

A TAXONOMIC STUDY OF THE GENUS *EUPHORBIA* L. (EUPHORBIACEAE) IN TAIWAN

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Abstract: Eight species of *Euphorbia* L. *sensu stricto* from Taiwan are treated in this revisional study including two taxa with nomenclatural corrections (*E. cyathophora* Murr. and *E. heterophylla* L.). *E. calonesiaca* Croizat, *Galarhoeus formosanus* (Hayata) Hurusawa var. *hayatai* Hurusawa and *E. taiwaniana* Ying are treated as synonyms of *E. formosana* Hayata, *E. shouanensis* Keng and *E. heterophylla* L., respectively. Discussions of taxonomic important characters, a key to all taxa along with their descriptions, illustrations, geographical distributions, specimens examined and taxonomic notes are presented.

INTRODUCTION

Euphorbia L. *sensu stricto*, according to Webster's definition (1967, 1975) consisting of 1200 species, is primarily distributed in subtropical and warm temperate regions throughout the world (Huft, 1990). The genus is represented in Taiwan (including Taiwan, Penghu Islands, Hsiao-liuchiu, Lutaο and Lanyu) by eight species.

Euphorbia sensu lato is characterized by highly reduced flowers subtended by an involucre (cyathium). It is separated into *Arthrohamnus* Klotzsch & Garcke, *Chamaesyce* S. F. Gray, *Euphorbia* L., *Euphorbiodendron* Millsp., *Poinsettia* Graham and *Tithymalus* Adans. by Millspaugh (1909); *Agaloma* Raf., *Arthrohamnus*, *Chamaesyce*, *Euphorbia*, *Galarhoeus* Haworth and *Poinsettia* by Hurusawa (1954); and *Agaloma*, *Chamaesyce*, *Cubanthus* Millsp., *Tithymalus* Trew and *Poinsettia* by Dressler (1961) for the New World species. Webster (1967) has intensively discussed the generic circumscription, separated *Chamaesyce* as a genus, and relegated other taxa within *Euphorbia*. In the taxonomic history of Taiwan, the broadly defined *Euphorbia* has been mostly adopted (Forbes & Hemsley, 1889; Henry, 1896; Hayata, 1904; Matsumura & Hayata, 1906; Kawakami, 1910; Hayata, 1917; Sasaki, 1928; Suzuki, 1936; Keng, 1951; Masamune, 1954; Keng, 1955; Hsieh, 1977), except that Hara (1938) and Hurusawa (1954) separated *Euphorbia sensu lato* into three genus (*Chamaesyce*, *Euphorbia* and *Galarhoeus*). Based on an intensive study on the *Euphorbia sensu lato* in Taiwan by the first author (Lin, 1989), we agree with Webster's treatment (1967, 1975) that *Euphorbia sensu lato* be separated into *Chamaesyce* (Lin *et al.*, 1991) and *Euphorbia sensu stricto*. *Euphorbia* is different from *Chamaesyce* by having alternate leaves with symmetrical bases, entirely wanting stipules or gland-like stipules, and carunculate seeds.

In Taiwan, the genus *Euphorbia* consists of eight species in three subgenera, *Esula* Pers. (5 species), *Euphorbia* L. (1 species), and *Poinsettia* (Graham) House (2 species). For each species, description, geographical distribution, citation

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of all examined specimens, and taxonomic notes are provided, based on the specimens deposited in the following herbaria: Institute of Botany, Academia Sinica (HAST); Department of Botany, Faculty of Science, Kyoto University (KYO); National Chiayi Institute of Agriculture (NCAI); Department of Forestry, National Taiwan University (NTUF); National Pingtung Institute of Agriculture (PAI); Department of Botany, National Taiwan University (TAI); Taiwan Forestry Research Institute (TAIF); Department of Forestry, National Chungshing University (TCF); The Laboratory of Plant Biology, University of Tokyo (TI); Department of Biology, Tunghai University (THAI).

TAXONOMIC CHARACTERS

Stem. All *Euphorbia* species in Taiwan are herbaceous, except that *E. tirucalli* is shrubby. The growth habit is erect. Rhizomes are found in *E. formosana*, *E. shouanensis* and *E. tarokoensis*.

Stipules. In the subgenus *Euphorbia* and *Poinsettia* a pair of glandular stipules are present at the base of leaf or petiole. However, stipules are absent in the subgenus *Esula*.

Leaves. Leaves are simple and alternate in the genus *Euphorbia*. Leaves of the subgenera *Esula* (except *E. peplus*) and *Euphorbia* are sessile and of the subgenus *Poinsettia* are petiolate. The shape and size of leaves display wide range of variation within the taxa in Taiwan. Leaf margins are entire in the *Esula* and *Euphorbia*, and entire to serrulate in subgenus *Poinsettia*. Leaf surfaces are glabrous in the *Esula*, and glabrous to pubescent in subgenus *Euphorbia* and *Poinsettia*.

Inflorescence (the arrangement of cyathia). The inflorescence of the subgenus *Esula* is a compound pleiochasium. Its composing cyathia are subtended by conspicuous bracteal leaves. The number and the shape of bracteal leaves vary within an inflorescence. The inflorescence of the subgenus *Euphorbia* is a simple trichasium, while that of the subgenus *Poinsettia* is a compound dichasium. Its terminal cyathium is usually caducous. The two first ordered dichotomous branches are long and have congested cyathia.

Cyathium. The cyathium, a basic character of the tribe Euphorbieae, is defined by Dressler (1957) as an inflorescence composed of fused involucre bracts surrounding a single, terminal female flower and usually composed of five clusters of male flowers. The basic shape of a cyathium is campanulate or turbinate. All *Euphorbia* species in Taiwan possess glands at the apex of involucre. In the *Esula* and *Euphorbia*, each involucre has four (rarely five) glands. In subgenus *Poinsettia*, each involucre has one (rarely two) gland. Female flowers of the genus *Euphorbia* are deficient of perianth. Male flowers are naked, monandrous and exerted beyond the top of the cyathium when mature.

Pollen. Pollen grains of available six species from subgenera *Esula* and *Poinsettia* were studied using SEM. Pollen grains of genus *Euphorbia* are tricolporate, oblate spheroidal to subprolate. The reticulate exine of pollen is more delicate in subgenus *Esula* (Fig. 1) and reticulate in the subgenus *Poinsettia* (Fig. 2). The magro, which constitutes the rim along pollen colpus, is comparatively wider in *Esula* (Fig. 1) than in *Poinsettia* (Fig. 2). Generally, the lumina are rounded and uniform in *E. formosana*, *E. jolkini* (Fig. 1, D-F) and *E. shouanensis*. Few adjacent lumina may fuse together. In *E. peplus* (Fig. 1, A-C), the lumina are polygonal and become larger towards the magro. Among these six species the largest

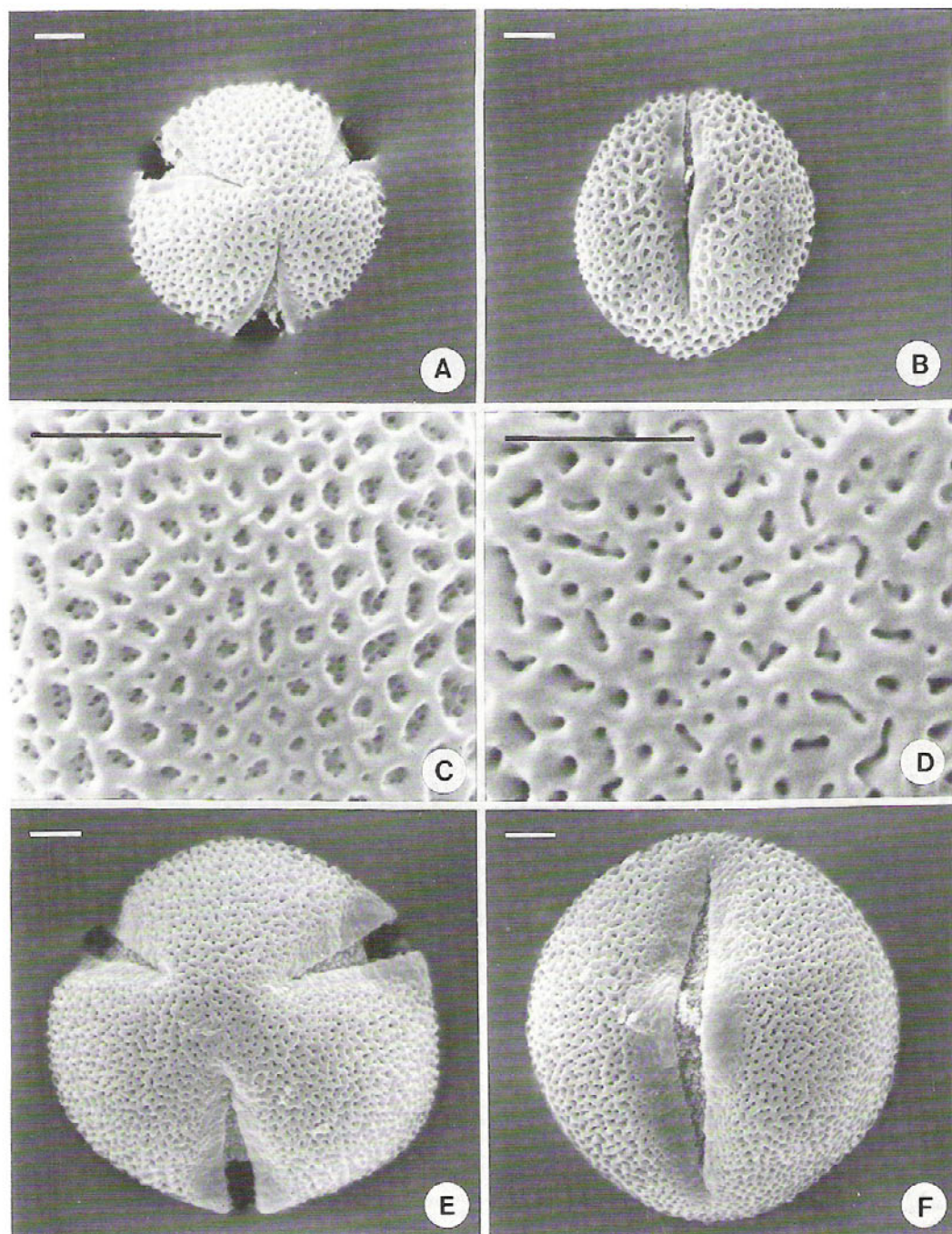


Fig. 1. Scanning electron micrographs of acetolyzed pollen grains of the subgenus *Esula*. A-C. Tricolporate pollen grains of *E. peplus* (Lin 683): A. polar view, B. equatorial view, C. exine surface. D-F. Tricolporate pollen grains of *E. jolkini* (Lin et al. 691): D. exine surface, E. polar view, F. equatorial view. Scale bars equal 5 μ m.

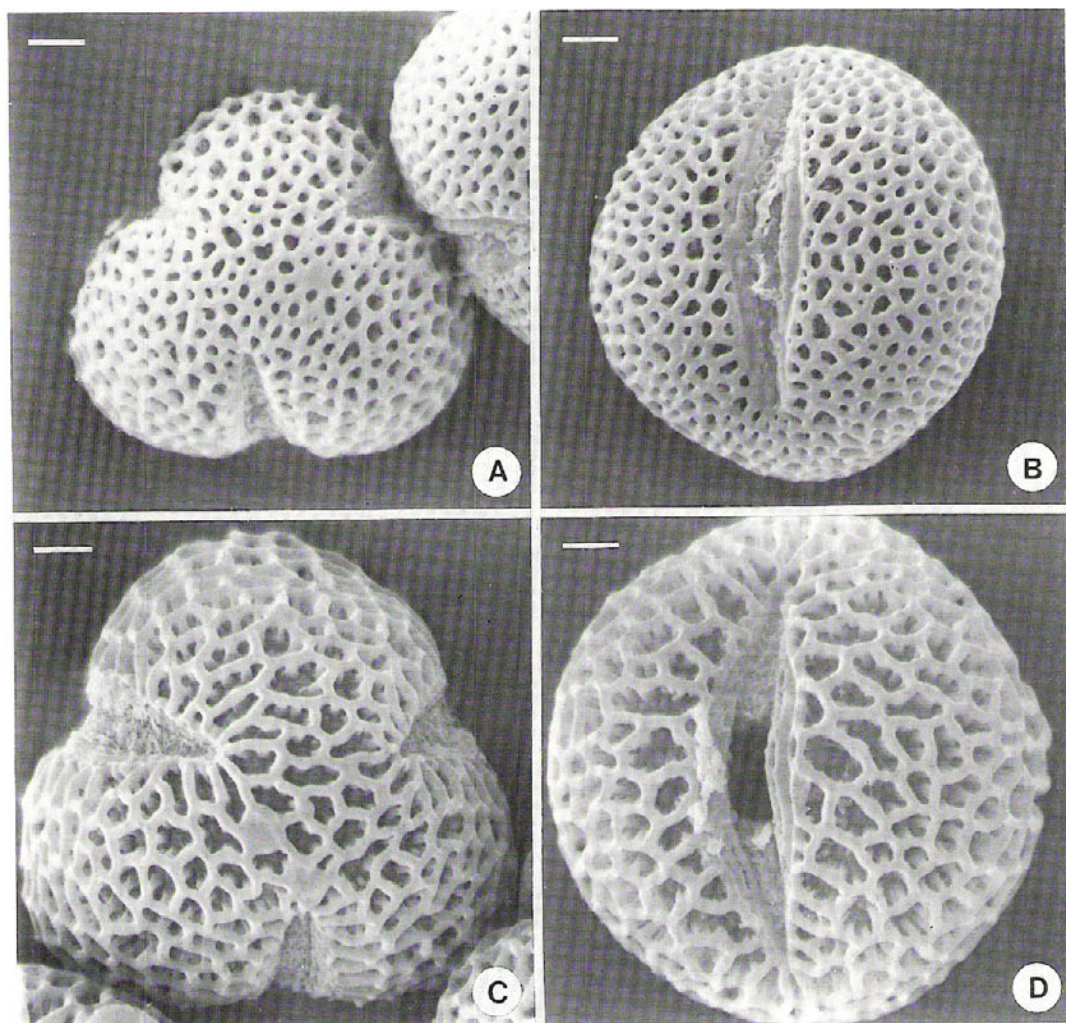


Fig. 2. Scanning electron micrographs of acetolyzed pollen grains of the subgenus *Poinsettia*. A & B. Tricolporate pollen grains of *E. cyathophora* (Lin 835). A. polar view, B. equatorial view. C & D. Tricolporate pollen grains of *E. heterophylla* (Lin 858): C. polar view, D. equatorial view. Scale bars equal 5 μm .

pollen belongs to *E. formosana* (44–54 \times 35–46 μm), and the smallest to *E. peplus* (20–24 \times 20–24 μm).

Fruits and seeds. Fruits of the genus *Euphorbia* are capsular and 3-celled, with single seed in each cell. The fruit surface varies from glabrous to pubescent and from smooth to verrucose. All seeds of the subgenera *Esula* and *Euphorbia* have a caruncle at the apex. The seed surface in these two subgenera are smooth except *E. peplus*, which is grooved and pitted. In subgenus *Poinsettia*, *E. heterophylla* have a small caruncle, but in *E. cyathophora* caruncle is wanted. The surfaces of seeds in these two species are tuberculate. Characteristics of seeds are useful in the identification of the species.

Euphorbia L., Sp. Pl. 1: 450. 1753; Gen. Pl. ed. 5. 208. 1754.

Monoecious, herbs or shrubs, latex whitish; stipules absent or gland-like. Leaves simple, alternate, entire, serrulate or lobed, sessile or petiolate, persistent or deciduous. Cyathia in compound dichasia or pleiochasia; involucre with 5 lobes, which alternate at the tips with 1-5 glands, glands without petaloid appendages; bracteoles linear to oblanceolate, usually fringed. Male flowers in 5 cymes, pedicellate, naked, monandrous. Female flowers solitary, pedicellate, naked, ovaries glabrous or pubescent, smooth or verrucose, 3-celled, 1-ovuled per cell; styles 3, free or connate basely, bifid. Fruits capsular, columella persistent. Seeds smooth, pitted or tuberculate, each with a caruncle or none.

Distribution: In Taiwan, *Euphorbia* species grow in habitats such as roadsides, grass lands, rocky places and seashores, and range from sea level to an elevation of approximately 2000 meters.

Key to the subgenera of the genus *Euphorbia*

1. Plant shrubby; stem succulent.....2. *Euphorbia*
1. Plant herbaceous; stem not succulent
 2. Stipules none; cyathia in compound pleiochasia; involucre glands 4 (rarely 5).....1. *Esula*
 2. Stipules gland-like; cyathia in compound dichasia; involucre glands 1 (occasionally 2).....3. *Poinsettia*

1. Subgenus *Esula* Pers.

Key to the species

1. Stems slender; involucre gland 2-cornate
 2. Leaves obovate to obovate-elliptic, petiolate; seeds pitted.....3. *E. peplura*
 2. Leaves linear to linear-oblong, sessile; seeds smooth.....5. *E. tarokoensis*
1. Stems stout; involucre gland not as above
 3. Leaves obtuse or retuse at apex; secondary bracteal leaves oblanceolate to elliptic.....2. *E. jolkini*
 3. Leaves acute at apex; secondary bracteal leaves broadly obovate, oval to rhombate-rounded
 4. Stems glabrous; styles and stigmas 2-4 mm long1. *E. formosana*
 4. Stems villous; styles and stigmas 1-2 mm long4. *E. shouanensis*
1. *Euphorbia formosana* Hayata in J. Coll. Sci. Univ. Tokyo 30: 262. 1911; Hayata, Gen. Ind. Fl. Form. 66. 1917; Hayata, Icon. Pl. Form. 9: 103. 1920; Sasaki, List Pl. Form. 260. 1928; Suzuki *In* Masamune, Short Fl. Form. 119. 1936; Hurusawa in J. Jap. Bot. 16: 579. 1940; Keng in Quart. J. Taiwan Mus. 4: 258. 1951; Masamune, List Vasc. Pl. Taiwan 46. 1954; Keng in Taiwania 6: 46. 1955; Hsieh *In* Li *et al.*, Fl. Taiwan 3: 461. 1977. (Holotype, Miyake s.n. 16 Jun 1898, TI!)

臺灣大戟 Fig. 3, 4.

Euphorbia dendroides sensu Hayata in J. Coll. Sci. Univ. Tokyo 20: 65. 1904; Matsumura & Hayata in J. Coll. Sci. Univ. Tokyo 22: 367. 1906, *non* L.

Euphorbia orientalis sensu Hayata in J. Coll. Sci. Univ. Tokyo 20: 70. 1904; Matsumura & Hayata in J. Coll. Sci. Univ. Tokyo 22: 367. 1906; Kawakami, List Pl. Form. 100. 1910; Hayata, Gen. Ind. Fl. Form. 66. 1917; Sasaki, List Pl. Form. 261. 1928; Suzuki *In* Masamune, Short Fl. Form. 119. 1936, *non* L.

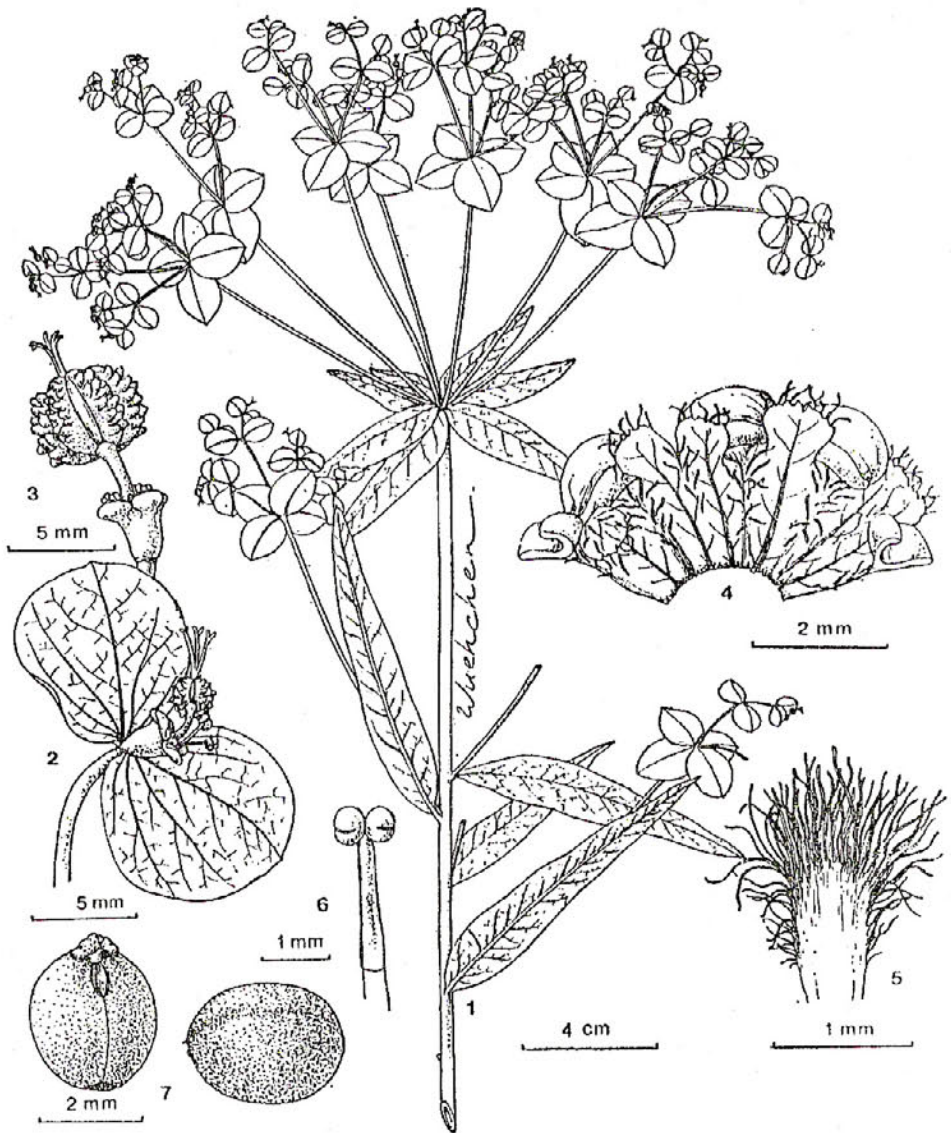


Fig. 3. *Euphorbia formosana* (Lin et al. 251). 1. habit; 2. portion of an inflorescence; 3. cyathium; 4. dissected involucre, adaxial view; 5. bracteole; 6. male flower; 7. seeds (Lin 832): right, abaxial view; left, adaxial view.

- Euphorbia calonesiaca* Croizat in J. Arnold Arb. 19: 97. 1938; Hurusawa in Jap. Bot. 16: 577. pl. 27. 1940; Keng in Quart. J. Taiwan Mus. 4: 258. 1951; Masamune, List Vasc. Pl. Taiwan 46. 1954; Keng in Taiwania 6: 45. 1955; Hsieh In Li et al., Fl. Taiwan 3: 461. 1977. (Type, Satake, s. n. 2 Mar 1898, TI!)
- Galarhoeus formosana* (Hayata) Hara in J. Jap. Bot. 14: 356. 1938.
- Galarhoeus calonesiaca* (Croizat) Hara in J. Jap. Bot. 14: 356. 1938; Croizat & Hara in J. Jap. Bot. 16: 384. 1940; Hurusawa in J. Fac. Univ. Tokyo III. 6(6): 263. f. 25. 1954.

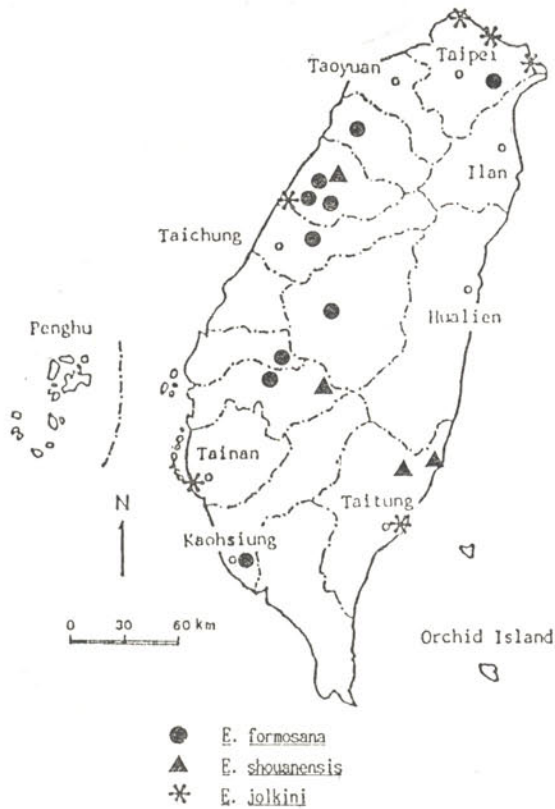


Fig. 4. Distributions of *Euphorbia formosana*, *E. jolkini* and *E. shouanensis*.

Galarhoeus formosanus (Hayata) Hurusawa in J. Fac. Sci. Univ. Tokyo III. 6(6): 261. f. 26. 1954.

A perennial herb. Stem annual, erect, glabrous except sometimes pubescent right below the node. Leaves sessile, linear-lanceolate, 50-120 mm long, 5-15 mm wide, acute at apex, attenuate at base, entire at margin, glabrous on both surfaces, or sometimes hairy on the adaxial surface of leaf base. Cyathia in terminal compound pleiochasia; primary bracteal leaves 5, 8, or 9, green or yellow green, linear-lanceolate or lanceolate, 20-95 mm long, 6-16 mm wide, acute at apex, obtuse at base; secondary bracteal leaves 3 or 4, green or yellow green, broadly obovate, oval, or rhomboid-rounded, 7-18 mm long, 5-15 mm wide, obtuse at apex, rounded or obtuse at base; tertiary bracteal leaves 2 or 3, green or yellow green, broadly obovate or rhomboid-rounded, 9-11 mm long, 8-11 mm wide, obtuse at apex, rounded at base; involucre turbinate, 2.1-3.6 mm long, glabrous abaxially, sericeous adaxilly, the stalk 1.1-1.8 mm long, the lobes ovate-oblong to obovate-oblong, emarginate to irregular dentate at apex, pilose at margin; glands 4, yellow, transversely elliptic, disc-like, 1.1-2.4 mm long; bracteoles oblanceolate, fringed. Male flowers 15-20, anthers yellow. Female flowers with glabrous, densely verrucose ovaries, styles and stigmas 2-4 mm long. Capsules 4-5 mm long, 5.7-6.3 mm in diam., glabrous, sparsely verrucose. Seeds brownish, or grayish, subglobose, 2.8-3.7 mm long, 2.3-2.7 mm in diam., smooth; caruncle semi-circular, revolute.

Distribution: *E. formosana* is an endemic species, restricted to the western parts of Taiwan.

Specimens examined: TAIPEI CO.: Pinlin, *Chin* s.n. 18 Apr 1977 (TAI); Tachichiao, *Ou* s.n. 5 Jun 1988 (TAI). HSINCHU CO.: Hsinchungtu, *M. T. Kao* 10689 (TAI). MIAOLI CO. Sansaho, *Sasaki* s.n. 1 May 1909 (TAIF); Tahu, *Kawakami & Mori* s.n. 28 Jul 1906 (TI); Cholan (Takuran), *Shimada* 1732C (TAI); Tunghsiao, *Suzuki* ST20048 (TAI); Peishihchi, *Lin et al.* 251 (HAST, THAI); Fenghu, *Lin & W. C. Kao* 850 (THAI). TAICHUNG CO.: Taichung City, C.M.C. Campus, *Namba* s.n. 25 Jun 1968 (TI). Tunghsing (Shutiliao), *Miyake* s.n. 16 Jun 1898 (Holotype of *Euphorbia formosana* Hayata, TI!); Tamaopu, *Satake* s.n. 2 Mar 1898 (Type of *Euphorbia calonesiaca* Croizat, TI!). NANTOU CO.: Juitien, *Lin* 684, 832 (HAST, THAI); Tsaoling, *Lu* s.n. 9 Sep 1984 (NCAI). CHIAYI CO.: Meishan, *M. T. Kao* 10487 (TAI).

Classification notes: Hurusawa (1940, 1954) and Keng (1951) separate *E. formosana* from *E. calonesiaca* by its narrower, denser leaves, smaller pleiochasium (umbellate) and bracteal leaves (floral leaves), shorter pleiochasium branches (umbellate branches) and internodes, and smaller and more deeply sulcate fruits (or ovaries with much denser verrucose surface. Although the types of *E. formosana* and *E. calonesiaca* (deposited at TI!) appear distinctive as described by Hurusawa and Keng, actually the above differences are due to collection of the above type materiales in different growing seasons. According to our field observations on the plant development and examination of additional herbarium specimens, intermediate forms between the above two taxa are common. Therefore, it seems more appropriate to include *E. calonesiaca* in *E. formosana*.

2. *Euphorbia jolkini* Boiss., Cent. Euphorb. 32. 1860; Boiss., DC., Prodr. 15: 121. 1862; Forbes & Hemsley in J. Linn. Soc. Bot. 26: 415. 1889; Henry, List. Pl. Form. 81. 1896; Hayata in J. Coll. Sci. Univ. Tokyo 20: 68. 1904; Matsumura & Hayata in J. Coll. Sci. Univ. Tokyo 22: 367. 1906; Kawakami, List Pl. Form. 100. 1910; Hayata, Gen. Ind. Fl. Form. 66. 1917; Sasaki, List Pl. Form. 260. 1928; Suzuki *In* Masamune, Short Fl. Form. 119. 1936; Hurusawa in J. Jap. Bot. 16: 512. 1940; Keng in Quart. J. Taiwan Mus. 4: 257. 1951; Musamune, List Vasc. Pl. Taiwan 46. 1954; Keng in Taiwania 6: 46. 1955; Hsieh *In* Li *et al.*, Fl. Taiwan 3: 462. 1977. 岩大戟 Fig. 4, 5.

Galarhoeus jolkini (Boiss.) Hara in J. Jap. Bot. 11: 385. 1935; Hurusawa in J. Fac. Sci. Univ. Tokyo III. 6(6): 253. f. 19. 1954.

A perennial herb. Stem annual, erect, glabrous. Leaves sessile, green or blue green, linear-oblancoate, 40-92 mm long, 6-18 mm wide, obtuse or retuse at apex, attenuate at base, entire at margin, glabrous on both surfaces. Cyathia in terminal compound pleiochasia; primary bracteal leaves 5, 8, or 9, blue green, elliptic or oblanceolate, 30-60 mm long, 10-20 mm wide, obtuse or retuse at apex, rounded at base; secondary bracteal leaves 2 or 3, blue green or yellow green at base, oblanceolate or elliptic, 20-30 mm long, 10-15 mm wide, obtuse, rounded or retuse at apex, rounded or obtuse at base; tertiary bracteal leaves 2, yellow green, ovate to obovate, 10-18 mm long, 9-12 mm wide, rounded or retuse at apex, rounded at base; involucre campanulate or turbinate, 2-4.3 mm long, glabrous abaxially, woolly adaxially, the stalk 2.4-7.8 mm long, the lobes semicircular to semi-elliptic, truncate to rounded at apex, velutinous at margin; glands 4 or 5, yellow, transversely elliptic, 1.5-2 mm long; bracteoles oblanceolate, fringed. Male flowers

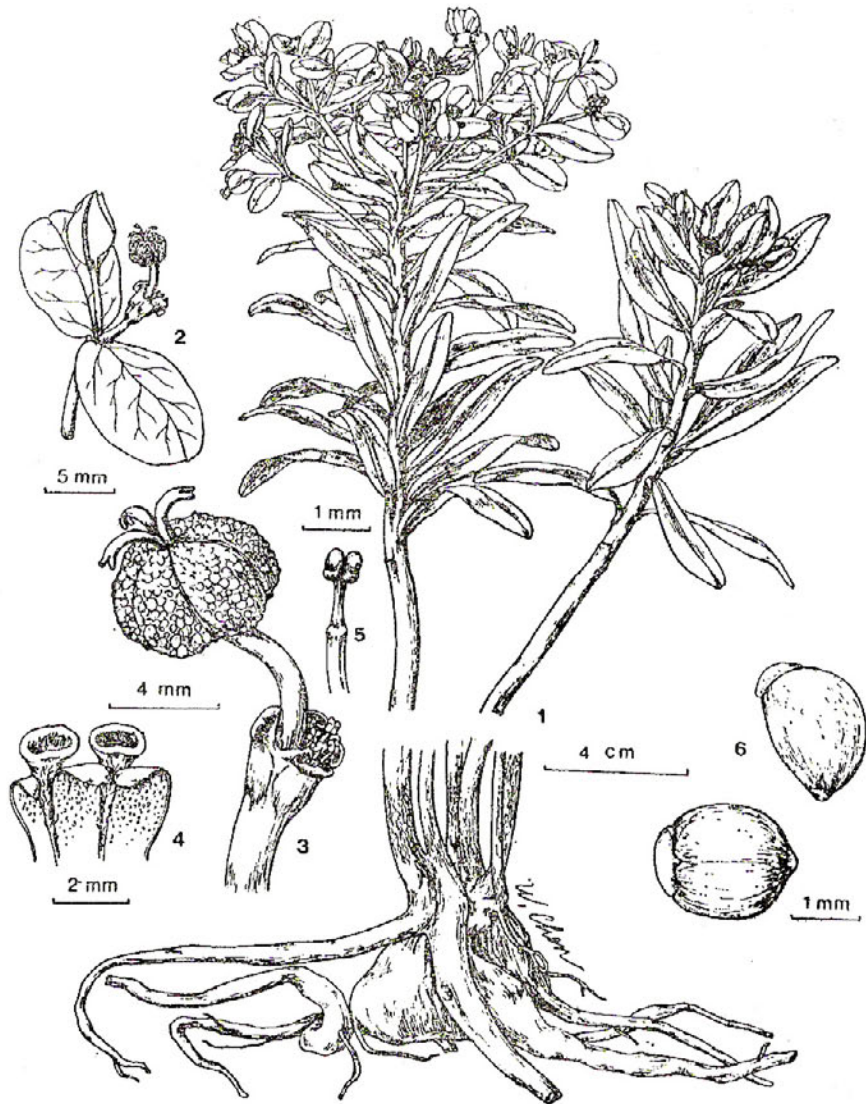


Fig. 5. *Euphorbia jolkini* (Lin et al. 693). 1. habit; 2. portion of an inflorescence; 3. cyathium; 4. portion of dissected involucre, adaxial view; 5. male flower; 6. seeds (Lin et al. 832): above, abaxial view; below, adaxial view.

10-15, anthers yellow. Female flowers with glabrous (occasionally hairy at top), densely verrucose ovaries, styles and stigmas 1-2 mm long. Capsules 4.4-5 mm long, 5.3-6.3 mm in diam., glabrous (occasionally hairy at top), densely verrucose. Seeds blackish, subglobose, 2.2-2.5 mm long, 2-2.3 mm in diam., smooth; caruncle depressed-conical, broadly obovate.

Distribution: *E. jolkini* primarily grows on rocks in northern coastal areas in Taiwan. This species also occurs in Korea, Japan and the Ryukyus (Keng, 1951).

Specimens examined: TAIPEI CO.: Keelung City, *Faurie* 421 (KYO), *Sasaki & Jeujii* s. n. Mar 1913 (TAIF), *Nagazawa* s. n. 6 May 1904 (KYO, TI), *Sasaki* s. n. 16

May 1908 (TAIF), *Hayata s.n.* 19 Mar 1914 (TAIF); Hopingtao, *Ohwi s.n.* 25 Mar 1933 (KYO), *Lin et al.* 692 (THAI). Wanli, *Lu* 4327 (TAIF), *Lin et al.* 691 (HAST, HTAI), *Hsieh & Tang s.n.* 1 Apr 1988 (THAI); Fukueichiao, *Shimada* 1159 (TAI), *Sasaki s.n.* 25 Mar 1924 (TAIF); Pitouchiao, *Lu* 22305 (TAIF); Fulung to Tashianganlan, *Wang* 889 (TAI); Tashianganlan, *Lin et al.* 284 (THAI); Lungtang, *Lin et al.* 693 (HAST, THAI). Taipei, without further locality, *Sasaki s.n.* Mar 1913 (TAIF), *Suzuki* 4752 (TAI). MIAOLI CO.: Yuanli, *Chin s.n.* 4 Apr 1977 (TAI). TAINAN

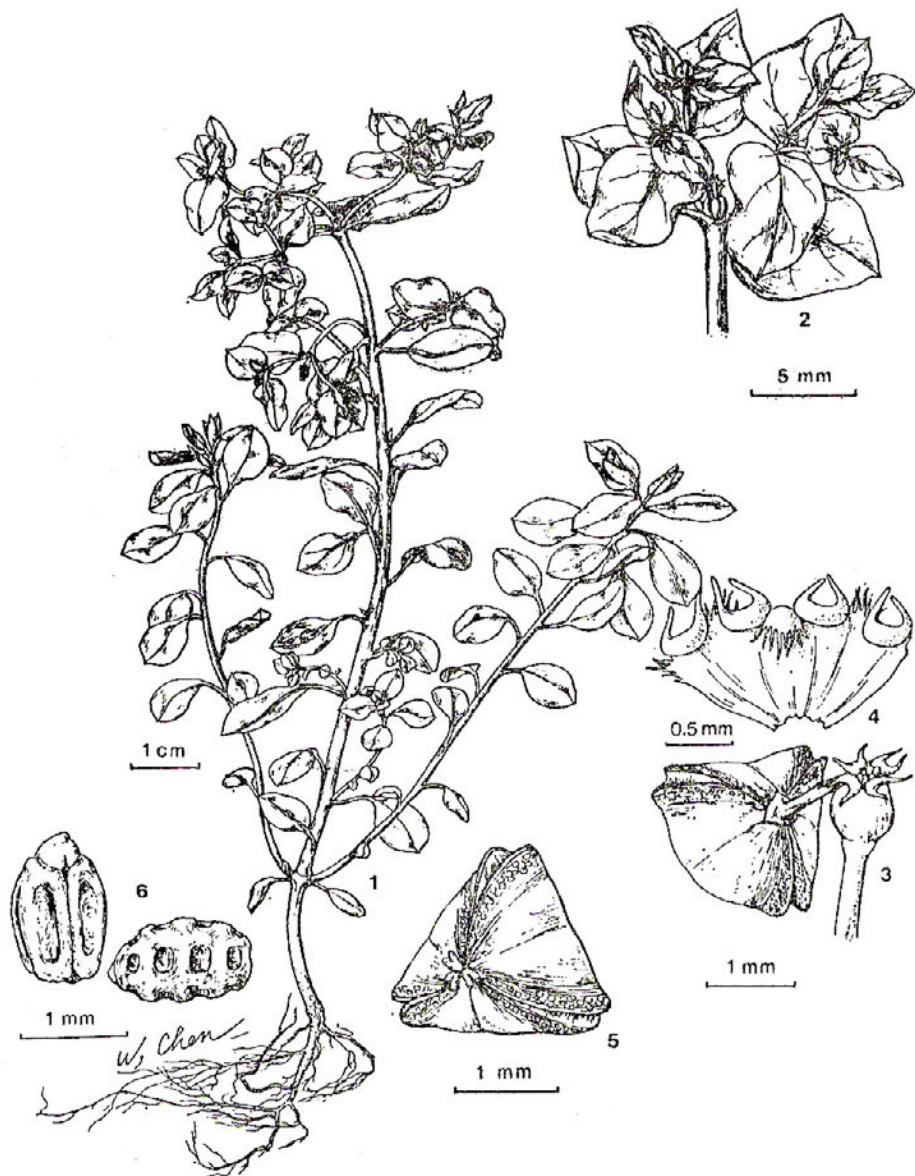


Fig. 6. *Euphorbia peplus* (Lin 683). 1. habit; 2. portion of an inflorescence; 3. cyathium; 4. portion of dissected involucre, adaxial view; 5. capsule, showing bicarinate angles; 6. seeds: right, abaxial view; left, adaxial view.

CO.: Tainan, *Kawakami & Shimada s.n.* Oct 1909 (TAIF). TAITUNG CO.: Taitung, *Kobayashi s.n.* Apr 1907 (TAIF).

3. *Euphorbia peplus* L. Sp. Pl. 456. 1753; Hayata, Icon. Pl. Form. 9: 103. 1920; Sasaki, List Pl. Form. 261. 1928; Suzuki *In* Masamune, Short Fl. Form. 119. 1936; Hurusawa in J. Jap. Bot. 16: 343. 1940; Keng in Quart. J. Taiwan Mus. 4: 259. 1951, *excl. sp.*; Masamune, List Vasc. Pl. Taiwan 47. 1954; Keng in *Taiwania* 6: 47. 1955, *excl. sp.* 葶艾類大戟 Fig. 6, 7.

Galarhoeus peplus (L.) Haworth *ex* Small, Manual S. E. Fl. 801. 1933; Hara in J. Jap. Bot. 14: 356. 1938; Hurusawa in J. Fac. Sci. Univ. Tokyo III. 6(6): 238. 1954.

A biennial herb. Stem erect, glabrous. Leaves obovate to obovate-elliptic, 10-18 mm long, 5-10 mm wide, obtuse to rounded at apex, attenuate at base, entire at margin, glabrous on both surfaces; petioles slender, 2.5-7 mm long. Cyathia in terminal compound pleiochasia; primary bracteal leaves 3, green, obovate to obovate-elliptic, 8-16 mm long, 4-8 mm wide, obtuse to rounded at apex, attenuate at base, petioles 2-7 mm long; secondary bracteal leaves 2, green or yellow green, triangular-ovate to obovate, 12-17 mm long, 7-11 mm wide, obtuse at apex, obliquely cuneate to attenuate at base; tertiary bracteal leaves 2 or 3, green or yellow green, the shape same as secondary, 11-16 mm long, 8-10 mm wide; involucre turbinate, 0.8-1 mm long, glabrous abaxially and adaxially, the stalk 0.8-1.6 mm long, the lobes ovate, ciliate; glands 4, pale green, lunate, much prolonged at each end into slender horns, 0.3-0.4 mm long; bracteoles linear, branched at top. Male flowers

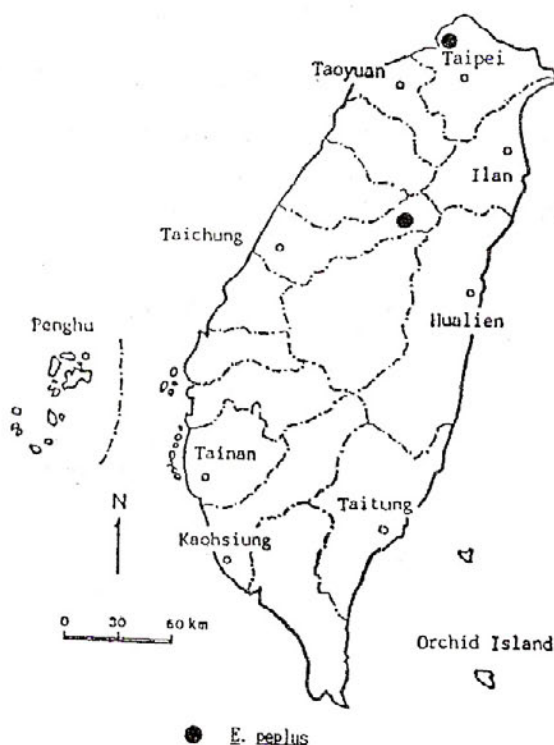


Fig. 7. Distribution of *Euphorbia peplus* (solid circle).

10-20, anthers yellow. Female flowers with glabrous ovaries, bicarinate at each angle, styles and stigmas 0.2-0.4 mm long. Capsules bicarinate at each angle, ca. 2 mm long, ca. 1.9 mm in diam., glabrous. Seeds grayish, ellipsoid, subhexagonal 1.3-1.5 mm long, 0.7-0.8 mm wide, the two ventral faces each with a large lengthwise depression, the four dorsal faces each with 1-4 large shallow pits in longitudinal rows, sometimes additional pits between the rows; caruncle conical.

Distribution: *E. peplus* is native to Europe, North Africa and Continental Asia (Backer and Bakhuizen, 1963), and now is a cosmopolitan weed (Huft, 1990). Specimens were collected from Tanshui and shady place of Wuling Farm in Taiwan.

Specimens examined: TAIPEI CO.: Tanshui, *Nagazawa* 798 (TI), *Kawakami & Mori s.n.* Jun 1907 (TI), *Mori s.n.* 7 Jun 1907 (TAIF), *Kuo* 6571 (TAI). TAICHUNG CO.: Wuling Farm, *Lin* 630, 683 (THAI, HAST).

Classification notes: *E. peplus* is characterized by its fibrous root, ovate and petiolate leaves, lunate glands, and pitted seeds. Its blooming and fruiting period is also different from other species in the same subgenus. Blooming and fruiting periods are year-round in *E. peplus*, while in other species are between February and August.

4. *Euphorbia shouanensis* Keng in J. Washington Acad. Sci. 41: 205. 1951; Keng in Quart. J. Taiwan Mus. 4: 257. pl. 1, 2. 1951; Masamune, List Vasc. Pl. Taiwan 46. 1954; Keng in *Taiwania* 6: 46. 1955; Hsieh *In Li et al.*, Fl. Taiwan 3: 464. 1977. (Holotype, *Suzuki* ST 20910, TAI!) 叔安大戟 Fig. 4, 6.

Galarhoeus shouanensis (Keng) Keng in Quart. J. Taiwan Mus. 4: 257. 1951; Hurusawa in J. Fac. Sci. Univ. Tokyo III. 6(6): 263. 1954; Keng in *Taiwania* 6: 46. 1955.

Euphorbia formosana sensu Yamamoto in J. Trop. Soc. Agric. 5: 179. 1933, *non* Hayata.

Galarhoeus formosanus (Hayata) Hurusawa var. *hayatai* Hurusawa in J. Fac. Sci. Univ. Tokyo III. 6(6): 263. f. 26. 1954.

A perennial herb. Stem annual, erect, villous. Leaves sessile, linear-lanceolate, 50-80 mm long, 6-18 mm wide, acute at apex, attenuate at base, entire at margin, glabrous on both surfaces or villous basally. Cyathia in terminal compound pleiochasia; primary bracteal leaves 5, 7, or 8, green or yellow green, oval, oblong to oblong-lanceolate, 15-43 mm long, 6-15 mm wide, acute at apex, rounded at base; secondary bracteal leaves 3 or 4, green or yellow green, broadly obovate, oval to rhomboid-rounded, 7-18 mm long, 7-14 mm wide, acute or obtuse at apex, rounded at base; tertiary bracteal leaves 2 or 3, green or yellow green, broadly obovate or rhomboid-rounded, 6-11 mm long, 5-9 mm wide, obtuse to rounded at apex, rounded at base, involucre turbinate, 1.8-2.8 mm long, glabrous abaxially, woolly adaxially, the stalk 1-1.3 mm long, the lobes ovate-oblong to obovate-oblong, emarginate to irregular, dentate at apex, velutinous at margin; glands 4, yellow, transversely elliptic, 0.8-1.5 mm long; bracteoles oblanceolate, fringed. Male flowers 15-20, anthers yellow. Female flowers with glabrous, densely verrucose ovaries, styles and stigmas 1-2 mm long. Capsules glabrous, sparsely verrucose. Seeds dark-brownish, subglobose, ca. 2.4 mm long, 2.1 mm in diam., smooth; caruncle depressed-conical, reniform.

Distribution: *E. shouanensis* is endemic to eastern and western regions of Taiwan. Local populations occur at exposed hill side and grass land of mountain.

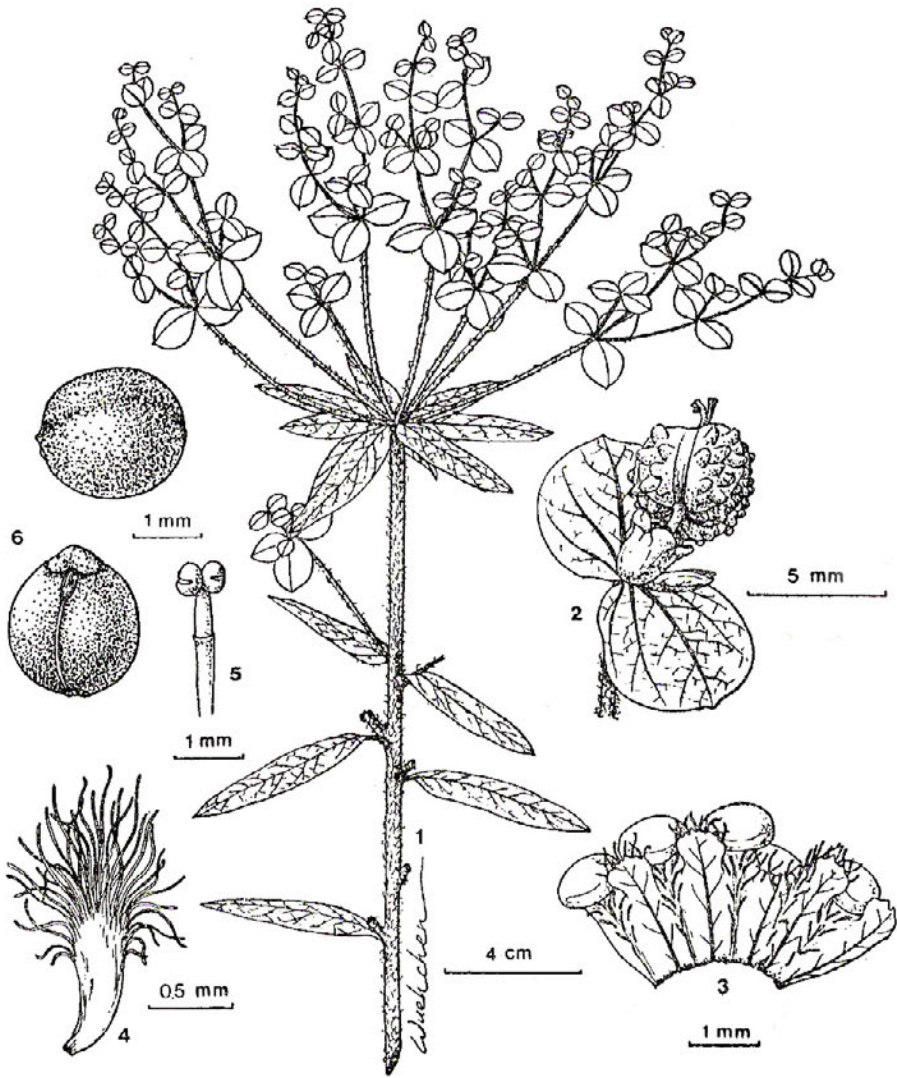


Fig. 8. *Euphorbia shouanensis* (Lin & Chou 269). 1. habit; 2. portion of an inflorescence; 3. dissected involucre, adaxial view; 4. bractcole; 5. male flower; 6. seeds: above, abaxial view; below, adaxial view.

Specimens examined: MIAOLI CO.: Peishi, *Chuang & Kao 2811* (TAI); Houlung, *Kao k3794* (TAI); Tunghsia to Yungli, *Lin & Chou 269* (THAI). CHIAYI CO.: Shouan, Hsiashan, *Suzuki ST 20910* (Holotype of *Euphorbia shouanensis* Keng, TAI!). TAITUNG CO.: Kuanshan, *Kawakami 4921* (TAIF); Painienpu, *Yamamoto 770* (TAI); Hsiaokang, *Kobayashi 4794* (TAIF).

Classification notes: *E. shouanensis* is distinguishable from *E. formosana* by its villous stem. Besides, the sizes of involucre, styles and seeds of *E. shouanensis* are smaller than those of *E. formosana*. Since Hurusawa described the variety *Galarhoeus formosana* var. *hayatai* Hurusawa, it has not been documented by any author for the local species of *Euphorbia*. We have been unable to locate the type specimen, Hayata s.n. 1912 (collected in Tyoreisan). But *Galarhoeus formosana* var. *hayatai*

Hurusawa is assignable to *Euphorbia shouanensis*, based on Hurusawa's description (1954), especially concerning to its villous stems.

5. *Euphorbia tarokoensis* Hayata, *Icon. Pl. Form.* 7: 34. *pl.* 9. 1918; Sasaki, *List Pl. Form.* 261. 1928; Suzuki *In Masamune*, *Short Fl. Form.* 120. 1936; Hurusawa in *J. Jap. Bot.* 16: 461. 1940; Keng in *Quart. J. Taiwan Mus.* 4: 257. 1951; Masamune, *List Vasc. Pl. Taiwan* 47. 1954; Keng in *Taiwania* 6: 47. 1955; Hsieh *In Li et al.*, *Fl. Taiwan* 3: 464. 1977. (Holotype, *Hayata & Sasaki s. n.* 27 Apr. 1917, TI!)

太魯閣大戟 Fig. 9, 10.

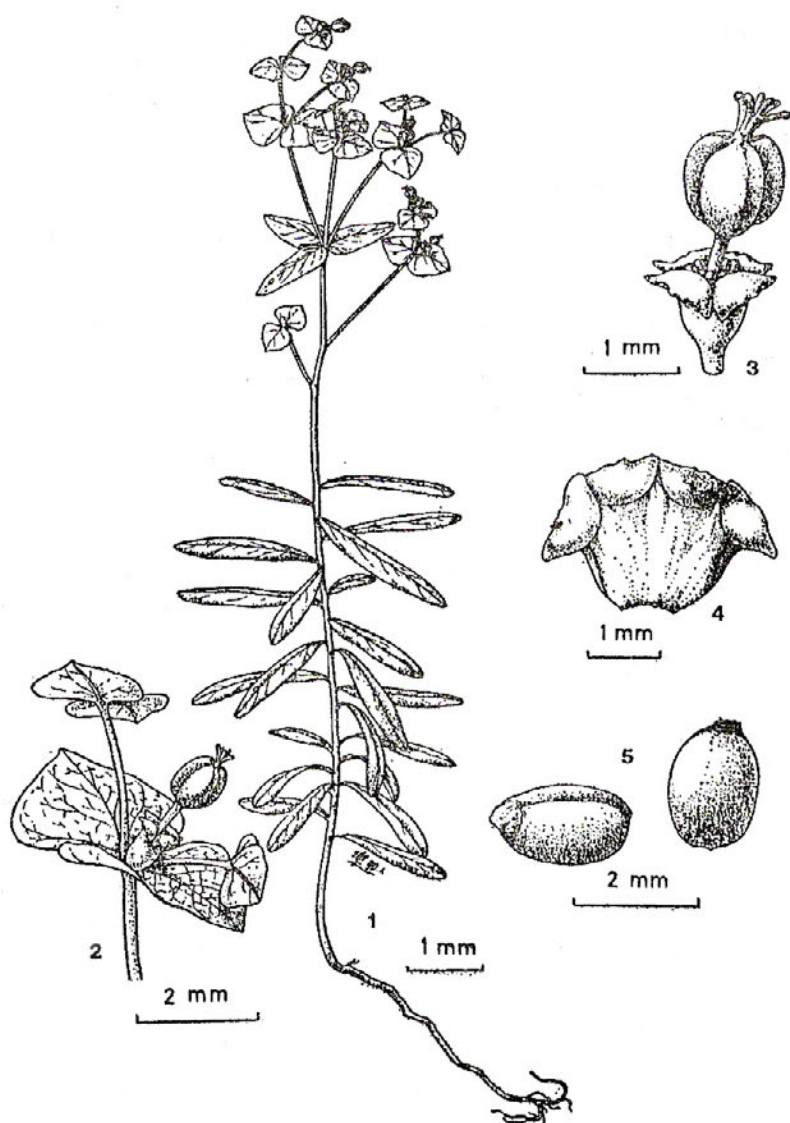


Fig. 9. *Euphorbia tarokoensis* (Lin & Noe 380). 1. habit; 2. portion of an inflorescence; 3. cyathium; 4. dissected involucre, adaxial view; 5. seeds: right, abaxial view; left, adaxial view.

Galarhoeus tarokoensis (Hayata) Hara in J. Jap. Bot. 14: 356. 1938; Hurusawa in J. Fac. Sci. Univ. Tokyo III. 6(6): 250. f. 17. 1954.

A perennial herb. Stem annual, erect, glabrous. Leaves sessile, linear to linear-oblong, 20–50 mm long, 2–7 mm wide, obtuse to rounded or retuse at apex, rounded at base, entire at margin, glabrous on both surfaces. Cyathia in terminal compound pleiochasia; primary bracteal leaves 3 or 4, green or yellow green, ovate, oblong-lanceolate or oblong-oblong, 7–17 mm long, 0.3–1.2 mm wide, obtuse or apiculate at apex, rounded at base; secondary bracteal leaves 2, green or yellow green, deltoid to reniform or rhomboid, 5–13 mm long, 0.6–1.2 mm wide, obtuse at apex, rounded, cordate or truncate at base; tertiary bracteal leaves 2, green or yellow green, the shape same as secondary, 6–10 mm long, 3–6 mm wide; involucre urceolate-turbinate, 1.3–1.9 mm long, glabrous abaxially, velutinous adaxially, the stalk 0.2–0.7 mm long, the lobes semi-rounded to semi-oblong, entire to emarginate at apex, ciliate; glands 4 to 5, yellow, semi-circular to lunate, entire to denticulate or crenulate at abaxial margin, 0.9–1.7 mm long; bracteoles linear, lacinate. Male flowers 10–15, anthers yellow. Female flowers with glabrous ovaries, styles and stigmas 0.5–1.1 mm long. Capsules glabrous. Seeds grayish, ellipsoid, 2–2.2 mm long, 1.4–1.5 mm in diam., smooth; caruncle depressed-conical, subcircular.

Distribution: *E. tarokoensis* is endemic to rocky places of mountains in Hualien county.

Specimens examined: HUALIEN CO.: Chingshuishan, *Nakamura T. N-3782* (TAI); Tatuanyai (Dangai), *Suzuki 10479* (TAI); Uchitaroko, *Kanehira & Sasaki s.n. 1 Jun 1919* (TAIF); Matakanshe (Batakan) to Uchitaroko, *Hayata & Sasaki s.n. 27 Apr*

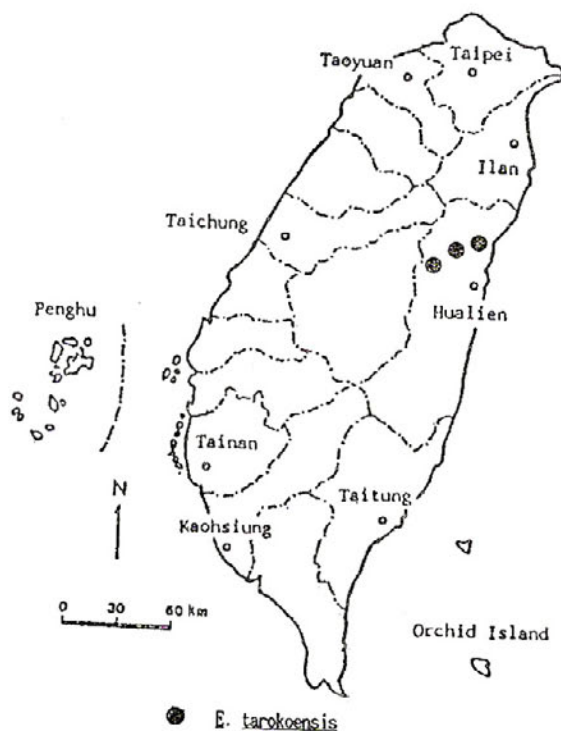


Fig. 10. Distribution of *Euphorbia tarokoensis* (solid circle).

1917 (Holotype and Isotype of *Euphorbia tarokoensis* Hayata, TI!); Niuku (Gukutu), *Matuda T549* (TI); Lihshoei, *Lu 15975* (TAIF), *Chiou & T. T. Lin s. n.* 4 Apr 1983 (TAIF); Hsincheng, *Ohwi s. n.* 22 Apr 1933 (KYO); Wenshen, *Shimizu 12657* (KYO); Yenhai Forest Trail, *Lin & Noe 380* (THAI), *Lin & Hsiao 628* (THAI), *Peng 13324* (HAST). Hualien, without further locality, *Nenkao & Ohwi s. n.* Jun 1933 (KYO).

2. Subgenus *Euphorbia* L.

1. *Euphorbia tirucalli* L. Sp. Pl. 452. 1753; Henry, List. Pl. Form. 82. 1896; Matsumura & Hayata in J. Coll. Sci. Univ. Tokyo 22: 367. 1906; Kawakami, List Pl. Form. 100. 1910; Hayata, Gen. Ind. Fl. Form. 66. 1917; Sasaki, List Pl. Form. 261. 1928; Kanehira, Form. Tree rev. ed. 339. 1936; Suzuki *In* Masamune, Short Fl. Form. 120. 1926; Hurusawa in J. Jap. Bot. 16: 335. 1940; Keng in Quart. J. Taiwan Mus. 4: 259. 1951, *excl. sp.*; Hurusawa in J. Fac. Sci. Univ. Tokyo III. 6(6): 231. 1954; Masamune, List Vasc. Pl. Taiwan 47. 1954; Keng in Taiwania 6: 47. 1955, *excl. sp.*; Hsieh *In* Li *et al.*, Fl. Taiwan 3: 466. 1977. 綠珊瑚 Fig. 11.

A shrub. Stem erect, branches numerous, green, terete, succulent, glabrous or sparsely puberulent. Leaves sessile, linear to oblanceolate, 10–16 mm long, 1.8–3 mm wide, obtuse to rounded at apex, attenuate at base, entire at margin, glabrous on both surfaces or puberulent below, caducous. Cyathia in terminal compound pleiochasia; primary bracteal leaves 3, secondary bracteal leaves 2; involucre turbinate, ca. 2.3 mm long, the lobes triangular-ovate, puberulent; glands 4, yellow, deltoid-ovate, ca. 2 mm long. Female flowers with puberulent ovaries, styles and

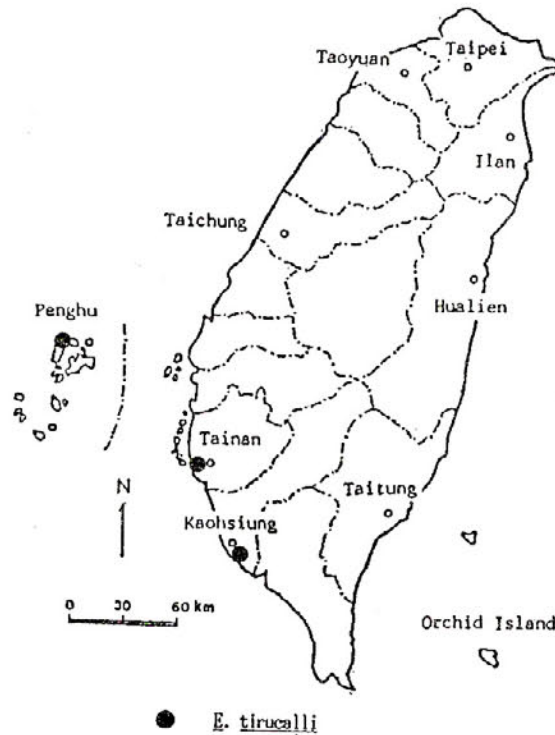


Fig. 11. Distribution of *Euphorbia tirucalli* (solid circle).

stigmas ca. 1.8 mm long. Capsules ca. 7.2 mm long, puberulent. Seeds pale yellow, ovoid, 3.8-4.3 mm long, 3-3.2 mm in diam., smooth; caruncle depressed-conical, subcircular to subcircular-lobate.

Distribution: *E. triucalli* is a native of East Africa and India (Stone, 1970). It has naturalized in coastal areas of southern Taiwan and Penghu Islands.

Specimens examined: TAIPEI CITY: Botanic Garden *Sasaki s.n.* Sep 1922 (TAI). TAINAN CO.: Anping, *Morilani 2360* (TI). KAOHSIUNG CO.: Kaohsiung City, *Kawakami & Mori s.n.* Oct 1907 (TAIF), *Sasaki s.n.* Aug 1916 (TAIF); *Yamada s.n.* Jan 1928 (TI); Shoushan, *Chang 1916* (PAI); Chiching, *Saito 602, 1001, 1657* (TI); Hsiaoliuchiu, *Hosokawa 1934* (TAI). PENGHU CO.: Tunglian, *Kudo & Mori 3047* (TAI).

Classification notes: This species is readily separated from its congeners in Taiwan by its shrubby habit and succulent branches.

3. Subgenus *Poinsettia* (Graham) House

Key to the species

1. Stems angled; bracteal leaves usually red at base; involucre gland bilabiate, the opening narrowly oblong; capsules glabrous..... 1. *E. cyathophora*
1. Stems rounded; bracteal leaves green or pale at base; involucre gland funnel-like, the opening circular; capsules puberulent..... 2. *E. heterophylla*
1. ***Euphorbia cyathophora*** Murr., *Comm. Götting. 7: 81. 1786*; Huft in *Ann. Missouri Bot. Gard. 71: 1022. 1984.* 猩猩草 Fig. 12, 13.

Euphorbia heterophylla sensu Kawakami, *List Pl. Form. 100. 1910*; Hayata, *Gen. Ind. Fl. Form. 66. 1917*; Sasaki, *List Pl. Form. 260. 1928*; Suzuki *In Masamune, Short Fl. Form. 119. 1936, non L.*

Poinsettia cyathophora (Murr.) Kl. & Gke., *Monatsb. Akad. Berlin 1859: 253. 1859*; Dressler in *Ann. Missouri Bot. Gard. 48: 338. 1962.*

A perennial herb. Stems ascending or erect, glabrous to sparsely puberulent; stipules gland-like. Leaves pandurate, ovate to ovate-lanceolate, 40-93 mm long, 20-42 mm wide, acute to obtuse at apex, cuneate to rounded at base, entire to serrulate or dentate at margin, glabrous to sparsely puberulent above, puberulent below; petioles slender, 5-17 mm long, puberulent. Cyathia in terminal compound dichasia; bracteal leaves usually red, rarely pale yellow at base, leaf-like; involucre elongate-turbinate, 3-4.6 mm long, glabrous abaxially, the stalk 1.2-17 mm long, the lobes depressed ovate, cleft to subsinuate at apex, sparsely puberulent at margin; glands 1 or rarely 2, yellow, more or less bilabiate, the opening narrowly oblong; bracteoles linear to oblanceolate, fringed. Male flowers 35-60, anthers yellow. Female flowers with glabrous ovaries, styles and stigmas 1-1.5 mm long. Capsules 4.1-5.2 mm long, 3.5-3.9 mm in diam., glabrous. Seeds brownish to blackish, ovate-ellipsoid, 2.6-3 mm long, 2-2.5 mm in diam., tuberculate, ecarunculate.

Distribution: *E. cyathophora* is a native of eastern and southern United States, northern South America and West Indies, and a naturalizer in the Old World (Huft, 1990). Local populations occur in waste places and roadsides of coastal areas.

Specimens examined: HSINCHU CO.: Nanliao, *Lin et al. 256* (THAI). TAICHUNG CO.: Taichungkang, *Lin 835* (THAI). YUNLIN CO.: Santiaolun, *Lin & Li 136, 139*

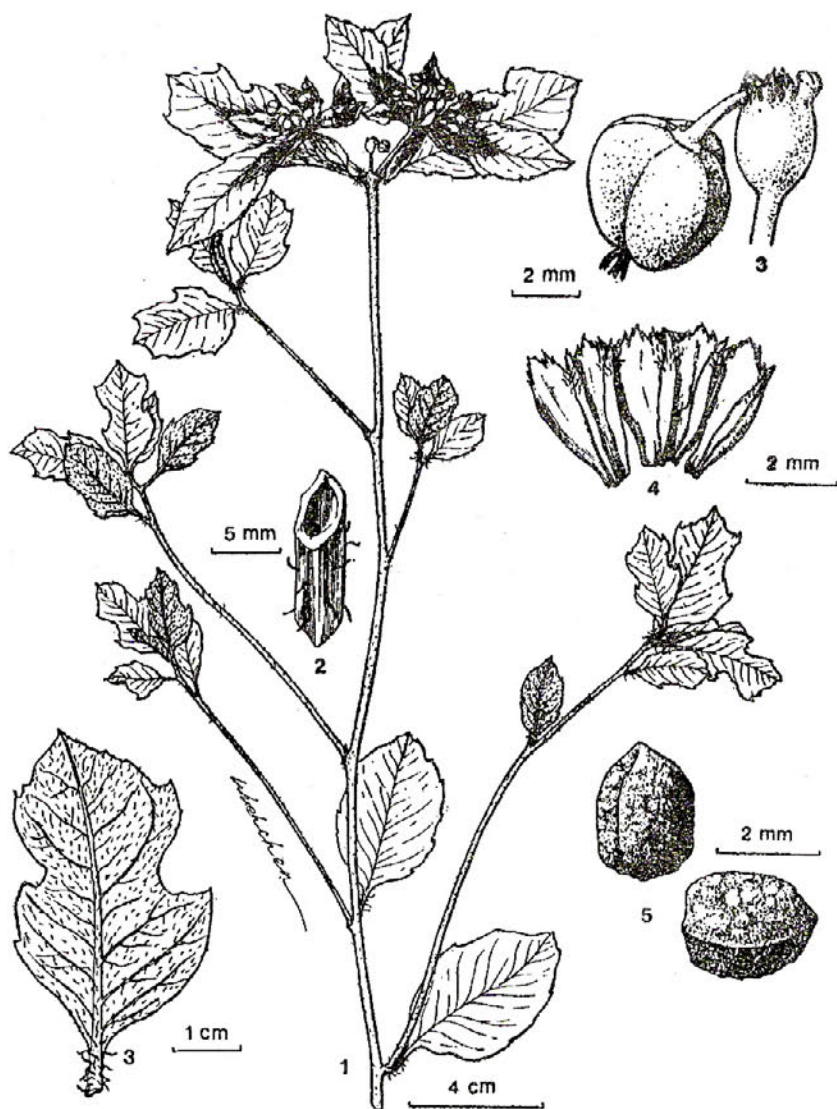


Fig. 12. *Euphorbia cyathophora* (Lin 662). 1. habit; 2. portion of stem, showing keeled stem; 3. leaf, abaxial view; 4. cyathium; 5. dissected involucre, adaxial view; 6. seeds: right, abaxial view; left, adaxial view.

(THAI). TAINAN CO.: Tainan, *Lin et al.* 394 (THAI). KAOHSIUNG CO.: Chungchou, *C.E. Chang & J.T. Chang* 6815 (PAI). PINGTUNG CO.: Pintung City, N.P.T.A.C. Campus, *C.E. Chang s.n.* 1 Jun 1968 (PAI), *Yang & He* 85 (PAI); Hungchun, *Kuo s.n.* 15 May 1956 (NTUF); Kenting to Nanwan, *Lin & Wang* 569 (THAI); Hsiaoliuchiu, *Lin et al.* 78, 80 (THAI). PENGHU CO.: Makung, *Chung* 438, 439 (PAI), *Peng* 12749 (HAST). TAITUNG CO.: Taitung, *Lin* 662 (THAI); Hsiaoyehliu, *Chen* 108 (PAI); Sanhsientai, *Lu* 19320 (TAIF).

Classification notes: This species had been mistaken as *E. heterophylla* L. by Kawakami, Hayata, Sasaki and Suzuki. Dressler (1962) has elucidated *E. heterophylla*

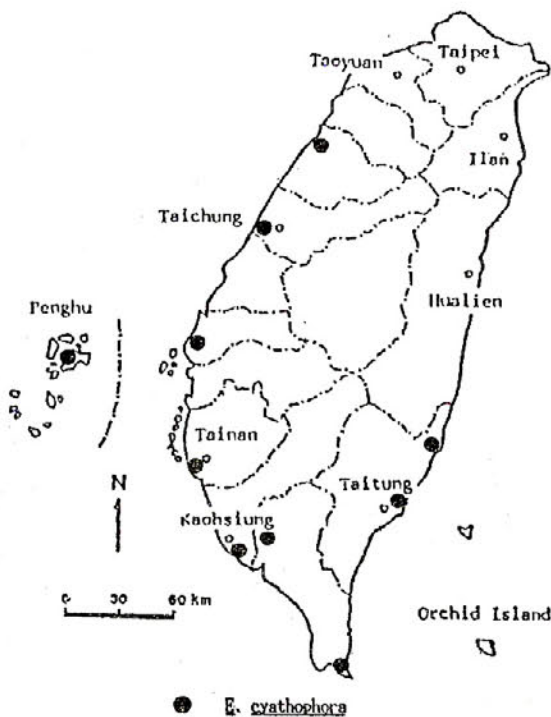


Fig. 13. Distribution of *Euphorbia cyathophora* (solid).

(as *Poinsettia heterophylla*) as having green or basally pale floral bracts and funnel-like glands, while *E. cyathophora* (as *P. cyathophora*) having bilabiate, oblong glands. Basing on Dressler's (1962) description and figures and Dr. Wunderlin's confirmation (person., comm.) we consider kawakami's species to be *E. cyathophora*.

2. *Euphorbia heterophylla* L., Sp. Pl. 453. 1753; Huft in Ann. Missouri Bot. Gard. 71: 1023. 1984. 白苞猩猩草 Fig. 14, 15.

Poinsettia heterophylla (L.) Kl. & Gke., Monatsb. Akad. Berlin 1859: 253 1859; Dressler in Ann. Missouri Bot. Gard. 48: 339. 1962.

Euphorbia geniculata Orteg, Nov. Pl. Rav. Hort. Matr. Decad. 18. 1797; Ou in Bull. Expr. For. NCHU 5: 60. 1983.

Euphorbia taiwaniana Ying, Col. Illust. Fl. Taiwan 2: 685. 1987. (Holotype, Ying s. n. 26 Jan 1985, NUTF!)

A perennial herb. Stems ascending to erect, sparsely hirsute; stipules gland-like. Leaves ovate to lanceolate, 30-120 mm long, 10-60 mm wide, acute to subacuminate at apex, obtuse to rounded at base, serrulate to entire at margin, puberulent on both surfaces; petioles slender, 4-12 mm long, hirsute. Cyathia in terminal compound dichasia; bracteal leaves green or pale at base, leaf-like; involucre elongate-turbinate, 2.1-3.1 mm long, sparsely puberulent abaxially at apex, the stalk 1.2-7.4 mm long, the lobes ovate, denticulate to cleft at apex, puberulent at margin; glands 1 or rarely 2, yellow, more or less funnel-like, the opening circular, 0.5-1 mm in

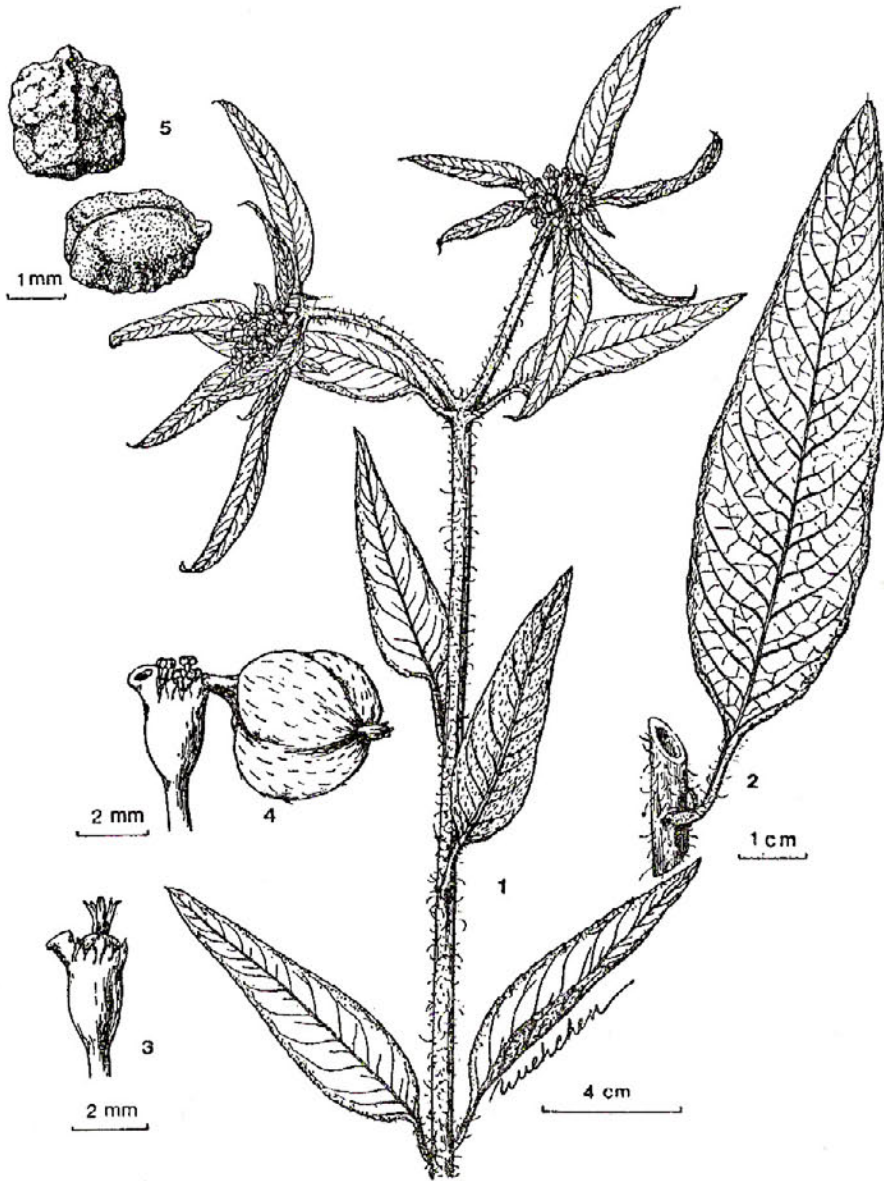


Fig. 14. *Euphorbia heterophylla* (Lin 858). 1. habit; 2. portion of stem with leaf, showing rounded stem and glandular stipule; 3. cyathium with female flower; 4. cyathium with nearly mature capsule; 5. seeds: above, abaxial view; below, adaxial view.

diam.; bracteoles linear to oblanceolate, fringed. Male flowers 15-30, anther yellow. Female flowers with puberulent ovaries, styles and stigmas 1.2-1.4 mm long. Capsules 5-5.7 mm long, 3.6-4.1 mm in diam., puberulent. Seeds brownish or grayish, truncate-ovoid, 2.5-2.9 mm long, 2.1-2.3 mm wide, tuberculate; caruncle small, black.

Distribution: *E. heterophylla* is a native of southern United States, the West

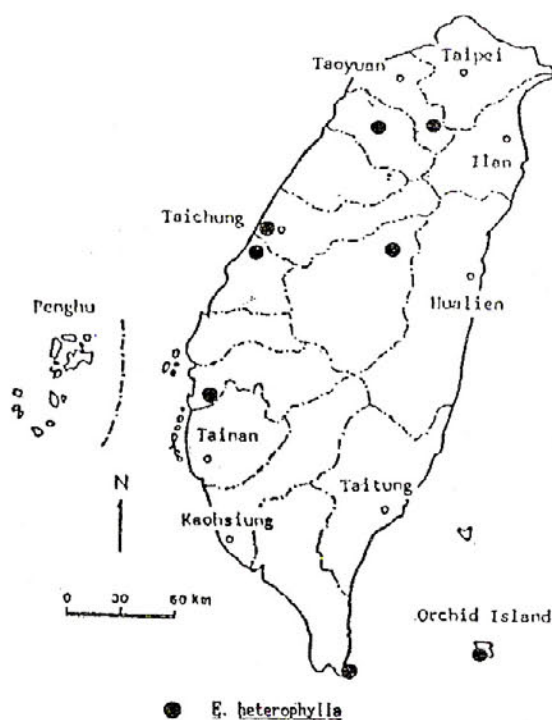


Fig. 15. Distribution of *Euphorbia heterophylla* (solid circle).

Indies, and Argentina, and naturalized in the Old World Tropics (Huft, 1990). In Taiwan, it grows in waste places, riversides and trailsides.

Specimens examined: TAOYUAN CO.: Upper Paling to Lalashan, *Peng* 11019 (HAST). HSINCHU CO.: Hengshan, *Peng* 12126 (HAST). TAICHUNG CO.: Taichung City, Liuchuan, *Lin* 64 (THAI); Tunghai Univ. Campus, *Lin* 20, 858 (THAI). Tatushan, *Yang* 801 (TAI); Lungchin, *Lin* 15 (THAI). NANTOU CO.: Aowantai, *Chen* 9600 (TCF); Shuangdong, *Lin et al.* 452 (THAI). CHANGHUA CO.: Shengkang, *Lin & Li* 49, 57 (THAI). PINGTUNG CO.: Oluanpi to Chialoshui, *Ying* s.n. 26 Jan 1985 (Type of *Euphorbia taiwaniana* Ying, NTUF!), *Ying* s.n. 27 Jan 1985 (NTUF). TAITUNG CO.: Kuanshan, *Lu* 19217 (TAIF); Lanyu, Shuangshihyen to Hungtou, *Lin* 772 (THAI); Lanyu, without further locality, *Chang* 15023 (PAI).

Classification notes: Careful examination and evaluation of the holotype of *Euphorbia taiwaniana* Ying led the authors to the conclusion that only one species is concerned here. Both are characterized by rounded stems, petiolate leaves, terminal dichasia, green (or basally pale) floral bracts and funnel-like glands.

ACKNOWLEDGEMENT

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臺灣大戟屬的分類研究

林叔芊 謝長富

摘 要

狹義的大戟屬 (*Euphorbia* L., 大戟科) 在臺灣共有 8 種。本文更正猩猩草的學名為 *E. cyathophora* Murr., 白苞猩猩草的學名為 *E. heterophylla* L.; 處理 *E. calonesiaca* Croizat, *Galarhoeus formosana* (Hayata) Hurusawa var. *hayatai* Hurusawa 和 *E. taiwaniana* Ying 分別為 *E. formosana* Hayata, *E. shouanensis* Keng 和 *E. heterophylla* L. 的同義名。此外, 亦討論屬內的分類特徵, 記述各種的性狀、地理分佈及觀察的標本, 並提供檢索表, 各種的繪圖以為辨識。