Cirsium tatakaense (Compositae), a new species from Taiwan

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Abstract
A new species of Cirsium, Cirsium tatakaense Y.H. Tseng & C.Y. Chang, from central-southern Taiwan is described and illustrated. This species is similar to C. kawakamii Hayata in leaf shape, achene and chromosome number (2n = 64), but can be readily distinguished from C. kawakamii by the narrower leaf lobes, usually higher number of florets and phyllaries, the purplish-red corolla (vs. white) and larger pollen grains. A key to the species of Cirsium in Taiwan is also presented.

Keywords
New species, Chromosome number, Cirsium tatakaense, Cirsium kawakamii, Compositae, Taiwan

Introduction

Cirsium Mill. is a genus of Compositae and comprises approximately 250 species widely distributed throughout the world’s temperate and subtropical zones (Kadota 2007). A total of 46 species are native to China (Shih and Greuter 2011), 64 to Japan (Iwatsuki et al. 1995) and 9 to Taiwan (Peng 2003).

Kitamura (1937) established the first infrageneric classification for East Asian Cirsium. In this classification, the Taiwanese species were placed in two of the sections, sect. Pseudoeriolepis (Nakai) Kitam. and sect. Onotrophe (Cass.) DC. and five subsections, subsect. Arenicola Kitam., subsect. Australicirsium Kitam., subsect. Nipponocirsium Kitam., subsect. Sinocirsium Kitam. and subsect. Spanioptilon Less. The latter subsection was subsequently raised to the rank of section (sect. Spanioptilon (Less.) Shih) by Shih (1984) and maintained by Iwatsuki et al. (1995).
Recently, we discovered a rare *Cirsium* growing in the high mountain areas of central-southern Taiwan. Based on the systems of Kitamura (1937) and Iwatsuki et al. (1995), this taxon belonged to section *Onotrophe* subsection *Nipponocirsium* and appeared to be similar to *Cirsium kawakamii* Hayata, sharing the longer leaf lobes, nodding bowl-shaped mature capitula and corolla lobes as long as the inflated part of the corolla tube.

**Materials and methods**

We compared the new species to the other two species of *Cirsium* sect. *Onotrophe* in Taiwan.

**Herbarium examination**

Materials primarily comprised fresh and dried specimens; voucher specimens were deposited in TCF, PPI and TNM. The herbaria referenced included HAST, KYO, PPI, TAI, TAIF, TCF, TI and TNM.

**Pollen morphology**

Pollen grains, all from fresh material, were directly mounted on a stub without any pretreatment and sputter coated with gold (Quorum SC7620) for observation with a scanning electron microscope (Hitachi S-3400N). The shape, size and exine ornamentation were studied following Erdtman (1952) and Hesse et al. (2009). Vouchers for the pollen material studied are provided in Table 1.

**Table 1.** Voucher material for the *Cirsium* Mill. pollen morphology.

| Taxa            | Location                                      | Coordinate                  | Altitude | Date       | Voucher       |
|-----------------|-----------------------------------------------|----------------------------|----------|------------|---------------|
| *C. tatakaense* | TAIWAN. Kaohsiung City Tautyuan District,     | 23°16.03’N,                | 2600 m   | 21 Oct 2014| C. Y. Chang 160 (TNM) |
|                 | Kuaiku to Yakou                               | 120°56.24’E                |          |            |                |
|                 | TAIWAN. Nantou County Sinyi Township, Tataka | 23°29.24’N,                | 2620 m   | 15 Nov 2014| C. Y. Chang 182 (TCF) |
|                 |                                               | 120°52.71’E                |          |            |                |
|                 | TAIWAN. Nantou County Sinyi Township, Tataka | 23°28.56’N,                | 2530 m   | 26 Oct 2015| C. Y. Chang 842 (TNM) |
|                 | to Shihshan                                    | 120°52.74’E                |          |            |                |
|                 | TAIWAN. Nantou County Sinyi Township, Tataka | 23°29.24’N,                | 2631 m   | 22 Dec 2015| C. Y. Chang 1017 (TCF) |
|                 | to Shihshan                                    | 120°52.71’E                |          |            |                |
| *C. kawakamii*  | TAIWAN. Taichung City Heping District,        | 24°26.52’N,                | 2800 m   | 13 Aug 2014| C. Y. Chang 264 (TNM) |
|                 | Mt. Pintian to Mt. Dabajian                    | 121°15.83’E                |          |            |                |
|                 | TAIWAN. Taichung City Heping District,        | 24°23.53’N,                | 3500 m   | 3 Oct 2015 | C. Y. Chang 774 (TCF) |
|                 | Mt. Syue Trail 8.9 km                          | 121°14.20’E                |          |            |                |
|                 | TAIWAN. Nantou County Ren’ai Township,         | 24°2.79’N,                 | 2600 m   | 29 Jan 2018| C. Y. Chang 1605 (TNM) |
|                 | Nengao cross-ridge historic trail 11 km        | 121°15.77’E                |          |            |                |
| *C. arisanense* | TAIWAN. Taichung City Heping District,        | 24°23.60’N,                | 3450 m   | 3 Sept 2015| C. Y. Chang 756 (TCF) |
|                 | Mt. Syue trail 8.9 km                          | 121°13.98’E                |          |            |                |
|                 | TAIWAN. Nantou County Ren’ai Township,         | 24°06.95’N,                | 2240 m   | 27 May 2016 | C. Y. Chang 1275 (TCF) |
|                 | Rueiyan river pipes road 2 km                  | 121°11.96’E                |          |            |                |
Karyotype analysis

Karyotype analysis was performed by following the same procedure applied by Ozcan et al. (2011) and Yüksel et al. (2013). Root tips were collected on sunny mornings and preserved in 0.002 M 8-hydroxyquinoline solution below 10 °C for eight hours. This material was then fixed with Carney’s solution (1 part acetic acid: 3 parts EtOH) for at least 24 hours at 4 °C. The fixed roots were then stained with acetic-orcein for 24 hours at room temperature, squashed and the slides examined using an stereo microscope (ACCU-ScoPE 3025). Voucher material is presented in Table 2.

Results and discussion

Morphological comparison

Following Kitamura (1937) and Iwatsuki et al. (1995), *Cirsium tatakaense* is placed in section *Onotrophe* together with *C. kawakamii* and *C. arisanense*. Amongst them, *C. arisanense* belongs to subsection *Australicirsium*, which is characterised by having rosette leaves, pot-shaped capitula which are erect or nodding when mature, corolla lobes equal in length to the inflated part of corolla tube and corona-like achene beaks. Both *C. tatakaense* and *C. kawakamii* belong to subsection *Nipponocirsium*, which is characterized by not having rosette leaves, larger bowl-shaped capitula which are nodding when mature, corolla lobes equal in length to the inflated corolla tube and tube-like achene beaks. In comparison with *C. kawakamii* (Table 3), *C. tatakaense* has purplish corolla (vs. white in *C. kawakamii*) (Figure 5[2]), usually more florets (136)161−308 (vs. (61)115−222 in *C. kawakamii*) (Figure 5[2]) and phyllaries 111−199 (vs. 79−123 in *C. kawakamii*) (Figure 5[2]) and narrower leaf lobes 7.3−11.9 mm (vs. 17.2−18.6 mm in *C. kawakamii*) (Figure 5[1]).

Chromosome number

The basic number of chromosomes amongst *Cirsium* species is often 2n = 34 (Hsu 1970; Funk et al. 2009; Chen and Yeh 2010a; Chen and Yeh 2010b), including in *C. arisanense* (Peng and Hsu 1978). However, the chromosome number of *C. tatakaense* is 2n = 64 (Fig. 6A), which is the same as that of *C. kawakamii* (Fig. 6B), indicating that

### Table 2. Voucher material for the *Cirsium* Mill. karyotype analysis.

| Taxa          | Location                              | Coordinate       | Altitude | Date     | Voucher         |
|---------------|---------------------------------------|------------------|----------|----------|-----------------|
| *C. tatakaense* | TAIWAN. Chiayi County Alishan Township, Tataka to Paiyun lodge | 24°28.40’N, 120°54.23’E | 2800 m   | 15 May 2016 | C. Y. Chang 1269 (TCF) |
| *C. kawakamii*  | TAIWAN. Taichung city Heping District, Mt. Syue trail 8.9 km | 24°23.73’N, 121°13.94’E | 3371 m   | 8 Nov 2015    | C. Y. Chang 874 (TCF) |
|               | TAIWAN. Taichung city Heping District, Mt. Syue trail 8.9 km | 24°23.73’N, 121°13.94’E | 3371 m   | 21 May 2016    | C. Y. Chang 1271 (TCF) |
the two species are similar in this respect. Notably, other taxa of the same subsection in Japan are $2n = 68$ (Iwatsuki et al. 1995). These findings imply that subsect. *Nipponocirsium* are tetraploids with aneuploid cells.

**Palynological study**

*Cirsium tatakaense* pollen has a larger diameter, up to 36–43 μm (vs. 32–35 μm in *C. kawakamii*) and its surface spines have broader bases of 4.2–5.6 μm (vs. 2.0–2.3 μm in *C. kawakamii*). The pollen grains of *C. tatakaense* are similar to *C. arisanense* (Fig. 7A, C). However, *C. kawakamii* (similar to *C. tatakaense* in macroscopic morphology) has the smallest pollen grains and spine in Taiwan (Fig. 7B). Pollen morphology is associated with pollination, thus implying reproductive isolation between the two species.

**Comparison of the distribution between *C. tatakaense* and *C. kawakamii***

Compared with *C. tatakaense*, *C. kawakamii* occurs at higher altitudes (up to 3500 m); *C. tatakaense* is seldom discovered over altitudes of 3000 m. In addition, *C. kawakamii* is usually distributed in alpine gullies and valleys, whereas *C. tatakaense* often appears on spacious roadsides, seemingly with no preference for valley habitats. Therefore, we believe that *C. kawakamii* prefers shaded and moist environments, whereas *C. tatakaense* prefers open areas with higher drought tolerance. Some geographical segregation appears to exist in the distributions of *C. tatakaense* and *C. kawakamii*.

**Table 3. Summary of characters between the species of *Cirsium* sect. *Onotrophe* in Taiwan.**

| Characters                  | *C. tatakaense* | *C. kawakamii* | *C. arisanense* |
|-----------------------------|-----------------|----------------|-----------------|
| Leaf size (cm)              | 27.2–34.8 cm × 16.4–19.4 cm | 27.5–30.6 cm × 17.8–20.2 cm | 10.6–21.3 cm × 3.0–6.3 cm |
| Leaf shape                  | Elliptic to broadly elliptic | Elliptic to broadly elliptic | Narrowly elliptic to deltoid |
| Leaf margin                 | Mainly pinnatisect | Pinnatisect or bipinnatisect | Pinnatapartite or bipinnatapartite |
| Leaf lobes Size             | 6.4–7.5 cm × 7.3–11.9 mm | 8.3–10.4 cm × 17.2–18.6 mm | 0.7–2.9 cm × 6.6–16.0 mm |
| Pair of leaflobes           | 4–6             | 6–7            | 6–10            |
| Mature Capitula             | Nodding         | Nodding        | Erect or nodding |
| Involucre shape             | Bowl-shaped (upper width ≥ base) | Bowl-shaped (upper width ≥ base) | Pot-shaped (upper width< base) |
| Corolla colour              | Purplish-red    | White          | Yellow          |
| Floret number               | (136)161–308    | (61)115–222    | 87–133          |
| Phyllary number             | 111–199         | 79–123         | 93–114          |
| Beak of achene              | Tube-like       | Tube-like      | Corona-like     |
| Pollen size (P/E)           | 34.2–42.6μm/ 35.2–44.7 μm | 31.7–34.5 μm/ 34.3–37.1 μm | 41.7–51.0 μm/ 44.7–49.3 μm |
| Pollen spine base width     | 4.2–5.6 μm      | 2.0–2.3 μm     | 2.8–4.8 μm      |
| Chromosome number           | 2n = 64         | 2n = 64        | 2n = 34 (Peng and Hsu 1978) |
| Distribution                | Endemic to Taiwan; open areas of fog forests at 2000–3000 m alt. central-southern Taiwan (Fig. 3) | Endemic to Taiwan; gullies and valleys at 1500–3500 m alt. central-northern Taiwan (Fig. 3) | Endemic to Taiwan; widely distributed in open areas of mountain area at 1500–3800 m alt. (Fig. 3) |
Taxonomic treatment

Key to the species of Cirsium Mill. in Taiwan

1 Biennial herb; involucre tube-shaped (length 2 times than width); corolla lobes < 2.5 mm long.............................................................. C. ferum
– Perennial herb; involucre pot or bowl-shaped (length approximates width), corolla lobes > 2.5 mm long................................................. 2

2 All leaves cauleine, basal rosette leaves absent.................................. 3
– Leaves in both a basal rosette as well as cauleine .............................. 5

3 Leaves densely cobwebbed on abaxial surface; mature capitula erect, involucre pot-shaped (upper width shorter than base); apical parts of inner phyllaries inflated, obtuse; outer phyllaries lanceolate, apex acute without spine; corolla lobes obviously longer than the inflated part of corolla tube.............. C. lineare
– Leaves glabrous on both surfaces; mature capitula nodding, involucre bowl-shaped (upper width greater or equal to base); apical parts of inner phyllaries acute or acuminate; outer phyllaries elliptic with long spine at the apex; corolla lobes as long as the inflated part of corolla tube............................ 4

4 Corollas white; leaves pinnatisect or bipinnatisect, lobes > 15 mm wide .......................................................... C. kawakamii
– Corollas purple; leaves mainly pinnatisect, lobes < 12 mm wide .......... 

5 Phyllaries narrowly ovate.............................................................. 6
– Phyllaries subulate .......................................................................... 7

6 Corollas white; phyllaries lanceolate, inner and outer phyllaries similar in length; stems cauleine, without rhizome............................ C. brevicaule
– Corollas purple; phyllaries narrowly ovate to ovate, inner and outer phyllaries distinct in length; stems both cauleine and rhizomatous ........... C. morii

7 Apical prominently parts of phyllaries longer than 4 mm, blade-like; corolla lobes as long as the inflated part of corolla tube ....................... 8
– Apical prominently parts of phyllaries shorter than 4 mm, spine-like; corolla lobes shorter than the inflated part of corolla tube .................. 9

8 Leaf abaxial surface pubescent; mature capitula erect or nodding ..................

9 Leaf abaxial surface densely cobwebbed; mature capitula nodding ........ 

10 Corollas purple; leaves surface shortly hairy ........ C. japonicum var. australae
– Corollas white; leaves surface glabrescent ........ C. japonicum var. takaense
Species treatments

*Cirsium kawakamii* Hayata in J. Coll. Sci. Imp. Univ. Tokyo. 159. 1911.
Figs 4B, 5B, 6B, 7B

**Type.** TAIWAN. Mt. Morrison, ca. 3000 m alt., 20 Oct.1906. *T. Kawakami & U. Mori* 2279 (holotype: TI!; isotype: TAIF!).

**Description.** Perennial herbs, stems 0.5–1.8 m tall, without rosette leaves. Leaves pinnatifid or pinnatisect, 27.5–30.6 cm long and 17.8–20.2 cm wide, U-shaped space between pinnae, smooth, elliptic to broadly elliptic, base truncate to cuneate, apex caudate, pinnae 8.3–10.4 cm long and 17.2–18.6 mm wide, space between pinnae 2.5–3.0 cm, 6–7 pairs. Capitula arranged into racemes or panicles, mature capitula nodding, involucrue bowl shaped, 3.4–3.8 cm long and 1.5–2.0 cm wide. Involucrue lacking abaxial appendages, inner phyllaries acute apically, outer phyllaries green with indistinct layers, 1.6–1.8 cm long and 1.8–2.4 mm wide, protrusion 6.0–11.0 mm. Florets with white corolla, 2.8–3.1 cm long, corolla lobes 5.2–6.0 mm long and 0.4–0.7 mm wide; 5 synantherous stamens, detached filaments with irregular protuberances, basal caudate extensions, white or brown, anthers 5.4–8.2 mm long, filaments 6.8–8.0 mm long. Stigmas bifid apically, style 2.0–3.4 cm long, ovaries 1.5–2.0 mm long. Achenes oblong, base acute, apex truncate, beige, 4.3–4.9 mm long and 1.7–1.8 mm wide, long tube-shaped beak apically. Pappus 1.3–2.1 cm long forming basal ring, easily shed.

**Phenology.** Flowering between September and October and fruiting between October and November.

**Distribution.** Endemic to central-northern Taiwan. Preference for gullies and valleys at 1500–3500 m alt. (Fig. 3).

**Chinese name.** Yu-shan-ji (玉山薊).

**Chromosome number.** 2n=64 (Fig. 6B).

**Palynology.** Pollen grains are tricolporate, spheroidal, microreticulate and 31.7–34.5 × 34.3–37.1 μm (P/E ratio: 0.9–1.0). The surface is densely covered with spines that are 2.5–3.2 μm long and 2.1–2.2 μm wide at the base. The distance between spines is 7.6–8.8 μm (Fig. 7B).

**Additional specimen examined.** TAIWAN. Taoyuan City, Fuxing District, Mt. Lalashan, 1550–1700 m alt., 25 Sept. 1991. *C. I Peng* 14628 (HAST!). Miaoli County, Tai’an Township, Tunnel of Mt. Shishihshan to Mt. Huoshihshan, 2480 m alt., 18 Sept. 1995. *C. M. Wang* 1728 (TNM!). Taichung City, Heping District, Mt. Syue to Mt. Chi-hchiayangdashan, 3300 m alt., 10 Sept. 2014. *C. Y. Chang et C. H. Liu* 68 (TNM); Mt. Pintian to Mt. Dabajianshan, 2800 m alt., 24°26.52′N, 121°15.83′E, 13 Aug. 2014. *C. Y. Chang* 264 (TNM); Mt. Syue Trail 8.9 km, 3500 m alt., 24°23.53′N, 121°14.20′E, 3 Oct 2015. *C. Y. Chang* 774, 1271 (TCF). Nantou County, Ren’ai Township, Nengao cross-ridge historic trail 11 km, 2600 m alt., 24°2.79′N, 121°15.77′E, 29 Jan 2018. *C. Y. Chang* 1605 (TNM); Chengkung lodge, 3140 m alt., 31 July 2015. *C. Y. Chang* 654 (TNM); Guandao river, 22 Oct. 1932. *S. Sasao s. n.* (CHIA!); Mt. Hohwanshan, 3300 m alt., 15 Oct. 1994. *Tinghai Collecting Team s. n.* (TNM!). Hualien County, Xiulin Township, Sungshielou lodge to Dayuling, 3 Aug. 1974. *C. N. Lin s. n.* (KYO!).
**Cirsium tatakaense** Y.H. Tseng & C.Y. Chang, sp. nov.  
urn:lsid:ipni.org:names:77194985-1  
Figs 1, 2, 4A, 5A, 6A, 7A

**Diagnosis.** Differs from *C. kawakamii* in having narrower leaf lobes (7.3–11.7 mm), usually more florets, (136)161–308 and phyllaries (111–199), a purplish-red corolla and larger pollen grains (34.2–42.6 × 35.2–44.7 μm).

**Type.** TAIWAN. Nantou County, Sinyi Township, Highway no. 18, Tataka to Shihshan, 2400 m alt., 23°28.52’N, 120°52.10’E, 3 October 2016. C. Y. Chang 1444 (holotype: TCF; isotype: TNM, PPI).

**Description.** Perennial herbs, stems 0.5–1.5 m tall, without rosette leaves. Leaves pinnatipartite or pinnatisect, 27.2–34.8 cm long and 16.4–19.4 cm wide, U-shaped space between pinnae, smooth, elliptic to broadly elliptic, base truncate to cuneate, apex caudate, pinnae 6.4–7.5 cm long and 7.3–11.9 mm wide, space between pinnae 2.9–3.0 cm, 4–6 pairs. Capitula arranged into racemes or panicles, mature capitula nodding, involucre bowl-shaped, 3.9–4.0 cm long and 1.7–2.1 cm wide. Involucre lacking abaxial appendages, inner phyllaries acute apically, outer phyllaries reddish-purple with indistinct layers, 1.1–2.2 cm long and 1.8–2.4 cm wide, protrusion 6.3–13.0 mm. Florets with purplish-red corolla, 3.2–3.3 cm long, corolla lobes 4.3–5.3 mm long and 0.4–0.7 mm wide; 5 synantherous stamens, detached filaments with irregular protuberances, basal caudate extensions, light purple or brown, anthers 6.4–6.8 mm long, filaments 7.1–8.1 mm long. Stigmas bifid apically, style 3.0–3.2 cm long, ovaries 1.7–1.9 mm long. Achenes oblong, base acute, apex truncate, beige, 3.0–3.5 mm long and 1.4–1.6 mm wide, long tube-shaped beak apically. Pappus 1.6–1.8 cm long forming basal ring, easily shed.

**Phenology.** Flowering between August and October and fruiting between September and November.

**Distribution.** Endemic species of Taiwan. *Cirsium tatakaense* is located in open areas of cloud forests of vegetation zones from the *Quercus* to *Abies* forest zone at alt. 2000–3000 m in central-southern Taiwan (Fig. 3). Based on the geographical climatic regions and vegetation zones (Su 1984, 1985), *C. tatakaense* is distributed mainly in the central-west inland regions. *Cirsium tatakaense* has been discovered in sunny environments, such as roadsides and forest margins, concentrated on the upper portions of hills along Provincial Highway no. 18. *Miscanthus transmorrisonensis* Andersson (Poaceae), *Rubus taitoensis* Hayata (Rosaceae) and *Senecio nemorensis* L. var. *dentatus* (Kitam.) H. Koyama (Compositae) are often discovered with *C. tatakaense*. Sometimes, *C. arisanense* Kitam. and *C. ferum* Kitam. are found near to *C. tatakaense*; however, no hybrid individual between these species has been observed.

**Chinese name.** Ta-ta-jia-ji (塔塔加薊).

**Etymology.** The species epithet *tatakaense* derives from the type location Tataka in Nantou County.

**Notes.** This species has in the past been mistakenly identified as *C. kawakamii* (S. Saito 3477, KYO; Yamazaki 945, KYO; C. I Peng 8026, 8936, 11788, 14628, HAST; K. F. Chung 1053, HAST; Kawakami & Sasaki s. n., TAIF; M. L. Weng 1723, TAI; Y. Kudo
Figure 1. Line drawings of *Cirsium tatakaense* Y.H. Tseng & C.Y. Chang. A habit B root C leaf D capitula E inner phyllary E’ middle phyllary E” outer phyllary F floret F’ floret (pappus removed) G synantherous H style branches I achene. Voucher: C. Y. Chang 1442 (TCF).

& S. Suzuki 300, TAI!; C. C. Hsu 4231, TAI!; C. I Peng 738, TAI!; C. T. Chao et al. 2534, TNM!; C. S. Kuoh 15146, TNM!) or less often as *C. arisanense* Kitam. (Yamamoto et al. 4142, TAI!; Y. J. Lin 169, PPI!). The earliest record of *C. tatakaense* was collected by T. Kawakami & S. Sasaki s. n. (TAIF!) at Mt. Morrison (alt. ca. 3000 m) on October 8, 1909.
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Other specimens collected from 1909–1930 were from Alishan (alt. ca. 2200 m). However, only a few populations remain in Alishan, with the largest population appearing along the Yushan Main Peak Trail from Tataka to Paiyun Lodge (alt. ca. 2800 m). We assume that use in herbal medicine as well as climate change have reduced the population of C. tatakaense.
Figure 3. Distribution map of *Cirsium tatakaense* Y.H. Tseng & C.Y. Chang (star); *C. kawakamii* Hayata (triangle); and *C. arisanense* Kitam. (circle) of Taiwan.

Figure 4. Holotypes of the three species of *Cirsium* sect. *Onotrophe* in Taiwan. **A** *C. tatakaense* Y.H. Tseng & C.Y. Chang, C. Y. Chang 1444 (TCF) **B** *C. kawakamii* Hayata, T. Kawakami & U. Mori 2279 (TI!) **C** *C. arisanense* Kitam., S. Kitamura s.n. (KYO!).
Figure 5. Comparison of the morphological characters amongst the species of *Cirsium* sect. *Onotrophe* in Taiwan. **A** *C. tatakaense* Y.H. Tseng & C.Y. Chang **B** *C. kawakamii* Hayata **C** *C. arisanense* Kitam.: 1 leaf 2 capitula 3 inner phyllary 3' middle phyllary 3'' outer phyllary 4 floret 4' floret (pappus removed) 5 synantherous 6 style branches 7 achene 7' achene with pappus.
Chromosome number. $2n = 64$ (Fig. 6A)

Palynology. Pollen grains are tricolporate, spheroidal, microreticulate and 34.2–42.6 × 35.2–44.7 μm (P/E ratio: 0.9–1.0). The surface of the pollen is densely covered with spines that are 3.2–5.1 μm long and 4.2–5.6 μm wide at the base. The distance between spines is 7.5–10.6 μm (Fig. 7A).

Conservation status. *Cirsium tatakaense* is distributed in central-southern Taiwan, with a population of more than 1000 mature individuals. Its habitats are mainly located in high and sunny mountain areas and many of them are difficult to locate. Therefore, following the International Union for Conservation of Nature (IUCN) Categories and Criteria (IUCN 2014), we regard this species as Least Concern. However, long-term monitoring of its population is still required.

Additional specimens examined (paratype). TAIWAN. Nantou County, Sinyi Township, Highway no. 18, Tataka to Shihshan, 2400 m alt., 23°28.52’N, 120°52.10’E, 3 Oct. 2016. C. Y. Chang 1442 (TCF); same loc., 3 Oct. 2016. C. Y. Chang 1443 (TCF); same loc., 12 Sept. 2012. C. T. Chao et al. 2534 (TNM!); Tunpu Hot Spring to Kuankao, 1300–2600 m alt., 3 July 1985. C. I Peng 8026 (HAST!). Chiayi County, Alishan Township, Alishan, 25 Dec. 1928. Y. Kudo & S. Suzuki 300 (TAI!); Tatachia saddle to Paiyunshanchuang, 2700–3000 m alt., 9 Nov. 1985. C. I Peng 8931 (HAST!); Tatachia saddle to Mt. Yushanchienfu, 2700–3100 m alt., 11 Nov. 1990. P. J. Wu et al. s. n. (TNM!). Kaohsiung City, Taoyuan District, Kuaiku to Yakou, 2600 m alt., 23°16.03’N, 120°56.24’E, 21 Oct. 2014. C. Y.
*Cirsium tatakaense* (Compositae), a new species from Taiwan

**Figure 7.** Comparison of the pollen morphology of the three species of *Cirsium* sect. Onotrophe in Taiwan. A *C. tatakaense* Y.H. Tseng & C.Y. Chang B *C. kawakamii* Hayata C *C. arisanense* Kitam.: 1 polar view 2 equatorial view 3 colporate view. Scale bar: 30 μm.

*Chang 160* (TNM); Gingzin bridge, 14 Sept. 1999. *C. S. Kuoh 15146* (TAN!). Taitung County, Yanping Township, Yen ping forest-road, 1500–1800 m alt., 2 July 2006. *Y. J. Lin 169* (PPI!).

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References

Chen CM, Yeh MS (2010a) Mass propagation of medicinal plant, *Cirsium japonicum* DC. *in vitro* and its chromosome number. Seed & Nursery 12(2): 33–47. [In Chinese]
Chen CM, Yeh MS (2010b) Micropropagation and chromosome number of *Cirsium brevicaule* A. Gray–A medicinal plant native in Taiwan. Journal of Agriculture and Forestry 59(4): 327–338. [In Chinese]

Erdtman G (1952) Pollen Morphology and Taxonomy. Stockholm Alomqvist and Wiksell, Sweden, 539 pp.

Funk VA, Susanna A, Stuessy TF, Bayen RJ (2009) Systematics, Evolution, and Biogeography of Compositae. International Association for Plant Taxonomy, Austria, 965 pp.

Hesse M, Halbritter H, Zetter R, Weber M, Buchner R, Frosch-Radivo A, Ulrich S (2009) Pollen Terminology an Illustrated Handbook. University of Vienna, 264 pp.

Hsu CC (1970) Preliminary chromosome studies on the vascular plants of Taiwan (III) The Aster Family, Compositae. Taiwania 15(1): 17–29.

IUCN (2014) The IUCN Red List of threatened species: Version 2013.2. IUCN Red List Unit, Cambridge. http://www.iucnredlist.org [Accessed: 15 January 2018]

Iwatsuki K, Yamazaki T, Boufford DE, Ohba H (1995) Flora of Japan Volume IIIb Angiosperms. Dicotyledoneae Sympetalae (b). Kodansha (Tokyo): 119–151.

Kadota Y (2007) Species diversification of genus *Cirsium* (Asteraceae) in Japan. Korean Journal of Plant Taxonomy 37(4): 335–349. https://doi.org/10.11110/kjpt.2007.37.4.335

Kitamura S (1937) Compositae Japonicae XIII. Memoirs of the College of Science, Kyoto Imperial University. Series B. Biology, Kyoto, 421 pp.

Ozcan M, Sema HA, Huseyın I (2011) Chromosome reports in some *Cirsium* (Asteraceae, Cardueae) Taxa from North-East Anatolia. Caryologia 64(1): 55–66. https://doi.org/10.1080/00087114.2011.10589764

Peng CI (2003) *Cirsium*. In: Boufford DE, Hsieh CF, Kuo CS, Ohashi H, Su HJ (Eds) Flora of Taiwan, Vol. 4 (2nd edn). Editorial Committee of the flora of Taiwan, Taipei, 903–913.

Peng CI, Hsu CC (1978) Chromosome numbers in Taiwan Compositae. Academia Sinica 19: 53–66.

Shih Z (1984) Notulae de plant tribus Cynarearum family Pompositarum Sinicae (II). Zhiwu Fenlei Xuebao 22(5): 386–396.

Shih Z, Greuter W (2011) *Cirsium*. In: Chen DZ, Shimizu T (Eds) Flora of China, Vol. 20. Flora of China Editorial, Beijing, 160–175.

Su HJ (1984) Studies on the climatic and vegetation types of the natural forests in Taiwan (II) altitudinal vegetation zones in relation to temperature gradient. Quarterly Journal of Chinese Forestry 17(4): 57–73.

Su HJ (1985) Studies on the climate and vegetation types of the natural forests in Taiwan (3) – A scheme of geographical climatic regions. Quarterly Journal of Chinese Forestry 18(3): 33–44.

Yüksel E, Kiran Y, Şahin A, Yildiz B, Arabaci T (2013) Karyological studies of 10 *Cirsium* sect. *Epitrachys* (Asteraceae) species from Turkey. Turkish Journal of Botany 37: 1085–1092. https://doi.org/10.3906/bot-1302-1