difficult to establish, because the labels do not include any

specific information. Turrill (1920), Johnston (1928a) and other authors provided relevant data about Bridges' itineraries in Chile. Most important information is contained in the manuscript entitled '*A catalogue of plants found in the province of Coquimbo, Republick [sic] of Chile SL 27 – 32, Collected by Thomas Bridges 1841*' consulted at the archives of the Natural History Museum in London. This catalogue contains approximate localities and collecting dates of all Bridges specimens used as types in *Heliotropium* sect. *Cochranea* (Nos 1338 – 1343). Other Bridges specimens corresponding to these species but distributed without numbers seem to be isolectotypes of them (see Johnston 1928a, b). I followed this information in the interpretation of Bridges material.

Conservation status is given according to IUCN (2001) categories. It was assessed with species distribution modelling for 13 species (Luebert 2010), and the criterion of area of occupancy (B2) was used. This renders conservative estimates, since areas predicted by species distribution models are likely larger than the actual areas of occupancy, and the predicted areas were not masked with land-use maps, which would constrain the estimated area of occupancy (IUCN 2010). Direct observation of the populations during field trips in both dry and rainy years was used as evidence of fluctuation in number of individuals and the fragmented nature of the populations and distribution range. The remaining four species were evaluated according to the more critical IUCN category, estimated from the surface of a Minimum Convex Polygon (criterion of extent of occurrence, B1) and from a buffer of 4 km² assigned to each occurrence (criterion of area of occupancy, B2), as recommended by IUCN (2001). Details of these analyses are in Luebert (2010).

Species Concept

The species concept applied here is in agreement with de Queiroz (2005, 2007). Morphologically differentiable and geographically segregated metapopulations are here recognised as different species. Given the young age of most of the species of *Heliotropium* sect. *Cochranea* (Luebert & Wen 2008; Luebert *et al.* 2011b), it is possible that closely related species are potentially interfertile. Johnston (1928b) did not present an explicit species concept for the species of *Heliotropium* sect. *Cochranea*. His species are geographically defined, making his delimitation highly consistent with the delimitation achieved in this revision.

Sympatric and locally parapatric species are recognised when they can be differentiated in terms of general morphology, paying attention to flower characters that can be associated with different pollinators and may therefore favour reproductive isolation. In this sense, the relation of the length of the

style and the stigmatic head and the relative position of the gynoecium in relation to the stamens can play a major role in the reproductive isolation of sympatric populations, as they could be associated with different pollinators. After examination of numerous specimens, it became clear that the relative length of the style and the stigmatic head is relatively constant within populations and is associated with other vegetative characters. Morphologically similar and geographically parapatric metapopulations are also recognised as different taxonomic entities, provided that they can be delimited with vegetative morphology and are geographically and ecologically recognisable. In the Atacama Desert, where most species of *Heliotropium* sect. *Cochranea* occur, climate fluctuates, with high inter-annual rainfall variability (Luebert & Pliscoff 2006: 45, and references therein). In the cases of both sympatry and parapatry, hybridisation might take place during rainy years, when more flowering individuals emerge and the geographic range of the metapopulations is fully expressed, so that parapatric populations come into contact at the edges of their distribution ranges. Allopatric metapopulations might expand their geographic ranges and come into contact less frequently, likely allowing gene flow among species during such ‘expansion’ periods. The geographic ranges are contracted during dry periods, leading to isolation of metapopulations.

Taxonomy

Nomenclature

Heliotropium L. sect. *Cochranea* (Miers) Kuntze in Post & Kuntze (1904: 271); Reiche (1907: 234; 1910: 192); Johnston (1928b: 25); Förther (1998: 72). Lectotype (Johnston 1928b: 25): *Cochranea conferta* Miers (= *Heliotropium stenophyllum* Hook. & Arn.).

Cochranea Miers (1868: 124); Bentham (1876: 834); Philippi (1881: 253); Gürke (1893: 95); Philippi (1895: 338). Type as above.

Meladendron Molina (1810: 143). Type: *Meladendron chilense* Molina.

Heliophytum (Cham.) DC. sect. *Heliophytum* (de Candolle 1845: 552) *pro parte* excl. type (ser. *stigma elongatum*, *lineari-conicum*, *striatum*, *apice bilobum*).

The name *Cochranea* honours Thomas Cochrane (Förther 1998), British officer who served in the war of Chilean independence (see Miers 1826). John Miers travelled in Chile between 1819 and 1825, initially attracted by Cochrane to develop the mining industry in this country (Marticorena 1995).

Habit

All species of *Heliotropium* sect. *Cochranea* are shrubs, but exhibit considerable variation in size and axis

orientation, from low decumbent (e.g., *H. megalanthum* I. M. Johnst.) to tall erect shrubs (*H. sinuatum* I. M. Johnst.). Tall erect shrubs are usually resinous and apparently more tolerant to drought than low shrubs, maintaining their above-ground structures during dry years and flowering throughout. Low shrubs generally lose all above-ground structures during dry years, maintaining at most only some latent stem axes, without producing leaves or flowers. The stems are dry but are still able to regenerate above-ground structures during rainy years (Fig. 1). These species are not resinous and usually have pubescent foliage. These two general strategies can be expressed in different degrees, depending on species and on the duration (in years) of the dry period. Some species, for instance *H. chenopodiaceum*, a low but resinous shrub, are able to resist one year without rainfall, still producing leaves and flowers, but a second year of drought causes the loss of all above-ground tissues. Several years of continuous drought can cause the loss of above-ground structures of whole populations, even of tall shrubs.

Only a few species have been characterised in terms of root morphology. In *Heliotropium stenophyllum* a laterally extended root system has been reported (Squeo *et al.* 1999) as well as for *H. pycnophyllum* Phil., where a short thick tap root branches into

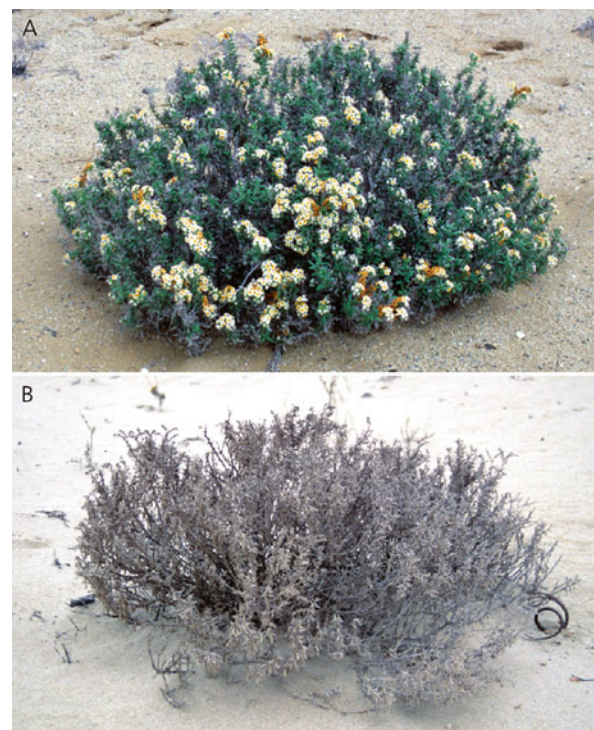


Fig. 1. *Heliotropium floridum* after a rainy and a dry period. A after a rainy season, Sept. 2004, between Totoral and Bahía Salada, south of Caldera, 27°49'S, 71°0'W; B after 2 years of drought, Jan. 2004, Playa Ramadas, north of Caldera, 26°59'S, 70°48'W. PHOTOS: F. LUEBERT.

secondary roots, which extend laterally (Rundel *et al.* 1980). Field observations indicate that most species of *Heliotropium* sect. *Cochranea* have such laterally extended root systems.

Leaf Morphology and Anatomy

Leaves of *Heliotropium* sect. *Cochranea* are alternate, sessile and usually small, ranging from $0.2 - 6.5 \times 0.05 - 1.1$ cm. Leaves can be solitary or grouped in fascicles of up to c. 20 leaves. Shape varies from linear to elliptic or spatulate (Fig. 2). The margins are entire or sinuate and usually revolute, thereby leaves of some species are terete or sub-terete in transverse section. Lamina is generally smooth, but in some species can also be rugose (*H. glutinosum* Phil., *H. sinuatum*, *H. taltalense* I. M. Johnst., *H. krauseanum* Fedde). Mesophyll thickness is usually about 500 μm , but it can vary from 100 μm in *H. krauseanum* to 1100 μm in *H. pycnophyllum*. Anatomy is most commonly isobilateral (*H. pycnophyllum*, *H. filifolium* I. M. Johnst., *H. glutinosum*, *H. longistylum* Phil., *H. floridum* Gay, *H. linariifolium* Phil., *H. megalanthum*, *H. chenopodiaceum*, *H. myosotifolium* Reiche), but can also be sub-bifacial (*H. inconspicuum* Reiche, *H. stenophyllum*,

H. philippianum I. M. Johnst., *H. eremogenum* I. M. Johnst.) or bifacial (*H. sinuatum*, *H. taltalense*, *H. krauseanum*). Leaves are generally amphistomatic, except in *H. sinuatum*, *H. taltalense*, *H. krauseanum* and *H. inconspicuum* that are hypostomatic. Palisade parenchyma (1 -) 2 (- 4)-layered; spongy parenchyma usually (2 -) 4 - 7 (- 10)-layered. Pubescence is variable in density and is present on both sides, but normally denser on the abaxial surface, most commonly composed of simple adpressed hairs in combination with stipitate or sessile glandular trichomes (see Diane *et al.* 2003; Brokamp 2006; Luebert *et al.* 2011a).

Flower Morphology

Flowers of *Heliotropium* are disposed in terminal scorpioid monchasia (boragoids, Buys & Hilger 2003). Flowers of section *Cochranea* conform to the general pattern found in *Heliotropium*. Calyx lobes are linear-lanceolate, totally free to partially fused. The corolla is infundibuliform, generally exceeding the calyx, mostly white with a yellow or orange throat, or completely orange as in *H. linariifolium*. In late anthetic flowers the corolla turns purplish or violet in several species

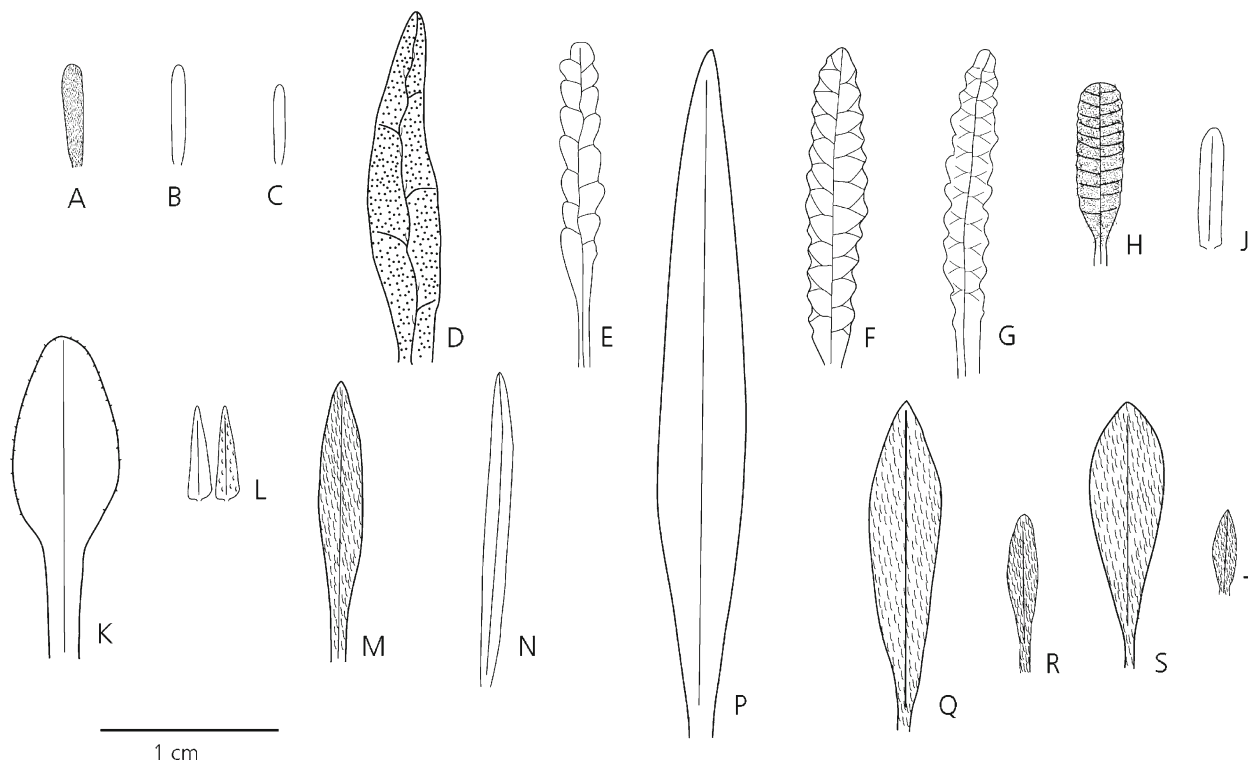


Fig. 2. Leaf outlines of all recognised taxa of *Heliotropium* sect. *Cochranea*. A *H. pycnophyllum*, from Luebert & Kritzner 1850 (BSB); B *H. filifolium*, from Luebert & Kritzner 1818 (BSB); C *H. jaffuelii*, from Jaffuel 2524 (G); D *H. glutinosum*, from Luebert & Torres 1970 (BSB); E *H. sinuatum*, from Luebert & Kritzner 1809 (BSB); F *H. taltalense*, from Dillon *et al.* 5583 (F); G *H. krauseanum* subsp. *krauseanum*, from Dostert & Cáceres 1025 (BSB); H *H. krauseanum* subsp. *jahuayense*, from Ferreyra 2511 (F); J *H. inconspicuum*, from Teillier *et al.* 2944 (F); K *H. megalanthum*, from Philippi s.n. (SGO 54364); L *H. chenopodiaceum*, from Gay s.n. (K); M *H. myosotifolium*, from Bridges 1338 (G); N *H. stenophyllum*, from Dillon *et al.* 5428 (F); P *H. longistylum*, from Ackermann 518 (BSB); Q *H. floridum*, from Philippi s.n. (SGO 54384); R *H. linariifolium*, from Teillier *et al.* 2727 (F); S *H. philippianum*, from Johnston 5233 (GH); T *H. eremogenum*, from Jaffuel 1120 (GH). DRAWN BY F. LUEBERT.

(e.g., *H. pycnophyllum*). Corolla length ranges from 2 to 11 mm and corolla limb 1.5 – 12.5 mm wide. Stamens are included, but in late anthetic flowers they can be exerted; filaments arise from inside the corolla tube and the anthers are linear with cordate base, usually glabrous or with apical papillae. A protuberant nectar disk at the base surrounds the ovary. The style can be elongated (mostly) or absent (*H. filifolium*, Figs. 3B and 5) and its relative length in relation to the stigmatic head varies among species, being shorter in some species, approximately equal, or longer (Fig. 3). The gynoecium is usually glabrous, except only in *H. pycnophyllum* where the style and the stigmatic head are short-pubescent (Figs. 3A and 4). The stigma is elongated into a conical structure (Fig. 3) with a basal receptive area, which is typical of Heliotropiaceae. The anthers can be located above the stigmatic head or, more commonly, the base of the anthers overlap the apical portion of the stigmatic head.

Fruit and Seed Morphology

The ovary is cleft by a commissure dividing it into two biovulate carpids, without empty cells, each composed of parts of both carpels (syn-mericarpids, Hilger 1992). Fruits are 4-seeded, usually fleshy, becoming ligneous at maturity, falling apart into two 2-seeded nutlets (each bicarpellate), while the calyx remains persistent on the dry inflorescence. Only in *Heliotropium pycnophyllum* the calyx remains attached to the fruit, which does not divide into nutlets. Fruits are subspherical, glabrous, rugose with a dark-brown to yellow exocarp. Diameter does not exceed 2 mm in most species. Testa is smooth. Embryo is straight.

Pollen Morphology

Pollen of 11 species of *Heliotropium* sect. *Cochranea* were studied by Marticorena (1968). According to this author, all species are 3-colporate, 3-pseudocolpate, pseudocolpi non-anastomosed at the poles; colpus sides almost parallel or little convex; amb 6-lobate. This combination of characters is consistent with type I of Nowicke & Skvarla (1974). The descriptions of the pollen provided for each species are based on Marticorena (1968) and my own scanning electron microscope (SEM) observations.

Distribution

Heliotropium sect. *Cochranea* is restricted to the Peruvian and Atacama Deserts of northern Chile and southern Peru (Map 1). Only one species occurs in Peru, *H. krauseanum*, from the Department of Lima (12°38'S, 75°58'W; Weigend *et al.* 2003) to the province of Iquique in northern Chile (19°37'S, 70°11'W; Luebert & Pinto 2004, Map 7, p. 72). The remainder of the group is distributed in the Atacama Desert of northern Chile, with the northernmost

population around Iquique (20°22'S, 70°12'W), to central Chile in the surroundings of La Calera and Lailay (32°50'S, 71°09'W). Two major centres of diversity can be recognised (Luebert & Wen 2008). The first is located in the coastal range of Taltal and Paposo (24° – 25°S latitude) in the region of Antofagasta, where six species can be found. The second is the region between Huasco and Caldera (27° – 28°S latitude), with eight species. Most species are distributed along the coastal range or at the immediately adjacent inland areas and only two species, *H. chenopodiaceum* and *H. glutinosum*, occur on the foothills of the Andes. *H. krauseanum*, *H. sinuatum* and *H. stenophyllum* can also reach the Andean foothills, but they are also present on the coast. The altitudinal range of *Heliotropium* sect. *Cochranea* extends from sea level to a maximum elevation of 2,200 m (*H. glutinosum*).

Ecology

The species of section *Cochranea* have their geographic range restricted to the arid and hyperarid zones of the Atacama and Peruvian Deserts, with *Heliotropium stenophyllum* as the only outlier reaching the sclerophyllous woodland zone of central Chile, where it is restricted to the driest slopes. *Heliotropium* is frequently a dominant component of the vegetation in which it takes part and several studies have documented their presence in specific vegetation types (see Gajardo 1994; Luebert & Plissock 2006, and references therein). *Heliotropium* sect. *Cochranea* is a characteristic element of the 'lomas' formations of northern Chile and southern Peru (Ferreira 1961; Dillon & Hoffmann 1997). Lomas formations are fog-dependent arid environments of the coastal range of northern Chile and Peru (Rundel *et al.* 1991; Dillon *et al.* 2003). Fog-dependent vegetation is located within a given elevation range, the so-called 'fertile belt' (Johnston 1929), which is the zone where fog tends to accumulate. Vegetation structure and composition at the fertile belt is therefore better-developed than above and below the fertile belt, where vegetation is more sparse and less diverse (Rundel & Mahu 1976; Schulz *et al.* 2011). *Heliotropium* sect. *Cochranea* can be found both inside and outside the fertile belt.

Heliotropium sect. *Cochranea* is one of the most diversified groups of plants of the Atacama Desert (Luebert & Wen 2008). Its diversity probably indicates the success of this group to survive in extremely arid environments and this should be reflected in morphological and/or physiological adaptations to tolerate drought. Ehleringer *et al.* (1998) studied carbon isotope ratios of three species of *Heliotropium* sect. *Cochranea* (*H. linariifolium*, *H. pycnophyllum* and *H. taltalense*) from the coastal areas of Paposo (25°01'S, 70°28'W) and Pan de Azúcar (26°01'S, 70°35'W). All three species were

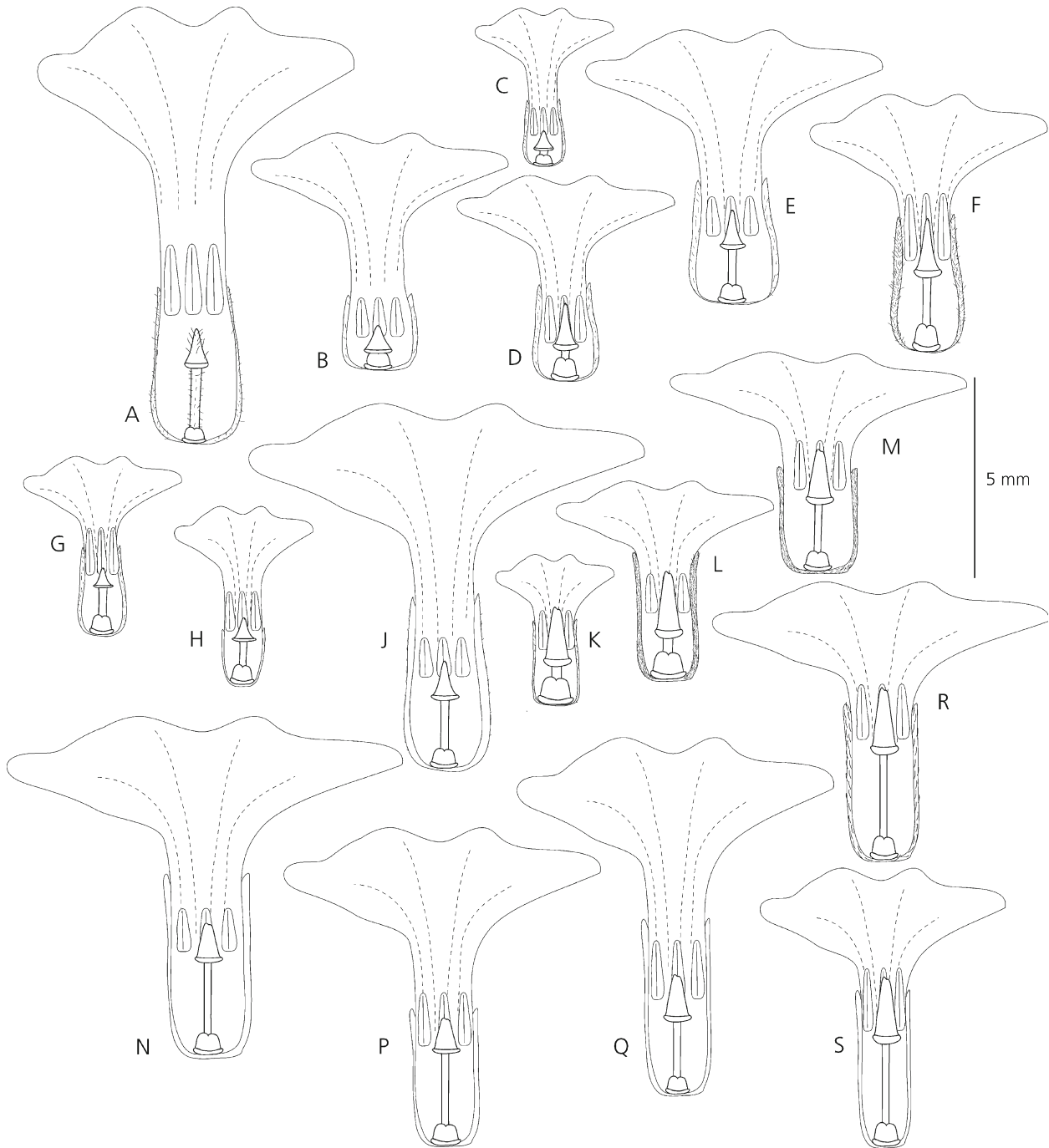


Fig. 3. Schematic representations of floral morphology of *Heliotropium* sect. *Cochrea*. Inner view showing style-stigma complex and approximate position of anthers is depicted. **A** *H. pycnophyllum*, based on Luebert & Kritzner 1850 (BSB); **B** *H. filifolium*, based on Luebert & Kritzner 1818 (BSB); **C** *H. jaffuelii*, based on Jaffuel 2524 (G); **D** *H. glutinosum*, based on Luebert & Torres 1970 (BSB); **E** *H. sinuatum*, based on Luebert & García 2492/886 (BSB); **F** *H. taltalense*, based on Luebert et al. 2083 (BSB); **G** *H. krauseanum* subsp. *krauseanum*, based on Dostert & Cáceres 1025 (BSB); **H** *H. inconspicuum*, based on Luebert & García 2690/1084 (BSB); **J** *H. megalanthum*, based on Luebert & Becker 2165 (BSB); **K** *H. chenopodiaceum*, based on Jiles 3152 (CONC); **L** *H. myosotifolium*, based on Luebert et al. 2011 (BSB); **M** *H. stenophyllum*, based on Luebert & Becker 2910 (BSB); **N** *H. longistylum*, based on Luebert et al. 2020 (BSB); **P** *H. floridum*, based on Schlegel 3876 (CONC); **Q** *H. linariifolium*, based on Luebert et al. 2055 (BSB); **R** *H. philippianum*, based on Luebert et al. 2124 (BSB); **S** *H. eremogenum*, based on Jaffuel 1120 (GH). DRAWN BY F. LUEBERT.

found to have the C3 photosynthetic pathway; Diane *et al.* (2003) also suggested the C3 photosynthetic pathway for *H. krauseanum* based on leaf anatomy.

Universally more positive-than-average values of leaf carbon isotope ratio (implying low intercellular CO₂ concentration), and a variation consistent with local

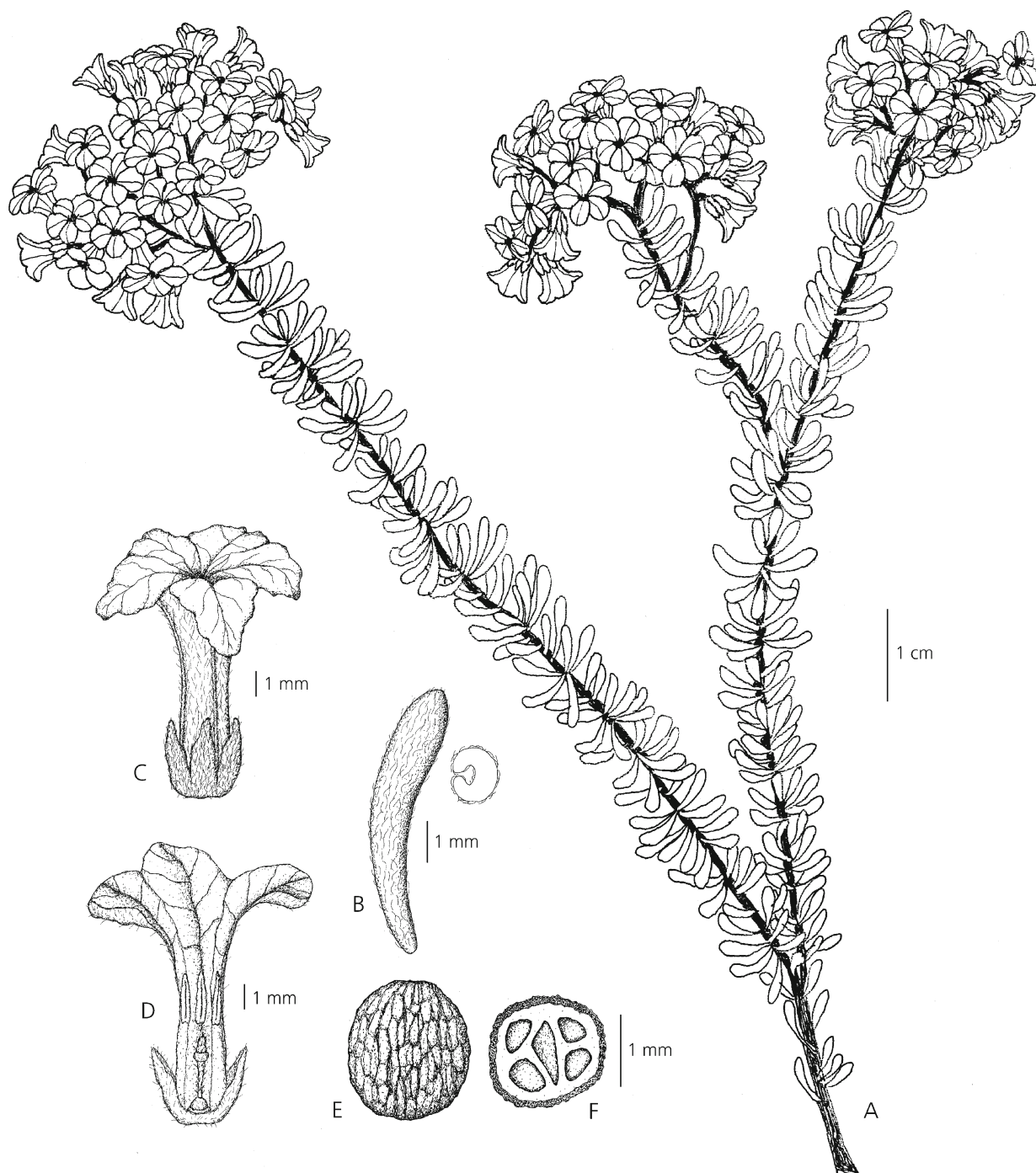
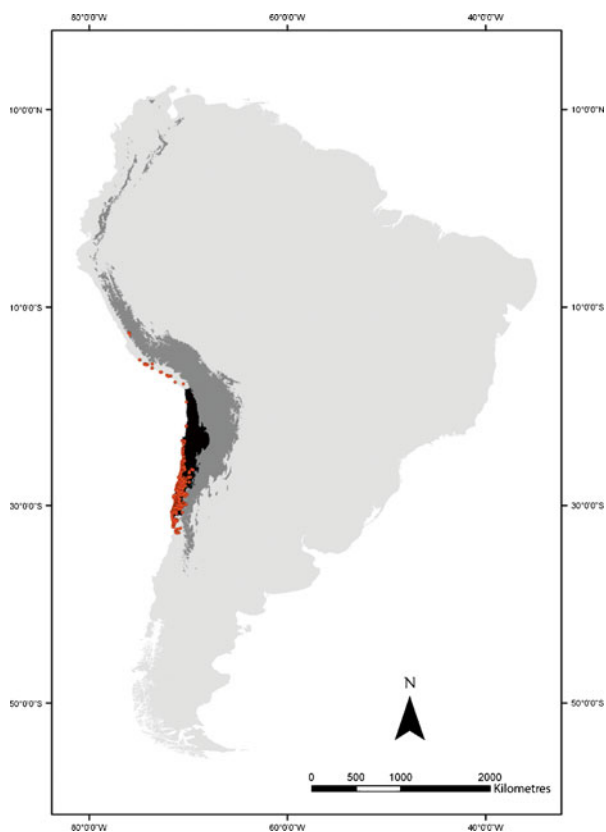


Fig. 4. *Heliotropium pycnophyllum*. A flowering branch; B leaf; C flower, outer view; D flower, opened out; E fruit, dorsal view; F fruit, t.s. A – D from Luebert & Kritzner 1850 (BSB); E, F from Luebert *et al.* 2128 (BSB). DRAWN BY ANJA SALCHOW.

changes in aridity were also reported by Ehleringer *et al.* (1998). Whether these low levels of intercellular CO₂ concentration represent an adaptation to hyperarid conditions was unknown, but the authors suggested that tolerating water stress might be a dominant factor in the plant life cycle of this region (Ehleringer *et al.* 1998). For *H. pycnophyllum*, Rundel *et al.* (1980) suggested that a main strategy of the species to tolerate aridity

is to become dormant during the driest periods. Secretion of resin, small leaf size and dense pubescence in some species of *Heliotropium* sect. *Cochranea* may be interpreted as complementary adaptations to reduce water loss.

The flowers of *Heliotropium* sect. *Cochranea* are generally white with a yellow to orange spot in the centre of the throat. This spot may be a visual



Map 1. Distribution of *Heliotropium* sect. *Cochranea* (orange points) in the Atacama Desert (black area). The dark grey area indicates zones higher than 3000 m, showing the major extension of the Andes. The area of Atacama not occupied by *Heliotropium* sect. *Cochranea* corresponds to the extension of the absolute desert, where almost no plants can be found.

indication for insects, where the nectar is located. Field observations indicate that the colour of the flowers changes over the flowering season. This change may be an indication to insects that the flower is not producing more nectar or pollen and that the stigma is no longer receptive (Weiss 1991). Weiss (1991) suggests that flowers that are no longer reproductively competent, and no longer offer a reward, do help attract pollinators from a distance. The flowers of *Heliotropium* have a nectar disk at the base of the ovary and the typical Heliotropiaceae sterile conical development of the stigma. The receptive tissue is located at the base of the stigmatic head and the stamens are positioned surrounding the stigmatic head or above it, enclosed by the apex of the corolla tube and leaving limited space for the insects to reach the nectar disk. Such spatial arrangement of the flower led Nowicke & Skvarla (1974) to suggest that most species of Heliotropiaceae may appear to be primarily self-pollinated, because it would make 'the stigma inaccessible to all but the smallest insect or insect part,' with which Weigend *et al.* (2003) agree. However, the variation in the position of stamens in relation to stigmatic head, and in their relative and

absolute length as well as flower display and the presence of a nectar ring at the basis of the ovary, which is observed among the species of *Heliotropium* sect. *Cochranea*, might be an indication of adaptation to insect pollination (Weigend *et al.* 2003). Pollination has not been systematically studied in *Heliotropium* sect. *Cochranea* and the evidence is anecdotal. *Chilicola deserticola* Toro & Moldenke 1979 and *C. erithropoda* Toro & Moldenke 1979 (Hymenoptera: Colletidae) have been observed visiting flowers of *H. stenophyllum* (Moure & Urban 2002).¹ Toro *et al.* (1996) report observations of a species of the genus *Megachile* (Hymenoptera: Apoidea) visiting flowers of *H. linariifolium*. Casual personal observations of flower visitors in *Heliotropium* sect. *Cochranea* include small Lepidoptera, Hymenoptera and Coleoptera. The role that these groups play in the pollination is however unknown.

Differences in phenology may account for reproductive isolation among species living in sympatry, but there is no empirical evidence for that. Phenology has been recorded for two species of *Heliotropium* sect. *Cochranea*, *H. megalanthum* (Vidiella *et al.* 1999) and *H. stenophyllum* (Olivares & Squeo 1999). In both species the peaks in flowering are reached at the beginning of the austral spring, after winter rains.

Diaspore dispersal of *Heliotropium* sect. *Cochranea* is probably geochorous. No seed predators are known, no adaptations to wind-dispersal are present and the seeds seem to remain in the immediate vicinity of the mother plants (Rundel *et al.* 1980).

Phytochemistry

Several phytochemical studies have been conducted in *Heliotropium* sect. *Cochranea*. Chemical composition of the resinous exudates has been reported for 9 species, *H. chenopodiaceum* (Urzúa *et al.* 1998), *H. filifolium* (Torres *et al.* 1994), *H. glutinosum* (Modak *et al.* 2007), *H. longistylum* (Villarroel *et al.* 2001, erroneously reported as *H. huascoense*), *H. megalanthum* (Urzúa *et al.* 2000), *H. pycnophyllum* (Wollenweber *et al.* 2002), *H. sinuatum* (Torres *et al.* 1996), *H. stenophyllum* (Villarroel *et al.* 1991; Wollenweber *et al.* 2002) and *H. taltalense* (Modak *et al.* 2009). Most of the compounds present in the resinous exudates are flavonoids and aromatic geranyl derivatives. Their presence appears to be directly related to the resin on the leaves and branches, thus the non-resinous species do not produce such compounds (R. Torres, pers. comm.). Apart from the apparent role of the resin itself in the control of

¹ It is probably not *Heliotropium stenophyllum*, because both insect species were collected around the town of Pueblo Hundido (now Diego de Almagro) in northern Chile (Toro & Moldenke 1979) where this species does not occur. Instead, it is most probably *H. glutinosum*, certainly inhabiting the surroundings of Diego de Almagro.

water loss, these compounds have antioxidant (e.g., Modak *et al.* 2007), antiviral (Torres *et al.* 2002), antibacterial (e.g., Modak *et al.* 2004a), and/or antifungal (Mendoza *et al.* 2008) properties. These kinds of compounds have not been reported for other *Heliotropium* groups apart from section *Cochranea* and are therefore of potential systematic value within the genus.

Pyrrrolizidine alkaloids have also been reported in *Heliotropium* sect. *Cochranea* (Reina *et al.* 1997, 1998). These kinds of compounds are ubiquitous in *Heliotropium* (e.g., Medina *et al.* 2009) and in the Boraginales (e.g., Boppré 2011).

Biogeography and Evolution

Heliotropium sect. *Cochranea* is a monophyletic group within Heliotropiaceae (Luebert & Wen 2008; Luebert *et al.* 2011a). The sister group of *Heliotropium* sect. *Cochranea* is a large clade composed of seven sections of South American *Heliotropium* (sects. *Coeloma*, *Heliotrophytum*, *Hypsogenia*, *Plagiomeris*, *Platygyne*, *Tiaridium* and *Schobera*) and *Tournefortia* sect. *Tournefortia*. The latter clade has a mostly Neotropical distribution (Johnston 1928b, 1930, 1935b; Förther 1998) with c. 12 representatives of *Tournefortia* in the

Indo-Pacific region (Johnston 1935a; Riedl 1997; Craven 2005). The biogeographical mechanisms by which these groups could have achieved such distribution have not been yet evaluated in detail. Age estimates performed by Gottschling *et al.* (2004) led these authors to suggest long-distance dispersal between America and the Indo-Pacific region during the Tertiary. *Heliotropium* sect. *Cochranea* may have originated in situ from a Neotropical ancestor. Luebert & Wen (2008) and Luebert *et al.* (2011b) estimated a middle Miocene age for the crown node of *Heliotropium* sect. *Cochranea*, with a major diversification event during the early Pliocene. These ages are in agreement with the proposed timing of increase in uplift rates of the Andes (Gregory-Wodzicki 2000; Garzzone *et al.* 2008), and the onset of hyperarid conditions in the Atacama Desert (Hartley 2003), respectively. The uplift of the Andes may have reinforced arid conditions over the Atacama (Hartley 2003) and, at the same time, isolated *Cochranea* on the western versant of the Andes (Luebert & Wen 2008; Luebert *et al.* 2011b). The final turn to hyperarid conditions in the Atacama may have triggered a rapid diversification process during the Pliocene (Luebert & Wen 2008).

Key to the Species of *Heliotropium* sect. *Cochranea*

1. Style and stigmatic head shortly hispid, calyx remains attached to the fruit during dispersal, fruit 4-seeded, not divided **1. *H. pycnophyllum***
 Style and stigmatic head glabrous, calyx persistent on the inflorescences, detached fruit dividing into two 2-seeded nutlets 2
2. Leaves terete, stigmatic head sessile or sub-sessile 3
 Leaves flat, margin revolute, stigmatic head with distinct style 4
3. Corolla limb more than 4 mm wide. Plants from Región de Atacama, Chile. **2. *H. filifolium***
 Corolla limb less than 4 mm wide. Plants from Tocopilla, Chile. **3. *H. jaffuelii***
4. (2) Leaves with sinuate margin and rugose on the adaxial surface 5
 Leaves with entire margin, smooth on the adaxial surface 9
5. Secondary veins of the leaves simple, reaching margin, not forked. 6
 Secondary veins of the leaves forked 8
6. Glands on the leaves visible with naked eye. Style shorter than the stigmatic head **4. *H. glutinosum***
 Glands on the leaves not visible with naked eye. Style longer than or equalling stigmatic head. 7
7. Resinous plant with scarce simple hairs on the adaxial surface. Plant from the provinces of Huasco and Elqui, Chile **5. *H. sinuatum***
 Resinous plant densely pubescent on the adaxial surface. Plant from the department of Arequipa, Peru **7a. *H. krauseanum* subsp. *jahuayense***
8. (5) Calyx densely hirsute, corolla tube longer than 4.5 mm at anthesis, style as long as or shorter than the stigmatic head. Plant from the coast of the province of Antofagasta, Chile. **6. *H. taltalense***
 Calyx sparsely hirsute, corolla tube not longer than 4.5 mm at anthesis, style longer than the stigmatic head. Plant from the coast and interior lomas of south-central Peru and northernmost Chile. **7. *H. krauseanum* subsp. *krauseanum***
9. (4) Style shorter than or equalling the stigmatic head 10
 Style definitely longer than the stigmatic head. 15
10. Stems without evident strigose pubescence on the vegetative parts of the plant. 11
 Stems with evident strigose pubescence on the vegetative parts 13
11. The longest leaves longer than 15 mm. **12. *H. stenophyllum***
 The longest leaves shorter than 15 mm. 12
12. Leaves linear-oblong with conspicuous white bands on the abaxial surface. Style as long as the stigmatic

- head **8. H. inconspicuum**
 Leaves linear-lanceolate without white bands on the abaxial surface. Style 3 or more times shorter than the stigmatic head **10. H. chenopodiaceum**
- 13 (10) Leaves pubescent only on the margin. **9. H. megalanthum**
 Leaves pubescence spread over the whole lamina 14
14. Glutinous plants. Calyx lobes fused at least to the half of their length. Corolla usually less than 5 mm wide **10. H. chenopodiaceum**
 Non-glutinous plants. Calyx lobes free. Corolla 5 – 7 mm wide. **11. H. myosotifolium**
- 15 (9) Leaves adaxially glabrous **13. H. longistylum**
 Leaves adaxially pubescent 16
16. Leaves shorter than 6.5 mm. Plant from the area of Antofagasta (La Chimba-Cerro Moreno), Chile, or north thereof **17. H. eremogenum**
 Leaves generally longer than 6.5 mm. Plants from south of Antofagasta 17
17. Decumbent shrubs, corolla orange **15. H. linariifolium**
 Erect shrubs, corolla white 18
18. Shrubs generally shorter than 0.6 m. Plants from Chañaral or south thereof **14. H. floridum**
 Shrubs taller than 0.6 m. Plants from north of Taltal **16. H. philippianum**

Species Descriptions

1. Heliotropium pycnophyllum Phil. (Philippi 1860a: 38); Reiche (1907: 238; 1910: 196); Johnston (1928b: 35); Marticorena (1968: 45); Förther (1998: 215). Type: Chile, Región de Atacama, Prov. Chañaral, Cachinal de la Costa, Dec. 1853, *R. A. Philippi* s.n. (holotype SGO 54374 [photo F, GH, NY, US], isotype W 12981).

Heliotropium breanum Phil. (Philippi 1895: 357). Type: Chile, Región de Antofagasta, Prov. Antofagasta, Breas, 1888, *A. Larrañaga* s.n. (holotype SGO 54371 [photo F, GH, MSB, NY, US]; isotypes GH, SGO 54373, SGO 54369 [photo MSB]).

Heliotropium brevifolium Phil. (Philippi 1895: 357), **nom. illegit.**, non Wall., in Roxburgh (1824: 2). Type: Chile, Región de Antofagasta, Prov. Antofagasta, Hueso Parado, Oct. 1887, *A. Borchers* s.n. (lectotype SGO 54372 [photo F, GH, MSB, NY, US], selected by Johnston (1928b: 35 – 36)).

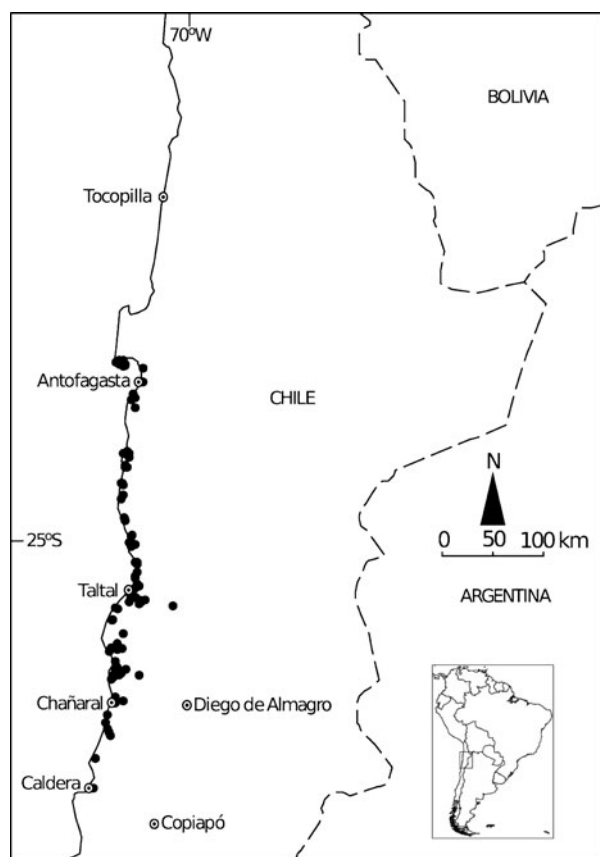
Cochranea pycnophylla F. Phil. ex Reiche (1907: 238). **nom. invalid.** (cited as a synonym).

Low and globose erect shrub, (0.2 –) 0.4 – 1.0 (– 1.5) m tall, profusely branched, with short branches, densely foliose to the apex. *Stems* and *foliage* densely covered by short, substrigose and incane pubescence, somewhat glutinous. *Leaves* alternate, solitary or grouped in fascicles of up to 16 leaves, sessile, succulent, linear, oblong-linear or oblong-ovate, 3.5 – 12 (– 16) × 0.7 – 3 (– 4.5) mm, sub-terete due to the strongly revolute margins; lamina pubescent, green to greyish-green, margin entire, base and apex obtuse, veins inconspicuous, pubescence short, incane, strigose. *Inflorescences* terminal, globose, dichotomously branched, to c. 5 cm long. *Flowers* sessile, alternate, erect, aromatic. *Calyx* cylindrical, pale green; calyx lobes linear, fused only at the base or rarely up to the middle, strigose on both

sides, 2.5 – 6.5 × 0.5 – 1 mm, free portion 0.5 – 5 mm long, apex acute or rarely obtuse. *Corolla* infundibuliform, hispid outside, white with yellow throat, becoming purplish or violet; limb horizontally spreading, 6 – 12 mm wide, lobes rounded; tube almost twice as long as the calyx, 6 – 10 (– 12.5) mm long. *Stamens* included; filaments adnate to petals; anthers oblong, glabrous, base cordate, apex obtuse, 2 – 2.5 mm long, generally located above the apex of the stigmatic head or shortly overlapping it. *Ovary* glabrous, c. 0.5 mm diam., with a basal nectar ring. *Style* hispid, c. 1.3 – 1.7 mm long, longer than the stigmatic head. *Stigmatic head* conic, 0.8 – 1.2 × 0.4 – 0.8 mm, column hispid. *Fruits* dry, spherical, rugose, glabrous, dark brown, 1.5 – 2.5 mm diam., 4-seeded, not falling apart at maturity, dispersed together with the calyx. *Pollen* prolate, 26 – 29.5 × 17 – 18.5 µm. Amb lobes not deep. Endoapertures c. 5 µm diam., circular or somewhat lalongate and then contracted at the centre. Exine thickness c. 1.3 µm, without differences between apocolpia and mesocolpia (from *Ricardi* 3134 in Marticorena 1968). Figs 2A, 3A and 4.

DISTRIBUTION. Coastal dry areas of the provinces of Chañaral (Región de Atacama) and Antofagasta (Región de Antofagasta) in Chile, 23°28' – 27°4'S (Map 2).

SPECIMENS EXAMINED. CHILE. Región de Antofagasta, Prov. Antofagasta: Peninsula Moreno, hills W Juan López, 23°30'S, 70°33'W, 250 m, 15 Oct. 1992, *Baumann* 18 (CONC, SGO, ULS); Quebrada La Chimba, 16 km N of Antofagasta, 500 m, 16 Dec. 1943, *Muñoz* 3641 (SGO); 5 km of Antofagasta, Cerro Coloso/Cerro Jarón area, Quebrada del Buey, 3 km W of the coast on mining road towards Pozo Lombriz, 23°47'S, 70°27'W, 180 m, 17 Feb. 1997, *Eggl*,



Map 2. Distribution of *Heliotropium pycnophyllum*.

Leuenberger & Arroyo-Leuenberger 2691 (B, CONC); Cerro Jarón, 8 Dec. 2002, *Pinto* 688 (SGO); Road to Caleta El Cobre, 24°15'S, 70°30'W, 1 Oct. 1987, *Teillier* 478 (CONC, SGO); Quebrada Remiendos, 24°21'S, 70°32'W, 100 m, 12 Feb. 1998, *Arancio & Squeo* 11159 (ULS); Morro Pintado, 24°22'S, 70°31'W, 350 m, 12 Feb. 1998, *Arancio & Squeo* 11171 (ULS); Quebrada Blanco Encalada, 50 – 250 m, 11 Dec. 1949, *Biese* 3133 (SGO); Caleta Botija, 24°30'5.8"S, 70°33'26.4"W, 80 m, 4 Oct. 2005, *Luebert & García* 2620/1014 (BSB, SGO); Quebrada Izcuña, 50 km N of Paposo, 24°36'S, 70°33'W, 1 Oct. 1987, *Teillier* 509 (CONC, SGO); Punta Colorada N of Paposo, 4 Dec. 1925, *Johnston* 5242 (GH); Panul, 24°47'27.1"S, 70°32'32.8"W, 200 m, 7 Oct. 2005, *Luebert & García* 2677/1071 (BSB); Aguada Panulcito, 24°47'52.5"S, 70°32'16.2"W, 165 m, 19 Sept. 2004, *Luebert, Becker & García* 2128 (BSB); Paposo, Quebrada El Médano, 4 Nov. 1973, *Niemeyer* s.n. (CONC 121917); Alluvium front of Cerro Carnero, N of Paposo, 24°56'18.4"S, 70°28'33.5"W, 200 – 300 m, 23 Oct. 2009, *Luebert & Moreira* 2997 (BSB, SGO); Quebrada Paposo, 700 m, 7 Oct. 1966, *Jiles* 4963 (CONC, M); Playa Cachinales, N of Taltal, 25°10'S, 70°27'W, 20 m, 25 Nov. 1997, *Dillon* 8096 (F); Cachinalcito N of Taltal, 20 m, 11 Sept. 1936, *Montero* 2984 (CONC, GH); Quebrada Cascabeles, N of Taltal,

10 m, 16 Sept. 1941, *Muñoz & Johnson* 2841 (SGO); Quebrada de San Ramón, N of Taltal, 26 Nov. 1925, *Johnston* 5155 (GH); Hueso Parado, Oct. 1887, *Borchers* (lectotype of *Heliotropium brevifolium* SGO 54372, isotype W 12981); Taltal, 100 m, Oct. 1925, *Werdermann* 849 (B, BM, CONC, F, GH, K, M, MSB, NY, US); Breas, 1888, *Larrañaga* s.n. (holotype of *Heliotropium breanum* SGO 54371, isotypes GH, SGO 54373, SGO 54369 [lectoparatype of *H. brevifolium*]); Quebrada Los Zanjones, 5 km SW on road to Cifuncho, 15 km SW of Taltal, 25°31'S, 70°25'W, 610 – 620 m, 25 Sept. 1988, *Dillon, Dillon & Poblete* 5499 (F, MSB); Quebrada to Bahía Tórtolas, S side of Cerro San Pedro, c. 22 km (air) SW of Taltal, c. 13 km N of Cifuncho, 25°33'S, 70°37'W, 20 – 70 m, 12 Oct. 1988, *Dillon & Dillon* 5673 (F); Cifuncho, on rocks above the town, 25°39'9.3"S, 70°38'40.5"W, 50 – 100 m, 24 Oct. 2009, *Luebert, Moreira & Dillon* 3004 (BSB, SGO); Sierra Esmeralda, Road to Esmeralda, 25°53'31.8"S, 70°33'33.2"W, 520 m, 12 Oct. 2005, *Luebert & García* 2779/1173 (BSB); Quebrada Cachina, Road to Esmeralda, 14 Sept. 1958, *Ricardi & Marticorena* 4623/1008 (CONC). Región de Atacama, Prov. Chañaral: Cachinal de la Costa, Dec. 1853, *Philippi* s.n. (holotype SGO 54374); N. P. Pan de Azúcar, 26°7'S, 70°38'W, 125 m, 15 Sept. 1992, *Teillier, Rundel & García* 2726 (F, SGO); Between Chañaral and Pan de Azúcar, coastal road km 10, 19 Jan. 2004, *Luebert & Torres* 1961 (BSB); Chañaral, Falda Verde, 140 m, 27 Sept. 1952, *Ricardi* 2263 (CONC); Vicinity of Puerto de Chañaral, hills back of El Barquito, 10 m, 28 – 29 Nov. 1925, *Johnston* 4807, (GH, K, US, W); Villa Alegre, 17 Sept. 2003, *Luebert & Kritzner* 1851 (BSB); Dunes behind Caleta Flamenco, 26°35'43.8"S, 70°40'9.2"W, 100 m, 14 Oct. 1991, *Teillier, Villarreal & Torres* 2594 (SGO).

HABITAT. A xerophyte of low areas next to the coast, on sandy substrates, alluvial foothills, and gravelly hillsides or on the eastern plains of the coastal Cordillera (see *Johnston* 1929), between sea level and 950 m. Never found in the fog zone. Locally dominant in the vegetation together with *Nolana villosa* (Phil.) I. M. Johnst. (Solanaceae), *Frankenia chilensis* C. Presl (Frankeniaceae), *Gypthomanium pinifolium* Phil. (Asteraceae), *Heliotropium linariifolium* (Heliotropiaceae) (*Reiche* 1911). It has also been reported from the coastal dunes, where the dominant species are *Nolana mollis* (Phil.) I. M. Johnst. (Solanaceae) and *Tetragonia maritima* Barnéoud (Aizoaceae) (*Kohler* 1970).

CONSERVATION STATUS. Least concern (LC), see *Luebert* (2010).

FLOWERING TIME. September to November.

ETYMOLOGY. The epithet *pycnophyllum* refers to its dense foliage.

VERNACULAR NAME. Palo negro (Spanish).

USES. *Riedemann et al.* (2006) suggest its potential use as an ornamental.

NOTES. A very distinct species from the coastal Atacama Desert. In gross habit it resembles the other species of sect. *Cochranea* with conspicuous pubescence, but it differs from all other species of the section in its strongly revolute leaves and in its hispid style and stigmatic head, a combination of characters that is only present in the distantly related Old World species *Heliotropium supinum* L. and *H. drepanophyllum* Baker (Hilger 1987; Verdcourt 1988). In the phylogenetic analysis of Luebert & Wen (2008) this species was resolved as sister to the remainder of the section.

Johnston (1928b: 36) pointed out the confusion in the original description of Philippi (1860b) and in Reiche (1907, 1910), who indicated orange-coloured corollas for *Heliotropium pycnophyllum*. Intensive field observations, including all type localities, confirm that the corollas of this species are never orange, a character only found in *Heliotropium linariifolium*.

Förther (1998) mentions a possible isotype collection of *Heliotropium pycnophyllum* at B (destroyed, photo F neg. no. 17341: F, GH, NY, US); this specimen does not correspond to *H. pycnophyllum*, but to *H. linariifolium*, except for the fragment seen at the bottom-right corner of the photograph. Muñoz (1960: 109) refers to three syntype collections of *H. brevifolium* (SGO 54369, 54372, 54371) and none to *H. breanum*. The first is actually a lectoparatype of *H. brevifolium* and, at the same time, an isotype of *H. breanum*; the second is the lectotype of *H. brevifolium*; the third is the holotype of *H. breanum* (it is the only specimen in SGO bearing the name in Philippi's handwriting).

2. *Heliotropium filifolium* (Miers) I. M. Johnst. (Johnston 1928b: 32); Förther (1998: 195). Type: Chile, Región de Atacama, 'Concepcion' [dry valleys and hills between Huasco and Copiapó], [Sept. 1841], *T. Bridges* 1343 (lectotype BM [fragm. + photo GH], selected by Johnston (1928b: 32); isoelectotypes A, E not seen (digital photograph), G, K [photo SGO 2263], P not seen [digital photograph, fragm. F 515812, photo MSB], W).

Cochranea filifolia Miers (1868: 131); Philippi (1881: 253; 1895: 346). Type as above.

Heliotropium chenopodiaceum (A. DC.) Clos var. *filifolium* (Miers) Reiche (1907: 244; 1910: 202). Type as above.

Cochranea kingi Phil. (Philippi 1895: 350). Type: Chile, Región de Atacama, Prov. Huasco, valle Carrizal, Sept. 1885, s. coll. [F. Philipp? (holotype SGO 54430 [fragm. GH, photo F, GH]; isotypes B† [photo F neg. no. 17321: F, GH, NY], K, WU).

Heliotropium kingi (Phil.) Reiche (1907: 238; 1910: 196). Type as for *C. kingi*.

Erect shrubs, 0.3 – 1 m tall, profusely branched, with short branches, densely foliose to the apex. *Stems* and

foliage glabrous, or papillose-tomentose on the younger parts, glutinous. *Leaves* alternate, grouped in fascicles of up to 10 leaves, sessile, linear, 2 – 11 (– 13.5) × 0.5 – 1.5 mm, terete; lamina glabrous, with inconspicuous glandular trichomes, green, margin entire, base and apex obtuse, veins inconspicuous. *Inflorescences* terminal, elongate, dichotomously branched, to c. 5 cm long. *Flowers* sessile, alternate, erect, aromatic. *Calyx* cylindrical, pale green; calyx lobes oblong or obovate, fused only at the base, sparsely strigose outside, glabrous within, 1 – 2.5 × 0.5 – 1.5 mm, free portion 1 – 2.5 mm long, apex obtuse. *Corolla* infundibuliform, hispid outside, white with yellow throat; limb horizontally spreading, 4 – 9 mm wide, lobes rounded; tube 2 – 3 times as long as the calyx, 2 – 6 mm long. *Stamens* included or exerted; filaments adnate to petals; anthers oblong, glabrous, base cordate, apex obtuse, 0.7 – 1.2 mm long, generally located above the apex of the stigmatic head or shortly overlapping it. *Ovary* glabrous, subglobose, c. 0.7 mm diam., with a basal nectar ring. *Style* glabrous, 0 – 0.05 mm long, shorter than the stigmatic head. *Stigmatic head* conic, glabrous, 0.4 – 0.9 × 0.8 – 1 mm. *Fruits* dry, ellipsoid, rugose, glabrous, light brown, c. 1.6 × 1.3 mm diam., falling apart at maturity into two 2-seeded nutlets, each c. 1.6 × 0.8 mm diam. *Pollen* prolate, 22 – 26 × 13 – 15.5 µm. Endoapertures 3 – 3.5 µm diam., circular or slightly elongate. Exine thickness c. 1 µm. Colpiferous sides slightly convex (from *Ricardi* 2281 in Marticorena 1968). Figs 2B, 3B and 5.

DISTRIBUTION. Coastal areas of the provinces of Huasco and Copiapó (Región de Atacama, Chile), 27°24' – 28°36'S. Its northern limit is in the surroundings of Totoral (Map 3).

SPECIMENS EXAMINED. CHILE. Región de Atacama, Prov. Copiapó: Totoral, 27°53'41.8"S, 70°57'54.7"W, 116 m, 13 Sept. 2004, Luebert, Becker & García 2015 (BSB, SGO). Región de Atacama, Prov. Huasco: Between Canto de Agua and Totoral, 27°56'48.5"S, 70°53'40"W, 274 m, 15 Sept. 2003, Luebert & Kritzner 1825 (BSB); Carrizal Bajo, 30 Sept. 1952, Ricardi 2281 (CONC); Valle Carrizal, near the coast, 28°6'26.4"S, 71°6'15.7"W, 55 m, 26 Sept. 2004, Luebert & Becker 2166 (BSB); Valle Carrizal, Sept. 1885, s. coll. [Philippi?] (holotype of *Cochranea kingi* SGO 54430 [fragm. GH], isotypes B†, WU, possible isotype K); Carrizal Alto, Cerro Azúcar, 28°7'S, 70°57'W, 5 Sept. 2004, Teillier s.n. (BSB); Canto de Agua, 23 Sept. 1972, Zöllner 6433 (CONC); Vallenar, road to Carrizal Bajo, 28°9'S, 71°3'W, 9 Oct. 1987, Teillier 960 (CONC, SGO); Road from highway toward Carrizal Bajo, Llano de La Jaula front of Sierra Los Nichos, 2 Nov. 1991, Muñoz-Schick, Teillier & Meza 2910 (SGO); Road Carrizal Bajo – Huasco, 28°15'57"S, 71°9'47.6"W, 20 m, 19 Oct. 2005, Luebert & Becker 2901 (BSB); 15 km N of Vallenar, along the highway, 28°35'S, 70°16'W, 4 Oct. 1987, Rechinger & Rechinger

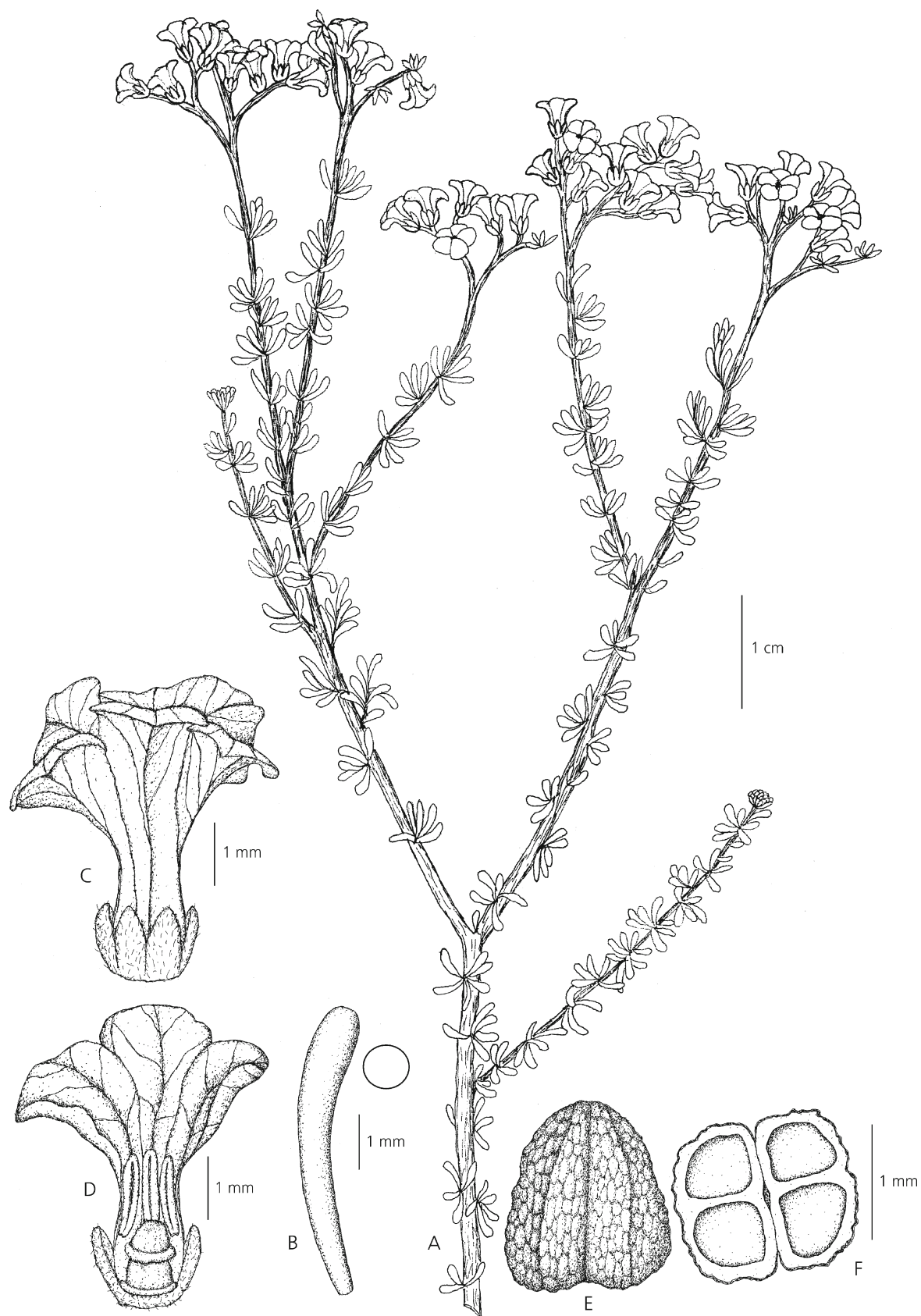


Fig. 5. *Heliotropium filifolium*. A flowering branch; B leaf; C flower, outer view; D flower, opened out; E fruit, dorsal view; F fruit, t.s. All from Luebert & Kritzner 1818 (BSB). DRAWN BY ANJA SALCHOW.



Map 3. Distribution of *Heliotropium filifolium*.

63308 (B, K, M, NY, W, WU); Vallenar, Sept. 1900, Reiche s.n. (BM). Región de Atacama, Indefinite: dry valleys and hills between Huasco and Copiapó, [Sept. 1841], Bridges 1343 (lectotype BM [fragm. GH], isolectotypes A, E, G, K, P [fragm. F 515812], W).

HABITAT. Coastal plains, slopes and ravines of the fog-free area, between 20 and 530 m. It also occurs some kilometres inland. Scarce, but sometimes is locally dominant. It forms part of a vegetation dominated by *Atriplex clivicola* I. M. Johnst. (Amaranthaceae), *Balsisia peduncularis* D. Don (Ledocarpaceae), *Eulychnia breviflora* Phil. (Cactaceae), *Nolana werdermannii* I. M. Johnst. (Solanaceae), *Oxalis virgosa* Molina (Oxalidaceae).

CONSERVATION STATUS. Vulnerable (VU), criterion B2(b,c). The area of occupancy was estimated to be less than 2,000 km² associated with a projected decline in its area, which is subject to extreme inter-annual fluctuations of climate that affects the number of mature individuals (Luebert 2010).

FLOWERING TIME. September to November, or throughout the year at locally humid spots.

ETYMOLOGY. The epithet *filifolium* refers to its thread-like leaves.

VERNACULAR NAME. Palo negro (Spanish).

USES. Natural and semi-synthetic compounds of the resin of *Heliotropium filifolium* have shown anti-viral properties (Torres *et al.* 2002; Modak *et al.* 2004a, 2010) as well as inhibitory effects on the complement system (Larghi *et al.* 2009), with potential pharmacological applications. Riedemann *et al.* (2006) suggest its potential use as an ornamental.

NOTES. Förther (1998: 229) erroneously quotes the material of Bridges 1343 at BM as the holotype, although Miers (1868: 131) had indicated two specimens (BM, K), one of which (BM) was later chosen by Johnston (1928b: 32) as the lectotype. The collection Bridges 1343 (G) was mentioned by de Candolle (1845: 553) among the syntypes of *Heliotropium chenopodiaceum*, but was distinguished by Miers (1868) as a different species. The collection was made by Bridges in 1841 (Johnston 1928a) without H. Cuming, as indicated by Förther (1998: 229, '[& Cuming]') (*sic*), because Cuming was not in Chile that year (Dance 1980).

Reiche (1907: 244; 1910: 202) applied this name (under *Heliotropium chenopodiaceum* var. *filifolium*) to a different species, namely *H. chenopodiaceum*, by placing *Cochranea sentis* Phil. under its synonymy (see discussion under *H. chenopodiaceum*). Since Reiche did not see the type specimen of *C. filifolia* and recognised *H. kingi* as a different, valid, species, even in a different section, the taxonomic placement of this name in Reiche's treatment is understandable. The recognition of *H. chenopodiaceum* and *H. filifolium* as different species is clear on the basis of morphology, geographic distribution and phylogenetic position (Johnston 1928b; Luebert & Wen 2008), while the synonymy of *C. kingi* under *H. filifolium* is evident and does not admit doubts (Johnston 1928b). The type specimen of *C. kingi* was likely collected either by F. Philippi or Juan King (see Philippi 1886), but not by Thomas King (Johnston 1928b; Förther 1998), because he was not in Chile in 1885 (Desmond 1994) when that material was collected. None of the type specimens has 'King' as collector in the label, and the Chilean materials of Thomas King were described by Philippi (1873).

3. *Heliotropium jaffuelii* I. M. Johnst. (Johnston 1937: 19); Förther (1998: 201). Type: Chile, Región de Antofagasta, Prov. Tocopilla, Tocopilla, Nov. 1931, *F. Jaffuel* 2524 (holotype GH; isotypes CONC, G).

Erect shrubs, laxly ramified. *Stems* and *foliage* glutinous, covered by inconspicuous short-strigose pubescence. *Leaves* alternate, solitary or grouped in fascicles of up to 8 leaves, sessile, linear, 4 – 10 × 0.5 – 1 mm, terete; lamina glabrous or inconspicuously pubescent, greyish-green, margin entire, base and apex obtuse, veins inconspicuous. *Inflorescences* terminal, dichoto-

mously branched, 1 – 4 cm long. *Flowers* sessile or shortly pedicellate (pedicel < 1 mm), alternate, erect. *Calyx* globose to cylindrical, pale green; calyx lobes linear-lanceolate, fused only at the base, pubescent outside, glabrous inside, 1.5 – 2 × 0.5 – 1 mm, free portion 0.8 – 1.5 mm long, apex acute. *Corolla* infundibuliform, inconspicuously pubescent outside; limb horizontally spreading 2.5 – 4 mm wide, lobes rounded, c. 0.8 × 0.8 mm; tube more than twice as long as the calyx, 3 – 4 mm long. *Stamens* included or little exerted; filaments adnate to petals; anthers lanceolate, glabrous, 0.4 – 0.9 mm, base cordate, apex acute, overlapping the apex of the stigmatic head. *Ovary* glabrous, c. 0.3 mm diam., with a basal nectar ring. *Style* glabrous, c. 0.1 mm long, shorter than the stigmatic head. *Stigmatic head* conic, glabrous, c. 0.3 – 1 × 0.5 – 0.6 mm. *Fruits* dry, ellipsoid, rugose, glabrous, light brown, c. 2.4 × 1.6 mm diam., falling apart at maturity into two 2-seeded nutlets, each c. 1.5 × 1.2 mm diam. *Pollen* prolate, 17.4 – 21.1 × 8.4 – 11.6 µm (from Jaffuel 2424, G). Figs 2C, 3C and 6.

DISTRIBUTION. Endemic to the coastal areas north of Tocopilla (22°S), Región de Antofagasta, Chile, 22°6' – 22°2'S (Map 4).

SPECIMENS EXAMINED. CHILE. Región de Antofagasta, Prov. Tocopilla: Road from Tocopilla to Quebrada Mamilla, 21 Oct. 1964, Ricardi, Marticorena & Matthei 1065 (CONC); Tocopilla, Nov. 1931, Jaffuel 2524 (holotype GH, isotypes CONC, G).

HABITAT. Coastal hills on gravelly slopes at the fog zone (Jaffuel 1936). The vegetation is a desert scrub dominated by *Eulychnia iquiquensis* (K. Schum.) Britton & Rose and *Ephedra breana* Phil. (Luebert *et al.* 2007).

CONSERVATION STATUS. Critically endangered (CR), according to the criterion of area of occupancy (B2 (a,c), IUCN 2001). This species is known from one locality, and has been collected only twice. The area occupied by this species is currently subject to the disturbance effects of urban expansion and mining associated with the development of the city of Tocopilla. There are currently no conservation measures being taken in that area, although its flora is known to contain several endemics (Luebert *et al.* 2007) that need to be protected.

ETYMOLOGY. The name was dedicated to Félix Jaffuel, collector of the type specimen.

NOTES. Only known from the type specimen and one additional gathering, both collected in the surroundings of Tocopilla, Chile. Attempts at recollecting the plant at the type locality failed. It is likely a very rare and local endemic. Due to its geographical distribution, leaf and floral morphology, this species is readily distinguished from the other members of section *Cochranea*.

4. *Heliotropium glutinosum* Phil. (Philippi 1860a: 38); Reiche (1907: 242; 1910: 200); Johnston (1928b: 33); Förther (1998: 197). Type: Chile, Región de Atacama, Prov. Chañaral, Agua Dulce in Deserto Atacama, 26°16' [sic] lat. S, 6300 p.s.m. [1920 m], 21 Feb. 1854, R. A. Philippi s.n. (holotype SGO 54387 [fragm. GH, photo F, GH, MSB, NY, US]); isotypes B† [photo F neg. no. 17323: F, GH, MSB, NY, US], W 12894).

Cochranea glutinosa (Phil.) Phil. (Philippi 1895: 349).

Type as above.

Erect shrubs, 0.2 – 0.8 (– 1.3) m tall, profusely branched, densely foliose to the apex, but losing most leaves during dry years. *Stems* and *foliage* glutinous. *Leaves* alternate, solitary or grouped in fascicles of up to 9 leaves, sessile, linear-oblong, 8 – 23 × 1.5 – 6 mm; lamina glutinous with evident red glands and few simple hairs, green or greyish-green, margin sinuate, revolute, base attenuated, apex acute, with the main and secondary veins conspicuous. *Inflorescences* terminal, elongate, dichotomously branched, to c. 4 cm long. *Flowers* sessile or shortly pedicellate, alternate, erect, aromatic. *Calyx* cylindrical, pale green; calyx lobes linear, fused only at the base, hirsute and glandulous outside, strigose within, 1.5 – 3.5 × 0.5 – 1.5 mm, free portion 1.5 – 3.5 mm long, apex obtuse. *Corolla* infundibuliform, hispid outside, dull white with yellow throat; limb horizontally spreading, 4.5 – 6.5 mm wide, lobes rounded; tube as long as or slightly longer than the calyx, 3.5 – 5 mm long. *Stamens* included or exerted at late anthesis; filaments adnate to petals; anthers oblong, glabrous, base cordate, apex obtuse, 1 – 1.5 mm long, overlapping the stigmatic head. *Ovary* glabrous, subglobose, c. 0.7 mm diam., with a basal nectar ring. *Style* glabrous, c. 0.2 mm long, shorter than the stigmatic head. *Stigmatic head* conic, glabrous, 1 – 1.5 × 0.4 – 0.6 mm. *Fruits* dry, ellipsoid, rugose, glabrous, light brown, c. 1.6 × 1.3 mm diam., falling apart at maturity into two 2-seeded nutlets, each c. 1.6 × 0.8 mm diam. *Pollen* prolate, 18.3 – 20.2 × 9.5 – 10.8 µm (from Luebert & Torres 1970, BSB). Figs 2D, 3D and 7.

DISTRIBUTION. Endemic to the Andean foothills of the province of Chañaral (Región de Atacama) in Chile, 26°04' – 27°10'S (Map 4).

SPECIMENS EXAMINED. CHILE. Región de Atacama, Prov. Chañaral: Quebrada de Doña Inés Chica, Jan. 1886, Gigoux s.n. (GH); Vicinity of Potrerillos, Rio Sal station, 1670 m, 27 Oct. 1925, Johnston 4749 (US); Quebrada Salado, Deserto Atacama, San Román s.n. (SGO 42215 42239 54386 54388); Agua Dulce in Deserto Atacama, 1920 m, 21 Feb. 1854, Philippi s.n. (holotype SGO 54387; isotypes GH, W12894); Road to La Finca de Chañaral, 26°35'59"S, 69°51'41.9"W, 1390 m, 25 Sept. 2004, Luebert & Becker 2161 (BSB, SGO); Inca de Oro, km 6 on road to La Finca, 26°42'28.9"S, 69°51'58.6"W, 1639 m, 18 Sept. 2003, Luebert & Kritzner

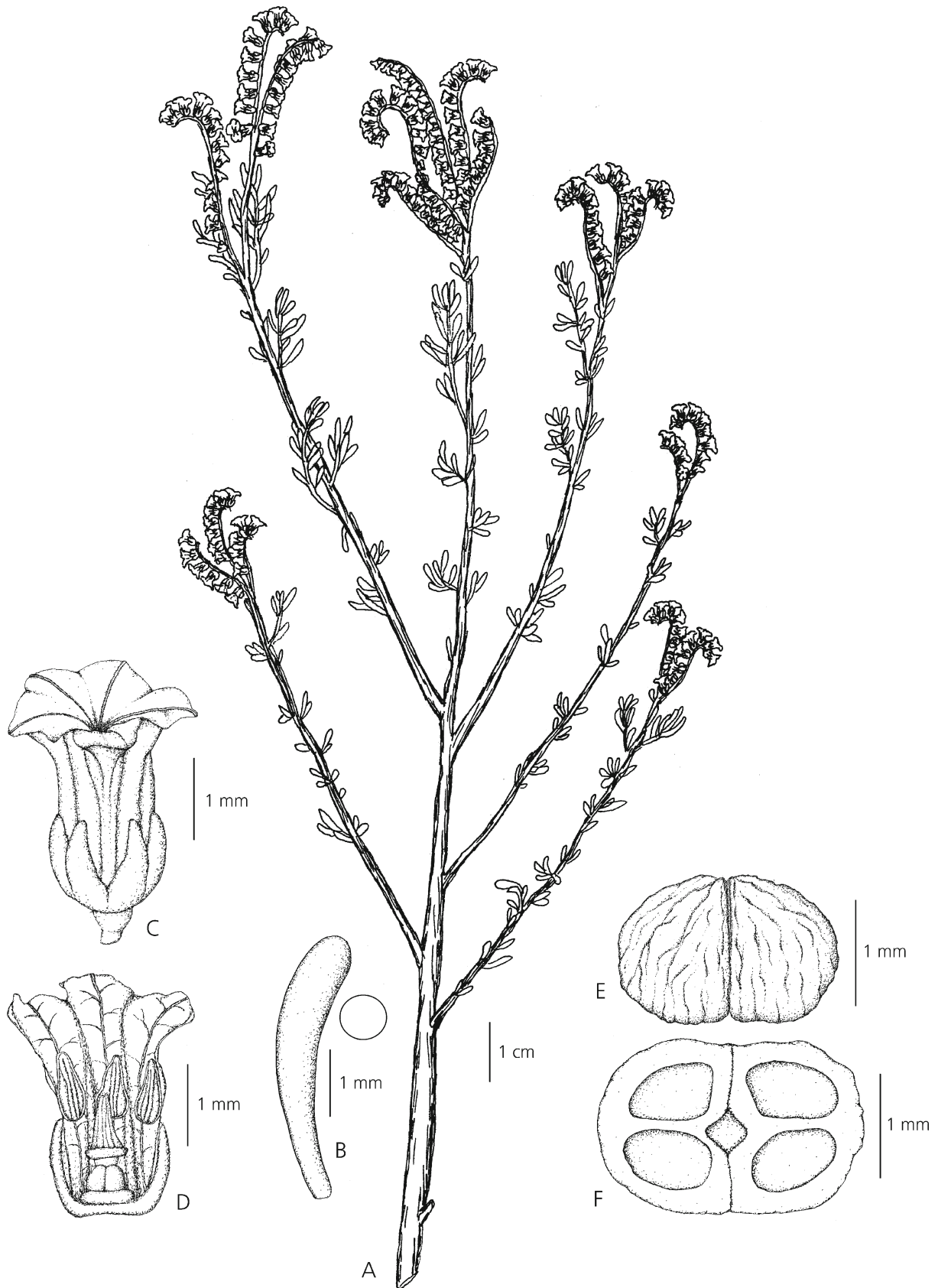


Fig. 6. *Heliotropium jaffuelii*. A flowering branch; B leaf; C flower, outer view; D flower, opened out; E fruit, dorsal view; F fruit, t.s. All from *Jaffuel* 2524 (G). DRAWN BY ANJA SALCHOW.



Map 4. Distribution of *Heliotropium jaffuelii* (●) and *H. glutinosum* (□).

1858 (BSB); Quebrada San Andrés, road to Salar de Maricunga, 27°10'49.6"S, 69°54'2.8"W, 1195 m, 18 Sept. 2005, *Luebert & García* 2508/902 (EIF).

HABITAT. Ravines or alluvial plains of the Andean foothills in a matrix of barren desert, 1195 – 2200 m. The species is locally common but not dominant. The vegetation is a desert scrub dominated by *Atriplex* spp. (Amaranthaceae), *Nolana leptophylla* (Miers) I. M. Johnst. (Solanaceae) and *Encelia canescens* Lam. (Asteraceae).

CONSERVATION STATUS. Endangered (EN), after the application of both IUCN (2001) criteria of extent of the presence (B1) and area of occupancy (B2). *Heliotropium glutinosum* occurs in an area where interannual climatic fluctuations are extreme, which directly affects the number of subpopulations and individuals. Only five locations are known for this species. Mining activities at large and small scale are present over the whole of the distribution of this species, which represents an additional threat, and no protected area has been officially established there.

FLOWERING TIME. Throughout the year provided sufficient moisture.

ETYMOLOGY. The epithet *glutinosum* refers to its resinous foliage.

VERNACULAR NAME. Palo negro (Spanish).

USES. No uses are reported in the literature, but Modak *et al.* (2007) indicate antioxidant activity of the resinous exudates.

NOTES. This species is readily distinct from the other members of sect. *Cochranea* due to the presence of conspicuous glandular trichomes on the leaf surface, as well as its geographic distribution and elevation. Only *Heliotropium chenopodiaceum* can be rarely found in the same geographical area, but the latter species has smaller leaves and flowers and the glandular trichomes are not visible to the naked eye.

Toro & Moldenke (1979) indicate that *Heliotropium glutinosum* (erroneously cited as *H. stenophyllum*) is pollinated by two *Colletidae* species: *Chilicola deserticola* Toro & Moldenke 1979 and *C. erithropoda* Toro & Moldenke 1979.

5. *Heliotropium sinuatum* (Miers) I. M. Johnst. (Johnston 1928b: 26); Förther (1998: 219). Type: Chile, 'Coquimbo', *T. Bridges* s.n. (lectotype BM [photo GH], selected by Johnston (1928b: 27); possible isoelectotypes BM, P not seen [digital photograph]).

Cochranea sinuata Miers (1868: 127); Philippi (1895: 342). Type as above.

Heliophytum floridum A. DC. var. *bridgesii* A. DC. (de Candolle 1845: 553). Type: Chile, 'in prov. Coquimbo' [dry valleys and hills between Huasco and Copiapó], [Sept. 1841], *T. Bridges* 1342 (holotype G-DC [photo SGO 11770, photo F neg. no. 27073, F, GH, US]; isotypes BM, E not seen [digital photograph], G, K [photo SGO 2255], P not seen [digital photograph, photo MSB], W).

Heliotropium floridum (A. DC.) Clos var. *bridgesii* (A. DC.) Clos in Gay (1849: 457). Type as for *Heliophytum floridum* var. *bridgesii*.

Cochranea conferta Miers var. *auriculata* Miers (1868: 126). Type: N Chile, *W. Lobb* 442 (holotype K; isotype BM).

Heliotropium rosmarinifolium Phil. (Philippi 1873: 514). Type: Chile, Región de Atacama, Prov. Huasco, Huasco, Oct. 1866, *R. A. Philippi* s.n. (holotype SGO 42229 [fragm. GH, photo F, GH, MSB, NY, US]; isotypes B† [photo F neg. no. 27072: F, GH, US], W 12893).

Cochranea rosmarinifolia (Phil.) Phil. (Philippi 1895: 349). Type as for *Heliotropium rosmarinifolium*.

Heliotropium izagae Phil. (Philippi 1895: 355). Type: Chile, Región de Atacama, Prov. Huasco, Chañarito prope Carrizal, Sept. 1885, *F. Philippi* s.n. (lectotype SGO 42231 [photo F, GH, MSB, NY, US], selected by Förther (1998: 201); isoelectotypes B† [photo F neg. no. 17344: F, NY, US], BM, GH [fragm.], SGO 54378 [photo MSB], WU [photo MSB], possible isoelectotype K [photo SGO 2257]).

Erect shrubs, 0.5 – 1.5 (– 2.6) m tall, profusely branched, densely foliose to the apex. *Stems* and *foliage* strongly

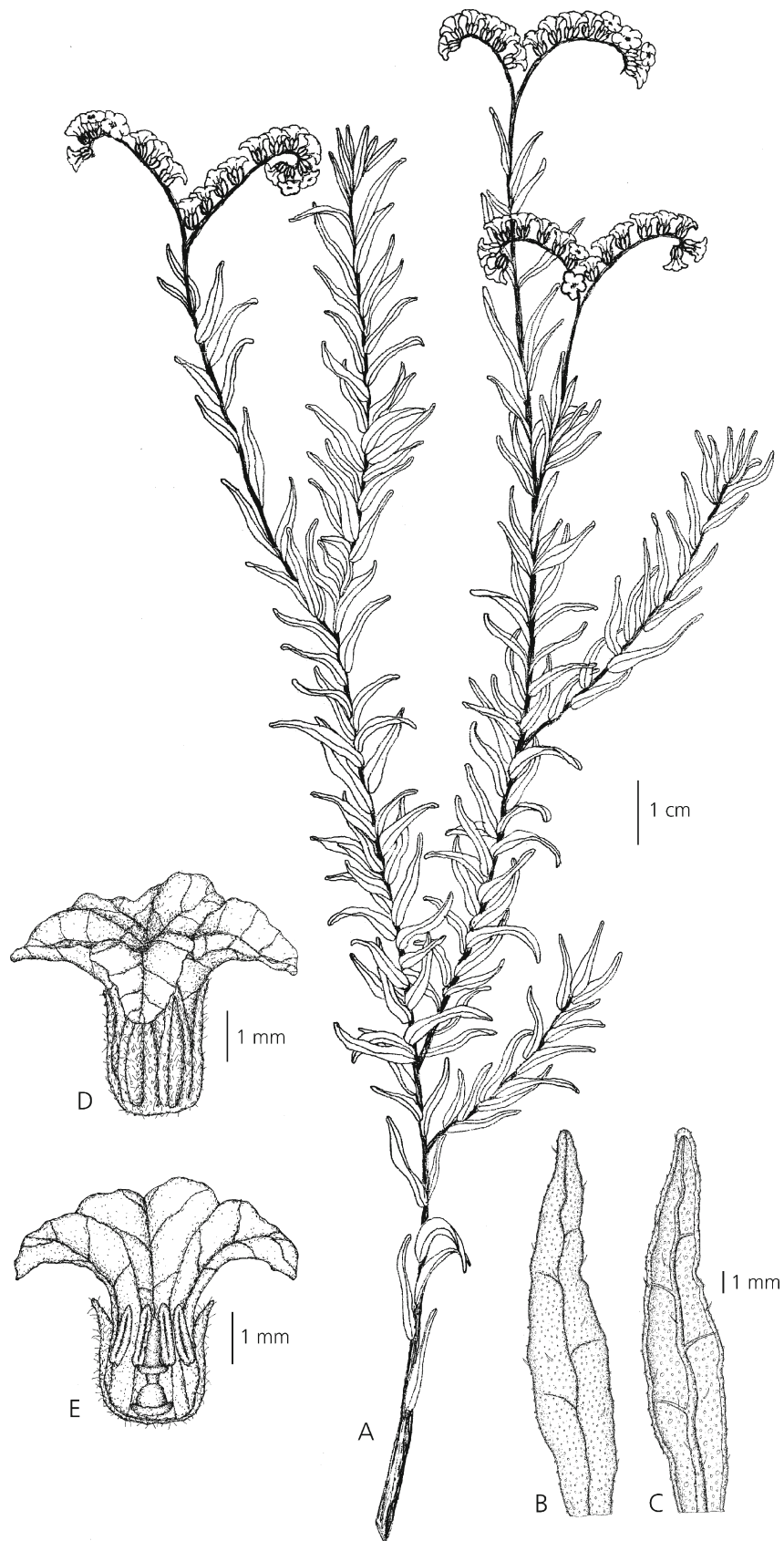
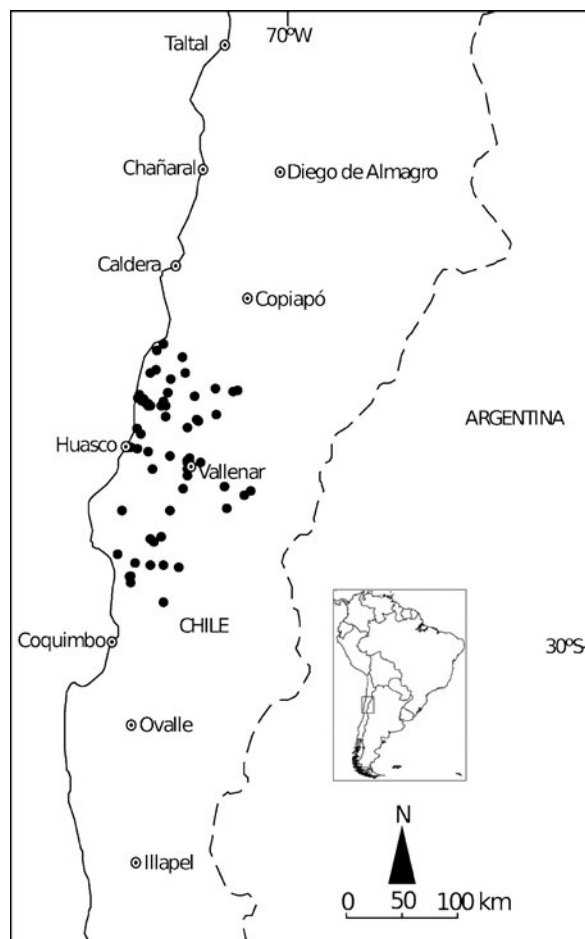


Fig. 7. *Heliotropium glutinosum*. A flowering branch; B leaf, adaxial surface; C leaf, abaxial surface; D flower, outer view; E flower, opened out. All from Luebert & Torres 1970 (BSB). DRAWN BY ANJA SALCHOW.

glutinous. *Leaves* alternate, solitary or grouped in fascicles of up to 25 leaves, sessile, linear-oblong to linear spatulate, 9 – 65 × 1 – 7 mm; lamina glutinous, sparsely strigose, dark-green or dark brownish-green, margin sinuate, revolute, base attenuated, apex acute, with the main and secondary veins conspicuous. *Inflorescences* terminal, elongate, dichotomously branched, to c. 5 cm long. *Flowers* sessile or shortly pedicellate (pedicel up to 2 mm), alternate, erect, aromatic. *Calyx* cylindrical, pale green; calyx lobes linear, fused only at the base or free, hirsute and glandulous outside, sparsely strigose within, 2 – 4.5 × 0.5 – 0.7 mm, free portion 0.5 – 3.5 mm long, apex obtuse. *Corolla* infundibuliform, hispid outside, white with yellow throat; limb horizontally spreading, 5 – 10 mm wide, lobes rounded; tube longer than the calyx, 3.5 – 8.5 mm long. *Stamens* included or exerted at late anthesis; filaments adnate to petals; anthers oblong, glabrous, base cordate, apex obtuse, c. 1 mm long, overlapping the stigmatic head. *Ovary* glabrous, subglobose, c. 0.5 mm diam., with a basal nectar ring. *Style* glabrous, c. 1 mm long, as long as or slightly shorter than the stigmatic head. *Stigmatic head* conic, glabrous, c. 0.8 – 1 × 0.4 – 0.6 mm. *Fruits* dry, ellipsoid, rugose, light orange brown or cream, c. 2.5 × 1.5 mm diam., falling apart at maturity into two 2-seeded nutlets, each c. 1.2 × 2 mm diam. *Pollen* prolate, 24.5 – 27.5 × 14.5 – 16.5 µm. Endoapertures c. 3.5 µm diam. in polar direction and contracted at the centre. Exine thickness c. 1 µm, slightly thicker at the poles (from *Ricardi & Marticorena* 3882 in Marticorena 1968). Figs 2E and 3E.

DISTRIBUTION. Coast and interior of the province of Elqui (Región de Coquimbo) and provinces of Huasco and Copiapó (Región de Atacama), Chile, 27°40' – 29°39'S, (Map 5). The assertion of Johnston (1928b: 34) that there are no reliable records of the species in the province of Coquimbo, where the plant occurs in sympatry with what Johnston (1928b) called *Heliotropium huasconense*, is certainly no longer valid. The locality in Zöllner 4472 (CONC) from the province of Arica is certainly erroneously given.

SPECIMENS EXAMINED. CHILE. Región de Atacama, Prov. Copiapó: Road Totoral – Caldera, 27°40'45.6"S, 70°56'59.2"W, 30 m, 16 Sept. 2003, *Luebert & Kritzner* 1831 (SGO); Estancia Castilla, 27°43'40.5"S, 71°0'2.4"W, 92 m, 16 Sept. 2003, *Luebert & Kritzner* 1828 (BSB); 7 km W of Totoral on gravel road towards Totoral Bajo (= 48 km W of Panamericana), 27°52'34"S, 71°0'25"W, 250 m, 9 Dec. 1994, *Eggl & Leuenberger* 2606 (B, CONC, SGO); Coastal road Carrizal Bajo – Totoral, at milestone on km 51 of the mining road southwards, 0 m, 5 Sept. 2000, *Muñoz-Schick* 4104 (SGO); Between Canto de Agua and Totoral, 27°56'48.5"S, 70°53'40"W, 274 m, 15 Sept. 2003, *Luebert & Kritzner* 1824 (BSB); Sierra Los Sapos, 28°2'30.5"S, 70°25'5.3"W, 840 m, 17 Sept. 2005, *Luebert & García* 2492/886 (BSB, SGO).



Map 5. Distribution of *Heliotropium sinuatum*.

Región de Atacama, Prov. Huasco: Crossroad Totoral – Canto de Agua, 28°4'38.7"S, 70°42'41.7"W, 300 m, 13 Sept. 2004, *Luebert, Becker & García* 2008 (BSB); Carrizal Bajo, 28°5'27.7"S, 71°8'43"W, 0 – 20 m, 15 Oct. 2009, *Luebert & Danitowicz* 2983 (BSB, K, SGO); Quebrada Carrizal, 28°6'45.2"S, 71°6'57.4"W, 30 m, 21 Jan. 2004, *Luebert & Torres* 1972 (BSB, SGO); Carrizal Alto, Cerro Azúcar, 5 Sept. 2004, *Teillier* s.n. (BSB); Chañarcito near Carrizal, 26 Sept. 1885, [*Philippi*] s.n. (lectotype of *Heliotropium izagae* SGO 42231 [fragm.: GH], isolectotypes B†, BM, SGO 54378, WU, possible isolectotype K); Road to El Bolsico, 28°13'2.7"S, 70°32'46.6"W, 622 m, 20 Sept. 2003, *Luebert & Kritzner* 1872 (BSB); Quebrada Baratillo, 28°21'56.7"S, 71°7'21"W, 150 m, 14 Sept. 2003, *Luebert & Kritzner* 1802 (BSB); Huasco, Oct. 1866, *Philippi* s.n. (holotype of *Heliotropium rosmarinifolium* SGO 42229 [fragm.: GH], isotype: B†, W 12893); Near Huasco, 17 Oct. 1955, *Böcher, Hjerting & Rahn* 463 (C); Valley of río Huasco near Freirina, 21 Sept. 1962, *Kubitzki* 291 (CONC, M); Vallenar, Quebrada del Jilgero, 11 Nov. 1956, *Ricardi & Marticorena* 3882 (CONC); Vallenar, Mina Algarrobo, 1000 m, Nov. 1923, *Werdermann* 145 (BM, F, K, M, MSB); Río El Transito, 1500 m, 8 Aug.

1985, *Callejas* s.n. (SGO 104963); San Félix, 1250 m, 9 Nov. 1956, *Ricardi & Marticorena* 3840 (CONC); Quebrada El Morado, 23 Oct. 1971, *Marticorena, Rodríguez & Weldt* 1792 (CONC); Domeyko, 778 m, 21 July 1973, *Zöllner* 6853 (CONC); Cuesta Pajonales, 17 July 1970, *Zöllner* 4168 (CONC, W). Región de Atacama, Indefinite: Dry valleys and hills between Huasco and Copiapó, Sept. 1841, *Bridges* 1342 (holotype of *Heliohytum floridum* var. *bridgesii* G-DC, isotypes BM, G, K [lectoparatype of *Cochranea sinuata*], W); prov. Coquimbo, *Bridges* s.n. (lectotype BM, possible isolectotype BM). Región de Coquimbo, Prov. Elqui: Valle Choros Bajos, 350 m, 13 June 1968, *Zalensky* XVIII-989(EIF); Mineral Los Plomos 16 km E of Tres Cruces, 1150 m, 3 Nov. 1949, *Biese* 2987 (SGO); La Higuera, 650 m, 7 Oct. 2000, *Luebert* 1289 (EIF); Road from Almirante Latorre to Condoriaco, km 2, 1000 m, 18 Oct. 1971, *Marticorena, Rodríguez & Weldt* 1535 (B, CONC); Cochiguas, 1500 m, *Zöllner* 11822 (W).

HABITAT. Coastal ravines and rocky hillsides, between sea level and 1500 m, where it can be dominant in desert scrubs together with *Adesmia argentea* Gill. ex Hook., *Balbisia peduncularis*, *Frankenia chilensis* C. Presl, *Nolana albescens* (Phil.) I. M. Johnst., *Oxalis virgosa*, *Pleocarphus revolutus* D. Don, among others. This species can occur in local sympatry with *Heliotropium filifolium*, *H. floridum*, *H. longistylum*, *H. megalanthum* and *H. stenophyllum*.

CONSERVATION STATUS. Least concern (LC), see *Luebert* (2010).

FLOWERING TIME. September to November, but throughout the year provided sufficient moisture.

ETYMOLOGY. The epithet *sinuatum* refers to its sinuate leaves.

VERNACULAR NAME. Palo negro, monte negro (Spanish).

USES. Chemical compounds of the resinous exudates of *Heliotropium sinuatum* have shown to have antibacterial (*Modak et al.* 2004b), as well as antioxidant (*Modak et al.* 2003) properties. *Riedemann et al.* (2006) suggest its potential use as an ornamental.

NOTES. This species is unique in *Heliotropium* sect. *Cochranea*, for its strongly rugose, sinuate leaves, with non forked secondary veins and for its geographical distribution, where no other species of section *Cochranea* with rugose leaves occurs. However, *Reiche* (1907, 1910) considered it in a broader sense under the name *H. rugosum* Phil., a synonym of *H. taltalense*. *H. taltalense* was distinguished from the present species by subsequent authors (*Johnston* 1928b; *Förther* 1998; *Luebert & Pinto* 2004), which is followed here. Apart from its geographical distribution, *H. sinuatum* is clearly distinguished from *H. taltalense* in that the latter has forked secondary veins and more pubescent leaves. Both are resinous, erect, shrubs with sinuate and rugose leaves.

Förther (1998) indicated that no lectotype had been selected, but he probably overlooked *Johnston* (1928b). The type specimen of *Cochranea sinuata* (*Bridges* s.n.) and that of *Heliohytum floridum* var.

bridgesii (*Bridges* 1342) probably come from the same collection, as they are morphologically very similar. The type material at BM (*Bridges* s.n.) has several small envelopes, one of which is annotated as '*Bridges* 1342'. That would confirm the assertion of *Johnston* (1928a) and the identities of the types of *C. sinuata* and *H. floridum* var. *bridgesii*. The F negative no. 27072 (*H. rosmarinifolium*) was distributed under the heading 'Types of the Delessert Herbarium' (G). However *Förther* (1998) cites it as from B, *Johnston* (1928b) refers to an isotype of *H. rosmarinifolium* at B, and no isotype of *H. rosmarinifolium* is to be found at G. One specimen at K labelled as *H. rosmarinifolium* (photo SGO 2258) was collected in Vallenar, probably by F. Philippi in 1885 and is therefore not a type.

In the protologue of *Heliotropium izagae*, *Philippi* (1895) indicated that the plant comes from Carrizal Bajo, which was followed by *Johnston* (1928b), *Muñoz* (1960) and *Förther* (1998). The specimens from that locality at SGO (42230 and 54376) were, however, determined by *Philippi* as *H. rosmarinifolium*. The type material of *H. izagae* comes from Chañarcito, and the specimens that serve as type of this name are coincident with the description of *Philippi* (1895) and with other materials collected in that area. All of them have larger, less sinuate and rugose leaves than the type of *H. rosmarinifolium*, intermixed with smaller and more rugose and sinuate leaves that make it possible to include the name in the synonymy of the present species. The locality given in the protologue of *H. izagae* (*Philippi* 1895) is thus probably erroneous.

6. *Heliotropium taltalense* (*Phil.*) *I. M. Johnst.* (*Johnston* 1928b: 27); *Marticorena* (1968: 47); *Förther* (1998: 223). Type: Chile, Región de Antofagasta, Prov. Antofagasta, prope Taltal, Oct. 1889, *L. Darapsky* 30 (holotype SGO 54432 [fragm. GH, photo F, GH, MSB, NY]).

Cochranea taltalensis *Phil.* (*Philippi* 1895: 349). Type as above.

Heliotropium rugosum *Phil.* (*Philippi* 1860a: 38); *Reiche* (1907: 239; 1910: 197), **nom. illegit.**, non *M. Martens & Galeotti* (1844: 336). Type: Chile, Región de Antofagasta, Prov. Antofagasta, Paposos, Dec. 1853, *R. A. Philippi* s.n. (holotype SGO 54381 [fragm. GH, photo F, GH, MSB, NY]; isotypes B† [photo F neg. no. 17347: F, GH, NY, US], W 12878 [photo F neg. no. 31913: F, GH]).

Cochranea rugosa (*Phil.*) *Phil.* (*Philippi* 1895: 351). Type as for *Heliotropium rugosum*.

Erect shrubs, 0.65 – 1.0 (– 1.8) m tall, profusely branched, densely foliose to the apex. *Stems* and *foliage* glutinous. *Leaves* alternate, solitary or grouped in fascicles of up to 20 leaves, sessile, linear-oblong to linear-lanceolate, 12 – 45 (– 50) × 1 – 5.5 mm; lamina

glutinous, pubescent on both sides, sparsely strigose on the adaxial surface, tomentose on the abaxial surface, dark-green or dark greyish-green, margin sinuate, revolute, base attenuated, apex obtuse, with the main and secondary veins conspicuous, the later forked toward the margin. *Inflorescences* terminal, elongate, dichotomously branched, to c. 8 cm long. *Flowers* sessile or shortly pedicellate, alternate, erect, aromatic. *Calyx* cylindrical, pale green; calyx lobes linear, free or fused only at the base, villous outside, glabrous or sparsely hirsute within, 2 – 5 × 0.5 – 1 mm, free portion 1.5 – 5 mm long, apex acute. *Corolla* infundibuliform, hispid outside, dull white with yellow throat; limb horizontally spreading, 3.5 – 7 mm wide, lobes rounded; tube longer than the calyx, 3.5 – 7.5 mm long. *Stamens* included or exerted at late anthesis; filaments adnate to petals; anthers linear-lanceolate, glabrous, base cordate, apex acute, 1.5 – 2 mm long, overlapping the stigmatic head. *Ovary* glabrous, subglobose, c. 0.7 mm diam., with a basal nectar ring. *Style* glabrous, 0.5 – 1.8 mm long, as long as or shorter than the stigmatic head. *Stigmatic head* conic, glabrous, 1 – 1.8 × 0.5 – 0.7 mm. *Fruits* dry, ellipsoid, rugose, glabrous, light brown, c. 1.5 – 3.5 × 1 – 2 mm diam., falling apart at maturity into two 2-seeded nutlets, each c. 1 – 2 × 1 – 2 mm diam. *Pollen* prolate, 29.5 – 31 × 18 – 18.5 µm. Endoapertures 3 × 5 µm diam., contracted at the centre. Exine thickness c. 1.3 µm, slightly thicker at the poles (from Ricardi 2614 in Marticorena 1968). Figs 2F, 3F and 8.

DISTRIBUTION. Coastal hills of the province of Antofagasta (Región de Antofagasta), Chile, most common between the localities of Miguel Díaz and Taltal, 24°30' – 25°29'S (Map 6).

SPECIMENS EXAMINED. CHILE. Región de Antofagasta, Prov. Antofagasta: Quebrada Botija, 24°31'S, 70°33'W, 90 m, 12 Feb. 1998, *Arancio & Squeo* 11134 (ULS); Between Blanco Encalada and Miguel Díaz, 160 m, 15 Nov. 1996, *Rodríguez* 3139 (CONC); Miguel Díaz, 24°33'5.3"S, 70°32'21.2"W, 890 m, 5 Oct. 2005, *Luebert & García* 2650/1044 (BSB, SGO); Quebrada Rancho Monte, 24°45'S, 70°33'W, 300 m, 11 Feb. 1998, *Arancio & Squeo* 11062 (ULS); Vicinity of Aguada Cardón, 30 Nov. 1925, *Johnston* 5293 (GH, K, US); Aguada Panulcito, 24°47'55.7"S, 70°31'36.6"W, 345 m, 19 Sept. 2004, *Luebert, Becker & García* 2123 (BSB); 20 km N of Paposo, Quebrada El Médano, April 1985, *Niemeyer* s.n. (SGO 104088); Alluvium front of cerro Carnero, N of Paposo, 24°56'14.5"S, 70°28'29.9"W, 200 – 300 m, 23 Oct. 2009, *Luebert & Moreira* 2998 (BSB, G, SGO); Rinconada de Paposo, 125 m, 1 Dec. 1989, *Gálvez, Cornejo & Villarroel* 8 (SGO); Portezuelo Quebrada Yumbe, 25°0'S, 70°26'W, 1060 m, 14 Feb. 1998, *Arancio & Squeo* 11316 (ULS); Paposo, Dec. 1853, *Philippi* s.n. (holotype of *H. rugosum* Phil., SGO 54381 [fragm. GH], isotypes B†, W 12878); Paposo,

road to Mina Liverpool, Quebrada Paposo, 25°1'15"S, 70°26'51.6"W, 450 m, 12 Dec. 2006, *Ackermann* 685 (BSB, M); Quebrada Los Yales, Paposo, 25 Aug. 1992, *Torres-Mura* s.n. (SGO 128786); Quebrada Portezuelo, 25°1'S, 70°27'W, 550 m, 2 July 1997, *León* 18 (ULS); Paposo, Quebrada Peralito, 25°2'S, 70°26'W, 601 m, 16 Nov. 2005, *Guerreiro & Rosas* 3103(K); Between Paposo and Punta Grande, 25°3'S, 70°30'W, 2 Oct. 1987, *Teillier* 564 (CONC, SGO); Quebrada de Paposo, Quebrada Guanillos, 25°3'S, 70°30'W, 610 m, 16 Sept. 1992, *Teillier, Rundel & García* 2823 (F); Quebrada Destiladora, 25°5'48.6"S, 70°26'34.3"W, 550 m, 8 Oct. 2005, *Luebert & García* 2694/1088 (BSB); Quebrada Matancilla, 25°6'59.6"S, 70°27'31"W, 220 m, 18 Sept. 2004, *Luebert, Becker & García* 2101 (BSB, SGO); Taltal, 200 m, Oct. 1925, *Werdermann* 837 (B, CONC, F, GH, K, MSB, NY, US); Cerro Perales, c. 5 km E of Taltal, 25°25'S, 70°25'W, 950 m, 21 Nov. 1998, *Dillon & Dillon* 5998 (F, MSB); Quebrada Las Tipias, 25°26'54.1"S, 70°26'9.1"W, 275 m, 17 Sept. 2004, *Luebert, Becker & García* 2076 (BSB); Taltal region in Quebradas, Oct. 1889, *Darapsky* 30 (holotype SGO 54432 [fragm. GH]); Breas, 1888, *Larrañaga* s.n. (SGO 54380, 54382).

HABITAT. Dry hillsides of the coastal Cordillera, usually outside and above the fog zone (Johnston 1929), 50 – 1060 m. It forms part of the coastal desert scrub (Luebert & Pliscoff 2006), where it is usually rare, but it can be locally dominant in the vegetation (Reiche 1911), along with *Balbisia peduncularis* (Ledocarpaceae), *Copiapoa tenebrosa* F. Ritter (Cactaceae), *Euphorbia lactiflua* Phil. (Euphorbiaceae), *Nolana divaricata* I. M. Johnst., *Nolana incana* I. M. Johnst. (both Solanaceae), *Ophryosporus triangularis* Meyen (Asteraceae), *Tetragonia maritima* (Aizoaceae), among others.

CONSERVATION STATUS. Vulnerable (VU), criterion B2(b,c). The reduced projected area of occupancy of this species is associated with a predicted decline in its area, in a zone subject to extreme interannual climatic fluctuations that directly affect the number of mature individuals (Luebert 2010).

FLOWERING TIME. September to November.

ETYMOLOGY. The epithet *taltalense* refers to Taltal, the type locality.

VERNACULAR NAME. Palo negro, monte negro (Spanish).

USES. Recently Modak *et al.* (2009) reported antioxidant activity of the resinous exudate. It is locally used (Matancilla) as an infusion against stomach ache. Riedemann *et al.* (2006) suggest its potential use as an ornamental.

NOTES. This species is a distinct inhabitant of the coastal hills of the areas around Taltal and Paposo. According to Johnston (1928b), *Heliotropium krauseanum* could be considered a variety of the present species, but they differ in flower size and indument and have different geographic ranges. Phylogenetic analyses (Luebert & Wen 2008) resolve *H. taltalense* and *H. krauseanum* in different grades. On the other hand, Reiche (1907, 1910)

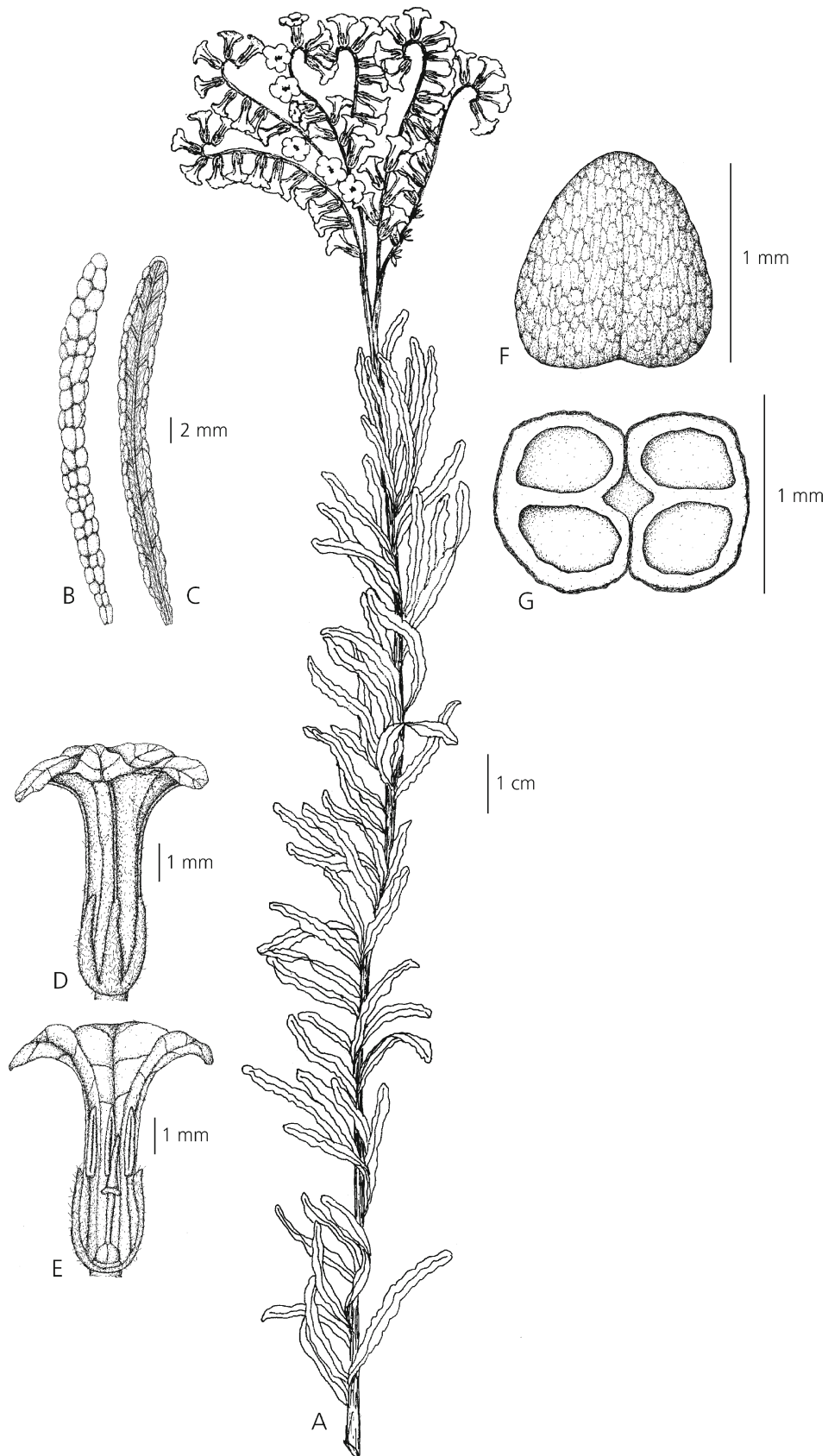


Fig. 8. *Heliotropium taltalense*. A flowering branch; B leaf, adaxial surface; C leaf, abaxial surface; D flower, outer view; E flower, opened out; F fruit, dorsal view; G fruit, t.s. All from Luebert *et al.* 2083 (BSB). DRAWN BY ANJA SALCHOW.



Map 6. Distribution of *Heliotropium taltalense*.

considered *H. sinuatum* as falling into the variability of *H. taltalense* (treated as *H. rugosum* Phil.). Although the latter two species are phylogenetically closely related (Luebert & Wen 2008), I concur with Johnston (1928b) in treating them apart (Luebert & Pinto 2004, see discussion under *H. sinuatum*).

In the protologue of *Heliotropium rugosum* (Philippi 1860a) two localities are mentioned: Hueso Parado and Paposo. Although the species certainly occurs in both localities, no material collected by R. A. Philippi in the former has been found in SGO nor in any other herbarium. Muñoz (1960) cites only one specimen (SGO 54381), which is considered the holotype, in accordance with Förther (1998). The photo F neg. no. 17347 (ex B) of *H. rugosum* at US has an annotation of I. M. Johnston 'not a type', which is certainly erroneous. Förther (1998) cites a possible isotype of *H. rugosum* at BM as well as a photo F neg. no. 31913 (ex W) at US, which are not to be found there.

7. *Heliotropium krauseanum* Fedde (1906: 72) subsp. *krauseanum*; Johnston (1928b: 28); Macbride (1960: 561); Ferreyra (1961: 111); Brako & Zarucchi (1993: 220); Förther (1998: 202); Galán de Mera *et al.* (2003: 331); Weigend *et al.* (2003); Luebert & Pinto (2004). Type: Peru, Depto. Arequipa, prope Mollendo, in saxosis, 50 – 100 m, Oct., A. Weberbauer 1552 (holotype

B† [photo F neg. no. 17327: F, GH, NY, US]); Peru, Depto. Arequipa, Mollendo, beach at Sta. Catarindo, 17°0'S, 72°1'W, 3 m, 3 Dec. 2006, M. Ackermann & F. Cáceres 630 (epitype USM, selected here; isoeptypes BSB, F, HUSA, M). Replacement name for *Heliotropium saxatile*. *Heliotropium saxatile* K. Krause (1906: 633), **nom. illegit.**, non Brandege (1905: 218). Type as above.

Erect shrubs, 0.5 – 1.5 m tall, profusely branched, densely foliose to the apex. *Stems* and *foliage* glutinous. *Leaves* alternate, solitary or grouped in fascicles of up to 17 leaves, sessile, linear-oblong to oblong, 10 – 55 (– 60) × 1.2 – 9 (– 10.5) mm; lamina glutinous, pubescent on both sides, sparsely strigose on the adaxial surface, tomentose on the abaxial surface, dark-green or dark greyish-green, margin sinuate, revolute, base attenuated, apex obtuse, with the main and secondary veins conspicuous, the latter forked toward the margin. *Inflorescences* terminal, elongate, dichotomously branched, to c. 5 cm long. *Flowers* sessile or shortly pedicellate, alternate, erect, aromatic. *Calyx* cylindrical, pale green; calyx lobes linear, free or fused only at the base, sparsely hirsute outside, glabrous or sparsely hirsute within, 1.5 – 3 × 0.3 – 1 mm, free portion 1.5 – 3 mm long, apex acute. *Corolla* infundibuliform, hispid outside, dull white with yellow throat; limb horizontally spreading, 2.5 – 5 mm wide, lobes rounded; tube longer than the calyx, 2.5 – 4.5 (– 6) mm long. *Stamens* included or exerted at late anthesis; filaments adnate to petals; anthers linear-lanceolate, glabrous, base cordate, apex acute, 1 – 1.5 mm long, overlapping the stigmatic head or above it. *Ovary* glabrous, subglobose, c. 0.5 mm diam., with a basal nectar ring. *Style* glabrous, 0.5 – 0.9 mm long, longer than the stigmatic head. *Stigmatic head* conic, bilobate and sometimes papillose at the apex, 0.3 – 0.7 × 0.3 – 0.7 mm. *Fruits* dry, ellipsoid, rugose, glabrous, light brown, c. 0.5 – 1 × 0.9 – 1.2 mm diam., falling apart at maturity into two 2-seeded nutlets, each c. 0.7 × 1 mm diam. Figs 2G, 3G and 9.

DISTRIBUTION. Coastal range of the Departments of Tacna, Moquegua and Arequipa in southern Peru (Johnston 1928b; Macbride 1960; Ferreyra 1961; Galán de Mera *et al.* 2003; Weigend *et al.* 2003). Two outliers have recently been found in the Andean foothills of the province of Yauyos, Department of Lima, Peru (Weigend *et al.* 2003) and in the coast of the province of Tamarugal, Región de Tarapacá, Chile, 12°37' – 19°37'S (Luebert & Pinto 2004). This is the only species of section *Cochranea* that ranges into Peru (Map 7).

SPECIMENS EXAMINED. PERU. Depto. Lima, Prov. Yauyos: Road from Yauyos to Imperial, km. 25.7 after Yauyos, 12°37'18"S, 75°58'4"W, 1700 m, 8 Oct. 2002, Weigend, Ackermann, Cano & La Torre 7316 (BSB, F, K, M, MA); Road from Huancayo to San Vicente de Cañete, 161 km from Huancayo, 12°38'39"S, 75°58'33"W, 1734 m, 22 Sept. 2001, Weigend & Skrabal 5887 (BSB, NY); Road

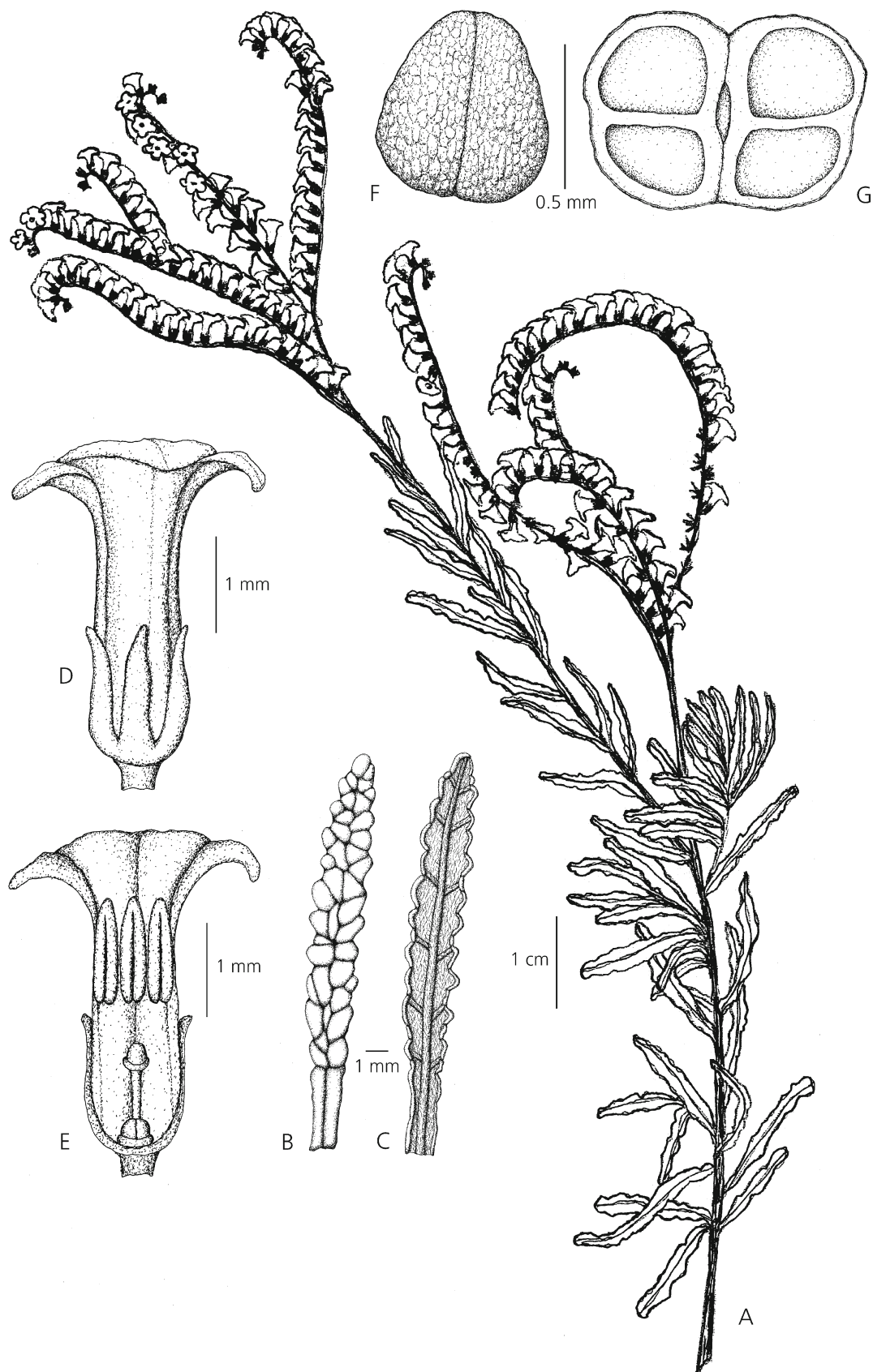
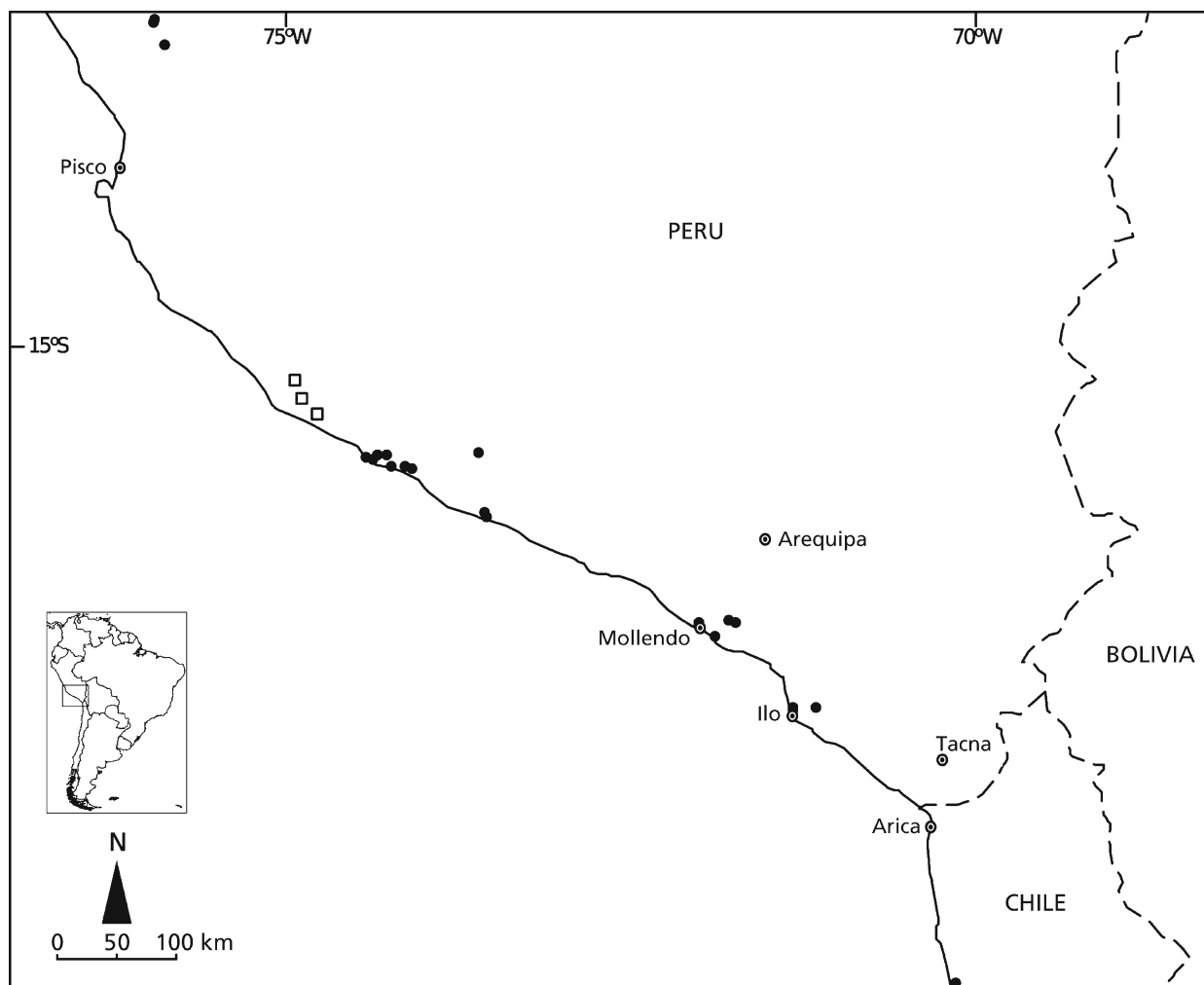


Fig. 9. *Heliotropium krauseanum*. A flowering branch; B leaf, adaxial surface; C leaf, abaxial surface; D flower, outer view; E flower, opened out; F fruit, dorsal view; G fruit, t.s. All from *Dostert & Cáceres 1025* (BSB). DRAWN BY ANJA SALCHOW.



Map 7. Distribution of *Heliotropium krauseanum* subsp. *krauseanum* (●) and *H. krauseanum* subsp. *jahuyayense* (□).

from Pacaran to Yauyos, km 26 after Pacaran, 12°48'25"S, 75°53'40"W, 1280 m, 6 Oct. 2002, *Weigend, Ackermann, Cano & La Torre* 7202 (BSB, F, K, M, MA). Depto. Arequipa, Prov. Caravelí: Between Atiquipa and the port of Chala, 280 m, Nov. 1915, *Weberbauer* 7188 (GH, MSB); Lomas de Atiquipa, 280 – 300 m, 9 Nov. 1952, *Ferreyra* 8813 (M); 7 – 8 km N of Atiquipa, 100 – 120 m, 20 Sept. 1938, *Worth & Morrison* 15647 (F, G, GH, K); km 585 Panamericana Sur, 250 m, 3 Oct. 1997, *Weigend & Förther* 97/727 (B, F, MSB); Lomas de Okopa, between Nazca and Chala, 300 – 400 m, 11 Oct. 1955, *Ferreyra* 11485 (MSB); 628 km from Lima (Panamerican Highway) N of Puerto Chala, 250 m, July 1956, *Køie* s.n. (B, C); Lomas de Capacc, near Chala, 200 – 260 m, 10 Oct. 1956, *Ferreyra* 11925 (MSB); Quebrada Honda, c. 6 km SE of Puerto Chala, at km 655 Panamericana, 120 m, 14 Jan. 1963, *Iltis, Iltis, Ugent & Ugent* 1565 (K); 1.5 km N of Atico (= km 695.5 Panamericana Sur), 50 m, 4 Oct. 1997, *Weigend & Förther* 97/751 (B, F, MSB); Lomas de Atico, between Chala and Camaná, 5 – 15 m, 10 Nov. 1949, *Ferreyra* 6360 (MSB). Depto. Arequipa,

Prov. Islay: Lomas de Cachendo (km 1028 Panamericana Sur), 775 m, 14 Oct. 1997, *Weigend & Förther* 97/859 (B, BSB, F, MSB); Mollendo, beach at Sta. Catarindo, 17°0'S, 72°1'W, 3 m, 3 Dec. 2006, *Ackermann & Cáceres* 630 (epitype, BSB, F, HUSA, M, USM); Mejía, S of Mollendo, 183 m, 18 Sept. 1937, *Stafford* 898 (BM, K). Depto. Moquegua, Prov. Ilo: Lomas de Mostazal, c. 10 km S Ilo (km 140 on coastal road Tacna – Ilo), 100 – 200 m, 12 Oct. 1997, *Weigend & Förther* 97/826 (BSB, F, MSB); N of Ilo, 0 m, 22 Sept. 1937, *Stafford* 913 (BM, K); Ilo, 150 – 200 m, 3 Dec. 1997, *F.L.S.P* 366 (NY); Playa Huaca Luna, 17°49'12"S, 71°8'31"W, 20 m, 3 April 2005, *Aedo & Galán de Mera* 11337 (MA). **CHILE.** Región de Tarapacá, Prov. Tamarugal: Punta Pichalo Sur, 22 Sept. 2002, *Pinto* 171 (SGO).

HABITAT. Foggy coastal lomas formations, usually on sandy and rocky slopes (*Ferreyra* 1961; *Weigend et al.* 2003; *Luebert & Pinto* 2004), 0 – 780 (– 1734) m. The populations of the province of Yauyos in the Department of Lima form part of the vegetation

dominated by cacti in the dry Andean valleys, above 1200 m (Weigend *et al.* 2003).

CONSERVATION STATUS. Least concern (LC), see Luebert (2010).

FLOWERING TIME. Throughout the year provided sufficient moisture.

ETYMOLOGY. The name was dedicated to Kurt Krause, who first described this species.

NOTES. In his description of *Heliotropium saxatile*, Krause (1906) associated this species with *H. lanceolatum* Ruiz & Pav. (Ruiz & Pavón 1799) from the section *Heliothamnus*. Johnston (1928b), however, placed the former species in section *Cochranea*, which was followed by subsequent authors (Macbride 1960; Förther 1998; Weigend *et al.* 2003; Luebert & Pinto 2004) based on morphology. Molecular phylogenetic analyses (Luebert & Wen 2008; Luebert *et al.* 2011a) have shown that *H. krauseanum* is a member of section *Cochranea* and is only distantly related to section *Heliothamnus*. The type specimen of *H. krauseanum* housed at B was destroyed during the Second World War, and only a picture remains (F neg. no. 17327). After consultation with the curators of the major herbaria holding Weberbauer's specimens (F, GH, MOL, USM, WRSL; see Luteyn *et al.* 2008) no isotype seems to exist, from which a lectotype could be selected. In order to fix and stabilise the application of the name, an epitype has been therefore selected from among the collections made at the same locality of the holotype.

7a. *Heliotropium krauseanum* Fedde subsp. jahuayense Luebert, subsp. nov. a subspecies *krauseanum* differt foliis supra dense pubescentibus, nervis secundariis non furcatis. Typus: Peru, Depto. Arequipa, Prov. Caravelí, Lomas de Jahuay, c. 52 km S Nazca, near border with Depto. Ica [15°22'S, 74°54'W], 365 – 380 m, 1 Nov. 1983, *M. O. Dillon & D. Dillon* 3766 (holotypus F; isotypus MSB).

<http://www.ipni.org/urn:lsid:ipni.org:names:77125611-1>

This subspecies is superficially similar to subsp. *krauseanum*, and it is undoubtedly conspecific with it, but it differs from subsp. *krauseanum* in its densely pubescent adaxial leaf surface and in the secondary nerves not forked. Conversely, subsp. *krauseanum* has the adaxial leaf surface only sparsely strigose (Weigend *et al.* 2003) and the secondary veins are clearly forked. Fig. 2H.

DISTRIBUTION. Endemic to the vicinity of Lomas de Jahuay (15°22'S, 74°54'W), in the north of the province of Caravelí, Depto. Arequipa, Peru (Map 7).

SPECIMENS EXAMINED. PERU. Depto. Arequipa, Prov. Caravelí: Cerro Los Cerrillos, W of Panam. Highway, 52 km S of Nazca, 15°14'S, 74°57'W, 650 m, 26 Aug. 1957, *Rahn* 116 (C, M); Lomas de Jahuay, c. 52 km S

Nazca, near border with Depto. Ica, 365 – 380 m, 1 Nov. 1983, *Dillon & Dillon* 3766 (holotype F, isotype MSB); Lomas de Jahuay, c. 15 km NW of Chaviña, 300 m, 7 Feb. 1983, *Dillon, Molau & Matekaitis* 3224 (F, K); Haway entre Nazca y Chala, 17 Nov. 1957, *Tovar* 2740 (MSB); Nazca – Chala, km 524, 17 Oct. 1946, *Ferreya* 1387 (GH); Near Jahuay, highway Lima – Chala, between Nazca and Atiquipa, km 545 – 546 highway Lima – Arequipa, 300 – 400 m, 7 Nov. 1947, *Ferreya* 2511 (F, MSB); km 545 from Lima, 23 Aug. 1948, *Scolnik* 1031 (GH); Jahuay, between Nazca and Chala, 400 m, 9 Nov. 1952, *Ferreya* 8802 (MSB); Lomas de Jahuay, 20 Dec. 1959, *Ferreya* 14011 (MSB); Jahuay, between Nazca and Chala, 300 – 400 m, 28 April 1983, *Ferreya, Cerrate & Chanco* 19775 (MSB); Lomas de Jahuay, between Nazca and Chala, 300 – 400 m, 5 Nov. 1984, *Ferreya* 20311 (MSB). Depto. Arequipa, Indefinite: Chala region, 457 m, April 1943, *Sandeman* 4019 (K).

HABITAT. Lomas formations, 300 – 500 m.

CONSERVATION STATUS. The conservation status of this subspecies has not been evaluated yet, but due to its restricted geographic range, it may be tentatively classified as endangered (EN).

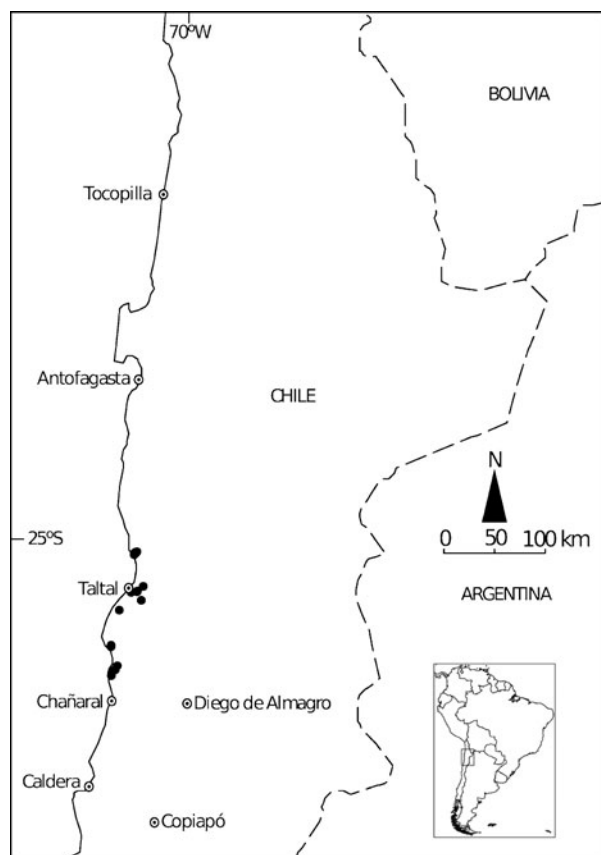
ETYMOLOGY. The name refers to the type locality.

NOTES. On the label of the paratype specimen *Sandeman* 4019, there is an annotation of I. M. Johnston 'sp. inet.'. Because of the collection date (1943), this annotation was made after Johnston published his revision of South American *Heliotropium* (Johnston 1928b) and was therefore not included in his treatment. Furthermore, all collections found were gathered after Johnston's revision.

8. *Heliotropium inconspicuum* Reiche (1907: 245; 1910: 203); Johnston (1928b: 28); Marticorena (1968: 44); Förther (1998: 200). Type: Chile, Región de Antofagasta, Prov. Antofagasta, Breas in desierto Atacama, 1888, *A. Larrañaga* s.n. (holotype SGO 54431 [fragm. GH, photo F, GH, MSB, NY, US]). Replacement name for *Cochranea parviflora*.

Cochranea parviflora Phil. (Philippi 1895: 350), non *Heliotropium parviflorum* L. (Linnaeus 1771: 201). Type as above.

Erect shrubs, 0.3 – 1 m tall, profusely branched, densely foliose to the apex. *Stems* and *foliage* glutinous. *Leaves* alternate, solitary or grouped in fascicles of up to 11 leaves, sessile or with short petiole, linear-oblongate to linear-spathulate, 4 – 10 × 0.7 – 2 mm; lamina glutinous, pubescent on both sides, sparsely strigose on the adaxial surface, white-tomentose on the abaxial surface, dark-green or dark greyish-green, with two white bands on the abaxial surface when dried, margin entire, revolute, base attenuate, apex obtuse, with only the main vein conspicuous. *Inflorescences* terminal, elongate, dichotomously branched, to c. 5 cm long.



Map 8. Distribution of *Heliotropium inconspicuum*.

Flowers sessile, alternate, erect. *Calyx* cylindrical, green; calyx lobes linear, glutinous, free or fused only at the base, sparsely strigose outside, glabrous within, 1 – 2 × 0.3 – 1 mm, free portion 0.8 – 2 mm long, apex acute. *Corolla* infundibuliform, hispid outside, dull white with yellow throat; limb horizontally spreading, 3 – 4 mm wide, lobes rounded; tube longer than the calyx, 2.5 – 4.5 mm long. *Stamens* included; filaments adnate to petals; anthers linear-lanceolate, glabrous, base cordate, apex acute, c. 1 mm long, overlapping the stigmatic head or above it. *Ovary* glabrous, subglobose, c. 0.5 mm diam., with a basal nectar ring. *Style* glabrous, c. 0.7 – 0.8 mm long, equal to or slightly longer than the stigmatic head. *Stigmatic head* conic, bilobate, c. 0.7 × 0.7 mm. *Fruits* dry, ellipsoid, rugose, glabrous, light brown, c. 2.5 – 3 × 4.5 mm diam., falling apart at maturity into two 2-seeded nutlets, each c. 3 × 3 mm diam. *Pollen* prolate, 28 – 30.5 × 15.5 – 18 µm. Amb lobes not deep. Endoapertures c. 3.5 µm diam., circular. Exine thickness c. 1 µm at the equator and c. 1.3 µm at the poles (from Ricardi 3122 in Marticorena 1968). Figs 2J and 3H.

DISTRIBUTION. Coastal hills of the provinces of Antofagasta (Región de Antofagasta) and Chañaral (Región de Atacama), Chile, between 25°5'S and 26°8'S (Map 8).

SPECIMENS EXAMINED. CHILE. Región de Antofagasta, Prov. Antofagasta: Quebrada Destiladora, 25°6'0.8"S, 70°26'41.9"W, 570 m, 18 Sept. 2004, Luebert, Becker & García 2095 (BSB, SGO); Quebrada Matancilla, 25°23'S, 70°23'W, 185 m, 18 Sept. 1992, Teillier, Rundel & García 2944 (F, SGO); Cerro Perales, Aguada Lora, 25°25'40.6"S, 70°26'7.8"W, 535 m, 17 Sept. 2004, Luebert, Becker & García 2081 (BSB, SGO); Quebrada de Taltal, 25°26'S, 70°29'W, 410 m, 17 Sept. 1992, Teillier, Rundel & García 2851 (F, SGO); Breas, 1888, Larrañaga s.n. (holotype SGO 54431, isotype GH); Taltal, Quebrada Setiembre, 6 Oct. 1954, Ricardi 3122 (CONC); Quebrada El Vetado, between Taltal and caleta Cifuncho, 600 m, 29 Sept. 1941, Pisano & Bravo 316 (SGO); Sierra Esmeralda, 25°52'40"S, 70°39'8.2"W, 600 m, 13 Oct. 2005, Luebert & García 2805/1199 (BSB); Sierra Esmeralda, road to Caleta Guanillos, 25°53'24.2"S, 70°39'11.2"W, 200 m, 13 Oct. 2005, Luebert & García 2783/1177 (BSB, SGO). Región de Atacama, Prov. Chañaral: Near Aguada Grande, 1925, Johnston 5810 (GH); Sierra Las Tipias, Pan de Azúcar National Park, 26°5'S, 70°37'W, 500 m, 30 Sept. 2005, Schulz 14 (ULS); Mirador Pan de Azúcar, 26°6'29.3"S, 70°38'46.7"W, 330 m, 14 Oct. 2005, Luebert & García 2827/1221 (BSB); Pan de Azúcar National Park, Quebrada El Castillo, 26°8'S, 70°39'W, 100 – 400 m, 18 Nov. 2005, Schulz PA98 (BSB).

HABITAT. Gravelly hillsides of the coastal Atacama Desert, 100 – 780 m, where it is usually scarce or rarely locally abundant. It forms part of the coastal scrub in the fog zone, where the dominant species are *Eulychnia iquiquensis* (Cactaceae), *Euphorbia lactiflua* (Euphorbiaceae), *Balbisia peduncularis* (Ledocarpaceae), *Nolana ramosissima* I. M. Johnst. (Solanaceae), *Oxalis gigantea* Barnéoud (Oxalidaceae), among others.

CONSERVATION STATUS. Vulnerable (VU), criterion B2 (a,c), see Luebert (2010). Populations of this species are both naturally severely fragmented due to its discontinuous distribution around ravines and streamlets and subject to extreme interannual fluctuation in the number of mature individuals due to climatic variability.

FLOWERING TIME. September to November.

USES. The presence of saponin in the leaves of *Heliotropium inconspicuum* (Ricardi *et al.* 1958) may give a pharmacological potential to this species.

NOTES. An illustration of *Heliotropium inconspicuum* can be found in Finger & Teillier (2010). This species is easily recognisable on herbarium specimens by its two white bands on the abaxial leaf surface after drying (Johnston 1928b), which are not developed by any other species of section *Cochranea*. However it is frequently confounded in herbaria, even with the very different species *H. philippianum* and *H. taltalense*. Although these two species have a similar geographic range to *H. inconspicuum*, they are morphologically very different. *H. philippianum* has leaves usually > 1 cm long, while in *H. inconspicuum* the leaves are

not longer than 1 cm. *H. taltalense* also has larger leaves, the leaf surface is rugose and the margin sinuate, while *H. inconspicuum* has leaves not rugose and the margin is straight. *H. inconspicuum* has also been confounded with *H. filifolium* and *H. chenopodiaceum*, both with small leaves, but different geographic ranges. From the former it differs in having the style equal to or longer than the stigmatic head and leaves not terete (vs sessile stigmatic head and leaves terete in *H. filifolium*); from the latter it differs in its leaves with rounded apex and in having the style equal to or longer than the stigmatic head (vs acute leaves and style shorter than the stigmatic head in *H. chenopodiaceum*).

9. *Heliotropium megalanthum* I. M. Johnst. (Johnston 1928b: 35; Marticorena (1968: 44); Förther (1998: 206). Type: Chile, in prov. Coquimbo [dry valleys and hills between Huasco and Copiapó], [Sept. 1841], *T. Bridges* 1341 (lectotype BM [photo GH], selected by Johnston (1928b: 35); isolectotypes E not seen [digital photograph], K [photo SGO 2266]). Replacement name for *Cochranea corymbosa*.

Cochranea corymbosa Miers (1868: 126); Philippi (1895: 340). Type as above.

Heliotropium corymbosum (Miers) Reiche (1907: 242; 1910: 200), **nom. illegit.**, non *H. corymbosum* Ruiz & Pav. (Ruiz & Pavón 1799: 2). Type as above.

Heliotropium crassifolium Phil. (Philippi 1873: 515); Reiche (1907: 240; 1910: 198), **nom. illegit.**, non *H. crassifolium* Boiss. & Noë in Boissier (1856: 131). Type: Chile, Región de Atacama, Prov. Huasco, Huasco, Oct. 1866, *R. A. Philippi* s.n. (lectotype SGO 54364 [photo F, GH, MSB, NY, US], selected by Förther (1998: 188); isolectotypes B † [photo F neg. no. 17331: F, GH, NY, US, photo SGO 67287], GH [fragm.], SGO 54365 [photo MSB], W [photo F neg. no. 31929: F, GH, US]).

Cochranea crassifolia (Phil.) Phil. (Philippi 1895: 349). Type as for *Heliotropium crassifolium* Phil.

Decumbent shrubs, 0.09 – 0.4 m tall, with ascending branches, densely foliose to the base of the inflorescence. *Stems* and *foliage* glabrous or sparsely strigose. *Leaves* alternate, somewhat succulent, solitary or grouped in fascicles of up to 12 leaves, sessile, oblanceolate to ovate-spathulate, 13 – 44 (– 50) × 3.5 – 10.5 (– 12) mm; lamina glabrous with hirsute (pustulate) pubescence only on the margin, dark-green, margin entire, revolute, base attenuate in a pseudopetiole, apex obtuse, with only the main vein conspicuous. *Inflorescences* terminal, elongate, dichotomously branched, to c. 15 cm long. *Flowers* sessile or shortly pedicellate, alternate, erect. *Calyx* cylindrical, green; calyx lobes linear, glutinous, fused only at the base, hirsute only on the margin outside, strigose within, (2 –



Map 9. Distribution of *Heliotropium megalanthum*.

2.5 – 6.5 × 0.5 – 1 mm, free portion 3 – 6 mm long, apex acute. *Corolla* infundibuliform, sparsely strigose to glabrous outside, dull white with yellow or orange-yellow throat; limb horizontally spreading, 7.5 – 12.5 mm wide, lobes rounded; tube longer than the calyx, 6.5 – 11 mm long. *Stamens* included or exerted at late anthesis; filaments adnate to petals; anthers linear-lanceolate, glabrous, base cordate, apex acute, c. 1 mm long, overlapping the stigmatic head. *Ovary* glabrous, subglobose, c. 0.5 mm diam., with a basal nectar ring. *Style* glabrous, c. 1 – 1.5 mm long, equal to or slightly longer than the stigmatic head. *Stigmatic head* conic, elongated, bilobate, c. 1 × 0.7 mm. *Fruits* dry, ellipsoid, rugose, glabrous, pale brown to yellowish, c. 1.5 × 2 mm diam., falling apart at maturity into two 2-seeded nutlets, each c. 1.5 × 1.5 mm diam. *Pollen* prolate, 28 – 32.5 × 19.5 – 24 µm. Amb almost 3-lobate. Mesocolpi concave in the polar view. Colpiferous sides convex. Endoapertures 3 – 3.5 µm diam., contracted at the centre. Exine thickness c. 1 µm uniform in the whole of its extent (from Ricardi 2300 in Marticorena 1968). Figs 2K and 3J.

DISTRIBUTION. Littoral and interior areas of the provinces of Copiapó and Huasco (Región de Atacama, Chile), between 27°42'S and 28°38'S (Map 9). The supposed locality for *Kummerow* s.n. (Fray Jorge, Prov. Limarí) is probably wrong.

SPECIMENS EXAMINED. CHILE. Región de Atacama, Prov. Copiapó: Huasco – Copiapó, 20 – 25 km N of Totoral, Oct. 1991, *Taylor et al.* 10802 (CONC); Road to Caleta Pajonales, 27°50'10.6"S, 71°0'29.1"W, 215 m, 13 Sept. 2004, *Luebert, Becker & García* 2019 (BSB); Estancia Castilla, 380 m, Sept. 1965, *Gleisner* 54 (CONC); On road between Totoral and Bahía Totoral, 400 m, 8 Sept. 1991, *von Bohlen* 1374 (SGO). Región de Atacama, Prov. Huasco: Road from Totoral to Carrizal Bajo, 27°57'S, 71°8'W, 50 m, 20 Sept. 1991, *Arancio* 91557 (ULS); 8 km N of Carrizal Bajo, Hacienda Higuera, 20 m, 14 Nov. 1985, *Schlegel* 8021 (SGO); Valle Carrizal, near the coast, 28°6'26.4"S, 71°6'15.7"W, 55 m, 26 Sept. 2004, *Luebert & Becker* 2165 (BSB, SGO); Road to Carrizal Bajo, near Mina Oriente, 28°6'S, 71°6'W, 30 Oct. 1987, *Muñoz-Schick & Meza* 2350 (SGO); Quebrada de Carrizal, 28°6'S, 71°7'W, 350 m, 13 Oct. 1991, *Teillier, Villarroel & Torres* 2567 (SGO); Carrizal Alto, Cerro Azúcar, 28°7'S, 70°57'W, 5 Sept. 2004, *Teillier* s.n. (BSB); Between Canto de Agua and Totoral, 28°8'25.3"S, 70°52'37.4"W, 295 m, 15 Sept. 2003, *Luebert & Kritzner* 1823 (BSB); Chañarcito near Carrizal, Oct. 1885, *Philippi* s.n. (BM, GH, SGO 42219, SGO 54368, SGO 54370, US 942361, WU); Road to Carrizal Bajo near Canto del Agua, 250 m, 2 Nov. 1991, *Muñoz-Schick, Teillier & Meza* 2921 (SGO); Near Huasco, 30 m, Oct. 1966, *Jiles* 4987 (CONC); Huasco Bajo, 28°28'S, 71°11'W, 10 m, 30 Sept. 1989, *Arancio* 89614 (ULS); Lomas in front of Las Lozas, 30 m, Nov. 1956, *Ricardi & Marticorena* 3933 (CONC); 10 km E of Huasco, 28°28'S, 71°12'W, 0 m, 8 Oct. 1987, *Teillier* 913 (CONC, SGO); Freirina, Las Totoras, Sept. 1952, *Ricardi* 2194 (CONC); Vallenar, 15 Oct. 1980, *León* s.n. (ULS 605); Road to El Algarrobo mine on the W side of the hill, 2.5 km from Route 5, 28°36'36.5"S, 70°46'56.1"W, 515 m, 2 Dec. 2005, *Acosta, Guereño & Rosas* 3169 (K); Freirina, Quebrada Agua del Medio on road to Maitenes, 28°38'S, 71°2'W, 4 Sept. 2004, *Teillier* s.n. (SGO); Huasco, Oct. 1866, *Philippi* s.n. (lectotype of *Heliotropium crassifolium* Phil. SGO 54364, isolectotypes GH, SGO 54365, W, possible isolectotype GH [Herb. Philippi No. 3]); 'Coquimbo' [dry valleys and hills between Huasco and Copiapó], 1841, *Bridges* 1341 (lectotype BM, isolectotype K). Región de Coquimbo, Prov. Limarí: Fray Jorge, 300 m, Sept. 1958, *Kummerow* s.n. (CONC 41313).

HABITAT. Coastal and interior sand plains and rocky outcrops of the south-central Atacama Desert, 0 – 620 m. It forms part of the scrub vegetation dominated by *Atriplex clivicola* (Amaranthaceae), *Eulychnia breviflora* (Cactaceae), *Oxalis virgosa* (Oxalidaceae), among others. *Heliotropium megalanthum* loses almost all its

above-ground structures (i.e., flowers and leaves) in dry years, when it is not possible to recognise it.

CONSERVATION STATUS. Vulnerable (VU), criterion B2 (a,b,c). The reduced projected area of occupancy of this species is associated with an extremely fragmented distribution of populations, a predicted decline in its area of occupancy (Luebert 2010), in a zone subject to interannual climatic fluctuations that directly affect the number of mature individuals.

FLOWERING TIME. September to October, with a flowering peak in September (Vidiella *et al.* 1999).

ETYMOLOGY. The epithet *megalanthum* refers to the large flowers this species possesses.

VERNACULAR NAME. *Heliotropio amarillo* (Spanish; Riedemann 2004, erroneously cited as *Heliotropium linariifolium*).

USES. According to Riedemann (2004) and Riedemann *et al.* (2006) this species has potential as an ornamental. Johnston (1928b) considered it a beautiful plant, a characteristic probably derived from the size of its flowers and inflorescences and its yellow to orange, sometimes spreading, corolla limb.

NOTES. This species is characterised by its large flowers with a yellow to orange corolla throat and its decumbent habit. The other two decumbent species in section *Cochranea* (*Heliotropium linariifolium* and *H. eremogenum*) have strigose lamina (vs glabrous lamina with pustulate pubescence only on the margin in *H. megalanthum*), definitely orange corollas (*H. linariifolium*) or smaller flowers (*H. eremogenum*), and both are distributed north of the geographic range of *H. megalanthum*, with which they do not overlap. In its area of distribution, *H. megalanthum* might be confounded with *H. floridum*, but the latter has strigose lamina and erect habit and the style longer than the stigmatic head.

Förther (1998: 228 – 229) considers a specimen, *Bridges* 1341 at B as the holotype of *Cochranea corymbosa*. This is not possible because in the original description of Miers (1868) only two specimens from BM and K are mentioned ('in herb. Mus. Brit. et Hook.'). The necessary lectotypification was undertaken by Johnston (1928b). There is no material of this collection of *Bridges* at B, and the Field Museum negative no. 17331, cited by Förther (1998), corresponds to an isotype of *Heliotropium crassifolium* Phil.

10. *Heliotropium chenopodiaceum* (A. DC.) Clos in Gay (1849: 458); Reiche (1907: 243; 1910: 201); Johnston (1928b: 29); Marticorena (1968: 42); Arroyo *et al.* (1984: 7); Förther (1998: 206). Type: Chile, prov. Coquimbo, 1939, *Gay* s.n. (lectotype G-DC [photo F neg. no. 7768: F, GH, NY, US; photo SGO 67285], selected by Miers (1868: 132) and narrowed by Förther (1998: 231); possible isolectotypes BM, F 515900 [fragm.], G, GH, K, LE not seen, P not seen [digital photograph, mixed with *Heliotropium myosotifolium*, photo MSB]).

Heliohytum chenopodiaceum A. DC. (de Candolle 1845: 553). Type as above.

Cochranea chenopodiacea (A. DC.) Miers (1868: 132); Philippi (1895: 348). Type as above.

Heliotropium chenopodiaceum (A. DC.) Clos var. *genuinum* I. M. Johnst. (Johnston 1928b: 29), **nom. invalid.** Type as above.

Cochranea ericoidea Miers (1868: 130); Philippi (1895: 344), **synon. nov.** Type: Chile, in prov. Coquimbo [mountains near the Andes valleys of Copiapó], [Sept. 1841], *T. Bridges* 1339 (lectotype BM [fragm. + photo GH], selected by Johnston (1928b: 29); isolectotypes E not seen (digital photograph), K, P not seen [digital photograph, fragm. F 515811, photo MSB]).

Heliotropium chenopodiaceum (A. DC.) Clos. var. *ericoideum* (Miers) Reiche (1907: 244; 1910: 202); Johnston (1928b: 29); Förther (1998: 185). Type as for *Cochranea ericoidea*.

Heliotropium pearcei Phil. (Philippi 1861: 65), **synon. nov.** Type: Chile, Coquimbo, *R. Pearce* s.n. (holotype SGO 42236 [photo GH, MSB], isotypes W 1889/146459, W 1889/146462).

Cochranea pearcei (Phil.) Phil. (Philippi 1895: 352). Type as for *Heliotropium pearcei*.

Heliotropium sclerocarpum Phil. (Philippi 1873: 515); Johnston (1928b: 30); Marticorena (1968: 45); Förther (1998: 218), **synon. nov.** Type: Chile, Región de Atacama, Prov. Huasco, Huasco, Oct. 1866, *R. A. Philippi* s.n. (lectotype SGO 54348 [photo GH, MSB, NY, US], selected by Förther (1998: 218); isolectotypes B† [photo F neg. no. 17343: F, GH, NY, US], GH [fragm.], SGO 42241 [photo MSB]).

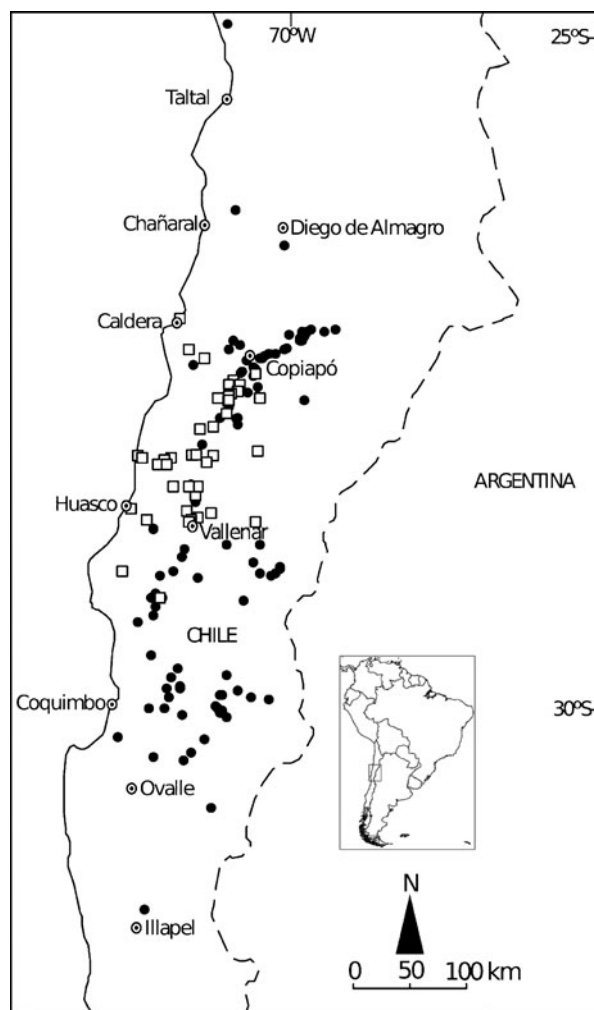
Cochranea sclerocarpa (Phil.) Phil. (Philippi 1895: 351). Type as for *Heliotropium sclerocarpum*.

Heliotropium chenopodiaceum (A. DC.) Clos var. *sclerocarpum* (Phil.) Reiche (1907: 244; 1910: 202). Type as for *Heliotropium sclerocarpum*.

?*Eritrichum glabratum* Phil. (Philippi 1891: 56), **synon. nov.** Possible type: Chile, Región de Atacama, Prov. Copiapó, Quebrada de Puquios, 1885, *F. Philippi* s.n. (SGO 54401).

Cochranea sentis Phil. (Philippi 1895: 351), **synon. nov.** Type: Chile, Región de Atacama, Prov. Copiapó, Piedra Colgada, Sept. 1885, *F. Philippi* s.n. (lectotype SGO 54434 [photo F, GH, MSB, NY], selected by Johnston (1928b: 31) and narrowed here; isolectotypes BM, GH [fragm.], SGO 42226 [photo MSB], possible isolectotype WU).

Erect shrubs, 0.2 – 0.8 (– 1) m tall, with ascending thin and reddish brown branches, densely foliose to the base of the inflorescence. *Stems* and *foliage* glabrous or hirsute, glutinous. *Leaves* alternate, solitary or, more frequently, grouped in fascicles of up to 13 leaves, sessile, linear-lanceolate, 2.5 – 12.5 × 0.5 – 2 (– 3) mm; lamina glabrous to hirsute, green or brownish-green,



Map 10. Distribution of *Heliotropium chenopodiaceum* (●) and *H. myosotifolium* (□).

margin entire, revolute, base attenuate, apex acute, with only the main vein conspicuous. *Inflorescences* terminal, elongate, dichotomously branched, to c. 5 cm long. *Flowers* sessile, alternate, erect, aromatic. *Calyx* cylindrical, green; calyx lobes linear, glutinous, fused to the half of their length, glabrous or hirsute outside, strigose within, 1 – 3.5 × 0.3 – 1 (– 1.5) mm, free portion 0.2 – 2 mm long, apex acute. *Corolla* infundibuliform, sparsely strigose, dull white with yellow throat; limb horizontally spreading, 1.5 – 4.5 (– 5.5) mm wide, lobes rounded; tube longer than the calyx, 2 – 4.5 mm long. *Stamens* included or exerted at late anthesis; filaments adnate to petals; anthers oblong-lanceolate, glabrous, base cordate, apex acute, c. 1 mm long, overlapping the stigmatic head. *Ovary* glabrous, subglobose, c. 1 mm diam., with a basal nectar ring. *Style* glabrous, c. 0.3 – 0.5 mm long, shorter than the stigmatic head. *Stigmatic head* conic, elongated, bilobate, c. 1 – 2 × 0.7 mm. *Fruits* dry, ellipsoid, dorsally sulcate, glabrous, pale

brown to yellow, c. 3×2 mm diam., falling apart at maturity into two 2-seeded nutlets, each c. 1.5×2 mm diam. Pollen prolate, $18-21 \times 13-14$ μ m. Endoapertures $3.5-4$ μ m diam., circular. Exine thickness c. 1 μ m (from Ricardi & Marticorena 3994 and 4370/955 (as 4730/955) in Marticorena 1968). Figs 2L and 3K.

DISTRIBUTION. Inland mountains and Andean foothills of the provinces of Chañaral, Copiapó, Huasco (Región de Atacama), Elqui, Limarí and Choapa (Región de Coquimbo), Chile. Together with *Heliotropium krauseanum* this is the species with the largest geographic range in section *Cochranea*, between $26^{\circ}14'S$ and $31^{\circ}30'S$ (Map 10). The northernmost collections cited by Johnston (1928b: 30, 1929: 97) from El Rincón ($24^{\circ}56'S$; Johnston 5545) and Panulcito ($24^{\circ}48'S$; Johnston 5477), isolated from the rest of the geographic range of the species, were not found at GH, and only one of them (5477) was found at W.

SPECIMENS EXAMINED. CHILE. Región de Antofagasta, Prov. Antofagasta: Aguada Panulcito, along trail to the old Andacolla mine on slopes above the water hole, 5 Dec. 1925, Johnston 5477 (W); Región de Atacama, Prov. Chañaral, Atacama, km 1000, 6 Oct. 1966, Jiles 4943 (CONC); Aguada Chañarcito, S of Diego de Almagro, 810 m, 16 Oct. 1980, Grau 2169 (M); Mineral de Coipa, Dec. 1887, Gigoux s.n. (GH). Región de Atacama, Prov. Copiapó: Caldera, Sept. 1876, Ortega s.n. (SGO 54400); Puquios, $27^{\circ}9'35.5''S$, $69^{\circ}53'10.8''W$, 1290 m, 18 Sept. 2005, Luebert & García 2501/895 (BSB, SGO); Quebrada de Puquios, Jan. 1885, Philippi s.n. (SGO 54401, possible type of *Eritrichium glabratum*); 15 km N Copiapó, road to Adrianitas off Panamerican Highway, 500 m, 18 Sept. 1987, Hannington 24 (K, SGO); road to Tinogasta, 9 km before Puquios, 1090 m, 25 Oct. 1964, Ricardi, Marticorena & Matthei 1106 (CONC, G); Quebrada San Andrés, road to Salar de Maricunga, $27^{\circ}16'27.8''S$, $70^{\circ}1'57.5''W$, 885 m, 18 Sept. 2005, Luebert & García 2510/904 (BSB); Piedra Colgada, Sept. 1885, Philippi s.n. (lectotype of *Cochranea sentis* SGO 54434, isolectotypes BM, GH [fragm.], SGO 42226, possible isolectotype WU); Mts NE of Copiapó, 300 m, 14 Sept. 1936, Montero 3000 (CONC, GH); 'Coquimbo' [mts near the Andes valleys of Copiapó], 1841, Bridges 1339 (lectotype of *Cochranea ericoidea* BM, isolectotypes F, GH, K); Paipote, 440 m, 31 Jan. 1973, Zöllner 6997 (CONC); Copiapó-Vallenar, km 10, Quebrada Cardones, 760 m, 9 Feb. 1988, Marticorena, Stuessy & Baeza 9919 (CONC); Tierra Amarilla, 500 m, Sept. 1924, Werdermann 399 (BM, CONC, F, G, GH, K, M, NY); La Puerta, 1000 m, 28 Oct. 1956, Ricardi & Marticorena 3664 (CONC); Travesía, 5 Nov. 1969, Jiles 5274 (CONC); Quebrada Cerrillos, 15 km E of Estación Checo, 700–900 m, 14 Oct. 1949, Biese 2744 (SGO); Road to Nantoco, $27^{\circ}36'48.2''S$, $70^{\circ}27'45.8''W$, 704 m, 19 Sept. 2003, Luebert & Kritznner 1865 (BSB); Quebrada de Serna,

1885, San Roman s.n. (SGO 54403); Quebrada La Rosa, 620 m, 8 Jan. 1973, Marticorena, Matthei & Quezada 601 (CONC); Chañarcillo, $27^{\circ}48'12.8''S$, $70^{\circ}24'37.1''W$, 946 m, 20 Sept. 2003, Luebert & Kritznner 1867 (BSB). Región de Atacama, Prov. Huasco: Yerba Buena, near Carrizal, [Borchers] s.n. (GH, SGO 42233, SGO 54356); Chañarcito, 26 Sept. 1885, Borchers 54 (BM); Llano Chacritas, c. 16 km N of Vallenar, $28^{\circ}25'S$, $70^{\circ}43'W$, 700 m, 2 Dec. 1987, Dillon & Teillier 5031 (F, MSB); Huasco, Oct. 1866, Philippi s.n. (lectotype of *Heliotropium sclerocarpum* SGO 54348, isolectotypes GH [fragm.], SGO 42241); 1 km N of Vallenar, $28^{\circ}32'51.4''S$, $70^{\circ}45'22.2''W$, 490 m, 19 Oct. 2005, Luebert & Becker 2907 (BSB, SGO); Vallenar, 27 Oct. 1951, Jiles 2074 (CONC, M); 5 km S of Vallenar, 9 Oct. 1958, Ricardi & Marticorena 4876/1261 (CONC); Freirina, Quebrada Agua del Medio on road to Maitenes, 4 Sept. 2004, Teillier s.n. (BSB, SGO); Road La Totorá – El Morro, km 2 from Chanchoquín, $28^{\circ}45'S$, $70^{\circ}14'W$, Feb. 2004, Teillier 5553 (BSB); 5 km N of Algarrobo, road between Vallenar and Algarrobo, 17 Sept. 1957, Looser 5783 (A, G); Llano Palacios, $28^{\circ}50'31.6''S$, $70^{\circ}49'5.9''W$, 1006 m, 20 Sept. 2003, Luebert & Kritznner 1876 (BSB); Rio Conay, 1700 m, 13 Oct. 1983, Marticorena 9544 (CONC, G); Domeyko, Quebrada de Algarrobal, 600 m, 16 Nov. 1956, Ricardi & Marticorena 3994 (CONC); Road El Tránsito – Conay, 1300 m, 12 Oct. 1991, Teillier, Villarreal & Torres 2555 (SGO); Rio Chollay, $28^{\circ}59'S$, $70^{\circ}9'W$, 1500 m, 16 Jan. 1994, Arancio, Squeo & León 94065 (CONC, ULS); Road to Las Campanas observatory, 15 km to the E after the cross, 16 Oct. 1992, Muñoz-Schick 3135 (SGO); 33 km S from San Félix, on road to Campamento El Colorado on the Proyecto Pascua (=16 km below the Campamento), $29^{\circ}9'79''S$, $70^{\circ}21'23''W$, 1850 m, 21 Oct. 1997, Egglí & Leuenberger 2988 (B, CONC, SGO); Cuesta Pajonales, 2 km N of mina Monte Cristo, $29^{\circ}9'S$, $70^{\circ}59'W$, 1220 m, 2 Dec. 1987, Dillon & Teillier 5015 (F); Between Mineral Los Cristales and La Laja, 1300 m, 22 Oct. 1971, Marticorena, Rodríguez & Weltdt 1743 (CONC); Incahuasi, 16 Sept. 1957, Ricardi & Marticorena 4370/755 (CONC); S of Incahuasi, road Vallenar – La Serena, 16 Feb. 1968, Ricardi 5547 (CONC). Región de Coquimbo, Prov. Elqui: Road Panamericana to Choros Bajos, km 3, 200 m, 21 Oct. 1971, Marticorena, Rodríguez & Weltdt 1655 (CONC); Quebrada Honda, 11 Oct. 1965, Rojas s.n. (CONC 121866); Road Condoriaco – Almirante Latorre, km 4, 1250 m, 18 Oct. 1971, Marticorena, Rodríguez & Weltdt 1532 (B, CONC); Quebrada Calvario, $29^{\circ}44'S$, $70^{\circ}29'W$, 1730 m, 17 Jan. 2000, Arancio & Squeo 12734 (ULS); Cross to La Silla observatory, 850 m, 8 Oct. 1991, Arancio 91615 (ULS); Cuesta de La Viñita, 1250 m, 21 Sept. 1957, Ricardi & Marticorena 4531/916 (CONC); Arqueros, 16 Oct. 1963, Marticorena & Matthei 317 (CONC); Arenales de Huanta, 25 km E of Rivadavia, along Rio Turbio, 1100 m, 19 Nov. 1940, Wagenknecht 18111 (CONC, G, US); Estero de

Guanta, 1500 m, 17 – 18 Jan. 1926, *Johnston* 6232 (US); Río Turbio, 22 km E of Rivadavia, Oct. 1940, *Wagenknecht* 4487 (G, GH, MSB); Road from Vicuña to Embalse La Laguna, 29°54'S, 70°18'W, 1400 m, 27 Nov. 2002, *Ehrhart* 2002/68 (M); Ruta 41 to Paso Agua Negra, km 148 after Junta de Toro, 29°55'S, 70°10'W, 2050 m, 3 Dec. 1988, *Arancio* 88382 (ULS); Rivadavia, Jan. 1904, *Reiche* 5 (GH, SGO 54355); El Molle, 5 Oct. 1966, *Jiles* 4922 (CONC); La Serena, Puerto Aereo El Pan de Azucar, 26 Sept. 1953, *Philippi* s.n. (SGO 69524); Road from Vicuña to Embalse La Laguna, km 44, Río Turbio, 1110 m, 5 Dec. 1996, *Ehrhart* & *Sonderegger* 96/1053 (MSB); Road Paihuano – Rivadavia, 28 Sept. 1948, *Behn* s.n. (CONC 26692); Paihuano, 950 m, 18 Sept. 1948, *Pfister* s.n. (CONC 8337); Quebrada San Carlos, 16 Oct. 1974, *Osorio*, *Torres*, *Villagrán* & *Gómez* s.n. (SGO 132054); Elqui valley E of Vicuña, c. 5 km below Monte Grande, 1000 m, 2 Aug. 2000, *Landrum* & *Landrum* 9848 (SGO); Puente San Guillermo along Río Claro, between Rivadavia and Monte Grande, 880 m, 14 Oct. 1940, *Looser* 4292 (CONC, G); Cerro Los Mantos, 670 m, 12 Oct. 1985, *Mahu* s.n. (SGO 102946); Tres Cruces, 1650 m, Oct. 1878, *Philippi* s.n. (SGO 42238, 54354). Región de Coquimbo, Prov. Limarí: Serón, 30 Aug. 1957, *Jiles* 3152 (CONC); Corral Quemado, Llano Los Pingos, 600 – 1000 m, 30 Oct. 1956, *Jiles* 3058 (CONC, M); Road between Fundina and Serón, 30°22'31.3"S, 70°48'22.9"W, 829 m, 15 Sept. 2005, *Luebert* & *García* 2462/856 (BSB, SGO); Colliguay, 30 Sept. 1994, *Olivares* s.n. (ULS); Los Molles, 8 Dec. 1957, *Jiles* 3348 (CONC, M); Fray Jorge, 800 – 900 m, 26 Nov. 1983, *Sepúlveda* s.n. (ULS). Región de Coquimbo, Prov. Choapa: Aucó, El Bolsico, 1100 m, 5 July 2003, *Luebert* 1736 (BSB); Aucó, Quebrada El Cuyano, 840 m, 6 July 2003, *Luebert* 1740 (BSB). Región de Coquimbo, Indefinite: Coquimbo, *Pearce* s.n. (holotype of *Heliotropium pearcei* SGO 42236, isotypes W 1889/146459, W 1889/146462); Prov. Coquimbo, 1839, *Gay* s.n. (lectotype G-DC, possible isolectotypes BM, F 515900 [fragm.], G, GH, K).

HABITAT. Rocky hillsides and sandy soils of the Andean Atacama Desert, 200 – 2250 m. *Heliotropium chenopodiaceum* is usually found in open dwarf scrubs, where it is usually dominant, especially in the northern portion of its distribution, together with *Aphyllocladus denticulatus* Cabrera, *Encelia canescens* (both Asteraceae) and *Nolana leptophylla* (Solanaceae) in the northern part, and with *Flourensia thurifera* DC. (Asteraceae), *Opuntia sphaerica* C. F. Först. (Cactaceae), *Fagonia chilensis* Hook. & Arn. (Zygophyllaceae), among others, in the southern part.

CONSERVATION STATUS. Least concern (LC), see *Luebert* (2010).

FLOWERING TIME. September to November, but with early (late) rains it can also flower from August (to January).

ETYMOLOGY. The epithet *chenopodiaceum* refers, according to de Candolle (1845), to its habit, similar to members of the Chenopodiaceae.

USES. *Riedemann et al.* (2006) suggest its potential use as an ornamental.

NOTES. *Heliotropium chenopodiaceum* is treated here in a broad sense. *Reiche* (1907, 1910), *Johnston* (1928b) and *Förther* (1998) recognised var. *ericoideum*, which differs from the typical variety in having pubescent leaves. Earlier authors (*Miers* 1868; *Philippi* 1895) treated the former variety at the species level. The geographic range of these varieties is similar. Field observations have revealed that individuals with glabrous and pubescent leaves coexist in the same geographic area and even in the same populations, making the taxonomic differentiation of *Heliotropium chenopodiaceum* var. *ericoideum* unsustainable under the present taxon concept. All names associated with specimens referable to this species with pubescent leaves have therefore been placed under the synonymy of *Heliotropium chenopodiaceum*. *Förther* (1998) considers *Bridges* 1339 (BM) as the holotype of *Cochranea ericoidea*. Since *Miers* (1868) mentions two specimens in his description, the above mentioned material must be considered a lectotype, according to *Johnston* (1928b).

Johnston (1928b) and *Förther* (1998) recognised *Heliotropium sclerocarpum* as a distinct species, in agreement with *Philippi* (1895), while *Reiche* (1907, 1910) reduced it to a variety of *H. chenopodiaceum*. The type specimen of *H. sclerocarpum* is an aberrant form of the pubescent *H. chenopodiaceum*, with lanose pubescence, but it cannot otherwise be distinguished from the latter species as here defined. The closest related species to *H. chenopodiaceum* seems to be *H. myosotifolium*, as suggested by *Johnston* (1928b). Both fall in a polytomous group in the phylogeny of *Heliotropium* sect. *Cochranea* (*Luebert* & *Wen* 2008). *H. chenopodiaceum* and *H. myosotifolium* are morphologically very similar and in some cases very difficult to distinguish from each other. *H. chenopodiaceum* tends to have smaller flowers and leaves than *H. myosotifolium*, but during rainy years, populations of the former can develop flowers and leaves that are as large as those of the latter species. The most consistent characters to differentiate these two species seems to be the calyx lobes, which are fused to half of their length in *H. chenopodiaceum* and are almost totally free in *H. myosotifolium*, and a denser pubescence in the foliage of the latter, which is not glutinous. Even so, in some geographic areas these characters seem to be very variable from one individual to another and intermediate stages are often found. The geographic areas of both species are parapatric (Map 10), and present zones of contact in the eastern portion of the geographic range of *H. myosotifolium* (alluvial plains between Vallenar and Copiapó), which coincides with

the western boundary of the geographic range of *H. chenopodiaceum*. These species probably diverged recently and may still hybridise in these areas of contact in rainy years, when the geographic range of both species is fully expressed. In dry years, flowering individuals of *H. chenopodiaceum* are restricted to the ravines of the Andean foothills, while *H. myosotifolium* does not develop any vegetative or reproductive structure. Probably as a result of the difficulty in differentiating *H. chenopodiaceum* from *H. myosotifolium*, Johnston (1928b) cited the name *Cochranea sentis* under the synonymy of *H. myosotifolium*. According to the present species concept of *H. chenopodiaceum* and to the lectotypification of *Cochranea sentis* made by Johnston (1928b), the latter name should be placed in the synonymy of *H. chenopodiaceum*, because it has the calyx lobes fused. Reiche (1907, 1910) cited *Cochranea sentis* in the synonymy of *H. chenopodiaceum* var. *filifolium* ($\equiv H. filifolium$, *C. filifolia*), which does not agree with the original description and type material of the former name (see discussion under *H. filifolium*). An additional source of confusion is the lectotypification of *C. sentis* made by Förther (1998). This author used a different syntype as the lectotype (Albert s.n., SGO 54433), a specimen that corresponds to *H. myosotifolium*. This lectotypification is superseded by Johnston's, who clearly indicated Philippi's material as the type of *C. sentis*. Since Philippi's two specimens of *C. sentis* are found at SGO, the lectotypification of Johnston (1928b) is narrowed here to the more complete of them.

Förther (1998: 231) lectotypified *Heliophytum chenopodiaceum* with the material of Gay at G-DC. Such a lectotypification had already been undertaken by Miers (1868) 120 years earlier, by segregating *Bridges* 1343, a syntype of *H. chenopodiaceum*, as the type of *Heliotropium filifolium*. Although identical, the lectotypification must therefore be attributed to Miers (1868).

Förther (1998) cites specimens at P and LE collected by Gay as isotypes of *Heliotropium chenopodiaceum*. It is not clear, however, whether these specimens are actually duplicates of the lectotype collection, since Gay was in direct contact with de Candolle (Marticorena 1995) and communicated specimens directly to him (Barros Arana 1876), at a time (1830s) that de Candolle was long settled back in Geneva (Gray 1863), so that these specimens did not necessarily go through Paris. The material at G-DC does not have indication of precise locality, nor does it have a collector number. The materials at P, however, come from a precise locality (Arqueros) and have a collector number (*C. Gay* 294). The specimens at F and GH are duplicates sent from P. The material at BM does not have a collector number but it has locality (Arqueros), so that it can also be identified with the materials at P. The materials at G and K have

neither collector number nor precise locality. I did not see the specimen at LE. Since Gay probably collected more than one specimen (there is one more specimen at SGO with the number *Gay* 1075), it is not possible to ascertain whether all the cited duplicate materials (BM, F, G, GH, K, P) correspond to the same gathering as that of G-DC.

Following Johnston (1928b), *Eritrichum glabratum* has been placed in the synonymy of *Heliotropium chenopodiaceum*. However, neither Johnston (1928b) nor Muñoz (1960) assigned any material from SGO to the former name. The specimen cited here (SGO 54401) as type of *E. glabratum*, although coincident with locality, collector and collection date, does not exactly match the description provided by Philippi (1891), and must therefore be regarded as tentative.

11. *Heliotropium myosotifolium* (A. DC.) Reiche (1907: 243; 1910: 201); Johnston (1928b: 31); Marticorena (1968: 45); Förther (1998: 208). Type: Chile, Coquimbo, [barren and stony hills between Huasco and Copiapó], [Sept. 1841], *T. Bridges* 1338 (holotype G-DC [photo SGO 11767]; isotypes BM [photo GH], E not seen digital photograph), G, GH, K [photo SGO 2262], P not seen [digital photograph, fragm. F 515813, photo MSB], W).

Heliophytum stenophyllum (Hook. & Arn.) A. DC. var. *myosotifolium* A. DC. (de Candolle 1845: 552). Type as above.

Heliotropium stenophyllum Hook. & Arn. var. *myosotifolium* (A. DC.) Clos in Gay (1849: 456). Type as above.

Cochranea myosotifolia (A. DC.) Miers (1868: 128); Philippi (1895: 343). Type as above.

Cochranea hebecula Miers (1868: 130); Philippi (1895: 343). Type: Chile, Coquimbo, *T. Bridges* s.n. (holotype BM [photo GH]; possible isotypes BM, BR not seen [digital photograph, photo + fragm. MSB], F 515813, P not seen [digital photograph], W 12891, W 1889/116389).

Cochranea hispidula Miers (1868: 132); Philippi (1895: 347). Type: In Chile boreali, *W. Lobb* 440 (holotype K; isotype BM).

Heliotropium hispidulum (Miers) Reiche (1907: 243; 1910: 201), **nom. illegit.**, non *H. hispidulum* Phil. (Philippi 1895: 356). Type as for *Cochranea hispidula*.

Heliotropium canum Phil. (Philippi 1895: 356). Type: Chile, in valle Carrizal loco dicto Yerba buena, Sept. 1885, [*A. Borchers*] s.n. (lectotype SGO 54347 [photo F, GH, MSB, NY, US], selected by Förther (1998: 189); isolectotypes B† [photo F neg. no. 17334: F, GH, NY, US], BM, GH [fragm.], K (ex Herb. Ball), K [photo SGO 2261], SGO 42222 [photo MSB], US 942362, WU).

Heliotropium hispidulum Phil. (Philippi 1895: 356). Type: Chile, Valle del Carrizal, Sept. 1885, *F.*

Philippi s.n. (holotype SGO 54345 [photo F, GH, MSB, NY, US]).

Erect shrubs, 0.1 – 0.5 m tall, with ascending thin branches, densely foliose to the base of the inflorescence. *Stems* and foliage strigose or villous, usually densely so, non-glutinous. *Leaves* alternate, solitary or grouped in fascicles of up to 10 leaves, sessile, linear to oblong-linear, 5 – 20 (– 30) × 0.7 – 2.5 (– 4) mm; lamina strigose or villous, greyish or brownish-green, margin entire, revolute, base attenuate, apex obtuse, with only the main vein conspicuous. *Inflorescences* terminal, elongate, dichotomously branched, to c. 5 cm long. *Flowers* sessile, alternate, erect, aromatic. *Calyx* cylindrical, green or greyish-green; calyx lobes linear, glutinous, fused only at the base or free, strigose on both sides, 2 – 5 × 0.5 – 0.7 mm, free portion 2 – 3 mm long, apex acute. *Corolla* infundibuliform, sparsely strigose, dull white with yellow throat; limb horizontally spreading, 5 – 7 (– 8) mm wide, lobes rounded; tube as long as the calyx, 3 – 5 mm long. *Stamens* included or exerted at late anthesis; filaments adnate to petals; anthers oblong-lanceolate, glabrous, base cordate, apex acute, c. 1 mm long, overlapping the stigmatic head. *Ovary* glabrous, subglobose, 0.5 – 1 mm diam., with a basal nectar ring. *Style* glabrous, c. 0.2 – 0.5 mm long, shorter than the stigmatic head. *Stigmatic head* conic, elongated, bilobate, c. 1.3 – 2.2 × 0.7 mm. *Fruits* dry, ellipsoid, rugose, glabrous, dark brown, falling apart at maturity into two 2-seeded nutlets. *Pollen* prolate, 22 – 23 × 11.5 – 14.5 µm. Amb 6-lobate. Endoapertures 2.5 µm diam. Exine thickness 1 µm at the mesocolpia and 1.5 µm at the apocolpia. Colpiferous sides almost parallel (from *Ricardi & Marticorena* 4393/788 in *Marticorena* 1968). Figs 2M and 3L.

DISTRIBUTION. Inland pampa of the provinces of Copiapó and Huasco, Región de Atacama, Chile, largely restricted to the plains located between the cities of Vallenar and Copiapó, between 27°30'S and 29°9'S (Map 10). The locality given in the collection of *Albert* s.n. ('Quinteros', Región de Valparaíso, Chile) is certainly erroneous.

SPECIMENS EXAMINED. CHILE. Región de Atacama, Prov. Copiapó: Bandurrias, 265 m, Sept. 1976, *Zöllner* 9075 (CONC); 2 km of Caserón, 10 Oct. 1965, *Alfaro* s.n. (CONC 121876); Panamericana km 723, S of Copiapó, 480 m, 26 Nov. 1980, *Grau* 2528 (BM); La Travesía, between Vallenar and Copiapó, 27 Oct. 1961, *Garaventa* 4396 (CONC); Quebrada Los Lirios, 2 Oct. 1997, *Muñoz-Schick* 3827 (SGO); Road between Copiapó and Vallenar, 19 Sept. 1952, *Jiles* 2175 (CONC, M); Llano de Churque, S of Copiapó, 7 Oct. 1987, *Teillier* 838 (CONC, SGO); Barros Luco, 8 Nov. 1956, *Ricardi & Marticorena* 3812 (CONC); Panamericana S of crossroad to Nantoco, 27°40'13.6"S, 70°28'15.4"W, 680 m, 25 Sept. 2004, *Luebert & Becker* 2162 (BSB, SGO); Estancia Castilla, 17 Sept. 1965, *Gleisner* 46

(CONC); Near Totoral on road to Caleta Pajonales, 27°48'32"S, 71°00'50"W, 232 m, 15 Sept. 2011, *Luebert* 3060 (BSB, SGO). Región de Atacama, Prov. Huasco: Yerba Buena, 28 Sept. 1885, [*Borchers*] s.n. (lectotype of *Heliotropium canum* SGO 54347, isolectotypes BM, GH, K, SGO 42222, US 942362, WU); Canto de Agua – Totoral, 28°4'45.2"S, 70°44'40.2"W, 330 m, 13 Sept. 2004, *Luebert, Becker & García* 2011 (BSB, SGO); Carrizal Bajo, 10 Oct. 1965, *Garaventa* 4734 (B, CONC); Quebrada Chuschampis, 480 m, 8 Jan. 1973, *Marticorena, Matthei & Quezada* 604 (CONC); Quebrada de Carrizal, 250 m, 13 Oct. 1991, *Teillier, Villarreal & Torres* 2568 (CONC, SGO); Carrizal Alto, Cerro Azucar, 5 Sept. 2004, *Teillier* s.n. (BSB); El Algarrobal, 19 Sept. 1952, *Jiles* 2179 (CONC, M); Chañarcito near Carrizal, Sept. 1885, *Philippi* s.n. (BM, GH [fragm.], K, SGO 42225, 54346 [photo F, GH, MSB, NY, US], WU); Valle de Carrizal o del Huasco, 26 Sept. 1885, [*Philippi*] s.n. (holotype of *H. hispidulum* SGO 54345); 30 km N of Vallenar, 17 Sept. 1957, *Cabrera* 12637 (K); Quebrada del Pretil, 14 Nov. 1956, *Ricardi & Marticorena* 3971 (CONC); Mina Lapingo, 28°31'S, 70°36'W, 1500 m, 31 Oct. 1991, *Arancio* 91692 (ULS); Freirina, Las Totoras, 24 Sept. 1952, *Ricardi* 2195 (CONC, M); Vallenar, Sept. 1952, *Peña* s.n. (CONC 121856, 121875); Quebrada El Morado, 23 Oct. 1971, *Marticorena, Rodríguez & Weldt* 1789 (CONC); Cuesta Pajonales, km 755, 11 Nov. 1969, *Jiles* 5507 (CONC). Región de Atacama, Indefinite: Coquimbo [barren and stony hills between Huasco and Copiapó], 1841, *Bridges* 1338 (holotype G-DC, isotypes BM, G, GH, K, W). Indefinite: 'Coquimbo', *Bridges* s.n. (holotype of *Cochranea hebecula* BM, possible isotypes BM, F 515813 [fragm.], W 1889/116389, W 12891); N Chile, *Lobb* 440 (holotype of *Cochranea hispidula* K, isotype BM); 'Quinteros', Jan. 1890, *Albert* s.n. (GH [fragm.], SGO 54433, 42248 [photo F, GH, MSB, NY]).

HABITAT. Dry inland sandy plains, subject to rain-shadow effects of the coastal mountains, 170 – 700 (– 1500) m. These areas are largely devoid of vegetation during dry years, but both woody and herbaceous plants emerge in the spring of rainy years giving rise to the so-called blooming desert. The vegetation of these areas has been studied by *Kohler* (1967, 1968). It consists of a scrub dominated by *Atriplex deserticola* Phil. (Amaranthaceae) and *Skytanthus acutus* Meyen (Apocynaceae), with a dense layer of ephemeral plants, such as *Nolana baccata* Dunal (Solanaceae) and *Cistanthe longiscapa* (Barnéoud) Carolin ex Hershk. (Portulacaceae), where *Heliotropium myosotifolium* is usually scarce.

CONSERVATION STATUS. Least concern (LC), see *Luebert* (2010).

FLOWERING TIME. September to October.

ETYMOLOGY. The epithet *myosotifolium* refers to its leaves similar to some species of the genus *Myosotis* L. (Boraginaceae).

VERNACULAR NAME. Palo negro (Spanish).

USES. Riedemann *et al.* (2006) suggest its potential use as an ornamental.

NOTES. This species is very similar to *Heliotropium chenopodiaceum* (see discussion under the latter species).

It has also sometimes been confounded with *Heliotropium floridum*, from which it is easily distinguished by its style shorter than the stigmatic head (vs style longer than the stigmatic head in *H. floridum*). The latter species has the leaves more succulent than *H. myosotifolium*, and is distributed west of the range of *H. myosotifolium*, closer to the coast.

Förther (1998) indicates the presence of two isotypes (*Bridges* 1338) housed at P. However, only one of them has a collector number. The other specimen, *Bridges* s.n., as well as the duplicate material at F (ex P), may more likely be a duplicate of the type of *Cochranea hebecula*. It is possible that these latter materials correspond to the same collection as *Bridges* 1338.

Förther (1998) selected a lectotype of *Heliotropium hispidulum* Phil. (SGO 54345). However, as already indicated by Johnston (1928b), this specimen constitutes the holotype, since it is the only one at SGO that can be associated with the description of Philippi (1895), who indicates that the material comes from 'Valle de Carrizal'. The other specimens (SGO 42225 and SGO 54346), cited by Muñoz (1960) and Förther (1998) as isotypes of *H. hispidulum* Phil., are labelled as from 'Chañarcito', as well as several duplicates of the latter at BM, GH, K and WU, which are not type specimens.

12. *Heliotropium stenophyllum* Hook. & Arn. (Hooker & Arnott 1830: 38); Steudel (1840: 744); Clos in Gay (1849: 456); Reiche (1907: 241; 1910: 199); Johnston (1928b: 33); Marticorena (1968: 47); Förther (1998: 220). Type: Chile, Región de Coquimbo, Prov. Elqui, Panamericana S of Coquimbo, *F. Luebert* & *C. Becker* 2910 (neotype SGO, selected here; isoneotype BSB).

Heliohytum stenophyllum (Hook. & Arn.) A. DC. (de Candolle 1845: 552). Type as above.

Cochranea stenophylla (Hook. & Arn.) Miers (1868: 128); Philippi (1895: 343). Type as above.

Meladendron chilense Molina (1810: 143), non *Heliotropium chilense* Bertero (1829: 647) = *H. curassavicum* L. (Linnaeus 1753: 130). Type not designated, see Förther (1998: 233).

Heliotropium rosmarinifolium Bertero ex Steud. (Steudel 1840: 744), **nomen nudum**.

Heliohytum rosmarinifolium Bertero ex A. DC. (de Candolle 1845: 552), **nomen nudum**.

Heliohytum stenophyllum (Hook. & Arn.) A. DC. var. *rosmarinifolium* DC. (de Candolle 1845: 552); Reiche (1907: 242; 1910: 200). Type: Chile, loco dicto La Calera Quillota, Oct. 1829, *C. Bertero* 1042 (holotype G-DC [photo SGO 11766]; isotypes BM, BREM not seen, F 1547440, F 515750, F 997919, FI, G, GH, HAL,

HOH not seen, KIEL not seen, L not seen, LE not seen, M, NY, P not seen (digital photograph), PR not seen, PRC not seen, TUB not seen, W).

Heliotropium stenophyllum Hook. & Arn. var. *rosmarinifolium* (DC.) Clos in Gay (1849: 456). Type as for *Heliohytum stenophyllum* var. *rosmarinifolium*.

Cochranea conferta Miers (1868: 125); Philippi (1895: 339). Type: Chile, Cuesta de Llaillay, *J. Miers* s.n. (lectotype BM, selected by Johnston 1928b: 34).

Cochranea congesta Miers (1868: 126), **nomen nudum**. Probably a typo of Miers (1868) intended to refer to *Cochranea conferta*.

Heliotropium huascoense I. M. Johnst. (Johnston 1928b: 34), **synon. nov.**; Förther (1998: 200). Type: Región de Atacama, Prov. Huasco, Huasco, 1920, *R. E. López* s.n. (holotype GH).

Erect shrubs, 0.6 – 2 m tall, with ascending branches, densely foliose to the base of the inflorescence. *Stems* and *foliage* finely strigose or glabrous, glutinous. *Leaves* alternate, solitary or grouped in fascicles of up to 20 leaves, sessile, linear to linear-spathulate, 9.5 – 35 (– 60) × 0.7 – 3 mm; lamina glabrous or finely strigose, dark green, margin entire, revolute, base attenuate, apex acute or obtuse, with only the main vein conspicuous. *Inflorescences* terminal, elongate, dichotomously branched, to c. 5 cm long. *Flowers* sessile, alternate, erect, aromatic. *Calyx* cylindrical, green or greyish-green; calyx lobes linear, fused only at the base or free, glutinous, with ciliated margins, strigose outside, glabrous or strigose within, 1 – 4.5 × 0.5 – 1 mm, free portion 1.5 – 4.5 mm long, apex acute. *Corolla* infundibuliform, sparsely strigose, dull white with yellow throat, becoming bluish at late anthesis; limb horizontally spreading, 4.5 – 9 (– 10) mm wide, lobes rounded; tube longer than the calyx, 2.5 – 7.5 mm long. *Stamens* included or exerted at late anthesis; filaments adnate to petals; anthers oblong-lanceolate, glabrous, base cordate, apex acute, c. 1.2 – 1.5 mm long, overlapping the stigmatic head. *Ovary* glabrous, subglobose, 0.4 – 0.6 mm diam., with a basal nectar ring. *Style* glabrous, c. 0.8 – 1.5 mm long, as long as or slightly shorter than the stigmatic head. *Stigmatic head* conic, elongated, bilobate, c. 1 – 1.8 × 0.7 mm. *Fruits* dry, ellipsoid, rugose, glabrous, light brown or cream, c. 2.5 × 1.5 mm diam., falling apart at maturity into two 2-seeded nutlets, c. 2 × 1.5 mm diam. *Pollen* prolate, 24.5 – 30.5 × 16.5 – 18.5 µm. Endoapertures 4 × 5 µm diam., lalongate. Exine thickness 1 µm at the mesocolpia and 1.5 µm at the apocolpia (from *Ricardi* & *Marticorena* 4332/717 in Marticorena 1968). Figs 2N, 3M and 10.

DISTRIBUTION. Coastal and inland areas of the provinces of Huasco (Región de Atacama), Elqui, Limarí, Choapa (Región de Coquimbo), Petorca, San Felipe and Quillota (Región de Valparaíso), Chile. It is

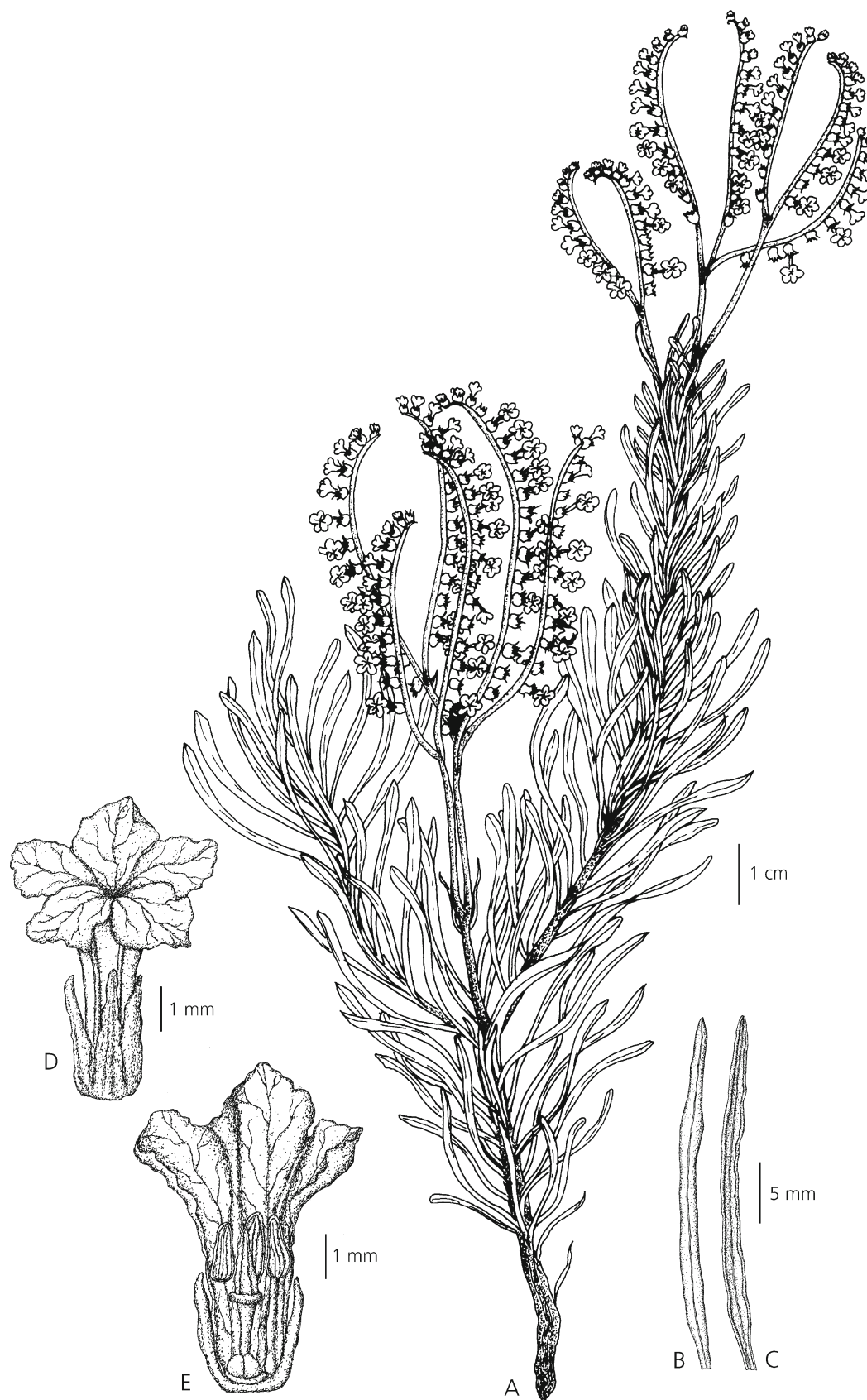


Fig. 10. *Heliotropium stenophyllum*. A flowering branch; B leaf, adaxial surface; C leaf, abaxial surface; D flower, outer view; E flower, opened out. All from Luebert & Becker 2910 (BSB). DRAWN BY GALINA KARABASCHEVA (A) AND ANJA SALCHOW (B – E).



Map 11. Distribution of *Heliotropium stenophyllum* (●) and *H. longistylum* (□).

broadly distributed between 28°28'S and 32°50'S (Map 11). It has been cited for Arica (*Jaffuel* 12), 'Concepcion' (*Caldcleugh* s.n.), Valdivia (*Bridges* 595) and even 'Perou' (s. col.), but these localities are all certainly erroneous. The material of *Bridges* at NY is probably his number 235 from the province of Quillota, whose label could have been confounded with 595. In the catalogues of the plants of *Bridges* at BM and K, number 595 actually comes from Valdivia, but the species mentioned there is not a *Heliotropium* but *Senecio otites* Kunze ex DC. (*Hooker & Arnott* 1841b).

SPECIMENS EXAMINED. CHILE. Región de Atacama, Prov. Huasco: Huasco, 1920, *López* s.n. (holotype of *Heliotropium huascoense* GH); Punta del Huasco, 28°28'7.9"S, 71°14'73.1"W, 20 m, 19 Oct. 2005, *Luebert & Becker* 2902 (BSB, SGO); Punta del Huasco, 1889, *Vidal* s.n. (SGO 54366); Las Lozas, 1 km S of Huasco, 20 Oct. 1955, *Böcher, Hjerting & Rahn* 541(C); Panamericana, Domeyko to Vallenar, 9 Oct. 1971, *Kausel* 5488 (SGO); Isla Chañaral, 115 m, 17 Nov. 2002, *Arancio* 15054 (CONC); Chañar de Aceitunas, 60 km W of Domeyko, 300 – 500 m, 8 Sept. 1949, *Biese* 2564 (SGO). Región de Coquimbo, Prov. Elqui: Isla

Damas, 29°14'S, 71°31'W, 30 m, 31 Aug. 2002, *Arancio* 14849 (CONC, ULS); Isla Choros, 29°15'S, 71°32'W, 70 m, 19 Oct. 2002, *Arancio* 14911 (ULS); Los Choros, 20 Sept. 1952, *Jiles* 2234 (CONC, M); Road to Punta Choros, 29°21'37.5"S, 71°8'22"W, 280 m, 20 Oct. 2005, *Luebert & Becker* 2908 (BSB); Panamericana frente a El Tofo, 29°28'39"S, 71°12'51.3"W, 460 m, 26 Sept. 2004, *Luebert & Becker* 2168 (BSB, SGO); Totoralillo, 150 m, 6 Dec. 1953, *Kausel* 3748 (F); Cuesta Buenos Aires, 29°33'32.3"S, 71°15'3"W, 515 m, 20 Oct. 2005, *Luebert & Becker* 2909 (BSB, SGO); c. 1 km S of Caleta Hornos, on road to La Serena, 29°38'19.4"S, 71°17'43"W, 100 – 200 m, 16 Oct. 2009, *Luebert & Danilowicz* 2985 (BSB, G, K, SGO); Cuesta de Porotitos, 26 km N of La Serena, 140 m, 29 Oct. 1990, *Lammers, Baeza & Peñailillo* 7596 (CONC, F, NY); Punta Teatinos, 10 km N of La Serena, 50 m, 15 Oct. 1940, *Looser* 4272 (G, GH); La Serena (Compañía Baja), 17 – 20 Sept. 1933, *Looser* 2901 (CONC, G, GH, M); La Serena, 29°54'S, 71°14'W, 80 m, 24 June 1957, *Schlegel* 1327 (CONC, F); Coquimbo, 1831 – 1833, *Gaudichaud* 64 (F, G-DC, K, W); Coquimbo, 100 m, Nov. 1923, *Werdermann* 120 (BM, F, GH); Coquimbo, July – Aug. 1856, *Harvey* s.n. (GH, K, lectoparatypes of *Cochranea conferta*); Vicinity of Coquimbo, Sept. 1931, *Jaffuel* 2686 (CONC, GH); Panamericana S of Coquimbo, 30°2'24.8"S, 71°22'35.8"W, 120 m, 20 Oct. 2005, *Luebert & Becker* 2910 (neotype SGO, duplicate BSB); Las Tacas, Sept. 1987, *Muñoz* s.n. (ULS); E of Huachalalume, 29°59'S, 71°11'W, 450 m, 27 Sept. 1999, *Arancio* 12075 (ULS); Coquimbo, La Herradura, 9 Aug. 1917, *Skottsberg & Skottsberg* 721 (GH, NY); Between Vicuña and La Serena, 15 Oct. 1940, *Looser* 4303 (G, GH); Vicuña, Oct. 1926, *Claude-Joseph* 4452 (US); Totoralillo bay, 30°5'S, 71°23'W, 50 m, 15 Jan. 2001, *Arancio* 14611 (ULS); Playa Las Estacas, road Coquimbo – Guanaqueros, 10 m, 29 Sept. 1984, *Landero* 508 (CONC); Lagunillas, 26 Sept. 1987, *Galindo* s.n. (ULS 1399); Between Socos and Coquimbo, km 66, Los Morrillos, 150 m, 11 Feb. 1988, *Marticoarena, Stuessy & Baeza* 9970 (CONC); Guanaqueros, *Zoellner* 6811 (CONC); Quebrada Tongocillo, 260 m, 19 Sept. 1948, *Jiles* 875 (CONC); Andacollo, 11 Oct. 1958, *Ricardi & Marticoarena* 4955/1340 (CONC); Quebrada El Romeral, 6 Oct. 1990, *Guerrero* s.n. (ULS); Tongoy, 8 Sept. 1948, *Jiles* 782 (M); Monte Redondo, 400 m, 1 Oct. 1947, *Jiles* 369 (M); Cuesta Las Cardas., 14 Sept. 1957, *Muñoz* 4165 (SGO); Between Ovalle and La Serena, 5 km N of Cuesta Las Cardas, 22 Dec. 1994, *Ehrhart & Sonderegger* 94/694 (MSB); 30 km S of Totoralillo and 58 km S of La Serena (km 421), 30°20'S, 71°24'W, 120 m, 29 Nov. 1987, *Dillon & Teillier* 4977 (F, MSB); c. 10 mi S of Tongoy, 30°30'S, 71°30'W, 30 Oct. 1991, *Taylor, von Bohlen & Marticoarena* 10634 (CONC, F). Región de Coquimbo, Prov. Limarí: Estancia Camarones, 11 Oct. 1968,

Jiles 5198 (CONC, M); Corral Quemado, 700 m, 30 Oct. 1956, *Jiles* 3116 (CONC); Samo Alto, 689 m, 25 May 2004, *Kritzner* s.n. (BSB); La Silleta, near Ovalle, 10 Sept. 1942, *Muñoz & Pisano* 3446 (SGO); Ovalle, Nov. 1928, *Barros* s.n. (CONC 121893); E of Fray Jorge, 30°38'2"S, 71°35'44.4"W, 220 m, 21 Oct. 2005, *Luebert & Becker* 2911 (BSB, SGO); Fray Jorge, 300 m, Sept. 1958, *Kummerow* s.n. (CONC 41311–41315, F 1811871); Near Fray Jorge National Park, 30°41'S, 71°40'W, 240 – 250 m, 22 Sept. 1988, *Dillon*, *Dillon & Poblete* 5428 (F, MSB); 33 km SW of Ovalle, 15 Dec. 1967, *O'Brien* 139 (SGO); El Reloj, 5 Sept. 1949, *Jiles* 1305 (CONC); Potrerillo Alto, 300 m, 21 Dec. 1976, *Valenzuela* 41–21 (EIF); Caleta El Toro, 30°43'53.3"S, 71°41'50.2"W, 0 m, 22 Oct. 2005, *Luebert & Becker* 2918 (BSB); Panamericana, 8 km N of Quebrada del Teniente, 13 Oct. 1963, *Martcorena & Matthei* 162 (CONC); Zorrilla, July 1947, *Jiles* 215 (CONC); Cuesta de Punitaqui, 13 Sept. 1948, *Behn* s.n. (CONC 8284); Talinay, 18 Sept. 1975, *Zöllner* 8352 (NY); Amolanas, Panamericana, 89 km N of Los Vilos, 13 Oct. 1963, *Martcorena & Matthei* 128 (CONC); Corral de Julio, El Silencio, 225 m, 7 Nov. 1976, *Muñoz-Schick* 951 (F, SGO). Región de Coquimbo, Prov. Choapa: Panamericana, km 296, 2 km N of crossroad to El Totoral, N of Puerto Oscuro, 100 – 200 m, 13 Oct. 2009, *Luebert & Danilowicz* 2976 (BSB, K, SGO); 2 km E of Canela Alta, 1200 m, 30 Sept. 1967, *O'Brien* 52 (SGO); Panamericana, c. 50 km N of Los Vilos near Puerto Oscuro, 15 m, 16 Sept. 1966, *Kausel* 5187 (SGO); Aucó, 580 m, 6 July 2003, *Luebert* 1752 (BSB); Rio Choapa, 9 Oct. 1965, *Montero* 7252 (CONC); Huentelauquen, 1 Oct. 1957, *Monsalve* 5 (SGO); Vicinity of Illapel, 6 Oct. 1914, *Rose & Rose* 19246 (NY, US); Cuesta Cavilolén, road Illapel to Los Vilos, 33 km, 560 m, 21 Nov. 1938, *Worth & Morrison* 16647 (GH, K); Camino Viejo, W of Salamanca, 14 Nov. 1994, *Ehrhart & Grau* 94/301 (MSB); Caleta Nague, 60 m, 23 April 1959, *Consigny* s.n. (CONC 41307); Los Vilos, 5 m, 25 Aug. 1954, *Consigny* s.n. (EIF 2955); Cerro Centinela, 27 July 1961, *Klempau* 375 (CONC); Pichidangui, 70 m, 11 Nov. 2001, *Aedo* 6834 (CONC, MA). Región de Valparaíso, Prov. Petorca: Quebrada El Chivato, S of Punta Molles, 30 m, 13 Oct. 1948, *Looser* 5518 (G, GH); On the road from San Felipe to Cabildo, c. 10 km below Cabildo, 32°26'17"S, 70°58'9"W, 314 m, 1 Oct. 2001, *Weigend, Hilger & Skrabal* 5939 (B, MSB, W); La Ligua, Valle Hermoso, 24 Sept. 1947, *Barros* 7212 (US); Palos Quemados, 400 m, 22 Jan. 1933, *Looser* s.n. (CONC 134788, G, M). Región de Valparaíso, Prov. San Felipe: Near Chagres, 410 m, 13 Nov. 1954, *Schlegel* 411 (CONC); Cuesta de Ocampo, 1862, *Philippi* s.n. (G, SGO 42245, 54395). Región de Valparaíso, Prov. Quillota: Near La Calera, Oct. 1829, *Bertero* 1042 (holotype of *Heliophytum*

stenophyllum var. *rosmarinifolium* G-DC, isotypes BM, F, G, GH, NY, possible isotypes F997919, G-DC G 00147885, NY, US 1706268, W); Cuesta Llaillay, 630 m, 8 May 2004, *Luebert & Becker* 1990 (BSB); Cuesta Llaillay, *Miers* s.n. (lectotype of *Cochranea conferta* BM); Cuesta Pachacama near Quillota, 1832, *Bridges* 235 (BM, K, W, lectoparatypes of *Cochranea conferta*); near Valparaíso, 1831, *Cuming* 377 (BM, GH, K, lectoparatypes of *Cochranea conferta*); s. loc., *Gay* s.n. (K, lectoparatype of *Cochranea conferta*).

HABITAT. Hillsides, usually on dry slopes, and sandy and rocky coastal areas, 5 – 1200 m. On the coast it is usually dominant, together with *Oxalis virgosa* (Oxalidaceae) (see *Weisser & Rundel* 1980), while in inland areas it is usually restricted to dry north-facing slopes, where it is sometimes dominant together with *Bridgesia incisifolia* Bertero ex Cambess. (Sapindaceae) *Cordia decandra* (Cordiaceae) and *Flourensia thurifera* (Asteraceae) (*Gajardo* 1978; *Etienne et al.* 1982).

CONSERVATION STATUS. Least concern (LC), see *Luebert* (2010).

FLOWERING TIME. August to November, but throughout the year provided sufficient moisture (*Olivares & Squeo* 1999).

ETYMOLOGY. The epithet *stenophyllum* refers to its narrow leaves.

VERNACULAR NAME. Palo negro, monte negro (Spanish).

USES. *Riedemann & Aldunate* (2001) and *Riedemann et al.* (2006) suggest its potential use as an ornamental. *Villarroel et al.* (1991) determined antioxidant activity of the resin exudates of *Heliotropium stenophyllum*. The leaves are locally (Pichasca) used for preparing vaginal washes.

NOTES. In the work of *Förther* (1998), *Gaudichaud* 64 is cited as the type of *Heliotropium stenophyllum*. This specimen comes from Coquimbo, Chile, the type locality given by *Hooker & Arnott* (1830), where the species actually grows. *Gaudichaud*, however, collected at Coquimbo during the expedition of l'Herminie (1831 – 1833) in 1832 (*Lasègue* 1845), two years after the description of the species. Therefore, this material cannot be part of the type. The specimens upon which the species of the Beechey's Voyage were described were collected by the naturalists *Lay* and *Collie* (*Hooker & Arnott* 1841a). The type material of *H. stenophyllum* is not to be found at the *Hooker herbarium* (now at K), at least since the 1860s (*Miers* 1868). Both the *Arnott herbarium* and part of the *Hooker herbarium* of the Beechey's voyage are now at E (*Stafleu & Cowan* 1979). However, according to *Noltie* (2010), the type specimen of *H. stenophyllum* should be regarded as missing, as is not to be found at E. A neotype has thus been selected here from modern material coming from the same locality cited by *Hooker & Arnott* (1830) and agreeing with the protologue and with the way *Hooker* applied the name to other material in his herbarium, which corresponds to the historical and current application of the name.

In his description of *Heliotropium huascoense*, Johnston (1928b) indicated that his new species is closely related to *H. stenophyllum*, but that it differs from the latter 'in its narrowly spatulate leaves, smaller corolla, shorter style, as well as more northern range'. Examination of more material reveals that none of these characters is consistent across the geographic range of both species, although the northernmost populations tend to have more spatulate leaves, but as a part of a rather gradual transition than a discrete change. Also, some specimens from the middle of the range of *H. stenophyllum* (e.g. *Luebert & Becker* 2918) also have spatulate leaves. Moreover, Johnston (1928b: 34) based his geographical differentiation of *H. huascoense* partially on the assumption that *H. sinuatum*, that was mixed in the same sheet of two paratype specimens (*Pearce* s.n. and *Lobb* 442, both K) along with material attributed to *H. huascoense*, does not occur in the region of Coquimbo, from where the mentioned specimens were labelled as coming. Modern material of *H. sinuatum* show that this assumption is false, and that what could be called *H. huascoense* occurs in the same geographic range of *H. stenophyllum* sensu Johnston (1928b). Due to this fact and the failure to consistently differentiate both species, *H. huascoense* is placed here under the synonymy of *H. stenophyllum*.

13. *Heliotropium longistylum* Phil. (Philippi 1873: 515); Reiche (1907: 240; 1910: 198); Johnston (1928b: 34); Förther (1998: 205). Type: Chile, Región de Atacama, Prov. Huasco, Carrizal Bajo, Dec. 1871, *T. King* s.n. (lectotype SGO 54363 [photo F, G, GH, MSB, NY, US], selected by Förther (1998: 205); isolectotypes GH [fragm.], K [photo SGO 2265], SGO 42221 [photo GH, MSB]). *Cochranea longistyla* (Phil.) Phil. (Philippi 1895: 349). Type as above.

Heliotropium vernicosum Phil. (Philippi 1895: 355). Type: Chile, Región de Atacama, Prov. Huasco, Carrizal Bajo, Sept. 1885, *F. Philippi* s.n. (lectotype SGO 54362 [photo F, GH, MSB, NY, US], selected by Förther (1998: 226); isolectotypes GH [fragm.], SGO 42218 [photo MSB]).

Erect shrubs, 0.4 – 1.2 m tall, with ascending branches, densely foliose to the base of the inflorescence. *Stems* and *foliage* finely strigose or glabrous, glutinous. *Leaves* alternate, solitary or grouped in fascicles of up to 12 leaves, sessile, linear to linear-elliptic, 12 – 62 × 1 – 6 (– 7) mm; lamina adaxially glabrous, sparsely pubescent abaxially, dark green, margin entire, revolute, base attenuate, apex obtuse, with only the main vein conspicuous. *Inflorescences* terminal, elongate, dichotomously branched, to c. 10 cm long. *Flowers* sessile, alternate, erect, aromatic. *Calyx* cylindrical, green or greyish-green; calyx lobes linear, fused only at the base, glutinous, with ciliated margins, strigose outside,

glabrous within, 3 – 6.5 × 0.5 – 1 mm, free portion 3.5 – 6 mm long, apex acute. *Corolla* infundibuliform, sparsely strigose, dull white with yellow throat; limb horizontally spreading, 7.5 – 12.5 mm wide, lobes rounded; tube longer than the calyx, 6 – 8.5 mm long. *Stamens* included or exerted at late anthesis; filaments adnate to petals; anthers oblong-lanceolate, glabrous, base cordate, apex acute, c. 1 – 1.2 mm long, overlapping the stigmatic head. *Ovary* glabrous, subglobose, 0.3 – 0.8 mm diam., with a basal nectar ring. *Style* glabrous, c. 1.1 – 2 mm long, longer than the stigmatic head. *Stigmatic head* conic, elongated, bilobate, c. 0.8 – 1.2 × 0.7 mm. *Fruits* dry, ellipsoid, rugose, glabrous, light brown or cream, c. 3.5 × 2 mm diam., falling apart at maturity into two 2-seeded nutlets, c. 2 × 2 mm diam. *Pollen* prolate, 21.4 – 25.1 × 16.5 – 19.3 µm (from *Ackermann* 518, BSB). Figs 2P and 3N.

DISTRIBUTION. Endemic to the coastal areas or the provinces of Copiapó and Huasco (Región de Atacama, Chile), between 27°43'S and 28°22'S (Map 11).

SPECIMENS EXAMINED. CHILE. Región de Atacama, Prov. Copiapó: Estancia Castilla, 27°43'40.5"S, 71°0'2.4"W, 92 m, 16 Sept. 2003, *Luebert & Kritzner* 1829 (BSB); Road to Caleta Pajonales, 27°50'10.6"S, 71°0'29.1"W, 215 m, 13 Sept. 2004, *Luebert, Becker & García* 2020 (BSB, SGO). Región de Atacama, Prov. Huasco: Carrizal Bajo, Quebrada Higuera, 100 m, Nov. 1985, *Schlegel* 8017 (CONC); Carrizal Bajo, Dec. 1871, *King* s.n. (lectotype SGO 54363, isolectotypes GH [fragm.], SGO 42221, possible isolectotype K); Carrizal Bajo, Sept. 1885, *Philippi* s.n. (lectotype of *Heliotropium vernicosum* SGO 54362, isolectotypes GH [fragm.], SGO 42218); Carrizal Bajo, road to Huasco, 28°5'S, 71°9'W, 10 m, 25 Sept. 1993, *Teillier, Torres & Villarreal* 3165 (SGO); Road to Mina Oriente, 28°6'51.1"S, 71°5'49.8"W, 30 m, 19 Oct. 2005, *Luebert & Becker* 2898 (BSB); Quebrada Carrizal, 28°6'45.2"S, 71°6'57.4"W, 30 m, 21 Jan. 2004, *Luebert & Torres* 1971 (BSB, SGO); Cerro Negro, Carrizal Bajo – Huasco., 28°9'S, 71°9'W, 12 Oct. 1994, *Teillier & Torres* 3905 (SGO); Punta Lobos, 28°11'6.7"S, 71°9'25.1"W, 20 m, 14 Sept. 2003, *Luebert & Kritzner* 1812 (BSB); Los Toyos on road from Carrizal Bajo to Huasco, 28°22'57"S, 71°10'44"W, 50 m, 27 Oct. 2002, *Ackermann* 518 (BSB).

HABITAT. Sandy plains, coastal rocks and ravines, always near the coast, 5 – 400 m. Usually scarce and rarely dominant, in a shrubby vegetation dominated by *Atriplex mucronata* (Amaranthaceae), *Eulychnia breviflora* (Cacataceae), *Heliotropium sinuatum* (Heliotropiaceae) and *Oxalis virgosa* (Oxalidaceae).

CONSERVATION STATUS. Endangered (EN), criterion B2 (a,b,c). The reduced projected area of occupancy of this species is associated with an extremely fragmented distribution of populations, a predicted decline in its

area of occupancy (Luebert 2010), in a zone subject to interannual climatic fluctuations that directly affect the number of mature individuals.

FLOWERING TIME. September to October.

ETYMOLOGY. The epithet *longistylum* refers to its long style.

USES. Riedemann *et al.* (2006) suggest its potential use as an ornamental.

NOTES. This species is closest to *Heliotropium stenophyllum*, from which it differs in its larger leaves and flowers, as well as in its style longer than the stigmatic head (vs style shorter than or as long as the stigmatic head in *H. stenophyllum*). *H. longistylum* is distributed north of the northernmost populations of *H. stenophyllum* (Map 11). Aberrant, small individuals of *H. longistylum* with strigose leaves can be confounded with *H. floridum*, but it can be distinguished from the latter in its glutinous foliage (vs non-glutinous in *H. floridum*). The possibility of hybridisation between *H. longistylum* and *H. floridum* cannot be ruled out, as they grow in local parapatry at some localities (e.g., Carrizal Bajo). Both species fall in an unresolved polytomous group in the phylogeny of section *Cochranea* (Luebert & Wen 2008).

14. *Heliotropium floridum* (A. DC.) Clos in Gay (1849: 457); Reiche (1907: 240; 1910: 198); Johnston (1928b: 37); Marticorena (1968: 44); Förther (1998: 195). Type: Chile, ad Coquimbo, 1839, C. Gay 1182 (holotype G-DC [photo F neg. no. 7769: F, GH, NY, US, photo SGO 67284]; isotypes GH, P not seen [digital photograph, fragm. F 515902, F 970065, photo MSB]) probable isotypes [Chili, Gay (1834 – 1842)] G, [Chili Gay] K, P not seen [digital photograph, photo MSB]). *Heliophytum floridum* A. DC. (de Candolle 1845: 553).

Type as above.

Cochranea florida (A. DC.) Miers (1868: 129). Type as above.

Heliotropium floridum (A. DC.) Clos var. *latifolium* Phil. (Philippi 1873: 516). Type: Chile, Región de Atacama, Prov. Huasco, Carrizal Bajo, Dec. 1871, T. King s.n. (lectotype SGO 54384 [photo F, GH, MSB, NY, US], selected by Förther (1998: 195); isolectotypes GH [fragm.], SGO 54385 [photo MSB], possible isolectotype K).

Erect shrubs, 0.15 – 0.8 (– 1) m tall, with ascending branches, densely foliose to the base of the inflorescence. *Stems* and *foliage* strigose. *Leaves* alternate, solitary or grouped in fascicles of up to 13 leaves, sessile, succulent linear to linear-spathulate, 6.5 – 30 (– 40) × 1 – 9.5 (– 11) mm; lamina strigose, green or greyish-green, margin entire, revolute, base attenuate, apex obtuse, with only the main vein conspicuous. *Inflorescences* terminal, elongate, dichotomously branched, congested, to c. 6 (– 9) cm long. *Flowers* sessile or shortly (< 1 mm) pedicellate, alternate, erect.



Map 12. Distribution of *Heliotropium floridum*.

Calyx cylindrical, green or brownish-green; calyx lobes linear, fused only at the base or free, strigose on both sides, 2.5 – 5.5 × 0.5 – 1.5 mm, free portion 2 – 5.5 mm long, apex acute. *Corolla* infundibuliform, sparsely strigose, dull white with yellow to orange throat, becoming bluish at late anthesis; limb horizontally spreading, 5.5 – 11.5 mm wide, lobes rounded; tube longer than the calyx, 5 – 9 mm long. *Stamens* included or exserted at late anthesis; filaments adnate to petals; anthers oblong-lanceolate, glabrous, base cordate, apex acute, c. 1.2 – 1.5 mm long, overlapping the stigmatic head. *Ovary* glabrous, subglobose, 0.4 – 0.6 mm diam., with a basal nectar ring. *Style* glabrous, c. 1.5 – 2 mm long, longer than the stigmatic head. *Stigmatic head* conic, elongate, bilobate, c. 0.7 – 1 × 0.7 mm. *Fruits* dry, ellipsoid, rugose, glabrous, brown, c. 2.5 × 1.5 mm diam., falling apart at maturity into two 2-seeded nutlets, c. 1.5 × 1.5 mm diam. Figs 1, 2Q and 3P.

DISTRIBUTION. Coastal range of the provinces of Chañaral, Copiapó, Huasco (Región de Atacama) and Elqui (Región de Coquimbo), Chile, between 26°2'S and 29°15'S (Map 12).

SPECIMENS EXAMINED. CHILE. Región de Atacama, Prov. Chañaral: Prov. Atacama, km 1031, near Las Bombas, 10 Nov. 1969, *Jiles* 5497 (M); Falda Verde, 26°17'S, 70°37'W, 100 m, 5 Nov. 2005, *Schulz* FV58 (BSB); Villa Alegre, 26°31'10.8"S, 70°41'40.1"W, 0 m, 15 Oct. 2005, *Luebert & Becker* 2838 (BSB, SGO). Región de Atacama, Prov. Copiapó: Between Caldera and Flamenco, 20 m, 14 Oct. 1991, *Teillier, Villarreal & Torres* 2591 (CONC, SGO); Bahía Obospito, Panamericana km 925, 16 Oct. 1980, *Grau* 2171 (BM, M); Caleta Mora, 15 m, 11 Oct. 1972, *Behn* s.n. (CONC 51923); Pampa Caracoles, 17 km N of Caldera, 26°57'S, 70°47'W, 100 m, 24 Sept. 1988, *Dillon, Dillon & Poblete* 5481 (F, M); Quebrada del León, 20 km N of Caldera along the coast, 150 m, 20 Oct. 1938, *Worth & Morrison* 16150 (G, K, M); Caldera, Playa Ramadas, 30 m, 19 Jan. 2004, *Luebert & Torres* 1958 (BSB); 5 km N of Caldera on road to Chañaral, 27°15'S, 70°50'W, 6 Nov. 1987, *Rechinger & Rechinger* 63446 (B, W); Desert of Atacama [Caldera], Sept. – Oct. 1890, *Morong* 1236 (F, G, K, US); Bahía Inglesa, 27°7'S, 70°54'W, 12 Nov. 1987, *Rechinger & Rechinger* 63611 (B, W, WU); Top of Morro Grande, 27°8'S, 70°56'W, 241 m, 19 Nov. 2005, *Arancio* 15228 (ULS); Caleta Los Patos, 27°10'S, 70°55'W, 49 m, 21 Nov. 2005, *Arancio* 15367 (ULS); Mina Los Fósiles, 27°9'S, 70°55'W, 92 m, 18 Dec. 2005, *Arancio* 15308 (ULS); W of Morro Chico, 27°11'S, 70°58'W, 19 m, 21 Nov. 2005, *Arancio* 15427 (ULS); Llanos, 27°14'S, 70°55'W, 90 m, 19 Dec. 2005, *Arancio* 15504 (ULS); Dunes N of Bahía Cisne, 27°19'S, 70°56'W, 102 m, 21 Nov. 2005, *Arancio* 15437 (ULS); El Caserón, road from Copiapó to Caldera, 175 m, 21 Sept. 1941, *Muñoz & Johnson* 1920 (SGO); Barranquilla, 27°30'43"S, 70°52'31.2"W, 60 m, 16 Sept. 2003, *Luebert & Kritzner* 1836 (BSB); Llano Travesía, 19 Sept. 1961, *Schlegel* 3876 (CONC); Totoral-Caldera, Cerca de Barranquilla, 27°37'39.7"S, 70°47'15.3"W, 130 m, 14 Sept. 2004, *Luebert, Becker & García* 2043 (BSB); Copiapó-Pabellón, Sept. 1885, *San Roman* s.n. (SGO 42224); Bandurrias, 1885, *Geisse* s.n. (SGO 42240, 42246); Between Totoral and Bahía Salada, 27°49'14.1"S, 71°0'8"W, 215 m, 14 Sept. 2004, *Luebert, Becker & García* 2031 (BSB, SGO). Región de Atacama, Prov. Huasco: Carrizal Bajo, Dec. 1871, *King* s.n. (lectotype of *H. floridum* var. *latifolium* SGO 54384, isolectotypes GH [fragm.] SGO 54385, possible isolectotype K); La Herradura, 28°6'8.9"S, 71°9'0.6"W, 30 m, 21 Jan. 2004, *Luebert & Torres* 1974 (BSB, SGO); Punta Lobos, 28°17'31.8"S, 71°10'37.1"W, 5 m, 14 Sept. 2003, *Luebert & Kritzner* 1810 (BSB); 11 km N of Huasco Bajo towards Carrizal Bajo (= 4 km S of Los Toyos), 28°23'38"S, 71°11'18"W, 20 – 70 m, 22 Oct. 1997, *Egglí & Leuenberger* 2997 (B, CONC, SGO); Tres Playitas, 28°24'28.1"S, 71°11'22.9"W, 20 m, 14 Sept. 2003, *Luebert & Kritzner* 1801 (BSB); Near Huasco, 17 Oct. 1955, *Böcher, Hjerting & Rahn* 481 (C); 15 km N of Vallenar, 12 Oct. 1994, *Teillier & Torres* 3902

(SGO); Isla Huacolda, 10 – 15 m, 26 Oct. 1938, *Worth & Morrison* 16232 (K); Chañaral de Aceituna, 23 Oct. 1971, *Martcorena, Rodríguez & Weldt* 1834 (CONC). Región de Atacama, Indefinite: 'Coquimbo' [sand hill desert between Copiapó and Huasco], 1841, *Bridges* 1340 (BM, G, GH, K, M). Región de Coquimbo, Prov. Elqui: Punta Choros, 5 km towards Carrizalillo, 29°12'58"S, 71°28'6"W, 9 Oct. 2002, *Moreira* 705 (SGO); Punta Choros North, 29°13'52.3"S, 71°27'33.3"W, 29 m, 13 Sept. 2003, *Luebert & Kritzner* 1761 (BSB, SGO); Prov. Coquimbo, 1836, *Gay* 1182 (holotype G-DC, isotypes F 515902 [fragm.], F 970065 [fragm.], GH, possible isotypes G, K [*C. Gay* s.n.]).

HABITAT. Coastal dunes, rocky hills and sandy plains, 0 – 270 m. In the sandy plains the vegetation is usually a scrub with columnar cacti, where *Heliotropium floridum* can be dominant together with *Atriplex clivicola* (Amaranthaceae) and *Eulychnia breviflora* (Cactaceae). In the coastal dunes it can also be dominant together with *Chuquiraga ulicina* (Hook. & Arn.) Hook. & Arn. (Asteraceae) and *Cristaria glaucophylla* Cav. (Malvaceae).

CONSERVATION STATUS. Least concern (LC), see *Luebert (2010)*.

FLOWERING TIME. September to November.

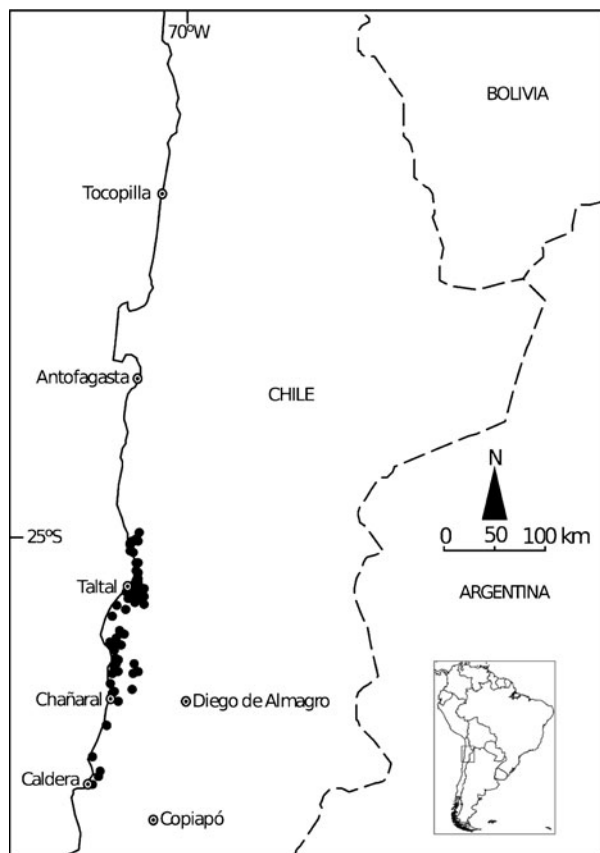
ETYMOLOGY. The epithet *floridum* refers to its congested inflorescence.

USES. *Riedemann et al. (2006)* suggest its potential use as an ornamental.

NOTES. This species might be locally confounded with *Heliotropium longistylum* and *H. megalanthum* (see discussion under these species). In herbaria it is frequently confounded with *H. linariifolium*. The latter has orange flowers and decumbent habit (vs white flowers and erect habit in *H. floridum*), but these characters are difficult to see in herbarium specimens. Both species overlap their geographic areas in the coastal range between the towns of Caldera and Chañaral, and material coming from that area is usually difficult to distinguish in herbarium specimens, unless there is indication of flower colour or habit.

Heliotropium floridum can also be confounded with *H. philippianum*, with which it does not overlap in geographic range. *H. philippianum* is distributed from Paposo (c. 25°S) northwards, while *H. floridum* occurs from Chañaral (c. 26°S) southwards. *H. philippianum* is a shrub usually taller than 0.6 m, while *H. floridum* is almost always shorter. Both species were recovered in an unresolved clade in the phylogeny of section *Cochranea* (*Luebert & Wen 2008*).

15. *Heliotropium linariifolium* Phil. (Philippi 1860a: 38; 1895: 354; Reiche (1907: 239; 1910: 197); Johnston (1928b: 37); Martcorena (1968: 44); Förther (1998: 203). Type: Chile, in regioni litorali deserti herbosa ad Cachinal de la Costa, 13 Dec. 1853, *R. A. Philippi* s.n. (lectotype SGO 42217 [photo F, GH, MSB,



Map 13. Distribution of *Heliotropium linariifolium*.

NY, US], selected by Johnston (1928b: 37); isoelectotype B† [photo F neg. no. 17329; F, GH, NY, US]).

Heliotropium linearifolium F. Phil. (Philippi 1881: 212), by mistake.

Heliotropium longiflorum Phil. (Philippi 1895: 354), **nom. illegit.**, non *H. longiflorum* (A. DC.) Jaub. & Spach (Jaubert & Spach 1852: 96, pl. 360). Type: Chile, in deserto Atacama ad Breas, 1888, A. Larrañaga s.n. (holotype SGO 54350 [photo F, GH, MSB, NY, US]; isotype SGO 54352).

Decumbent shrubs, 0.15 – 0.3 (– 0.6) m tall, with ascending branches, densely foliose to the base of the inflorescence. *Stems* and *foliage* strigose. *Leaves* alternate, solitary or grouped in fascicles of up to 13 leaves, sessile, linear to linear-spathulate, 8.5 – 40 × 1 – 5.5 mm; lamina strigose on both sides, green or greyish-green, margin entire, revolute, base attenuate, apex acute or obtuse, with only the main vein conspicuous. *Inflorescences* terminal, elongate, dichotomously branched, congested, to c. 8 (– 14) cm long. *Flowers* sessile or shortly (c. 1 mm) pedicellate, alternate, erect. *Calyx* cylindrical, green or brownish-green; calyx lobes linear, fused only at the base or free, strigose on both sides, 3 – 6 × 0.5 – 0.7 mm, free portion 2.5 – 6 mm, apex acute. *Corolla* infundibuliform, sparsely

strigose, orange; limb horizontally spreading, 5.5 – 10 mm wide, lobes rounded; tube longer than the calyx, 6 – 8.5 mm long. *Stamens* included or exerted at late anthesis; filaments adnate to petals; anthers oblong lanceolate, glabrous, base cordate, apex acute, c. 1.5 mm long, above the apex of or overlapping the stigmatic head. *Ovary* glabrous, subglobose, c. 0.4 mm diam., with a basal nectar ring. *Style* glabrous, c. 0.7 – 1.8 mm long, longer than the stigmatic head. *Stigmatic head* conic, elongate, bilobate, c. 0.5 – 1.5 × 0.5 – 0.7 mm. *Fruits* dry, ellipsoid, rugose, glabrous, brown, c. 2 × 1.5 mm diam., falling apart at maturity into two 2-seeded nutlets, c. 1.5 × 1.5 mm diam. *Pollen* prolate, 26.5 – 28 × 15 – 17 µm. Endoapertures c. 3.5 µm diam., circular or contracted at the centre. Exine thickness c. 1.3 µm. Amb lobes not deep. Colpiferous sides convex (from Ricardi 3144 in Marticorena 1968). Figs 2R and 3Q.

DISTRIBUTION. Coastal range of the provinces of Antofagasta (Región de Antofagasta), Chañaral and Copiapó (Región de Atacama), Chile, between 24°56'S and 27°4'S (Map 13). The collection locality of Zalensky XV866, given as Lago Chungará (c. 4200 m) is certainly erroneous.

SPECIMENS EXAMINED. CHILE. Región de Antofagasta, Prov. Antofagasta: Quebrada de Paposo, c. 12 km E of Caleta Paposo, 25°1'S, 70°25'W, 920 m, 7 Dec. 1987, Dillon & Teillier 5121 (F, MSB); Quebrada Los Yales, Paposo, 25 – 26 Aug. 1992, Torres s.n. (SGO 128787); Quebrada Guanillo, 18 Sept. 1941, Muñoz & Johnson 2974 (SGO); Quebrada Paposo, 650 m, 5 Sept. 1991, von Bohlen 1266 (SGO); Quebrada Matancilla, 25°6'44.7"S, 70°27'28.7"W, 300 m, 8 Oct. 2005, Luebert & García 2724/1118 (BSB); Quebrada Bandurrias, Taltal-Paposo, 80 m, 5 Oct. 1991, Quezada & Ruiz 232 (CONC); Quebrada Anchuña, 20 Sept. 1953, Ricardi 2531 (CONC); Taltal, towards La Puntilla, 1 Oct. 1940, Grandjot 4401 (CONC, SGO); Quebrada Cascabeles, 4 Oct. 1954, Ricardi 3111 (CONC); Quebrada Peralito, 16 Sept. 1953, Ricardi 2476 (CONC); Quebrada San Ramón, 10 – 100 m, 25 Sept. 1941, Pisano & Bravo 228 (SGO); 7 – 15 km N of Taltal, 25°24'S, 70°29'W, 7 Nov. 1987, Reehinger & Reehinger 63514 (B, NY, W, WU); Hueso Parado, 2 Oct. 1953, Ricardi 2705 (CONC, G); Taltal, 200 m, Oct. 1925, Werdermann 767 (B, BM, CONC, F, G, GH, K, M, NY, SGO, US); Quebrada Taltal, 9 km E of Taltal, 25°26'S, 70°35'W, 4 Oct. 1997, Teillier 647 (CONC, SGO); Breas, 1888, Larrañaga s.n. (holotype of *Heliotropium longiflorum* SGO 54350, isotype SGO 54352); c. 16 km SE of Taltal, 2 – 5 km NE of Breas, 25°29'S, 70°22'W, 590 – 610 m, 29 Oct. 1988, Dillon & Dillon 5791 (F, MSB); Quebrada Los Zanjones, 5 km SW on road (B-900) to Cifuncho, 15 km SW Taltal, 25°31'S, 70°25'W, 610 – 620 m, 25 Sept. 1988, Dillon, Dillon & Poblete 5502 (F, MSB); Taltal, Quebrada Setiembre, 6 Oct. 1954, Ricardi 3144 (CONC);

Las Tórtolas, Sierra de San Pedro, 25°33'30.3"S, 70°35'44.5"W, 170 m, 12 Oct. 2005, *Luebert & García* 2763/1157 (BSB); Cifuncho, 24 Oct. 1964, *Ricardi, Marticorena & Matthei* 1083 (CONC); Sierra Cifuncho, 25°46'12.7"S, 70°34'19.4"W, 800 m, 16 Sept. 2004, *Luebert, Becker & García* 2067A (BSB); Cifuncho to Panamericana, S crossroad from Cifuncho, 25°48'S, 70°32'W, 690 m, 8 Dec. 2002, *Ehrhart* 2002/233 (M); Aguada Cachina, 13 Dec. 1949, *Biese* 3256 (SGO); Quebrada Guanillos (10 km N of Cachinal de la Costa), 250 m, 14 Dec. 1949, *Biese* 3341 (SGO); Sierra Esmeralda, road to Esmeralda, 25°53'31.8"S, 70°33'33.2"W, 520 m, 12 Oct. 2005, *Luebert & García* 2778/1172 (BSB); Quebrada Agua Grande, between Pan de Azucar and Caleta Esmeralda, 660 m, 30 Oct. 1942, *Pisano & Bravo* 566 (CONC, SGO). Región de Atacama, Prov. Chañaral: Pan de Azúcar National Park, Las Lomitas, 2 km E of coast, 26°1'S, 70°35'W, 720 m, 12 Nov. 1997, *Dillon & Trujillo* 8020 (CONC, F, MSB, SGO); Cachinal de la Costa, Dec. 1853, *Philippi* s.n. (lectotype SGO 42217); Pan de Azucar, 26°7'55.2"S, 70°27'33.1"W, 115 m, 15 Sept. 2004, *Luebert, Becker & García* 2054 (BSB, SGO); 12 km from the coastal access to Pan de Azúcar National Park, 31 Oct. 1991, *Muñoz-Schick, Teillier & Meza* 2809 (SGO); Panamericana Las Bombas – Chañaral, km 27, 23 Oct. 1965, *Ricardi, Marticorena & Matthei* 1435 (CONC); Falda Verde, 26°17'S, 70°37'W, 350 m, 5 Nov. 2005, *Schulz* 36 (ULS); Vicinity of Puerto de Chañaral, hills back of El Barquito, 28 – 29 Oct. 1925, *Johnston* 4750 (K, W); La Ánimas, Dec. 1853, *Philippi* s.n. (SGO 54353 [photo F, GH, MSB, NY, US]); Caleta Flamenco, 26°34'12.9"S, 70°40'48.3"W, 0 m, 15 Oct. 2005, *Luebert & Becker* 2843 (BSB). Región de Atacama, Prov. Copiapó: Panamericana km 908, N of Caldera, 11 Oct. 1980, *Grau* 2089 (BM, M); Quebrada Los Leones, 26°57'17.7"S, 70°44'7.1"W, 240 m, 16 Oct. 2005, *Luebert & Becker* 2844A (BSB, SGO); Caldera, 6 Nov. 1969, *Jiles* 5306 (CONC).

HABITAT. Rocky slopes, sandy plains and gravelly streamways, out of the fog zone, 0 – 1000 (– 1300) m. It can be found at low elevations below the fog zone, high elevations above the fog zone or leeward of the coastal mountains. It is seldom dominant, although in rainy years can become very abundant. It forms part of the coastal scrubs where *Heliotropium pycnophyllum* (Heliotropiaceae), *Gypothamnium pinifolium*, *Oxyphyllum ulicinum* Phil. (both Asteraceae), and *Gymnophyton foliosum* Phil. (Apiaceae) are the dominant species. *Kohler* (1970) reports it as part of the vegetation of dunes, where *Tetragonia maritima* (Aizoaceae), *Nolana divaricata* (Lindl.) I. M. Johnst. and *N. carmosa* Miers ex Dunal (Solanaceae) are dominant.

CONSERVATION STATUS. Least concern (LC), see *Luebert* (2010).

FLOWERING TIME. September to November.

ETYMOLOGY. The epithet *linariifolium* refers to its leaves similar to species of the genus *Linaria* Mill. (Plantaginaceae).

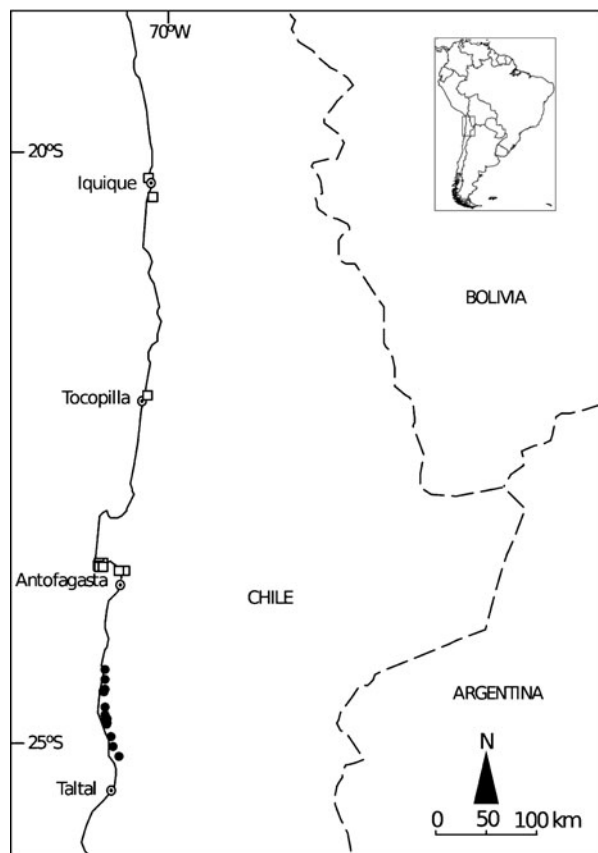
USES. *Johnston* (1928b) and *Riedemann et al.* (2006) suggest its potential use as an ornamental.

NOTES. In the protologue of *Heliotropium linariifolium*, *Philippi* (1860a) cites three syntypes, one from Miguel Díaz (SGO 42220), one from Paposo (SGO 42216, W12898), and one from Cachinal de la Costa (SGO 42217). In the protologue, the species is described as being 1.2 m tall, leaves 25 – 30 mm long, 3.7 – 4.2 mm wide, calyx 4.2 mm long, corolla white 7.5 mm long. These characters corresponds to what *Johnston* (1928b) described as *H. philippianum*, whose paratypes are the two first mentioned *Philippi* specimens. *Johnston* (1928b) lectotypified *H. linariifolium* with the material of Cachinal de la Costa, which is a decumbent shrub, not taller than 0.5 m, with orange corollas. This lectotype is therefore in conflict with the protologue and should be superseded in favour of one of the other *Philippi* specimens (Art. 9.19). In this case *H. philippianum* should be treated as synonym of *H. linariifolium*. However, such a change would contradict Art. 57.1, because the name *H. linariifolium* has been, since *Reiche* (1907), persistently applied to the species with orange flowers. The lectotypification of *Johnston* (1928b), although in conflict with the protologue of *H. linariifolium*, is here accepted. As a consequence, *H. philippianum* is the only valid name available for the species with white flowers.

Heliotropium linariifolium is easily distinguished from the other species of section *Cochranea* by its orange corollas. Since corolla colour is sometimes difficult to determine in dry material, herbarium specimens of this species can be confounded with *H. floridum* (see discussion under that species), *H. philippianum* and, sometimes, *H. eremogenum*. These four species are phylogenetically closely related (*Luebert & Wen* 2008). From the latter it clearly differs in its larger leaves, but it is otherwise very similar, thus *Johnston* (1932: 7) erroneously cited material of *H. eremogenum* from Iquique as *H. linariifolium*. From *H. philippianum*, herbarium specimens are almost indistinguishable when there is no indication of flower colour or habit. *H. philippianum* is an erect shrub with white flowers, while *H. linariifolium* is a decumbent shrub with orange flowers. This is particularly problematic in the area around Paposo, where both species occur.

16. *Heliotropium philippianum* I. M. Johnst. (*Johnston* 1928b: 36); *Förther* (1998: 212). Type: Chile, Región de Antofagasta, Prov. Antofagasta, Vicinity of Paposo, hill directly back of Punta Grande, 29 Nov. 1925, I. M. *Johnston* 5233 (holotype GH; isotypes E not seen (digital photograph), K [photo SGO 2267], US 1495296).

Erect or subscaudent shrub, 0.6 – 1.5 (– 2) m tall, with ascending branches, densely foliose to the base of the inflorescence. *Stems* and *foliage* strigose. *Leaves* alternate, solitary or grouped in fascicles of up to 8 leaves,



Map 14. Distribution of *Heliotropium philippianum* (●) and *H. eremogenum* (□).

sessile, linear-spathulate, linear-elliptic or elliptic, 5 – 30 × 1 – 6 mm; lamina strigose on both sides, green or greyish-green, margin entire, revolute, base attenuate, apex acute or obtuse, with the main vein conspicuous and the secondary veins sometimes visible. *Inflorescences* terminal, elongate, dichotomously branched, congested, to c. 5 cm long. *Flowers* sessile or shortly (< 1 mm) pedicellate, alternate, erect, aromatic. *Calyx* cylindrical, green or brownish-green; calyx lobes linear, free, strigose outside, glabrous or strigose within, (1.5 –) 3.5 – 5 × 0.1 – 1 (– 2) mm, free portion 3.5 – 5 mm long, apex acute. *Corolla* infundibuliform, sparsely strigose, white with orange or yellow throat; limb horizontally spreading, 5.5 – 9 mm wide, lobes rounded; tube longer than the calyx, 4 – 7.5 mm long. *Stamens* included or exerted at late anthesis; filaments adnate to petals; anthers oblong-lanceolate, glabrous, base cordate, apex acute, c. 1 – 1.5 mm long, above the apex of or overlapping the stigmatic head. *Ovary* glabrous, subglobose, c. 0.6 mm diam., with a basal nectar ring. *Style* glabrous, c. 1.8 – 2.5 mm long, longer than the stigmatic head. *Stigmatic head* conic, elongated, bilobate, c. 1.5 – 2 × 0.7 mm. *Fruits* dry, ellipsoid, smooth or rugose, glabrous, brown, c. 2 × 1.5 mm diam., falling apart at maturity into two 2-seeded nutlets, c. 1 × 1.5 mm diam. *Pollen* prolate, c. 20.5 –

22.1 × 10.6 – 12.5 μm (from Luebert *et al.* 2124, BSB). Figs 2S and 3R.

DISTRIBUTION. Endemic to the coastal range of the area between Paposo and Blanco Encalada (province of Antofagasta, Región de Antofagasta, Chile), between 24°26'S and 25°6'S (Map 14).

SPECIMENS EXAMINED. CHILE. Región de Antofagasta, Prov. Antofagasta: Quebrada Blanco Encalada, 50 – 250 m, 11 Dec. 1949, *Biese* 3131 (SGO); 10 km S of Caleta Blanco Encalada, 200 – 800 m, 11 Dec. 1949, *Biese* 3194 (SGO); Miguel Díaz, 23 Dec. 1853, *Philippi* s.n. (SGO 42220 [photo F, GH, MSB, NY, US]); Vicinity of Aguada Miguel Díaz, 1 – 4 Dec. 1925, *Johnston* 5415 (GH); Quebrada La Plata, 300 m, 6 Oct. 1991, *Quezada & Ruiz* 274 (CONC, G); Vicinity of Aguada Cardón, 30 Nov. 1925, *Johnston* 5294 (GH, US); Aguada Panul, 24°47'42.1"S, 70°31'50.3"W, 215 m, 7 Oct. 2005, *Luebert & García* 2672/1066 (BSB); Aguada Panulcito, 24°47'55.7"S, 70°31'36.6"W, 345 m, 19 Sept. 2004, *Luebert, Becker & García* 2124 (BSB, SGO); Quebrada El Médano, near the waterhole, 24°49'43.9"S, 70°31'11.7"W, 300 – 400 m, 23 Oct. 2009, *Luebert & Moreira* 3003 (BSB, G, SGO); Quebrada La Rinconada, c. 5 km N of Paposo, 24°56'S, 70°29'W, 500 m, 18 Nov. 1997, *Dillon, Trujillo & Villarroel* 8065 (CONC, F, MSB, SGO); Paposo, 19 Dec. 1853, *Philippi* s.n. (SGO 42216 [photo F, GH, MSB, NY, US], W 12898); Vicinity of Paposo; hill directly back of Punta Grande, 29 Nov. 1925, *Johnston* 5233 (holotype GH, isotypes K, US).

HABITAT. Gravelly and rocky hillsides and gravelly stream-ways of the fog zone, never dominant. It forms part of the coastal scrub typically dominated by *Euphorbia lactiflua* (Euphorbiaceae) and *Eulychnia iquiquensis* (Cactaceae) (Johnston 1929; Luebert & Pliscoff 2006).

CONSERVATION STATUS. Critically endangered (CR), according to the criterion of extent of occurrence (B1(a,c), IUCN 2001). Populations are severely fragmented due to the presence of unsuitable areas out of the fog zone, occurrence of landslides and roads. The zone is subject to extreme interannual climatic fluctuations that cause the death of mature individuals during dry periods. This species is distributed in an area that bears priority for biodiversity conservation in Chile, but so far no protected area has been officially established (Pliscoff & Fuentes-Castillo 2011). Current and historical threats are mostly goat grazing and trampling associated with human settlements and mining, but human population density in the area and the accessibility is very low (Paposo, the largest village in the area, has a stable population of c. 300 people).

FLOWERING TIME. September to November.

ETYMOLOGY. The epithet *philippianum* honours Rodulfo A. Philippi, the first collector of the species.

NOTES. Finger & Teillier (2010) provide an illustration of a flowering branch. This species is morphologically similar and probably closely related to *Heliotropium floridum*, *H. linariifolium* and *H. eremogenum*. See discussion under the two former species. From *H. eremogenum*, this species differs in its generally longer leaves, erect habit (vs decumbent habit in *H. eremogenum*) and more southerly geographic range (Map 14).

17. *Heliotropium eremogenum* I. M. Johnst. (Johnston 1937: 20); Förther (1998: 192). Type: Región de Antofagasta, Prov. Antofagasta, Antofagasta, 29 Oct. 1930, F. Jaffuel 1120 (holotype GH).

Decumbent shrubs, 0.1 – 0.3 m tall, with ascending branches, densely foliose to the base of the inflorescence. *Stems* and *foliage* strigose. *Leaves* alternate, solitary or grouped in fascicles of up to 5 leaves, sessile, linear-oblongate or linear-elliptic, 2 – 6.5 × 1 – 2 mm; lamina strigose, green or greyish-green, margin entire, revolute, base attenuate, apex acute, with only the main vein conspicuous. *Inflorescences* terminal, elongate, dichotomously branched, congested, to c. 3 cm long. *Flowers* sessile, alternate, erect. *Calyx* cylindrical, green or brownish-green; calyx lobes linear, free, strigose outside, glabrous or strigose within, (1 –) 2.5 – 3.5 (– 4.5) × 0.5 – 0.7 mm, free portion 2.5 – 3.5 mm long, apex acute. *Corolla* infundibuliform, sparsely strigose, white with yellow throat; limb horizontally spreading, 5 – 7 mm wide, lobes rounded; tube longer than the calyx, 4.5 – 6 mm long. *Stamens* included or exerted at late anthesis; filaments adnate to petals; anthers oblong-lanceolate, glabrous, base cordate, apex acute, 1.5 – 2 mm long, above the apex of or overlapping the stigmatic head. *Ovary* glabrous, subglobose, c. 0.6 mm diam., with a basal nectar ring. *Style* glabrous, c. 1.5 – 2.5 mm long, longer than the stigmatic head. *Stigmatic head* conic, elongate, bilobate, c. 1 – 2 × 0.7 mm. *Fruits* dry, ellipsoid, smooth or rugose, glabrous, brown, c. 1.5 × 1 mm diam., falling apart at maturity into two 2-seeded nutlets, c. 0.7 × 1 mm diam. *Pollen* prolate, 21.5 – 24.8 × 11.3 – 12 µm (from Luebert & García 2575/969, BSB). Figs 2T and 3S.

DISTRIBUTION. Endemic to the coastal range of the area of Antofagasta (Cerro Moreno – La Chimba, 23°28'S – 23°39'S, province of Antofagasta, Región de Antofagasta, Chile), with two isolated stations in the surroundings of Tocopilla (22°3'S, province of Tocopilla, Región de Antofagasta, Chile) and Iquique (20°13'S – 20°22'S, province of Iquique, Región de Tarapacá, Chile) (Map 14). The locality of the collection of Kuschel s.n. (Putre) is very doubtful. A search of the database of SGO showed that Kuschel actually collected in La Chimba just before his trip to

Putre. It is therefore very likely that this specimen was erroneously labelled.

SPECIMENS EXAMINED. CHILE. Región de Tarapacá, Prov. Iquique: Iquique, Dec. 1913, Salinas s.n. (GH); Punta Gruesa, 20°22'41"S, 70°7'53"W, 1015 m, 23 Sept. 2004, Luebert, Becker, García & Pinto 2159 (SGO). Región de Antofagasta, Prov. Tocopilla: Quebrada La Higuera, N of Tocopilla, 22°3'6"S, 70°10'34"W, 150 m, 29 Sept. 2005, Luebert & García 2566/960 (BSB). Región de Antofagasta, Prov. Antofagasta: Cerro Moreno, 23°29'19.1"S, 70°35'31"W, 670 m, 2 Oct. 2005, Luebert & García 2575/969 (BSB, SGO); Peninsula Moreno, hills W of J. López, 23°30'S, 70°33'W, 830 m, 18 Oct. 1992, Baumann 39 (CONC, ULS); Quebrada La Chimba, 300 m, 30 Sept. 1991, Quezada & Ruiz 85 (CONC, M); Antofagasta, open rocky canyon, 100 – 300 m, 3 April 1925, Pennel 13022 (NY); Antofagasta, 29 Oct. 1930, Jaffuel 1120 (holotype GH); Antofagasta, 6 Nov. 1931, Jaffuel 2639 (G, GH). Indefinite: Putre, 5 Dec. 1946, Kuschel s.n. (SGO 66193).

HABITAT. Coastal hills, on rocky slopes of the fog zone in a very arid area, between 100 – 1,020 m, where several years without rain are common. All materials from Tocopilla and Iquique are fragmentary, probably due to long periods of aridity. The vegetation corresponds to a desert scrub dominated by *Ephedra breana* (Ephedraceae), *Euplychnia iquiquensis* (Cactaceae) and *Nolana peruviana* (Gaudich.) I. M. Johnst. (Solanaceae) (Johnston 1929; Luebert et al. 2007).

CONSERVATION STATUS. Critically endangered (CR), according to the criterion of extent of occurrence (B1(a,c), IUCN 2001). This species is known from three localities (Cerro Moreno-La Chimba) in a zone under extreme interannual climatic fluctuations that affect the number of mature individuals. The area of La Chimba is currently subject to the disturbance effects of urban expansion associated with the development of the city of Antofagasta. Cerro Moreno has recently (in 2010) been put under official protection by the Chilean government. **FLOWERING TIME.** September to November.

ETYMOLOGY. The epithet *eremogenum* probably refers to the very arid areas where this species grows.

NOTES. The closest relative of this species seems to be *Heliotropium philippianum*. It is also morphologically similar and phylogenetically related to *H. floridum* and *H. linariifolium*. See discussion under these species.

This species was mentioned by Johnston in several works as an undescribed *Heliotropium* species (Johnston 1928b, 1929, 1932), until Jaffuel's material became available. Johnston (1937) suggests that the materials from Iquique and Tocopilla are closely allied to this species, but, due to its fragmentary nature, he did not include them, saying that good collections will prove that it corresponds to a different species. While such good collections have not become available yet, these populations are provisionally regarded here as part of *H. eremogenum*.

Material from Iquique was included in the phylogenetic analysis of Luebert & Wen (2008). It falls in an unresolved clade together with most species of section *Cochranea*.

Excluded Names

Cochranea anchusaefolia (Poir.) Gürke (1893: 97) ≡ *Heliotropium anchusaefolium* Poir. (Poiret 1813: 23) = *Heliotropium amplexicaule* Vahl (1794: 21) (sect. *Heliotrophytum*)

Cochranea anchusaefolia (Poir.) Görke var. *latifolia* Hicken (1910: 194) ≡ *Heliohytum anchusaefolium* (Poir.) DC. var. *latifolium* DC. (de Candolle 1845: 554) = *Heliotropium amplexicaule* Vahl (sect. *Heliotrophytum*)

Heliotropium macrostachyum (DC.) Hemsl. (Hemsley 1881 – 1882: 375) ≡ *Heliohytum macrostachyum* DC. (de Candolle 1845: 556). Johnston (1939) regarded this species as a member of section *Cochranea*. The examination of the type material (G-DC) reveals that this species has few common morphological characters with the members of section *Cochranea*. The leaves of *H. macrostachyum* are broadly elliptic c. 8 × 3 cm or larger, densely pubescent, with a petiole of c. 2 cm long, while in section *Cochranea* the leaves are usually linear or narrowly elliptic and very rarely wider than 1 cm, in which case are never densely pubescent; the leaves in *Cochranea* are at most shortly petiolate and mostly sessile. The inflorescences of *H. macrostachyum* are not, or only once-divided and up to 20 or even 30 cm long. In section *Cochranea* the inflorescences are twice or more-divided and are never longer than 15 cm. The corolla tube is villous inside and pubescent outside in *H. macrostachyum*, while in *Cochranea* it is always glabrous inside and hirsute or villous outside. The fruits of *H. macrostachyum* are apically bi-horned, globose, c. 3 mm diam., with 2 cells empty, falling into two one-seeded nutlets, while in *Cochranea* fruits are never bi-horned, usually 1 – 2 cm diam., without empty cells, and falling into two two-seeded nutlets. *H. macrostachyum* and section *Cochranea* have totally different geographic ranges, the former occurring only in Mesoamerica. Based on its morphology, *H. macrostachyum* seems rather to be a member of section *Tiaridium* of the *Tournefortia* clade of Luebert *et al.* (2011a) and its systematic placement in phylogenetic analyses remains to be seen.

Heliotropium genovefae I. M. Johnst. (Johnston 1939: 378). Johnston (1939) described this species as a member of section *Cochranea*. However it has a few or no characters that associate it with the latter section. In gross aspect it is similar to *H. macrostachyum* and the description of the fruits by Johnston (1939) apparently agree in size with the latter species,

although in *H. genovefae* there are no empty cells. I have only seen an isotype specimen (K), which bears no fruits. It probably belongs to the *Tournefortia* clade (Luebert *et al.* 2011a), perhaps to section *Tiaridium*, but it has never been included in phylogenetic analyses.

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M. T. Kalin 81667 (10); **E. Kausel** 2655 (12); 3748 (12); 3760 (12); 5066 (1); 5101 (11); 5117 (5); 5187 (12); 5463 (12); 5488 (12); SGO 109222 (10); SGO 109223 (10); SGO 80552 (14); **G. Kausel** 5095 (5); 5315 (5); **Ph. King** SGO 42238 (10); **T. King** 10 (10); GH 97636 (14); GH 97646 (13); K 583538 (14); K 583541 (13); SGO 42221 (13); SGO 54363 (13); SGO 54383 (14); SGO 54384 (14); SGO 54385 (14); **H. Klempau** 375 (12); **A. Kohler** 110 (1); 123 (14); **K. Kubitzki** 73 (12); 291 (5); **J. Kummerow** CONC 41311 (12); CONC 41312 (12); CONC 41313 (9); CONC 41314 (12); CONC 41315 (12); F 1811871 (12); **G. Kunkel** 926 (12); **O. Kuntze** F 294542 (12); US 701107 (12); **R. P. B. Kuschel** SGO 66193 (17).

T. Lammers, C. Baeza & P. Peñailillo 7596 (12); **L. Landbeck** SGO 54390 (12); **A. Landero** 508 (12); **L. Landrum & S. Landrum** 7499 (15); 7510 (12); 9828 (12); 9848 (10); **H. Larraguibel** 2 (12); 34 (12); **A. Larrañaga** GH 244228 (1); GH 97836 (8); SGO 54350 (15); SGO 54352 (15); SGO 54369 (1); SGO 54371 (1); SGO 54373 (1); SGO 54380 (6); SGO 54382 (6); SGO 54431 (8); **C. Latorre, C. Villagrán & A. Maldonado** 261 (15); **M. León** 18 (6); **X. León** ULS 605 (9); **W. Lobb** 440 (11); 442 p.p. (5); 442 p.p. (12); **G. Looser** 2895 (12); 2901 (12); 4272 (12); 4292 (10); 4303 (12); 5518 (12); 5782 (10); 5783 (10); 5785 (12); CONC 134788 (12); **López** CONC 121898 (12); **R. E. López** GH 97626 (12); **Loyola** 949 (6); 9415 (1); **F. Luebert** 1289 (5); 1732 (12); 1735 (12); 1736 (10); 1740 (10); 1752 (12); 2007 (12); 3047 (5); 3048 (2); 3051 (2); 3057 (9); 3058 (13); 3060 (11); 3061 (14); **F. Luebert & C. Becker** 1990 (12); 2161 (4); 2162 (11); 2165 (9); 2166 (2); 2167 (5); 2168 (12); 2195A (12); 2838 (14); 2843 (15); 2844A (15); 2845 (14); 2888 (14); 2894 (14); 2897 (5); 2898 (13); 2899 (5); 2901 (2);

2902 (12); 2907 (10); 2908 (12); 2909 (12); 2910 (12); 2911 (12); 2918 (12); **F. Luebert & E. Daniłowicz** 2983 (5); 2976 (12); 2985 (12); **F. Luebert & N. García** 2462/856 (10); 2487/881 (12); 2488/882 (5); 2492/886 (5); 2501/895 (10); 2508/902 (4); 2509/903 (10); 2510/904 (10); 2512/906 (10); 2566/960 (17); 2575/969 (17); 2607/1001 (1); 2614/1008 (1); 2620/1014 (1); 2641/1035 (16); 2650/1044 (6); 2656/1050 (16); 2672/1066 (16); 2677/1071 (1); 2690/1084 (8); 2694/1088 (6); 2707/1101 (8); 2723/1117 (6); 2724/1118 (15); 2731/1125 (15); 2732/1126 (1); 2754/1148 (15); 2759/1153 (1); 2763/1157 (15); 2774/1168 (15); 2778/1172 (15); 2779/1173 (1); 2783/1177 (8); 2805/1199 (8); 2806/1200 (15); 2810/1204 (1); 2813/1207 (1); 2821/1215 (15); 2827/1221 (8); **F. Luebert & L. Kritzner** 1761 (14); 1775 (14); 1780 (12); 1800 (5); 1801 (14); 1802 (5); 1809 (5); 1810 (14); 1811 (13); 1812 (13); 1815 (5); 1818 (2); 1819 (14); 1820 (2); 1821 (5); 1822 (13); 1823 (9); 1824 (5); 1825 (2); 1826 (13); 1827 (13); 1828 (5); 1829 (13); 1830 (14); 1831 (5); 1835 (14); 1836 (14); 1837 (14); 1838 (14); 1840 (14); 1843 (1); 1850 (1); 1851 (1); 1852 (4); 1857 (4); 1858 (4); 1859 (10); 1860 (10); 1865 (10); 1866 (10); 1867 (10); 1868 (5); 1872 (5); 1875 (5); 1876 (10); 1877 (5); **F. Luebert & A. Moreira** 2997 (1); 2998 (6); 3003 (16); **F. Luebert & R. Torres** 1958 (14); 1961 (1); 1966 (1); 1968 (10); 1969 (10); 1970 (4); 1971 (13); 1972 (5); 1973 (2); 1974 (14); 1977 (2); **F. Luebert, C. Becker & N. García** 2008 (5); 2009 (11); 2011 (11); 2015 (2); 2019 (9); 2020 (13); 2031 (14); 2043 (14); 2049 (14); 2054 (15); 2055 (15); 2059 (1); 2061 (1); 2067A (15); 2068 (1); 2076 (6); 2079 (15); 2081 (8); 2083 (6); 2093 (8); 2094 (8); 2095 (8); 2099 (8); 2100 (8); 2101 (6); 2108 (16); 2122 (6); 2123 (6); 2124 (16); 2128 (1); 2131 (16); 2145 (1); 2149 (1); **F. Luebert, C. Becker, N. García & R. Pinto** 2159 (17); **F. Luebert, A. Moreira & M. O. Dillon** 3004 (1); 3005 (15); 3006 (8).

M. Mahu SGO 102946 (10); **Mancinelli** CONC 24253 (12); **C. Marticorena** 9544 (10); **C. Marticorena & O. Matthei** 128 (12); 162 (12); 272 (12); 296 (10); 299 (12); 317 (10); **C. Marticorena, O. Matthei & M. Quezada** 479 (10); 601 (10); 604 (11); **C. Marticorena, O. Matthei & R. Rodríguez** 265 (12); **C. Marticorena, R. Rodríguez & E. Weldt** 1420 (12); 1524 (10); 1532 (10); 1535 (5); 1608 (12); 1655 (10); 1743 (10); 1789 (11); 1792 (5); 1834 (14); 1835 (12); 1863 (14); 1887 (1); **C. Marticorena, T. Stuessy & C. Baeza** 9815 (10); 9906 (1); 9919 (10); 9938 (5); 9970 (12); **J. Martínez** CONC 121865 (10); **O. Matthei & R. Rodríguez** 34 (12); **M. McMahon & L. Hufford** 552 (15); **P. L. Meserve** 46 (12); SGO 134956 (5); **G. Monsalve** 5 (12); SGO 132186 (12); **G. Montero** 1875 (12); 2379 (12); 2870 (1); 2881 (6); 2984 (1); 3000 (10); 6309 (15); 7252 (12); 11021 (9); 11032 (12); 11953 (12); **Monypenny** 46 (12); 47 (10); **A. M. Mora** SGO

131748 (12); **G. Morales** 11 (15); **M. Morales & A. Córdoba** SGO 138613 (12); **Morales** 21 (6); **A. Moreira** 705 (14); **T. Morong** 1236 (14); 1342 (10); **C. Muñoz** 17 (13); 155 (12); 3641 (1); 4165 (12); 4225 (10); B155 (12); SGO 135276 (14); ULS 599 (14); **C. Muñoz & A. Coronel** 1408 (12); **C. Muñoz & G. T. Johnson** 1920 (14); 1946 (11); 1956 (2); 2769 (12); 2841 (1); 2950 (6); 2974 (15); 3311 (12); 3446 (12); **C. Muñoz & E. Pisano** 3263 (12); **P. Muñoz** CONC 121899 (12); **M. Muñoz-Schick** 951(12); 1915 (12); 1956 (11); 1976 (15); 2995 (11); 3116 (5); 3135 (10); 3825 (9); 3827 (11); 4104 (5); **M. Muñoz-Schick & I. Meza** 2227 (11); 2234 (5); 2254 (15); 2297 (1); 2348 (2); 2349 (5); 2350 (9); **M. Muñoz-Schick, I. Meza & E. Barrera** 1023 (11); 1047 (11); 1076 (9); 1094 (11); 1111 (5); **M. Muñoz-Schick, S. Teillier & I. Meza** 2784 (15); 2823 (1); 2897 (5); 2910 (2); 2621 (12); 2704 (10); 2706 (10); 2718 (10); 2772 (4); 2778 (4); 2809 (15); 2822 (15); 2890 (11); 2920 (9); 2921 (9); 2956 (14).

L. Neé 40 (12); MA 218843 (12); MA 232441 (12); MA 232466 (12); **A. Newswander** EIF 5452 (12); **Niemeyer** CONC 121886 (12); **H. Niemeyer** CONC 121917 (1); SGO 104088 (6); **H. Niemeyer & C. Fernández** 9722 (14).

O'Brien 52 (12); 139 (12); CONC 38409 (12); **P. Ortega** SGO 54391 (12); SGO 54400 (10); **R. Osorio, R. Torres, C. Villagrán & G. Gómez** SGO 132054 (10).

R. Pearce 40 (9); SGO 42236 (10); W 1889/146459 (10); W 1889/146462 (10); W 1889/146463 (12); W 1889/146471 (5); **L. E. Peña** CONC 121867 (6); **Peña** CONC 121856 (11); CONC 121873 (11); CONC 121875 (11); **F. W. Pennel** 13022 (17); **E. Petersen & J. P. Hjerting** 1131 (7); **A. Pfister** CONC 8337 (10); CONC 8385 (10); CONC 9576 (5); [**F. Philippi**] GH 97750 (13); SGO 42218 (13); SGO 54362 (13); BM 992024 (5); BM 992029 (11); GH 244230 (5); SGO 42231 (5); SGO 54345 (11); SGO 54378 (5); **F. Philippi** 106 (14); 107 (12); BM 992027 (11); BM 992028 (11); BM 992030 (10); SGO 42219 (9); SGO 42223 (14); SGO 42225 (11); SGO 42226 (10); SGO 42230 (5); SGO 42232 (12); SGO 42237 (10); SGO 42238 (10); SGO 42244 (12); SGO 42266 (10); SGO 54346 (11); SGO 54354 (10); SGO 54360 (14); SGO 54361 (14); SGO 54368 (9); SGO 54370 (9); SGO 54376 (5); SGO 54391 (12); SGO 54394 (12); SGO 54399 (10); SGO 54401 (10); SGO 54434 (10); US 942361 (9); US 942630 (10); US 944663 (12); **R. A. Philippi** GH 97635 (4); GH 97637 (9); GH 97638 (9); GH 97740 (5); GH 97742 (6); GH 97746 (10); SGO 42216 (16); SGO 42217 (15); SGO 42220 (16); SGO 42229 (5); SGO 42234 (12); SGO 42241 (10); SGO 42245 (12); SGO 54348 (10); SGO 54353 (15); SGO 54358 (14); SGO 54359 (14); SGO 54364 (9); SGO 54365 (9); SGO 54374 (1); SGO 54381 (6); SGO 54387 (4); SGO 54395 (12);

SGO 69524 (10); W 12878 (6); W 12883 (12); W 12884 (12); W 12889 (12); W 12894 (4); W 12893 (5); W 12898 (16); W 12981 (1); W 1889/117585 (12); **R. Pinto** 171 (7); 566 (17); 567 (1); 568 (17); 595 (17); 665 (1); 672 (1); 688 (1); 700 (1); 761 (17); **E. Pisano & R. Bravo** 228 (15); 316 (8); 526 (1); 566 (15); 805 (5); 948 (11); 1042 (10); **P. Pladiur** 39 (12); **C. Ponce** 16 (12); **Prizessin Therese von Bayern** 265 (12).

M. Quezada CONC 24126 (12); **M. Quezada & E. Ruiz** 55 (17); 62 (1); 85 (17); 131 (1); 211 (6); 224 (6); 232 (15); 274 (16); 318 (16); 371 (6).

K. Rahn 79 (7); 116 (7a); **R. Ramírez** ULS 1401 (12); **K. H. Rechinger & W. Rechinger** 63296 (12); 63308 (2); 63313 (11); 63382 (5); 63396 (2); 63402 (9); 63403 (9); 63408 (11); 63443 (14); 63446 (14); 63465 (1); 63514 (15); 63611 (14); 63615 (14); 63659 (10); 63688 (12); 63706 (12); **K. Reiche** 5 (10); SGO 54349 (15); SGO 54367 (9); SGO 54392 (12); SGO 61442 (6); SGO 61443 (8); SGO 61444 (1); SGO 61446 (15); SGO 61447 (15); **M. Ricardi** 2030 (12); 2194 (9); 2195 (11); 2220 (11); 2248 (14); 2263 (1); 2281 (2); 2299 (5); 2300 (9); 2452 (1); 2462 (6); 2476 (15); 2531 (15); 2563 (15); 2614 (6); 2705 (15); 2726 (6); 3039 (17); 3082 (1); 3111 (15); 3122 (8); 3134 (1); 3144 (15); 3565 (6); 5463 (5); 5524 (15); 5547 (10); CONC 12828 (12); **M. Ricardi & C. Marticorena** 3664(10); 3812 (11); 3813 (11); 3840 (5); 3882 (5); 3933 (9); 3971 (11); 3994 (10); 4636 (15); 4332/717 (12); 4370/755 (10); 4393/778 (11); 4531/916 (10); 4618/1003 (14); 4623/1008 (1); 4872/1257 (5); 4876/1261 (10); 4955/1340 (12); **M. Ricardi, C. Marticorena & O. Matthei** 509 (10); 517 (10); 540 (10); 545 (10); 622 (10); 1053 (14); 1065 (3); 1083 (15); 1106 (10); 1120 (10); 1123 (5); 1274 (14); 1423 (1); 1435 (15); 1469 (10); 1505 (11); 1518 (5); 1533 (12); **M. Richter** 94/2 (6); 94/4 (16); 94/10 (17); 94/11 (1); 94/12 (1); 94/13 (1); **C. A. Ridoutt** 14499 (7); **L. Rodríguez** ULS 750 (12); **R. Rodríguez** 3080 (1); 3109 (1); 3139 (6); **Rodríguez & Rivera** 59 (5); **X. Rodríguez** 2 (15); **V. Rojas** CONC 121866 (10); **Mr & Mrs S. N. Rose** 19246 (12).

J. Saa CONC 121860 (10); CONC 121864 (10); CONC 121880 (5); CONC 121892 (12); **C. Sandeman** 4019 (7a); **V. San Martín** ULS 1513 (12); **F. San Román** SGO 42215 (4); SGO 42224 (14); SGO 42239 (4); SGO 54386 (4); SGO 54388 (4); SGO 54403 (10); SGO 54404 (11); **R. Santesson** 798 (12); 799 (12); **F. Schlegel** 411 (12); 1327 (12); 2837 (12); 3876 (14); 3898 (12); 3909 (12); 7784 (1); 7819 (17); 7903 (6); 7958 (15); 8017 (13); 8021 (9); 8033 (5); SGO 73213 (1); **R. T. Schuh & N. I. Platnick** 6 (12); **N. Schulz** 2 (15); 4 (1); 14 (8); 15 (1); 36 (15); 36 (12); 63 (15); 96 (12); 14F24132 (15); 21F25 (6); 48MD (16);

FV58 (14); PA98 (8); **G. Schwabe** 250 (12); **R. Scolnik** 1031 (7a); **S. Sepúlveda & J. Villagrán** 128 (12); **M. Silva** CONC 44045 (12); CONC 44046 (12); CONC 44047 (12); **C. Skottsberg & I. Skottsberg** 721 (12); F 737186 (12); **O. Solbrig** 3034 (12); **B. Sparre** 2514 (12); **F. Squeo** 88196 (5); **D. Stafford** 898 (7); 913 (7).

C. M. Taylor & A. Pool 11586 (1); 11590 (15); 11612 (5); 11619 (2); **C. M. Taylor et al.** 10802 (9); **C. M. Taylor, C. von Bohlen & A. Marticorena** 10634 (12); 10715 (15); **S. Teillier** 478 (1); 500 (1); 509 (1); 564 (6); 589 (1); 647 (15); 733 (10); 838 (11); 839 (11); 907 (11); 913 (9); 918 (5); 960 (2); 987 (5); 1021 (10); 1056 (12); 4736 (14); 5553 (10); **S. Teillier & R. Torres** 3902 (14); 3903 (10); 3904 (2); 3905 (13); **S. Teillier, P. Rundel & P. García** 2643 (1); 2648 (15); 2682 (15); 2683 (15); 2695 (15); 2726 (1); 2727 (15); 2757 (15); 2823 (6); 2851 (8); 2923 (6); 2934 (15); 2938 (15); 2944 (8); **S. Teillier, R. Torres & L. Villarroel** 3165 (13); 3166 (13); 3167 (14); **S. Teillier, L. Villarroel & R. Torres** 2555 (10); 2559 (5); 2562 (11); 2563 (5); 2564 (2); 2565 (2); 2567 (9); 2568 (11); 2569 (14); 2570 (13); 2571 (5); 2590 (1); 2591 (14); 2592 (14); 2593 (14); 2594 (1); 2595 (15); **W. Till & E. Vitek** 232 (7); **A. Torres** 108 (1); SGO 135453 (15); **J. C. Torres** SGO 128787 (15); SGO 128786 (6); **R. Torres, C. Villagrán & C. Gómez** CONC 121858 (10); **O. Tovar** 2679 (7); 2740 (7a).

A. Urzúa SGO 107257 (12).

H. Valenzuela 41 21 (12); 01 17 (5); EIF 5852 (12); **F. Vidal** SGO 42242 (12); SGO 54366 (12); SGO 54393 (12); **C. Villagrán, M. T. Kalin, J. Armesto & [P.] Moreno** 1967 (10); **C. von Bohlen** 1243 (14); 1266 (15); 1281 (1); 1324 (11); 1373 (13); 1374 (9); 1380 (2).

R. Wagenknecht 644 (1); 4487 (10); 5779 (10); 18111 (10); **B. J. Wallace** 323 (12); **W. A. Weber & B. Johnston** 949 (12); **A. Weberbauer** 7188 (7); **M. Weigend & H. Förther** 97/727 (7); 97/743 (7); 97/751 (7); 97/826 (7); 97/859 (7); 97/868 (7); **M. Weigend & J. Skrabal** 5887 (7); **M. Weigend, A. Ackermann, A. Cano & M. I. La Torre** 7202 (7); 7316 (7); **M. Weigend, H. H. Hilger & J. Skrabal** 5939 (12); **P. Weisser** CONC 105393 (5); **E. Weldt** 466 (12); **E. Werdermann** 120 (12); 145 (5); 399 (10); 767 (15); 837 (6); 849 (1); **J. West** 3875 (1); 3886 (12); **C. R. Worth & J. L. Morrison** 15647 (7); 15788 (8); 15796 (15); 16150 (14); 16232 (14); 16298 (12); 16647 (12). **O. Zalensky** XV866 (15); XVIII989 (5); **A. Zárate** SGO 137451 (12); **O. Zöllner** 1735 (15); 1870 (15); 2714 (1); 2881 (1); 3358 (17); 3497 (1); 4168 (5); 4472 (5); 6433 (2); 6811 (12); 6853 (5); 6997 (10); 7086 (1); 7095 (1); 7802 (1); 7857 (10); 8056 (1); 8352 (12); 8909 (1);

8975 (5); 9075 (11); 9270 (11); 9324 (4); 9780 (10); 9811 (5); 9840 (9); 9942 (10); 10434 (10); 10500 (1); 11669 (12); 11822 (5); 11964 (10).

s. coll. SGO 54430 (2); SGO 61445 (1); SGO 150350 (9); SGO 54405 (10); SGO 54377 (5); SGO 54379 (5).

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