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Taxonomic revision of *Aspidistra* Ker-Gawl. (Asparagaceae) in Taiwan

Chang-Tse LU[1,2], Kuei-Chun CHUANG[2], Yen-Hsueh TSENG[3], Chao-Chien WANG[2], Jenn-Che WANG[2,*]

1. Department of Biological Resources, National Chiayi University, 300 Syuefu Rd., Chiayi City 60004, Taiwan.
2. Department of Life Science, National Taiwan Normal University, 88 Ting-Chow Rd., Sec 4, Wenshan, Taipei City 11677, Taiwan.
3. Department of Forest, National Chung Hsing University, 250 Kuokwang Rd., Taichung City 40227, Taiwan.
[*]Corresponding author's email: biofv017@ntnu.edu.tw

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ABSTRACT: The genus *Aspidistra* has restricted distribution in Southeast Asia, Japan, and China, with more than 160 species. Hayata described three endemic species naturally occurring in Taiwan: *Aspidistra attenuata* Hayata, *A. mushaensis* Hayata, and *A. daibuensis* Hayata, but their descriptions in prologues are incomplete. Based on intensive field surveys, specimen observations, and literature consultations, we reexamine the morphology of these three species and further attempt to determine the diversity of this genus in Taiwan. Therefore, we confirm that there are four species in Taiwan, including one new species, *A. longiconnectiva* C.T. Lu, K.C. Chuang & J.C. Wang.

KEY WORDS: *Aspidistra*, endemic species, Taiwan, taxonomic revision.

INTRODUCTION

Aspidistra Ker-Gawl., which occurs in tropical and subtropical Southeast Asia (Lý *et al.*, 2017) is a speciose genus of angiosperm. Since 2000, the number of species has explosively increased from 55 (Liang and Tamura, 2000) to over 170 (Tillich and Averyanov, 2018). Many new species (e.g. Averyanov *et al*., 2017; Lý *et al.*, 2017; Nguyen *et al*., 2017; Vislobokov *et al.*, 2017; Wang *et al*., 2017; Xu *et al*., 2017; Zou *et al*., 2017; Averynov *et al*., 2018; Cai *et al*., 2018; Huang *et al*., 2018; Nong *et al.*, 2018; Lin *et al*., 2019) have been recorded in southern China and northern Vietnam; this area is considered to be the species diversity center of this genus (Tillich, 2005, 2014).

Taiwan is located on the northern boundary of the geographic distribution of this genus, but still three species described by Hayata, i.e., *A. attenuata* Hayata, *A. daibuensis* Hayata, and *A. mushaensis* Hayata occur in this region. Because no detailed figures were available and the original prologues were inadequate and unclear with respect to the important characters, these three species were considered problematic (Tillich, 2008; Averyanov and Tillich, 2012). By reviewing the taxonomic history of this genus in Taiwan, we found that the taxonomic treatments of these three species have several inconsistencies. Since Hayata (1912, 1920), only a few taxonomists agreed upon this treatment; for example, Liu and Yang (1978) in *Flora of Taiwan*, Liang and Tamura (2000) in *Flora of China*, and Wang (2004). Ying (2000) in *Flora of Taiwan 2nd edition* combined the three species and regarded them as varieties of *A. elatior* Blume. Soon after, Yang (2001) in *Manual of Taiwan Vascular Plants* reduced *A. mushaensis* Hayata to a synonym of *A. attenuata* Hayata and kept *A. daibuensis* Hayata as a distinct species. However, Tillich (2008) argued that Ying (2000) reducing the three species to varieties of *A. elatior* Blume was obviously incorrect. All these studies indicate that there is an urgent need for the taxonomic study of this genus in Taiwan.

In this study, field surveys, specimen observations, and literature consultations were conducted in Taiwan to reexamine these three species and to reveal the species diversity of the genus *Aspidistra* in Taiwan. Based on the results, we recognized four taxa, including one new species, and show that the diversity of *Aspidistra* in Taiwan is greater than previously thought.

MATERIALS AND METHODS

The field surveys were carried out from 2012 to 2019 in Taiwan. *Aspidistra* flowers are always fleshy, and their structures are generally largely distorted in the process of making herbarium specimens. Therefore, observations of flowers were mostly made on living plants in their habitats and/or in cultivation. Flowers were also preserved in 70% ethanol for subsequent studies. Measurements of floral parts for description were made on both living and liquid-preserved material, because the floral parts shrink up to 20%–30% in size in the drying process of preparing herbarium specimens (Averyanov and Tillich, 2017). We examined the specimens deposited at PPI, TAI, TAIF, TNU, and TNM, and the digital type specimens at TI (herbarium codes follow Thiers, 2017). Relevant literature, including protologues of concerned taxa, was consulted.

The morphological characteristics described in this article are based on the general terminology by Beentje (2012) and the publications of Tillich (2005, 2008). In addition, the extent of occurrence (EOO) and area of occupancy (AOO) (IUCN, 2012) were calculated with the Geospatial Conservation Assessment Tool (GeoCAT)

(Bachman *et al*., 2011) (accessed from http://geocat.kew.org) to assess the conservation status of each taxon.

RESULTS & DISCUSSION

As a result of the investigation of the specimens and fresh plants collected during our study, four taxa, *Aspidistra attenuata* Hayata, *A. daibuensis* Hayata, *A. mushaensis* Hayata, and one new species, *A. longiconnectiva* Lu, Chuang & Wang sp. nov., were recognized in Taiwan. According to the classification system of the genus *Aspidistra* proposed by Li (2004), the Taiwanese species were placed in ser. *Aspidistra* based on their peltate stigma and stigma surface radiation, 4-costa or 4-furcate. However, we believe that the peltate, rotund, or disc-shaped stigma, and 4-furcate stigma surface, bilobed lobe apex, and campanulate or urceolate perianth show that the Taiwanese species should belong to ser. *Fimbriatae* rather than ser. *Aspidistra*, which have strongly dilated and elevated peltate stigma, and 4-fissurate stigma surface radiation, lobe apex furcate, and perianth campanulate. A phylogenetic study on the genus *Aspidistra* by Huang (2013) showed these three Taiwanese species were sister species to *A. elatior* Blume, which belongs to *Fimbriatae.* This result supports our viewpoint.

In the past two decades, increasing numbers of *Aspidistra* species have been documented; their floral diversity has exceeded our past estimations. The classification system needs to be upgraded, however the molecular phylogeny of *Aspidistra* remains unsolved (Kocyan & Renner 2007; Huang *et al.* 2013). Further molecular phylogenetic studies are needed to reveal the relationships between these highly diverse flower species.

Taxonomic treatment

1. ***Aspidistra attenuata*** Hayata, Icon. Pl. Form. 2: 145. 1912; Hayata, Icon. Pl. Form. 9: 143. fig. 52. 1920; Chang & Hsu, Taiwania 19 (1): 68. 1974; Liu & Ying in H. L. Li *et al*. (eds.), Fl. Taiwan 5: 47. 1978; Liang & Tamura in Wu & Raven (eds.), Fl. China 24: 244. 2000; Yang *et al.*, Man. Taiwan Vasc. Pl. 5: 22. 2001, excl. syn. *A. mushaensis*. Type: Formosa. Mt. Arishan, January 1912, leg. *B. Hayata & S. Sasaki s.n.* (holotype: TI, photo!) **薄葉蜘蛛抱蛋 Figs. 1A–E**

Aspidistra elatior Blume var. *attenuata* (Hayata) S.S. Ying in Huang *et al*. (eds.), Fl. Taiwan 2nd ed. 5: 40. 2000. pro. parte.
Aspidistra lurida auct. non Ker-Gawl., Lang in Wu & Tang (eds.), Fl. China 15: 19. 1978.

***Description*:** Perennial herb with thickened and creeping rhizomes; rhizome elongate, subterete, horizontal thickened, 1.5–2.0 cm thick, nodes dense. Leaves simple, glabrous; petiole elongate, 10–70 cm; blade oblanceolate, oblique, 55–103 cm × 8.2–10.5 cm, sometimes with yellowish white spots. Peduncle erect, 0.3–6 cm; bracts 6–10, ovate-deltoid, imbricated. Flowers solitary, bisexual. Perigone fleshy, purple or yellowish white, 6–8(–10)-lobed apically, campanulate or urceolate-campanulate, ~2.6 cm long, 3.5–4.0 cm in diameter; lobes acute, reflexed, thickened, papillose adaxially, 7–25 mm × 5–10 mm, usually in 2 whorls, inner whorl narrower; lobes adaxially 2- to 3-keeled, keels fleshy, papillose; segments basally expanded inward forming subulate appendages, ~3.0 mm; apex usually reflex. Stamens as many as and opposite perianth lobes, nearly inserted below middle of perianth tube, subsessile; anthers dorsifixed, longitudinal dehiscence, oblong, 2.2–4.0 mm × 0.7–1.0 mm. Pistil funnel-shaped, 8.5–12 mm; ovary 1.5–2.2 mm long, 3- or 4-loculed, axile placenta, ovules 5–7 per locule; style short, ~2 mm; stigma large, peltate, 6–13 mm in diameter, concave, obpyramid, 3- or 4-lobed at margin, adaxial color same as perianth. Fruit a berry, tuberculate, 2–4 cm in diameter; seeds 1 to several, rounded to reniform, ca. 1 cm.

***Distribution, phenology, and conservation status*:** *Aspidistra attenuata* Hayata is endemic to Taiwan and commonly distributes from central to southern parts of Taiwan, in mountainous regions (Figure 3A). The populations of *A. attenuata* Hayata usually occur in primary and secondary evergreen broadleaved forests on rocky slopes at approximately 600–1,700 (2,000) m a.s.l. Terrestrial herbs usually form large dense colonies in shady places, particularly on rich soils in depressions between rocks. Flowering in nature was observed from October to January. According to the assessment of GeoCAT (EOO about 2,934 km^2 and AOO less than 56 km^2) and the IUCN Red List guidelines (IUCN 2012), *A. attenuata* Hayata should be assigned an extinction risk of "Endangered" [EN B1b(iii)B2b(iii)+C1].

***Specimens examined*:** **TAIWAN.** Nantou: Sinyi, Tung-pu, around Rainbow waterfall, 6 July 1985, *H. R. Huang et al. 1582* (TNU); Sinyi, Sha-li-hsien-hsi, 9 July 2003, *C. C. Wang et al. 338* (TNU); Sinyi, Pa-tung-kuan trail, around Yun-lun Waterfall, 28 August 2003, *C. C. Wang et al. 533* (TNU); Luku, Chi-tou to Fong-huan-shan to Sian-ku-liau, 9 January 1972, *C. S. Kuoh 3648* (TAI); Hsitou to Shanlin Stream, elev. 1000–1100 m, 8 October 2005, *S. W. Chung, T. C. Hsu & S. K. Yu 8681-1* (TAIF). Chiayi: Chuchi, Fen-chi-hu, 10 September 1984, *S. Y. Lu 15095* (TAIF); Arisan, Mt. Arisan, 1 March 1915, *T. Soma s. n.* (TAIF); Arisan, Te-fu-yeh, 24 October 2001, *W. C. Leong et al. 2556* (HAST); Arisan, from Feng-shan to Ta-tien-yu Waterfall, 14 February 1995, *J. C. Wang et al. 9493* (TNU); Arisan, en route to Mai-mai-shan, 24 October 2003, *C. C. Wang 567* (TNU). Kaohsiung: Taoyuan, Teng-chih, 16 May 1988, *S. Z. Yang 5946* (PPI); Yeni Shelter, elev. 1100–1200 m, 31 October 2010, *P. F. Lu 21031* (TAIF). Pingtung: Wutai, forest trail from Ali to Hsiao-kuei-hu, 2 September 1992, *C. C. Liao et al. 637* (TNU); Wutai, en route from Wutai to Ali, 8 December 1986, *C. I Peng 10227* (HAST); Wutai, Wu-tou-shan to Ching-chieh-shan, 26 October 1992, *S. Z. Yang 24673* (PPI); Wutai, Wu-tou-shan, 30 October 1989, *S. Z. Yang & C. G. Lin 11040* (PPI); Taiwu, Pei-ta-wu-shan, between Mt. hiking entrance and Kuai-ku lodge, 6 February 1990, *C.-I Peng et al. 13228* (HAST); Mt. Peitawu entrance to Kuaiku shelter, elev. 1600–2150 m, 24 October 2008, *P. F. Lu 17130* (TAIF); Taitung: Peinan, Wutoushan, 26 May 1988, *H. L. Chiang s. n.* (TAIF).

***Taxonomic notes*:** In *Flora of Taiwan 2nd edition*, Ying (2000) regarded *A. attenuata*, *A. mushaensis* and *A. daibuensis* as the same species, and treated it as a variety

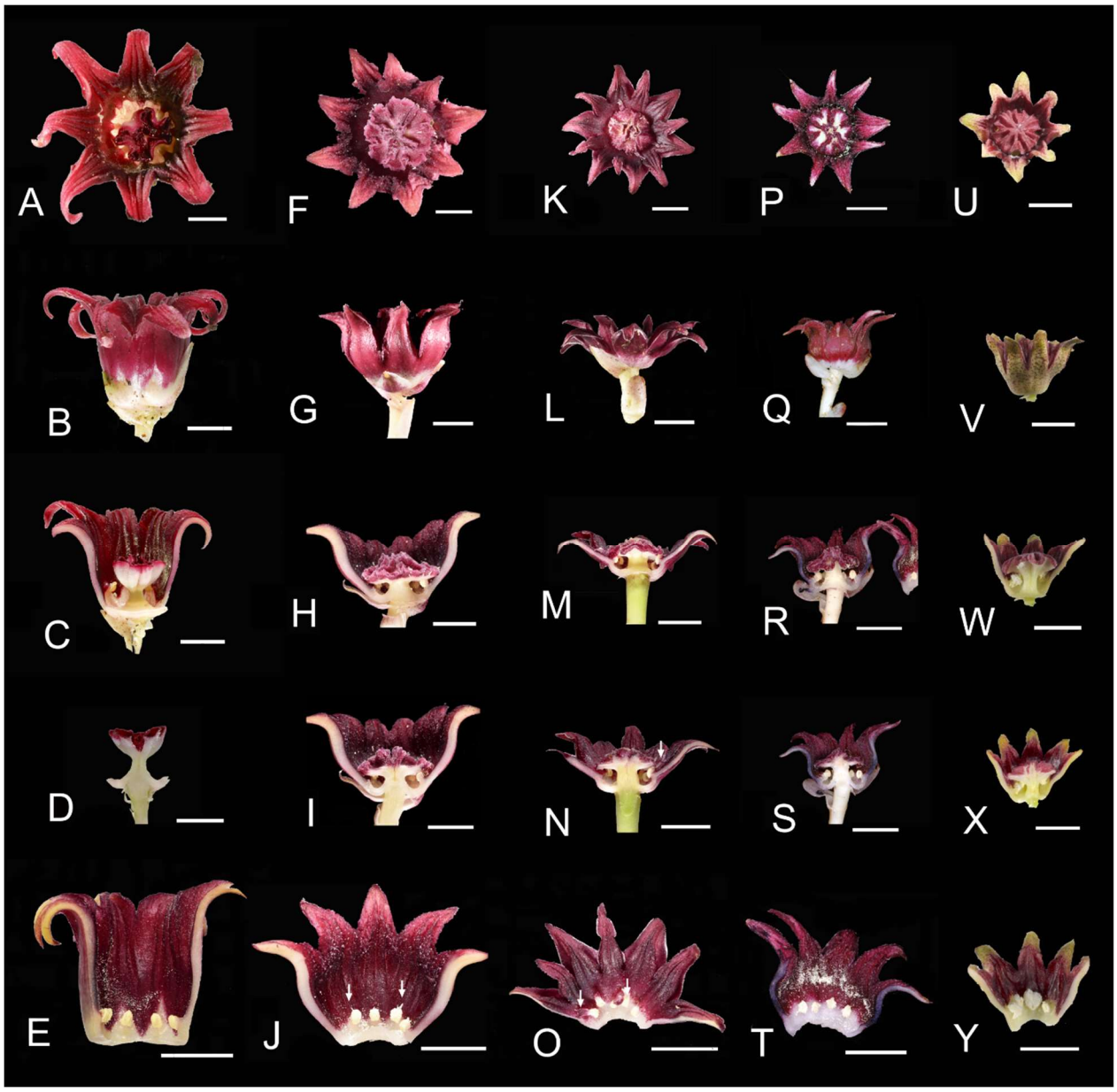

Fig. 1. Floral morphological comparison of four *Aspidistra* species of Taiwan. **A–E**. ***A. attenuata***. **F–J**. ***A. daibuensis***. **K–O**. ***A. longiconnectiva***. **P–T**. ***A. mushaensis***. **U–Y**. ***A. elatior***. **A, F, K, P, U**. Flowers in front view. **B, G, L, Q, V**. Flower in side view. **C, H, M, R, W**. Inside of flowers. **D, I, N, S, X**. Longitudinal section of flower. **E, J, O, T, Y**. Inside of flower with pistil and half of perianth removed. Bar = 10 mm.

of *A. elatior* Blume. However, Yang *et al.* (2001) lumped *A. mushaensis* and *A. attenuata* together but regarded *A. daibuensis* as a distinct species. In this study, we treated *A. attenuata, A. mushaensis*, and *A. daibuensis* as distinct species, based to the following reasons.

First, after examining the fresh materials throughout Taiwan and specimens in the herbaria, we found that *A. attenuata* has some morphological variety in leaf shape and length and flower texture and shape. Some individuals that grow on rocks have longer leaves and thin perianth tubes, and some individuals that grow on the ground have shorter and wider leaves and thicker perianth tubes. However, the stigma morphology of these two are similar. They both have funnel-shaped stigma, and 4-lobed stigma margins; however, the lobes vary from inflexed to oblique.

Second, Hayata (1912) described *A. attenuata* Hayata as being the "nearest to *A. elatior*" (Hayata, 1912), which caused Ying (2000) to consider *A. attenuata* as a variety of *A. elatior.* We compared the morphological characteristics of *A. attenuata* Hayata to those of *A. elatior* Blume, and found that *A. attenuata* Hayata can be delimited from the latter by the longer leaves blade (up to 150 cm vs. ~100 cm), longer perianth

Table 1. Morphological comparison of Taiwanese *Aspidistra*, *A. elatior*, and *A. fimbriata*

Taxa	*A. attenuata*	*A. daibuensis*	*A. elatior**	*A. fimbriata*#	*A. longiconnectiva*	*A. mushaensis*
Rhizome (in diam.)	15–20 mm	10–14 mm	5–10 mm	4–5 mm	ca. 15 mm	ca. 12 mm
Leaf blade	Oblanceolate to oblong-lanceolate, 55–103 cm × 8.2–10.5 cm	Oblanceolate to oblanceolate-oblong, 32–60 cm × 5–10 cm	Oblong-lanceolate, lanceolate or sub-elliptic, 20–45 cm × 6–10 cm	Oblong-lanceolate, 30-43 cm × 3.5-6 cm	Narrow elliptic to oblong-lanceolate, 86–95 cm × 6.3–8.0 cm	Oblanceolate to oblanceolate-oblong, 37–62 cm × 4.5–10 cm
Petiole	10–70 cm	4–20 cm	5–35 cm	26–35 cm	27–40 cm	13–35 cm
Perianth	Broadly cylindrical, apical campanulate, 26 mm long	Urceolate-campanulate to broadly campanulate, ca. 23 mm long	Campanulate, 10–12 × 10–15 mm	Campanulate, 13–15 mm long	Broadly campanulate, 10–12 mm long	Broadly campanulate, 12–16 mm long
Perianth lobes	Curved triangular, more or less tubercular, 7–25 mm × 5–10 mm	Apex slightly curve, ovate-triangular, 14–17 mm × 6.8–9.2 mm	Deltoid, 6–8 mm × 3.5–4 mm	Ovate-deltoid, 6-8 mm × 3.5–5 mm; fimbriate keels axially	Apex slightly curved, ovate-triangular, 14–16 mm × 9–10 mm	Apex slightly curved, densely papillose adaxially, 9.5–12 mm × 5–7 mm
Lobe thickness	1.2–2.5 mm	2.2–2.7 mm	No data	No data	0.8–1.4 mm	0.6–1.2 mm
Anther	Elongate-oblong, 2.2–4.0 mm × 0.7–1.0 mm	Ovate, 1.2–2.0 mm × 0.4–0.7 mm	Elliptic, ca. 2 mm	Broadly ovate, ca. 1.8 mm	Oblong, 2.7–3.2 mm × 0.6 mm	Round, 1.7–1.9 mm × 0.5 mm
Anther connective tissue	Without	With shortly bilobed connective tissue	Without	Without	With long lamella-like connective	Without
Stamen position	Inserted nearly at one third of the perianth tube	Inserted nearly on the base of the perianth tube	No data	Inserted nearly at one quarter of the perianth tube	Inserted nearly at the apex of the perianth tube	Inserted nearly at the base of the perianth tube
Stigma	Wide campanulate, 6–13 mm in diam.; upper surface concave, irregular folded, 5–6-lobed. Lateral view obpyramid	15–18 mm in diam., upper surface, convex centrally; 4-lobed, lobes emarginate at apex, margin up curved. Lateral view mushroom-shaped	Peltate, 4-lobed, 10–13 mm in diam. lobes emarginate at apex, margin down curved	Peltate, 4-lobed, 7–10 mm in diam., lobes emarginate at apex	11.5–12.5 mm in diam., upper surface flat or slightly convex, deeply 4–5-lobed, lobe margins retuse. Lateral view mushroom-shaped	11–12 mm in diam., upper surface convex centrally, distinctly 4-lobed, lobe margins retuse. Lateral view mushroom-shaped

*. Description of *A. elatior* based on Flora of China (2000) and Blume (1834).
#. Description of *A. fimbriata* based on Flora of China (2000) and Lang (1978).

tube (2.0–2.5 cm vs. 1.0–1.2 cm) and tube length longer than width (vs. tube length shorter than width), funnel-shaped stigma (vs. mushroom-shaped), stigma without filling the tube (vs. completely filling the tube), and flowering from October to January (vs. January to April) (see Table 1). Consequently, we considered it is reasonable to treat them as different species.

Third, Hayata (1920) diagnosed that *A. mushaensis* Hayata resembled *A. attenuata* Hayata but could be distinguished by smaller flower and leaves and campanulate perianth. We confirmed this point and found that *A. mushaensis* could be distinguished from *A. attenuata* by the perianth tube shape (broadly campanulate vs. campanulate to urceolate-campanulate), lobe appendage size (0.6–1.2 mm vs. 1.2–2.5 mm), and stigma shape (mushroom-shaped vs. funnel-shaped) (see Table 1).

Finally, *A. daibuensis* Hayata resembles *A. mushaensis* Hayata, but can be distinguished from the latter by perianth lobe thickness (Hayata, 1920). It can be distinguished from *A. attenuata* Hayata by its short leaves, broadly campanulate perigone, and mushroom-shaped stigma. The differences between *A. daibuensis* and *A. mushaensis* is provided in the taxonomic notes of *A. daibuensis* Hayata.

According to the above discussion, we believed that *A. attenuata* differs from *A. elatior*. The morphological comparison of these taxa is provided in Table 1.

2. *Aspidistra daibuensis* Hayata, Icon. Pl. Form. 9: 143. 1920; Chang & Hsu, Taiwania 19 (1): 68. 1974; Liu & Ying in H.L. Li *et al*. (eds.), Fl. Taiwan 5: 48. 1978; Liang & Tamura in Wu & Raven (eds.), Fl. China 24: 244. 2000; Yang *et al*., Man. Taiwan Vasc. Pl. 5: 22. 2001. ***Type***: Formosa. Daibusan, January 1917, leg. *Y. Matsuda* s. n. (holotype: TI, photo!)

大武蜘蛛抱蛋 Fig. 1F–J

***Description*:** Rhizome terete, epigeous to hypogeous, creeping to distally ascendant, branching, 1.0–1.4 cm in diameter, densely nodal. Cataphylls convolute, dull reddish-brown, up to 10 cm long. Leaves solitary, petiolate. Petiole stiff, erect, up to 20 cm long. Leaf blade upright to horizontal, oblanceolate to oblanceolate-oblong, oblique, attenuate at base and apex, 32–60 cm long, 5–10 cm wide, dark green with numerous small irregular yellowish spots, plicate, with prominent midvein on lower surface. Flowers odorless, solitary, subsessile to pedunculate. Peduncle greenish to almost white, ca. 1.6 cm long, with 3–4 bracts; bracts triangular-ovate,

papyraceous, white to dull dirty purple, obtuse. Perigone ca. 23 mm long, 3.0–3.8 cm in diameter, with 8–10 lobes, tube urceolate-campanulate to widely campanulate, 7.6–9.8 mm tall, 2.0–2.8 mm in diameter, white base and reddish-purple apex outside, white base and dark purple-violet apex inside. Lobes ovate-triangular, apex acute, fleshy, thickened, rugose or finely warty, spreading, apex slightly curved, dull reddish-pink, 14–17 mm long, 6.8–9.2 mm wide at base, with 2 prominent submarginal fleshy keels in deep groove between 2 median parallel, segment margins basally expanded inward forming subulate appendages, 3.5–5.2 mm wide. Stamens 8; anthers subsessile, ovoid, 1.2–2.0 mm long, 0.4–0.7 mm wide, inserted nearly on base of tube; pollen yellowish or white; anther connective shortly bilobed. Pistil mushroom-shaped, 7.4–8.5 mm long. Ovary inconspicuous, 4-loculed, placentation axile, 5–8 ovules per locule; style stout, white, shortly cylindrical, ca. 0.5 mm tall; stigma fleshy, purple, peltate, large, orbicular, convexed centrally, 15–18 mm diameter, 4-lobed, each lobe apex bilobed, touching tube wall. Fruit unknown.

***Distribution, phenology, and conservation status*:** *Aspidistra daibuensis* Hayata is endemic to Taiwan and has restricted occurrence in primary and secondary evergreen broadleaved forests at elevations of 100–1350 m a.s.l. in the southern and southeastern parts of Taiwan (Figure 3B). It usually grows on rocky slopes and forms large dense colonies in shady places, particularly on rich soils in depressions between rocks. *A. daibuensis* Hayata flowers from February (May) to June. According to the assessments of GeoCAT (EOO approximately 405 km^2 and AOO less than 20 km^2) and the IUCN Red List (IUCN 2012), *A. daibuensis* Hayata should be assigned an extinction risk of "Endangered" [EN B2b(iii)+D1].

***Specimens examined*:** TAIWAN. Pingtung: Chunjih, Tahan Forest Road, at road mileage sign 20 km, elev. ca. 1200 m, 30 Dec. 1999, *Ching-I Peng 17888* (HAST); Chunjih, Chinshuiying, elev.ca. 1350 m, 11 Sept. 1999, *W.-C. Leong 1400* (HAST); Mt. Hutou, elev. 100–200 m, 17 Jun. 2011, *C. T. Lu 1906* (TAIF); Shihtzu, Nei-wen, 25 Feb. 2004, *C. C. Wang 637* (TNU); Shihtzu, Li-lung-shan, 4 May 2004, *C. C. Wang & S. C. Liu 642* (TNU). Taitung: Chinfeng, Ta-li-nan, 5 May 2004, *C. C. Wang & S. C. Liu 644* (TNU).

***Taxonomic notes*:** Hayata (1920) noted that *A. daibuensis* Hayata resembles *A. mushaensis* Hayata, but can be distinguished by the thicker perianth-lobe (2.2–2.8 vs. 0.6–1.2 mm), appendages along the margin of perianth-lobe (two vs. without), length of perianth-lobes (14–17 vs. 8–11 mm), and position of stamens located nearly at the base of the perianth-tube (vs. at a quarter up the perianth-tube from the base of the perianth-tube) (Table 1).

Our research showed that this species is confined to southern and southeastern Taiwan, while *A. mushaensis* is confined to central Taiwan. Thus they are allopatrically distributed, implying that they are differentiated ecologically. We consider that they are differentiated at the specific level.

Additionally, *A. daibuensis* is also similar to *A. elatior*, but they can be distinguished by the thicker rhizome (10–14 mm vs. 5–10 mm), perianth tube shape (urceolate-campanulate to broadly campanulate vs. campanulate), longer perianth lobes (14–17 mm vs. 6–8 mm), and stigma morphology (4-lobed, lobe margins up-curved vs. lobe margins down-curved). A more detailed morphological comparison is shown in Table 1. Moreover, the flower character comparison of these two species is shown in Fig. 1 F–J and U–Y.

3. *Aspidistra longiconnectiva* C.T. Lu, K.C. Chuang & J.C. Wang, ***sp. nov. Type***: TAIWAN. Nantou County, Jenai Township, Huisun Experimental Forest, in a valley along a stream, elev. ca. 600 m, 15 May, 2012, *C.T. Lu 2230* (holotype TNU; isotype TAI).

長葯隔蜘蛛抱蛋 Figs 1K–O & 2

***Diagnosis*:** Similar to *A. mushaensis* Hayata, but differs by its thicker rhizome (ca. 15 vs. ca. 12 mm in diameter), more deeply lobed perianth-lobe (14–15 vs. 8–11 mm long), shape of stigma (square vs. orbicular in front view) and elongated anther connective.

***Description*:** Rhizome terete, epigeous to hypogeous, creeping to distally ascendent, branching, ca. 1.5 cm in diameter, densely nodal. Cataphylls convolute, dull reddish-brown, up to 10 cm long. Leaves solitary, petiolate. Petiole stiff, erect, 27–40 cm long. Leaf blade upright to horizontal, narrow elliptic to oblong-lanceolate, oblique, attenuate at base and apex, 86–95 cm long, 6.3–8.0 cm wide, dark green, plicate, with prominent midvein on lower surface. Flowers odorless, solitary, pedunculate. Peduncle white, 3–3.5 cm long, ca. 5 mm in diameter, with 3–4 bracts; bracts gradually wider from base to apex of peduncle, basalmost bract broadly ovate-cucullate, white with purplish red, 7–16 mm × 10–11 mm wide, apex obtuse. Perigone 10–12 mm long, 3.5–3.7 cm in diameter, with 8–12 lobes; tube broadly campanulate, 3.1–3.4 mm tall, ca. 13 mm in diameter, both surfaces white. Lobes ovate-triangular, apex slightly curve, distinctly 2-whorled, the outer whorl 14–16 mm long, 9–10 mm wide at base, with 2 prominent submarginal fleshy keels in between 2 median parallel, the inner whorl smaller, reddish-purple outside, dark purple-violet inside. Stamens 8–10; anthers subsessile, oblong, pale yellow, 2.7–3.2 mm long, ca. 0.6 mm wide, distally below level of stigma, connective elongated, lamella-like, 4.5–5.2 mm long, extending to the stigma and attaching to its margin. Pistil obconic, ca. 10 mm long, white with purple upper surface. Ovary ovate, ca. 3 mm × 4.5 mm; style stout, white, shortly cylindrical, 2–3 mm long, distally with a join between stigmatic lobes and style; stigma fleshy, large, peltate, slightly convex, adaxially purple, 11.5–12.5 mm in diameter, deeply 4–5-lobed, lobes margin retuse.

***Etymology*:** The specific epithet is due to this new species having elongated connective anther appendages. Moreover, it further attaches to the margin of the stigmatic lobe.

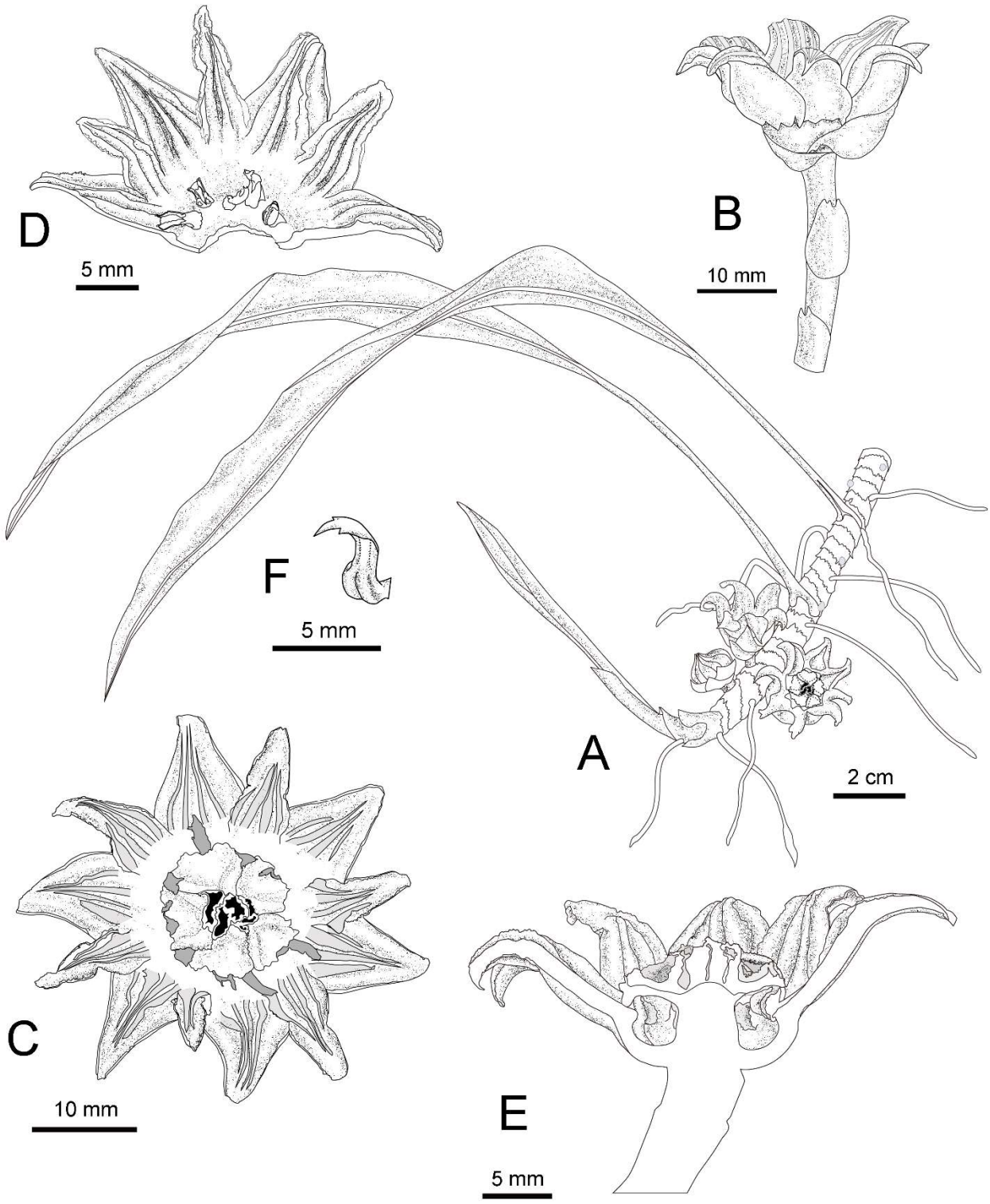

Fig. 2. *Aspidistra longiconnectiva*. A. Habitat. B. Flower on top of peduncle. C. Flower in front view. D. Dissected flower, showing stamens and pistil. E. Longitudinal section of flower. F. Stamen. Drawn by C.-T. Lu (drawing from holotype)

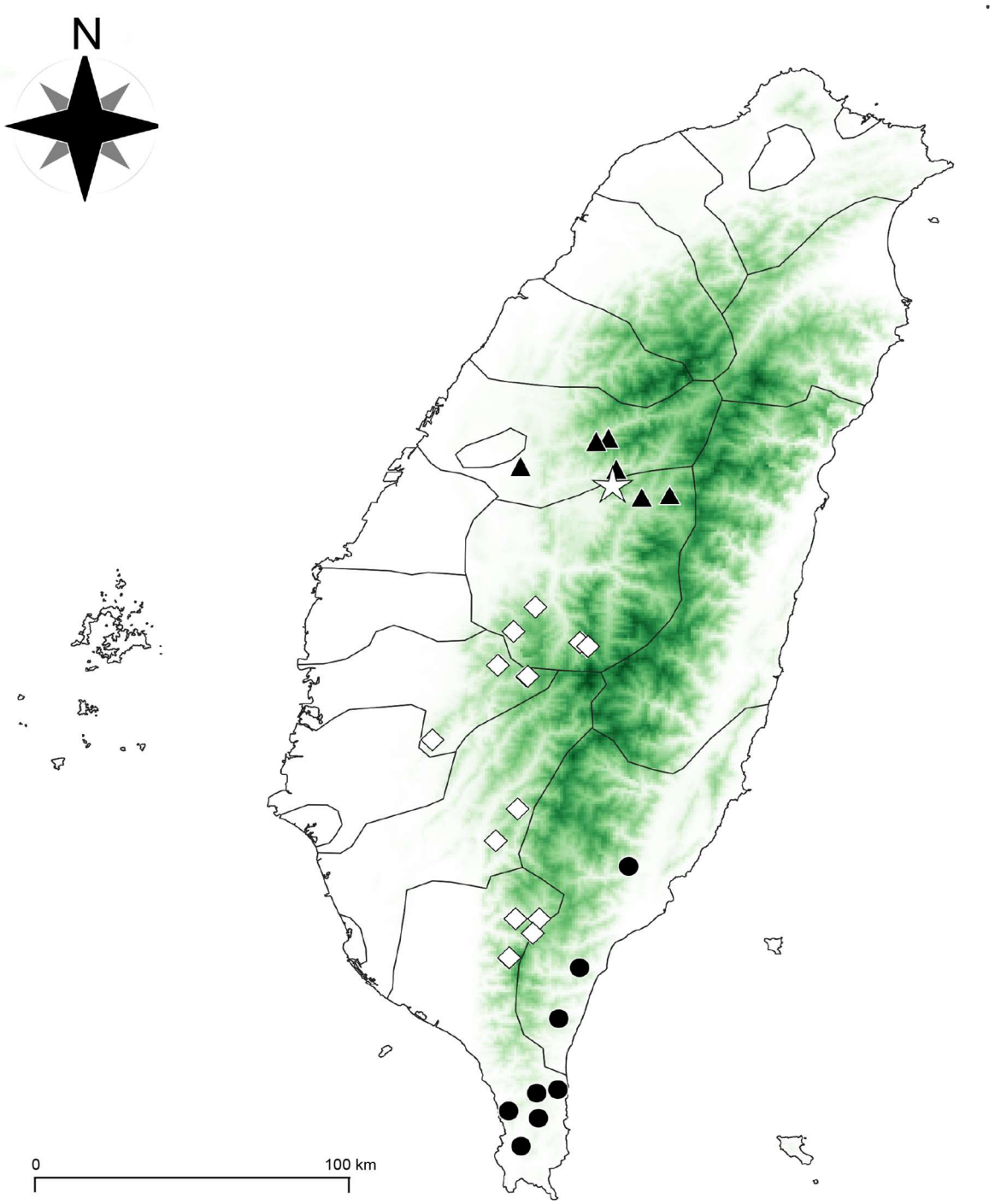

Fig. 3. Distribution of four species of *Aspidistra* in Taiwan. ◇: *A. attenuata*. ●: *A. daibuensis*. ☆: *A. longiconnectiva*. ▲: *A. mushaensis*.

***Distribution, phenology, and conservation status*:** To date, the distribution of *A. longiconnectiva* appears to be restricted to the type locality in Huisun Experimental Forest (Nantou County, Taiwan) (Figure 3C). The only known *A. longiconnectiva* population occurs on shady rocky slopes at an elevation of approximately 800 m within a secondary evergreen broadleaved forest. *A. longiconnectiva* flowers from April to May and the type locality population contains less than 50 flowering individuals. According to the IUCN Red List guidelines (IUCN 2012), *A. longiconnectiva* should be assigned an extinction risk of "Critically Endangered" [CR B2ab(iii)+D1].

***Specimens examined*: TAIWAN.** Nantou: Jenai county, Huisun Experimental Forest, 10 April 2012, *K.-C. Chuang s.n.* (TNU); same locality, 23 May 2019, *C.-T. Lu s.n.* (TNU).

***Taxonomic notes*:** *Aspidistra longiconnectiva* is markedly distinct from its congeners of Taiwan by the deep-lobed perianth lobes, short perianth tube, and extended anther connectives. Its stigma is somewhat similar to that of *A. mushaensis*, all with 4 radial, inconspicuous bifurcate lines in the central part and 4-lobed margin; however, it differs by the split degree of the stigma lobes (Figure 1). Morphological comparisons between the two species are shown in Figure 1 and Table 1.

4. *Aspidistra mushaensis* Hayata, Icon. Pl. Form. 9: 144. 1920; Chang & Hsu, Taiwania 19 (1): 69. 1974; Liu & Ying in H.L. Li *et al*. (eds.), Fl. Taiwan 5: 48. 1978; Liang & Tamura in Wu & Raven (eds.), Fl. China 24: 244. 2000. ***Type***: Formosa. Musha, ad. 3000 ped. alt., April 1916, leg. *B. Hayata s.n.* (holotype: TI, photo!)

霧社蜘蛛抱蛋 Figs. 1P–T

Aspidistra attenuata auct. non Hayata in Yang *et al*., Man. Taiwan Vasc. Pl. 5: 22. 2001, pro parte.

Aspidistra elatior Blume var. *attenuata* (Hayata) S.S. Ying in T.C. Huang *et al*. (eds.), Fl. Taiwan 2nd ed. 5: 40. 2000. pro parte.

***Description*:** Rhizome terete, epigeous to hypogeous, creeping to distally ascendent, branching, ca. 1.2 cm in diameter, densely nodal, covered with scales. Cataphylls convolute, dull reddish-brown, up to 10 cm long. Leaves solitary, petiolate. Petiole stiff, erect, to 13–35 cm long. Leaf blade upright to horizontal, oblanceolate to oblong, oblique, attenuate at base and apex, 37–62 cm long, 4.5–10 cm wide, dark green, sometimes with numerous small irregular yellowish spots, plicate, with prominent midvein on lower surface. Flowers odorless, solitary, subsessile to pedunculate. Peduncle erect, white, 1.6–3.2 cm long, with 3–4 bracts; bracts triangular-ovate, papyraceous, white to dull dirty purple, obtuse. Perigone fleshy, purple, 12–16 mm long, 2.5–2.9 cm in diameter, with 8–10 lobes, tube broadly campanulate, ca. 7.5 mm tall, 15–17 mm in diameter, white base purple red apex outside, white base and dark purple red apex inside. Lobes acute, reflex, fleshy, rugose or finely warty, outcurved, dull reddish-pink, 9.5–12 mm long, 5–7 mm wide at base, with 2 prominent submarginal fleshy keels in deep groove between 2 median parallels. Stamens 8–10, inserted near base of perianth tube, sessile to subsessile; anther ovoid, 1.7–1.9 mm long, ca. 0.5 mm wide. Pistil mushroom-shaped, ca. 6 mm long. Ovary inconspicuous, 3.2–3.5 mm in diameter, ovule 4–6 per locule; style short, white, shortly cylindrical, ca. 2 mm long; stigma large, fleshy, peltate, white below, distinctly 4-lobed, orbicular, sometimes centrally convex, adaxially purple, 11–12 mm in diameter, lobes bilobed at margin. Fruit a berry, tuberculate, 2 cm in diameter.

***Distribution, phenology, and conservation status*:** The distribution of *Aspidistra mushaensis* Hayata was restricted to the central part of Taiwan (Nantou County and Taichung County) (Figure 3D). Populations of *A. mushaensis* Hayata commonly occur on semishaded rocky slopes or soil slopes at approximately 400–1,100 m a.s.l. under a semi-humid evergreen broadleaf forest. Each population contains at least 200 flowering individuals and forms a large colony in shady places, especially on rich soils in depressions between rocks. *A. mushaensis* Hayata flowers from March to May. According to the assessment of GeoCAT (EOO approximately 335 km^2 and AOO less than 28 km^2) and the IUCN Red List guidelines (IUCN 2012), *A. mushaensis* Hayata should be assigned an extinction risk of "Endangered" [EN B2b(iii)+D1].

***Specimens examined*: TAIWAN**. Taichung: Hoping, Pa-hsien-shan, 18 May 2003, *C. C. Wang et al. 330, 332* (TNU). Nantou: Jenai, Huisunlinchang, *C. H. Chen et al. 1568* (TNU); ibidem, 17 May 2003, *C. C. Wang et al. 321* (TNU); Jenai, Wu-she, Jen-chih-kuan, 16 May 2003, *C. C. Wang et al. 311* (TNU); Jenai, Lu-shan Hotspring, 29 March 2003, *C. C. Wang et al. 197* (TNU); ibidem, 16 May 2003, *C. C. Wang et al. 318* (TNU).

***Taxonomic notes*:** *Aspidistra mushaensis* resembles *A. fimbriata* F.T. Wang & K.Y. Lang, but can be distinguished from each other by the thicker rhizome (ca. 12 mm vs. 4–6 mm), keels on perianth lobes axially (densely papillose vs. fimbriate), larger stigma diameter (11.5–12.5 mm vs. 7–10 mm), different somatic chromosome number ($2n$ = 36 vs. $2n$ = 38) (Li, 2004), and different flowering season (Apr.–May vs. Nov.–Dec.). A detailed comparison of these two species is shown in Table 1.

Key to species of *Aspidistra* in Taiwan

1a. Stem 1.5–2.0 cm in diameter; leaves oblanceolate, petiole up to 70 cm long, blade 50–103 cm long. …….. 2.
1b. Stem less than 1.5 cm in diameter; leaves lanceolate to oblong, or oblanceolate to oblanceolate-oblong, petiole 4–35 cm long, blade 32–62 cm long…… 3
2a. Stem more than 1.5 cm in diameter; perianth tube campanulate or urceolate-campanulate, ca. 2.5 cm long; top of stigma concave; anther connective without extension ……..… 1. ***A. attenuata***
2b. Stem ca. 1.5 cm in diameter; perianth tube urceolate to broadly campanulate, less than 2 cm long; top stigma nearly flat; anther connective extended. …… 3. ***A. longiconnectiva***
3a. Perianth urceolate to broadly campanulate, perianth lobes 14–15 mm long, apparently thickened (1.6–2.5 mm in thickness), margin apparently expanded inward forming appendages.. 2. ***A. daibuensis***
3b. Perianth broadly campanulate, perianth lobes 8–11 mm long, 0.6–1.2 mm in thickness, margin without inward expansion …… ……..…….. 4. ***A. mushaensis***

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