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Tribulus cistoides L. (Zygophyllaceae): a new record for the flora of Taiwan

Shu-Miaw Chaw[1], Shu-Chien Lin[2] and Bing-Shin Wang[1]

[1]*Institute of Botany, Academia Sinica, Taipei, Taiwan 115, Republic of China*

[2]*Department of General Studies, National Yangming Medical College, Taipei, Taiwan 112, Republic of China*

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Abstract. *Tribulus cistoides* L., which has been collected in Taiwan several times since 1933 but misidentified as *T. terrestris* L., is here reported as a new record for the flora of Taiwan. In addition to the distinguishing characters often cited in floristic works, new taxonomic traits for characterizing *T. cistoides* and its only congener in Taiwan, *T. terrestris* L., are discussed. Species descriptions and illustrations of this new record, a key, distribution maps, and SEM micrographs for the two species are provided.

Key words: *Tribulus cistoides*; *T. terrestris*; Taxonomy; Zygophyllaceae.

On a field trip to the Penghu Islands in September 1991, a vinealis weed resembling *Tribulus terrestris*, but with larger, showier flowers, attracted our attention. Our identification revealed that this plant (*Chaw et al. 1331*) was *T. cistoides* L., a species not previously reported from Taiwan in the literature. Further study revealed, however, that this species actually has been collected from the islands and Taiwan proper several times since 1933, but that the specimens were all misidentified as *T. terrestris*. Therefore, we reported this new record and provide morphological diagonostic features and distribution maps of both species in order to clarify their identities. Fresh leaves, stamens, and flowers was studied via scanning electron microscopy (SEM). These materials were dehydrated through an ethanol series and acetone, critical-point dried with CO_2, coated with gold and examined with a Zeiss 950 SEM.

Tribulus cistoides is remarkably similar to *T. terrestris* in growth habitat and vegetative and floral morphology. In other parts of the world where the two species grow together, they have been distinguished mainly on the basis of habit (perennial versus annual), flower size, and the nature of intrastaminal nectaries (laterally connate versus free) (Backer and Bakhuizen van den Brink, 1965; Dassanayake 1987; Mill, 1990). However, we also found the degree of pubescence on the upper leaf surface, the relative length of the stigma and style (cf. Edgeworth and Hooker, 1872), and the shape of the exine columellae to be useful taxonomically for characterizing these two allied species at least in Taiwan. These differences are depicted in Fig. 2, and summarized in the following key. Furthermore, the statement that intrastaminal scales (Dassanayake, 1987) or nectaries (Mill, 1990) are "laterally connate" in *T. cistoides* is not accurate. Our SEM observations (Fig. 2, I & J) clearly show they are contiguous rather than fused.

1a. Prostrate to ascending perennial herbs; upper surface of leaves sericeous on midrib and lateral veins, otherwise puberulent; petals 11-13 mm long; intrastaminal nectaries laterally adjacent; pistil slender, style 0.8-1.2 mm long, stigmas linear, 0.4-0.8 mm long, ca. half to equaling the style in length; exine columellae obclavate . . . . 1. *T. cistoides*

1b. Prostrate annual herbs; upper surface of leaves sericeous along lower part of midrib, otherwise

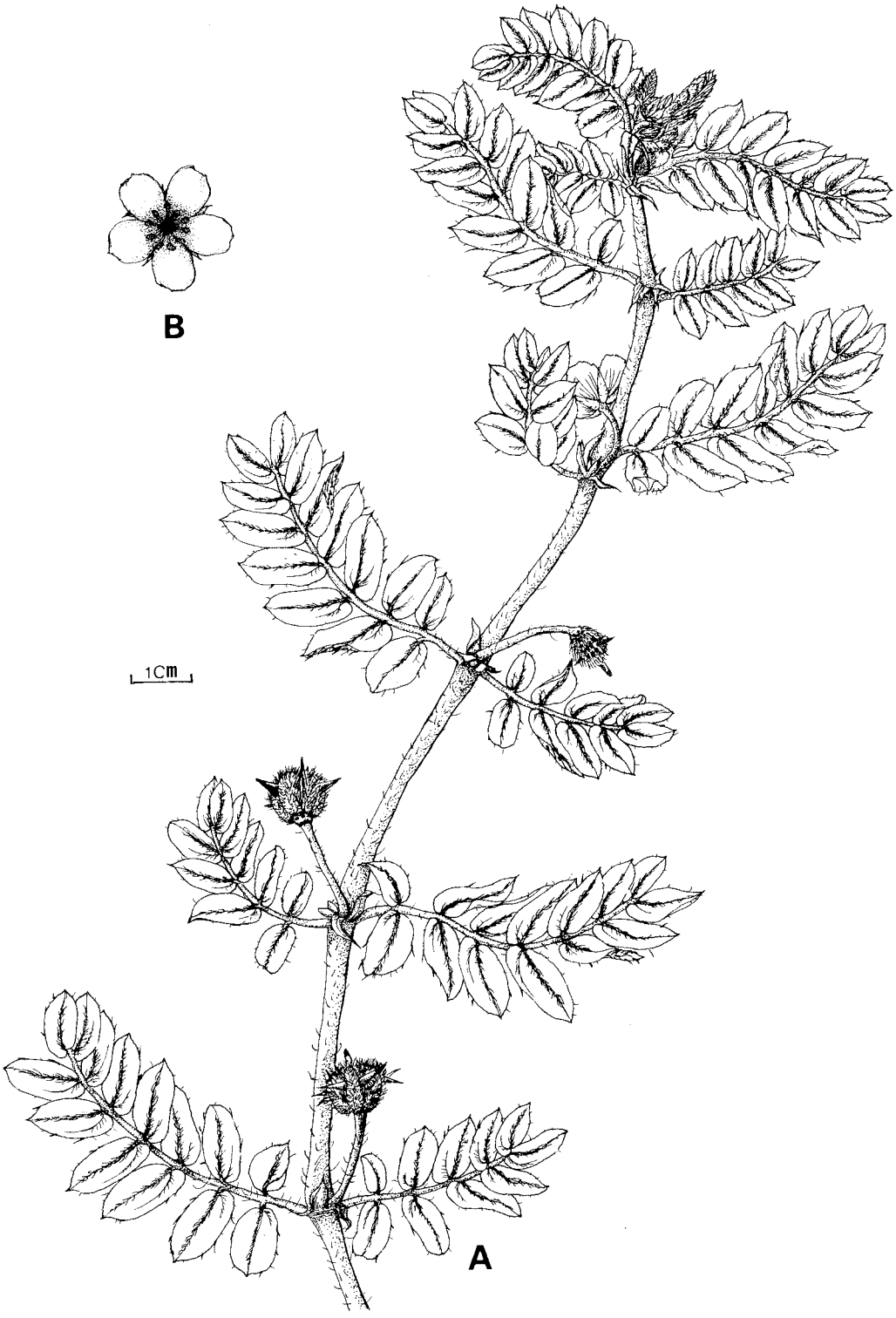

Fig. 1. Illustration of *Tribulus cistoides* (from *Chaw 1351*). A, habit; B, flower.

glabrous; petals 3-5 mm long; intrastaminal nectaries separated laterally; pistil stout, style 0.4-0.8 mm long, stigmas capitate, 0.8-1.0 mm long, more than half the style in length; exine columellae terete. . . . . 2. *T. terrestris*

1. **Tribulus cistoides** L. Sp. Pl. 1: 387. 1753; Edgeworth & Hook. *f. In* Hook. *f.*, Fl. Brit. Ind. 1: 423. 1872; Backer & Bakhuizen van den Brink, Fl. Java 2: 242. 1965; Dassanayake, *In* Fl. Ceylon 6: 423. 1987; Mill *In* Manual Flow. Pl. Hawai'i. 1343. 1990.
大花蒺藜 Fig. 1; 2A-B, E-G, I-J; 3
Kallstroemia cistoides (L.) Endl. Ann. Wiener Mus. Naturgesch. 1: 184. 1836.

Perennial tap rooted herbs; stems prostrate to ascending; branchlets to several meters long, terete (semi-terete when dry), sericeous and sparsely hirsute; stipules deltoid to lanceolate on the lower stem, to 7 mm long, 4 mm wide, appressed-sericeous on both surfaces, ciliate along margin, upper stipules often ruptured by the stem. Leaves opposite, to 7 cm long, with 4-8 pairs of leaflets; leaflets subsessile, to 22 mm long, 10 mm wide, appressed-sericeous abaxially, base obliquely cordate, appressed-sericeous on midrib and puberulent adaxially. Flowers 2.0-2.5 cm in diam., yellowish to bright yellow; sepals lanceolate, strigose abaxially, glabrous adaxially except sericeous at tip, 3-4 mm long, 1.5-2 mm wide; petals 5, separate, widely spreading, oblong to obovate, 3-5 mm long, 1-3 mm wide, often notched and undulate at tip, caducus; stamens 10, dorsifixed, in 2 whorls of 5, the whorl opposite the sepals with nectaries at base both abaxially and adaxially, the one opposite the petals without nectaries; outer nectaries bilobed, inner nectaries contiguous laterally and forming a shallow ring around base of ovary; anthers sagittate, ca. 1.5 mm long, filaments ca. 3 mm long; pollen grains subglobose, inaperturate, 43-47 μm in diam., tectum reticulate, columellae obclavate, sexine depressed where nexine is likely to extrude during pollen germination; ovary strigose, grooved, 5-celled; ovule 1; style 1, glabrous, 0.8-1.2 mm long; stigmas 5, linear, 0.4-0.8 mm long. Fruit ca. 1.5 cm in diam. (including the spines); mericarps 5, dorsally crested, tuberculate and sericeous, each bearing two lateral stout spines to 1 cm long, sometimes with 2 smaller spines near base.

Specimens examined: Taichung Co.: Wuchi Harbour, Aug 1992, *Chaw 1351* (HAST). Tainan Co.: Jente Village, Jul 1984, *Peng 7051* (HAST); Tainan City: Hsikan, Jun 1982, *Kao 10402* (TAI); Anping, Jan 1972, *Hsu 13633* (TAI), Jun 1982, *Kao 9779* (TAI); Szukunshen, Nov 1991, *Wang 883* (HAST); without further locality, Aug 1988, *T.C. Huang & S. F. Huang 13736* (TAI), Nov 1934, *S. Suzuki 6209* (TAI). Kaohsiung City: Sun Yat-sen University, Feb 1992, *Chaw & Lin 1341* (HAST); Chichin, Jan 1960, *T. I. Chuang & Kao 2981* (HAST), Jun 1986, *Yang 2025* (TAI); Chienjeng High School, May 1973, *Chien s.n.* (TAI *154996, 154997*). Kaoshiung Co.: Hunei, Jan 1992, *Peng 14814* (HAST); Tahu, Nov 1987, *Peng 11284* (HAST); Kichun, May 1980, *T. C. Huang 8425* (TAI). Lingyuan, Nov 1986, *T. C. Huang & S. F. Huang 12984* (TAI). Pingtung Co.: Hsiaoliuchiu, May 1990, *Lin 460* (HAST). Penghu Co.: Tunliang, Aug 1933, *Cheng s.n.* (TAI *064763*); Neian, Sep 1991, *Chaw et al. 1331* (HAST); Fengkuei, Jul 1989, *Peng 12735* (Hast); Lichengchiao, Jul 1989, *Peng 12764* (HAST).

Distribution and ecology: *Tribulus cistoides* is native to the eastern part of Madagascar (Backer and Bakhuizen van den Brink, 1965), and tropical and subtropical southern Africa (Dassanayake, 1987). Mill (1990) reported it to be widely naturalized pantropically, often occurring in maritime habitats. In Taiwan, this species is commonly found in sandy areas and on dunes along the southwestern coast, ranging from Penghu County to Pingtung County, with an outlying population in Taichung County. Flowering and fruiting specimens have been gathered from May through mid-Feburary, except in October.

2. **Tribulus terrestris** L., Sp. Pl. 1: 387. 1753; Thw., Pl. Zeyl. 68. 1858; Edgeworth & Hook. *f. In* Hook. *f.*, Fl. Brit. Ind. 1: 423. 1872;Trimen, Handb. Fl. Ceylon 1: 194. 1893; Huang *In* Li *et al.*, Fl. Taiwan 3: 434. 1977; Dassanayake, *In* Fl. Ceylon 6: 422. 1987; Mill *In* Manual Flow. Pl. Hawai'i. 1344. 1990.
蒺藜 Fig. 2C-D, H, K-L; 3.

Prostrate annual herbs; branchlets to ca. 1 m long, terete (semi-terete when dry), sericeous and sparsely hirsute; stipules deltoid to lanceolate on the lower stem, to 5 mm long, 2 mm wide, appressed-sericeous abaxially, sparsely pubescent adaxially, much ser-

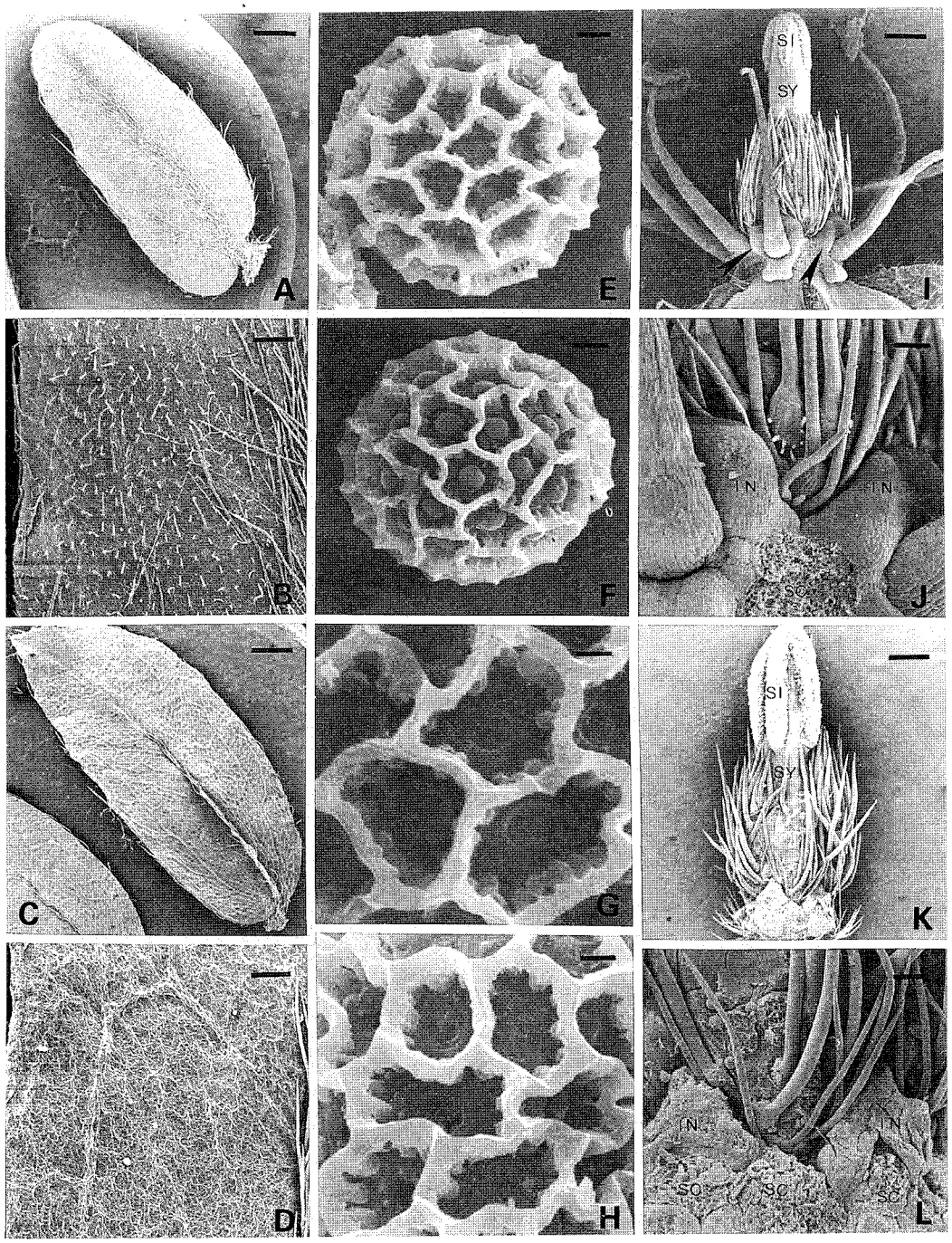

Fig. 2. SEM micrographs of *Tribulus cistoides* (A, B, E, F, G, I, J; from *Chaw et al. 1331*) and *T. terrestris* (C, D, H, K, L; from *Chaw et al. 1312*). A-D. Upper surface of leaf: B and D represent enlarged portions of A and C, respectively; A and B puberulent, while C and D glabrous. E-H. Pollen with reticulate tecta: E, showing reticulum with depressed area where nexine is extruded during germination, as shown in F; G, enlarged portion of E, obclavate columellae; H, terete columellae. I-L. Gynoecia: I, linear stigma and extrastaminal and intrastaminal nectaries (arrows); J. enlarged portion of I, showing contiguous intrastaminal nectaries; K, compatively longer stigmas and distant intrastaminal nectaries. SI= stigma; SY= Style; IN=intrastaminal nectary; SC= staminal scar. Scales= 1 mm (A, C); 200 μm (B, D); 5 μm (E, F); 2 μm (G, H); 500 μm (I, K); 100 μm (J, L).

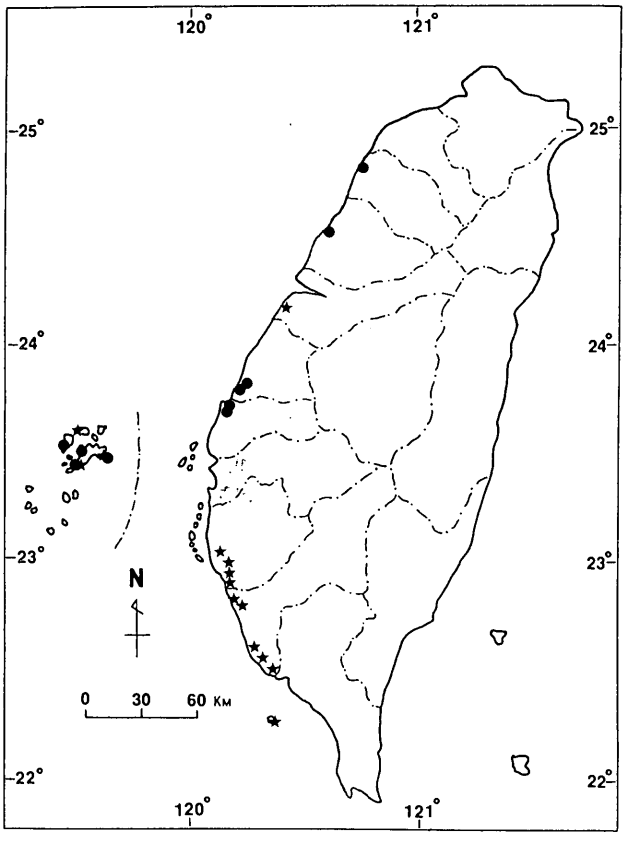

Fig. 3. Distribution of *Tribulus cistoides* (stars) and *T. terrestris* (dots) in Taiwan.

iceous toward apex and ciliate along margin, upper stipules often ruptured by the stem. Leaves opposite, to 5 cm long, with (4-) 5-7 pairs of leaflets; leaflets subsessile, to 4-12 mm long, 2-5 mm wide, appressed-sericeous abaxially, base oblique, sericeous on the lower part of midrib, otherwise galbrous. Flowers 0.8-1.5 cm in diam., yellowish to bright yellow; sepals lanceolate, strigose abaxially, glabrous adaxially except sericeous at tip, 3-5 mm long, 1.5-2 mm wide; petals 5, separate, widely spreading, deltoid-obovate, 3-5 mm long, 2-3 mm wide, often notched and undulate at tip, caducus; stamens 10, dorsifixed, in 2 whorls of 5, the whorl opposite the sepals with nectaries at base both abaxially and adaxially, the one opposite the petals without nectaries; outer nectaries somewhat bilobed, inner nectaries, triangular, free; anthers sagittate, ca. 0.8 mm long, filaments ca. 2 mm long; pollen grains subglobose, inaperturate, 43-48 um in diam., tectum reticulate, columellae terete, sexine with dispersed gemmae of various sizes, and with depressed areas where nexine is likely to extrude during pollen germination; ovary strigose, grooved, 5-celled; ovules 1; style 1, glabrous, 0.4-0.8 mm long; stigmas 5, linear, 0.8-1.0 mm long. Fruit ca. 1.5 cm in diam. (including the spines); mericarps 5, dorsally crested and with short and long, pustulate hairs, each bearing two pairs of stout spines, the upper pair to 6 mm long, the lower 2-3 mm long.

Specimens examined: Miaoli Co.: Ronkan, Sep 1968, *Kao 7393* (TAI). Hsinchu Co.: Longkan, Nov 1964, *C. C. Chuang 3066* (TAI). Changhwa Co.: Fangyuan and Hsikang, Aug 1970, *Chow 100* (TAI); Houliao, Jul 1968, *Hsu 9317* (TAI). Yunlin Co.: Hsutsoliao, Oct 1984, *Tang 704* (TAI); Houan, Oct 1984, *Wang 2532* (TAI), Aug, 1984, *Yang 486* (TAI). Penghu Co.: Anchiaoyu, Sept 1991, *Chaw et al. 1312* (HAST); Makung, Jul 1929, *Horikawa s.n.* (TAI *064760*); Fengkei, Jul 1972, *Hsieh 1077* (TAI), Jul 1989, *Peng 12736* (HAST); Lichengchiao, Jul 1989, *Peng 12762, 12763, 12765* (HAST); Penghu proper without further locality, Mar 1931, *Kudo & Mori 3087* (TAI), Aug 1973, T. C. *Huang & Kao 6815, 6903* (TAI).

Distribution and ecology: In Taiwan, *Tribuluous terrestris* has been collected from Hsinchu County southward to Penghu County. The flowering and fruiting period, based on specimen data, is between July and October.

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臺灣新記錄植物－大花蒺藜

趙淑妙[1] 林叔芊[2] 王冰心[1]

[1]中央研究院植物研究所
[2]國立陽明醫學院共同科

本文描述臺灣自 1933 年以來即被採集，但被忽略的蒺藜科蒺藜屬植物－大花蒺藜(*Tribulus cistoides* L.)。其主要特徵是多年生、匍匐至斜向上草本，葉上表皮被微柔毛，花徑大於 2 公分，小蕊內側之蜜腺緊密相接，柱頭長於花柱，花粉外皮的小柱爲倒立棒形。本種一直被誤認爲蒺藜(*T. terrestris* L.)；兩者之外表形態及生育環境類似，但後者爲一年生草本，花徑小於 1.5 公分，葉上表皮除中肋外皆被毛。大花蒺藜原產馬達加斯加的東部，在本島主要分佈於西海岸的南部和澎湖群島，多生長於海岸附近的沙地。