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Aster kanoi (Asteraceae, Astereae), a new species from Taiwan, with lectotypification and morphological emendation of *Aster takasagomontanus*

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ABSTRACT: *Aster kanoi* S. W. Chung, W. J. Huang & T. C. Hsu (Asteraceae, Astereae), a new species from Taiwan, is described and illustrated. *A. kanoi* is morphologically similar to *A. takasagomontanus* Sasaki but can be distinguished by its slenderer rhizome, up to 7-headed corymbiform synflorescence, smaller capitulum and fimbriate-ciliate margin of phyllary. A lectotype of *A. takasagomontanus* is also designated due to the absence of the original holotype, and its morphological delimitation is reappraised.

KEY WORDS: Asterinae, Alpine, Endemic, Kano Tadao, Lectotypification.

INTRODUCTION

Aster L. is the type genus of Asteraceae, containing ca. 160 species mainly distributed in Eurasia (Nesom, 1994; Chen *et al.*, 2011; Mabberley, 2017). The circumscription of the genus has been problematic (Dorn, 2003; Li *et al.*, 2012). Traditionally, *Aster s.l.* comprises of up to 1000 species distributed in both Eurasia and North America (Ling *et al.*, 1985; Nesom, 1994; Ito and Soejima, 1995; Noyes and Rieseberg, 1999). Evidences from morphology, cytology and molecular phylogeny suggest that *Aster s.s.* is restricted to Eurasia with only one exception reaching the New World (Nesom 1994; Noyes & Rieseberg 1999; Li *et al.* 2012). Yet many related genera, such as *Kalimeris, Heteropappus and Miyamayomena,* were found to be nested within *Aster* clade in the phylogenetic tree, while many well-recognized species of Chinese *Aster s.s.* were left outside the clade (Li *et al.*, 2012; Korolyuk *et al.*, 2015). On the other hand, new species of *Aster* were continuously found in the south-western China, the largest diversity center of *Aster*, in recent years (Li & Liu, 2002; Li & Chen, 2006; Zhang *et al.*, 2015; Li *et al.*, 2017; Xiao *et al*., 2019).

Despite its relatively small area, Taiwan also exhibits high species diversity of *Aster*. Of the 16 *Aster* species recorded in Taiwan, nine species are known to be endemic (Soejima and Peng, 2003) and they occupy a broad range of habitats including subtropical seashore (e.g., *A. oldhamii*), misty forests (e.g., *A. taiwanensis*), limestone ridges (e.g., *A. chingshuiensis*) and alpine exposed rocks (e.g., *A. takasagomontanus*). During our recent field investigations around the northern part of the Central Range, we found that the small-sized *Aster* plants growing in the high elevation above 3000 meters, all of which were previously identified as *A. takasagomontanus,* actually comprise of two morphologically distinct taxa. After examination of the fresh materials and related specimen preserved in herbaria (HAST, TAI and TAIF), we conclude that the undescribed species can be readily distinguished from *A. takasagomontanus* by some distinctive features in synflorescence, capitulum, phyllary, and rhizome, and it could not match any other known *Aster* taxa, so it is herein described as a new species, *Aster kanoi* S. W. Chung, W. J. Huang & T. C. Hsu.

Besides, the deposition of the holotype of *Aster takasagomontanus* was not declared in the protologue, nor found in TAI, TAIF or TI, in which most of Sasaki's specimen are deposited, thus the holotype had been presumably lost. Because there are no holotype or isotypes available for study, lectotypification must be made from the four paratypes stated in the protologue for further comparison. Here we choose a comparably complete and well-preserved paratype specimen as the lectotype for *A. takasagomontanus* based on Art. 9.11 and 9.12 of the ICN (Turland *et al.*, 2018). The revised morphological description of *A. takasagomontanus* and a key to diagnose related species in Taiwan are also given.

Key to the alpine/limestone *Aster* species in Taiwan

1a. Plants dwarf, less than 5 cm tall …….. ***A. itsunboshi***
1b. Plants 10–40 cm tall ……. 2
2a. Cauline leaves usually > 3 cm long, acuminate at apex ……... ……..…… ***A. morrisonensis***
2b. Cauline leaves usually < 3 cm long, acute to rounded at apex … 3
3a. Cauline leaves usually more than 5; capitulum 1–2 cm in diam.; plants growing in limestone regions of 1500–2500 m asl …… ……..……..…… ***A. chingshuiensis***
3b. Cauline leaves usually fewer than 5; capitulum usually 2–4 cm in diam.; plants growing in alpine or subalpine regions of 2800–3800 m asl. ……... 4
4a. Synflorescence 1–3(–4)-headed, subscapose, capitulum 3–4 cm in diam.; phyllary oblong to oblong-ovate, margin ciliate …… ……..…… ***A. takasagomontanus***
4b. Synflorescence (1–)3–7-headed, corymbiform, capitulum 2–3 cm in diam.; phyllary lanceolate, margin fimbriate-ciliate …... ***A. kanoi***

Table 1. Morphological comparison of ***Aster kanoi*** and ***A. takasagomontanus***.

	Aster kanoi	*A. takasagomontanus*
Rhizome	Slender, less than 5.0 mm across	Thickened, 5.5–7.0 mm across in mature plants
Synflorescence	Usually 3–7-headed, corymbiform, rarely solitary	Solitary or 2–3(–4)-headed, subscapose
Capitulum	2–3 cm in diam.	3–4 cm in diam.
Ligules of ray florets	6.0–9.0 × 1.5–2.0 mm	13–18 × 1.5–4.0 mm
Phyllary	Lanceolate, margin fimbriate-ciliate, 3.5–5.5 × 0.7–1.5 mm	Oblong to oblong-ovate, margin ciliate, 5.5–9.0 × 2–3.5 mm
Capitulum		
No. of ray florets	8–16	ca. 12–33
No. of disk florets	11–38	ca. 60–100

* Data of *A. kanoi* are based on *Chung 13946* (TAIF), *Chung 11229* (TAIF), *Liu 2027* (TAIF), *Lu 23415* (TAIF) and *Hsu 11950* (TAIF). Data of *A. takasagomontanus* are based on *Kodaira* (TAI109718), *Kano* (TAI109716), *Lu 23476* (TAIF), *Lin et al. L1272* (TAIF), *Hsu 6059* (TAIF) and *Lu 24151* (TAIF).

TAXONOMIC TREATMENT

Aster kanoi S. W. Chung, W. J. Huang & T. C. Hsu, ***sp. nov***. **鹿野氏馬蘭 Figs. 1, 2A–D & 3**.

***Type*:** TAIWAN. Taichung City (臺中市), Heping District (和平區), Chungyangchienshan (中央尖山) N24°19'3.5"; E121°25'13.6". 2936 m, 21 August 2019, *S. W. Chung 13946* (holotype: TAIF; isotypes: TAI, HAST).

***Diagnosis*:** *Aster kanoi* is similar to *A. takasagomontanus* in habit but could be distinguished by the combination of several morphological features. *A. kanoi* has slender rhizome which is less than 5 mm in diam. (vs. usually thickened rhizome, 5.5–7.0 mm across in mature plants), up to 7-headed corymbiform (vs. 1–3(–4)-headed subscapose) synflorescence, 2–3 cm (vs. 3–4 cm) across capitula, fimbriate-ciliate (vs. ciliate but not fimbriate) margin of phyllaries, ca. 8–16 (vs. up to 33) ray florets, 11–38 (vs. up to 100) disk florets, 6.0–9.0 × 1.5–2.0 mm (vs. 13–18 × 1.5–4.0 mm) ligules of ray florets. A detailed comparison of the two species is presented in Table 1.

***Morphology*:** Small perennial herbs. Stems usually erect, sometimes decumbent to ascending, terete, 10–30 cm tall, densely pubescent, sparsely minutely yellow glandular (punctate); branches few. Radical leaves few to 12, present at anthesis, spatulate, 1.3–6.5 × 0.4–1.6 cm, apex usually acute, base narrowed into winged petiole, petiole 0.9–4 cm, margin remotely serrate with 1–3 pairs of shallow teeth, midvein conspicuous, densely pubescent and scarcely glandular punctate on both surfaces, rarely without glands. Cauline leaves sparse, gradually smaller upward, lanceolate to oblong, sessile or subsessile, 1–4 cm long, 1.5–10 mm wide, margin entire or sparsely serrate, apex acute, base attenuate, densely pubescent, scarcely yellow glandular punctate. Heads (1–)3–7 in terminal corymbiform synflorescence, 2–3 cm across; peduncle 1.4–3.8 cm long; bract 1 or absent, linear-oblanceolate, entire, densely pubescent, sparsely minutely yellow glandular punctate. Involucre tubular-campanulate, phyllaries herbaceous, 16–26, 2–4 seriate, subequal, margin narrowly scarious, fimbriate-ciliate distally, tinged reddish purple, lanceolate, 3.5–5.5 mm long, 0.7–1.5 mm wide, densely hirsute outside. Ray florets 8–16 in one row, pistillate, ligules white, 6.0–9.0 mm long, 1.5–2.0 mm wide, apex inconspicuously (1–)2–3 denticulate, tube light green, glabrous, 2–3.5 mm long, eglandular, style apically bifid, glabrous, ovary 1–1.5 mm long, densely pubescent, pappus tawny, 3–4.5 mm long. Disk florets yellow, 11–38, 5–8 mm long, bisexual, fertile, tube and proximal limb rarely hairy, corolla funnelform, 3.0–4.0 mm long, 5-lobed, rarely 4- or 6-lobed, lobes spreading, triangular, unequal, 1–1.5 mm long; stamens 5, ca. 1.7 mm long, inserted within corolla tube, filaments adnate to proximal part of corolla, base obtuse, apical anther appendages acute, triangular; style ca. 5.5 mm long, apically bifid, papillose; pappus tawny, 4.0–4.5 mm long at maturity. Achenes narrowly obovate, 3.5–4 mm long, ca. 1 mm wide, densely puberulous, brown.

***Distribution, habitat and phenology*:** *Aster kanoi* is endemic to Taiwan, distributed around the northern part of the Central Mountain Range, including Mt. Chungyangchienshan (中央尖山), Mt. Nanhutashan (南湖大山) and Mt. Tarokotashan (太魯閣大山). Plants were found among exposed rocks in alpine regions 2800–3800 m a.s.l., accompanied by ground vegetation including *Epilobium nankotaizanense* Yamam., *Saussurea kiraisanensis* Masam., *Pimpinella niitakayamensis* Hayata, *Erigeron morrisonensis* Hayata, *Rododendron pseudochrysanthum* Hayata, *Swertia tozanensis* Hayata, *Geranium hayatanum* Ohwi, *Euphrasia transmorrisonensis* Hayata, *Gentiana scabrida* Hayata, *Fragaria hayatae* Makino and *Juniperus formosana* Hayata. Flowering was recorded from July to September and fruiting from to September to November.

***Etymology*:** The specific epithet *kanoi* refers to Dr. Kano Tadao (1906–1945), a famous Japanese naturalist and anthropologist, who devoted his life in exploring the nature and folklore of Taiwan and left numerous influential studies among zoology, botany, entomology, alpine geology, and anthropology. Especially, Dr. Kano Tadao, together with Taihoku First High School Mountaineering Team, is the one who first completed the summit of Mr. Chungyangchienshan, the type locality of this species, in 1928. We also propose "鹿野氏馬蘭", "Kano's aster", as its vernacular name.

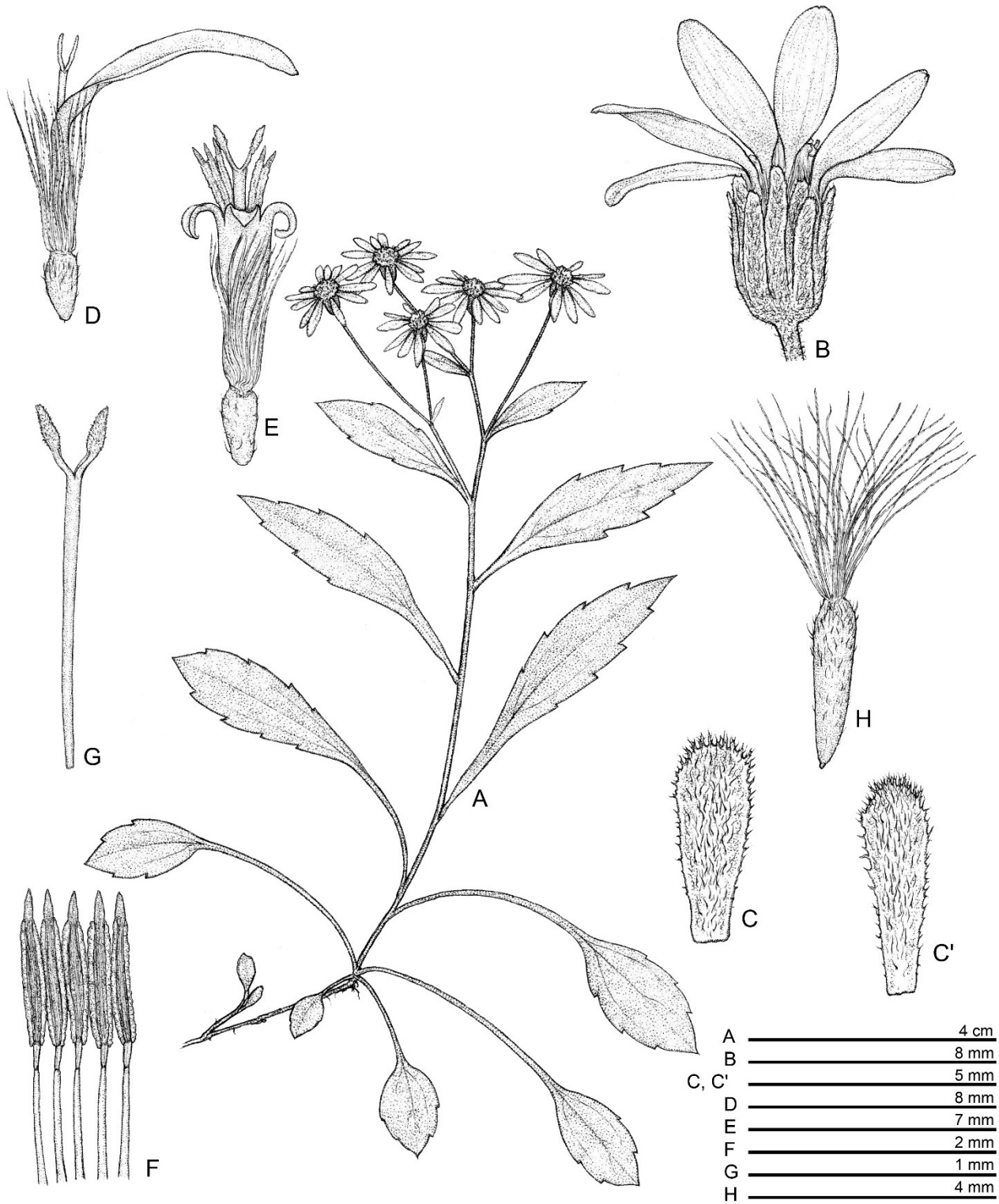

Fig. 1. Illustration of ***Aster kanoi*** S. W. Chung, W. J. Huang & T. C. Hsu from holotype. **A**. Habit. **B**. Capitulum. **C**. Outer phyllary. **C'**. Inner phyllary. **D**. Ray floret. **E**. Disk floret. **F**. Stamens. **G**. Pistil. **H**. Achene. Drawn by Che-Wei Lin.

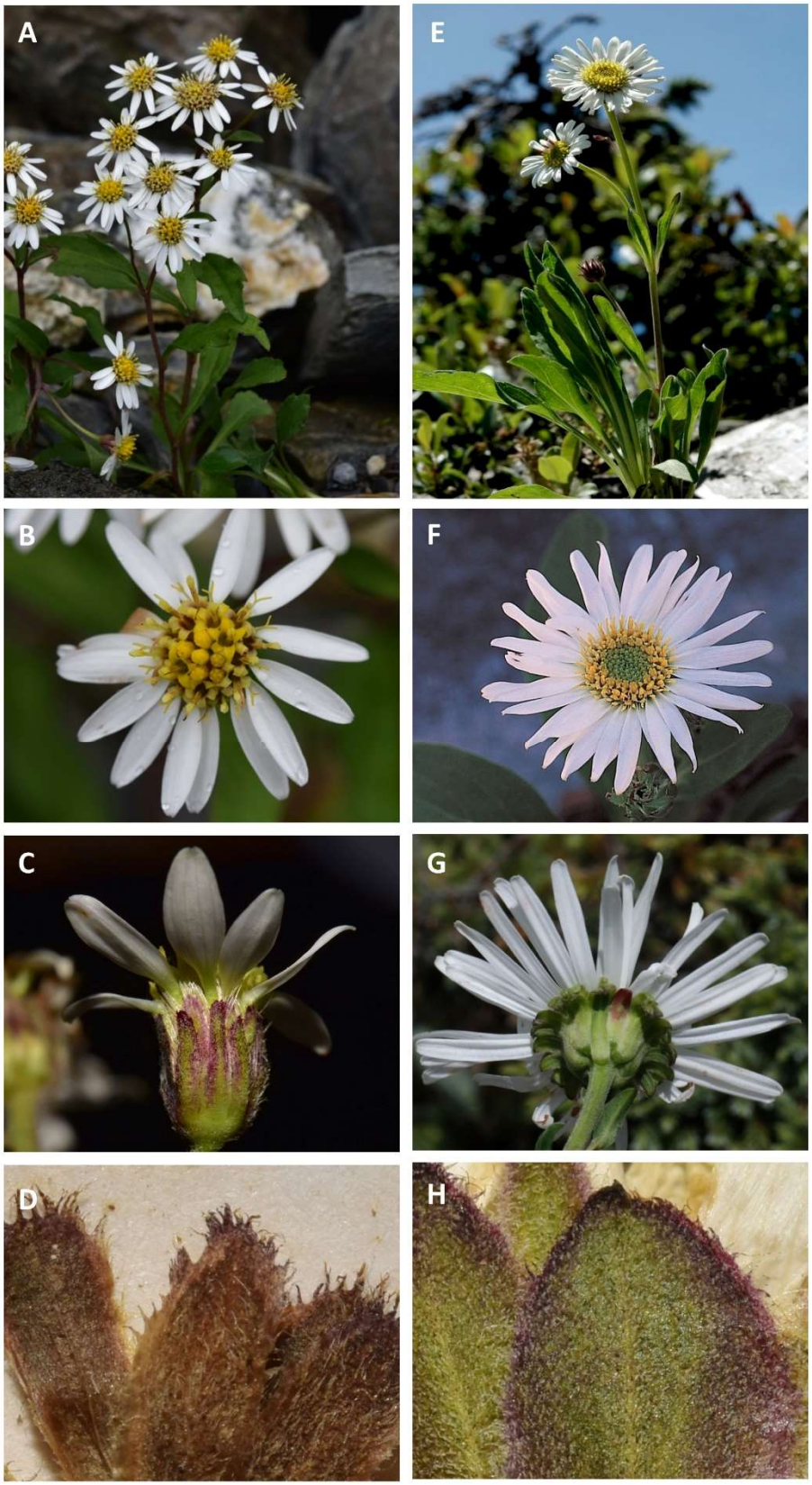

Fig. 2. Comparison of ***Aster kanoi*** S. W. Chung, W. J. Huang & T. C. Hsu and ***A. takasagomontanus*** Sasaki. **A–D**. *A. kanoi*. **A**. Habit. **B–C**. Capitulum. **D**. Phyllary, from holotype *Chung 13946* (TAIF). **E–H**. *Aster takasagomontanus*. **E**. Habit. **F–G**. Capitulum. **H**. Phyllary, from *Chung 7815* (TAIF). (**E** photographed by Chih-Kai Yang, **G** photographed by Jin-Yuan Wang)

Fig. 3. Flower of ***Aster kanoi*** S. W. Chung, W. J. Huang & T. C. Hsu from holotype. **A**. Ray floret. **B**. Disc floret. **C**. Achene. **D**. Stamens. **E**. Pistil. Scale bars = 3 mm.

***Conservation Status*:** *Aster kanoi* is an endemic species known only from alpine rocky regions at elevations of 2800–3800 m in the northern part of the Central Range. The estimated EOO and AOO are less than 100 km^2 and 10 km^2 respectively. Though the range of its distribution is limited, all of which is included in Taroko National Park and the Ecological Protection Area. The main threats to this species come from the instability of alpine rocky slopes and disturbances from fast-growing mountaineering activities. Under these conditions, we assess *A. kanoi* as **Near Threatened** [B2b(iii); C2a(i); D] under IUCN Red List Categories and Criteria (IUCN, 2012; Editorial Committee of the Red List of Taiwan Plants, 2017).

***Additional specimens examined*:** TAIWAN. Hualien County: Hsiulin Township, along trail from Tailuko Sancha camping site to Tailukotashan, ca. 3030 m, 11 September 2001, *Huang 678* (HAST); en route from Nanhu pond shelter to S-peak of Nanhutashan, ca. 3380 m, *Huang 2713* (HAST). Ilan County: Nanhutashan, 3400 m, 21 August 1969, *Yamazaki 270* (TAI); Chi-li-ting to Nan-hu-shan-chuang, 3000–3550 m, 21 August 1969, *Hsu 5953A* (TAI); Mt. Nanhutashan, 26 September 2012, *Chung 11229* (TAIF); Mt. Nanhutashan to Mt. Chungyangchienshan, 25 August 1970, *Hsu s.n.* (TAIF). Taichung City: Heping District, en route from Nanhu Lodge to Nanhutashan major peak, 3300–3740 m, 9 September 1991, *Hsu 775* (HAST); Nanhutashan Cirque, 11 November 1986, *Lu s. n.* (TAIF); same locality, 21 July 1988, *Lu 23415* (TAIF); same locality, 9 September 2004, *Liu 2027* (TAIF); Mt. Nanhuta-shan, 3100–3580 m, 10 September 1984, *Tateishi et al. 18777* (HAST); en route from Chungyangchienshan shelter to Chungyangchienshan, ca. 3100 m, 2 August 2006, *Huang 2742* (HAST); Chungyangchienshan, 2850 m, 21 August 2019, *Hsu 11950* (TAIF).

Aster takasagomontanus Sasaki, Trans. Nat. Hist. Soc. Formosa 21: 151. 1931

雪山馬蘭 Figs. 2E–H & 4

Lectotype (designated here)**:** TAIWAN. Hsinchu city (新竹市), Mt. Taihsaenzan (大霸尖山), 3400 m above the sea level, August 1927*, K. Kodaira* (TAI109718!)

***Morphology*:** Small perennial herbs. Rhizome thickened, 5.5–7.0 mm across in mature plants. Stems erect, terete, 10–30(–40) cm tall, strigose, sparsely glandular. Radical leaves present at anthesis, up to 15 in rosette, coriaceous, oblong, oblanceolate to spatulate, 1.5–7.0 cm long, 0.4–1.2(–1.7) cm wide, apex acute to obtuse, sometimes mucronate, base narrowed into winged petiole or subsessile, petiole 1–3(–4) cm, margin sparsely serrate to subentire, midvein conspicuous, strigose and sparsely glandular on both surfaces. Cauline leaves sparse, gradually smaller upward, subcoriaceous, lanceolate to oblong, subsessile, 1–4 cm long, 1.5–12 mm wide, margin subentire to shallowly coarsely crenulate, strigose and sparsely glandular on both surfaces. Heads solitary or 1–3 at apex, 3–4 cm across; peduncle 1.5–5 cm long; bract 1 or absent, narrowly lanceolate or oblanceolate, strigose and sparsely glandular on both surfaces. Involucre hemispheric or bowl-shaped; phyllaries herbaceous, 3 seriate, subequal, ovate to lanceolate, margin entire and ciliate, purplish green, 5–10 mm long, 1.5–3 mm wide, densely hirsute outside. Ray florets ca. 12–33, pistillate, ligules white, 8.5–17 mm long, ca. 2 mm wide, apex acute or rounded. Disk florets yellow, tube glabrous; style apically bifid, ovary 2–2.5 mm long, densely pubescent and glandular. Disk florets yellow, ca. 60–100, ca. 6 mm long, bisexual; tube glabrous, ca. 3 mm long; stamens 5, included; style apically bifid; ovary 2–2.5 mm long, pubescent and glandular. Achenes narrowly obovate, ca. 4 mm long, strigose, pappus tawny, ca. 3 mm long. Fl. Jul–Sep.

***Distribution & Habitat*:** *Aster takasagomontanus* is endemic to Taiwan, distributed among alpine exposed rocks in the Xueshan Range (including Mt. Xueshan, 雪山, and Mt. Dabajianshan, 大霸尖山) and the northern part of the Central Range (including, Mt. Chungyangchienshan, 中央尖山, and Mt. Nanhutashan, 南湖大山), at elevations of 3400–3800 m.

***Lectotypification*:** Sasaki (1931) cited holotype and four paratypes in the protologue of *A. takasagomontanus*, which are listed below:

A. Mt. Nanko-taizan (南湖大山), 3636 m above the sea level, leg. *S. Sasaki*, July 24, 1922, holotype (lost);
B. Mt. Tugitaka (雪山), 3930 m above the sea level, leg. *Y. Simada 2465*, Oct. 8, 1925 (lost);
C. Mt. Taihsaenzan (大霸尖山), 3400 m above the sea level, leg. *K. Kodaira*, Aug. 1927 (TAI109718!);
D. Mt. Tyuwosenzan (中央尖山), *T. Kano*, Aug. 9, 1928 (TAI109716 right side!);
E. Mt. Tugitaka (雪山), *T. Kano*, Aug. 25, 1928. (TAI109716 left side!)

After examination of the currently existing three paratypes C, D and E, we select the collection from Mt. Taihsaenzan (Fig. 4; TAI109718!) as the lectotype for *A. takasagomontanus*, because it is the best-preserved specimen and possesses all of the diagnostic characters.

Fig. 4. Lectotype of ***Aster takasagomontanus*** Sasaki designated in this study: Mt. Taihsaenzan, 3400 m above the sea level, leg. *K. Kodira*, August 1927. (TAI109718, image from Plants of Taiwan website, http://tai2.ntu.edu.tw)

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