Cirsium taiwanense (Compositae, Cirsium sect. Onotrophe, subsect. Australicirsium), a new species from Taiwan

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Abstract

A new species of Cirsium, C. taiwanense Y.H.Tseng & Chih Y.Chang from central-northern Taiwan is reported in this article. This species is similar to C. hosokawae Kitam. in having a densely cobwebby abaxial leaf surface, but differs in its yellow (vs. vivid purplish red) corolla and the angle between the midrib and the lateral veins of the leaf, which is acute as opposed to nearly at a right angle in C. hosokawae. Cirsium taiwanense has 2n = 32 chromosomes, which is different from the other species in the Taiwanese subsect. Australicirsium Kitam. (2n = 34). An identification key to the Cirsium taxa of Taiwan is presented.

Keywords

Australicirsium Kitam., central-northern Taiwan, Cirsium, karyotype analysis, pollen morphology, subsect

Introduction

The genus Cirsium Mill. (Compositae) contains ca. 250 extant species, with its center of diversity in southern Europe and Caucasia (Werner 1976; Garcia-Jacas et al. 2002). This genus contains perennial, biennial, and annual spiny herbs, and has capitula with only disc florets, involucres of 5 to 20 series, setiferous receptacles, anther bases with caudate extensions, an achene apex with a short beak, and plumose pappus (Keil 2006; Funk et al. 2009). In East Asia, Cirsium has been reported in China (46 species, Shih and Greuter 2011), Japan (64 species, Iwatsuki et al. 1995), and Korea (8 species, Song and Kim 2007). According to Peng et al. (1998), nine species are recorded in Taiwan,
one of which is represented by two varieties. Recently, Chang et al. (2019) described a new species endemic to Taiwan, namely *C. tatakaense* Y.H.Tseng & Chih Y.Chang, and Chang and Tseng (2019) reported a newly recorded variety, *C. japonicum* DC. var. *fukienense* Kitam. In addition, Chang and Tseng (2020) reported a newly naturalized species, *C. vulgare* (Savi) Tenore. The Taiwanese species are distributed from seashores to high altitude areas.

The island of Taiwan is located about 150 km off the southeast coast of China, between 21°45’N and 25°37’N, and 119°18’E and 122°06’E. Its climate ranges from tropical to subtropical. Taiwan is at the border between the paleotropical floristic kingdom and the Holarctic floristic kingdom (Good 1964; Takhtajan 1986). Several peaks exceed 3500 m a.s.l. and the highest is Mr. Yushan at 3952 m a.s.l., making Taiwan the fourth-highest island in the world (Chen 1980; Wang et al. 2009). Taiwan contains a diverse range of ecological niches in its mountains, which might have accelerated speciation and facilitated the evolution of endemic high-altitude plant species (Hsieh 2002). For example, there are seven native *Cirsium* species distributed from mid- to high altitudes, and all of them are endemic (Peng et al. 1998; Chang and Tseng 2019).

According to the infrageneric classification of East Asian *Cirsium* (Kitamura 1937; Shih 1984; Iwatsuki et al. 1995), the ten native species of Taiwan belong to three sections, viz. sect. *Onotrophe* (Cass.) DC., sect. *Pseudoeriolepis* (Nakai) Kitam., and sect. *Spanioptilon* (Less.) Shih. Section *Onotrophe* (Cass.) DC. is further subdivided into four subsections (Kitamura 1937), viz. subsect. *Arenicola* Kitam., subsect. *Australicirsium* Kitam., subsect. *Nipponocirsium* Kitam., and subsect. *Sinocirsium* Kitam. Following this infrageneric system, subsect. *Australicirsium* has only two species in Taiwan, *C. arisanense* Kitam. and *C. hosokawae* Kitam., which are characterized by erect or nodding capitula, phyllaries with a distinct midrib, and corolla lobes that are as long as the inflated part of the corolla tube (Kitamura 1937).

Recently, we discovered an unknown *Cirsium* belonging to subsect. *Australicirsium* (sect. *Onotrophe*) growing in the high mountain areas of central-northern Taiwan. This taxon appeared to be similar to *C. hosokawae*, with abaxial leaf surfaces covered with dense cobwebby hairs and by having nodding mature capitula. However, it can readily be distinguished from the latter by its yellow flowers, and the smaller angle between the midrib and the lateral veins. The aim of the present study was to elucidate the taxonomic status of this taxon using morphological, palynological and cytological approaches. After detailed examinations, we concluded that the taxon represents a new species and it is here described as *Cirsium taiwanense*.

**Materials and methods**

**Morphological comparison**

We compared the two Taiwanese taxa of subsect. *Australicirsium* with the unknown taxon. Morphological measurements were made using both fresh and dried specimens.
For the morphological description, the terminology used by Peng et al. (1998) and Funk et al. (2009) was applied.

Herbarium resources

Herbarium acronyms follow Index Herbariorum (Thiers 2021, continuously updated). Voucher specimens collected for the current study were deposited in PPI, TCF, and TNM. Specimens of the following herbaria were also examined: CHIA, HAST, KYO, PPI, TAI, TAIF, TCF, TI, TNM and TNU. The holotypes of both *C. arisanense* and *C. hosokawae* were also studied.

Pollen morphology

Pollen grains were collected from fresh materials, and directly mounted on a stub. After air drying for 24 h at room temperature, the samples were sputter-coated with gold at 10–15 mA for 100 s (Quorum SC7620), and observed with a scanning electron microscope (Hitachi S-3400N). The shape, size and exine ornamentation were recorded using the methods of Erdtmann (1952) and Halbritter et al. (2018). Information about voucher specimens is provided in Table 1.

Karyotype analysis

Karyotype analysis was performed using the procedures of Ozcan et al. (2011) and Yüksel et al. (2013). Root tips were collected on sunny mornings and pre-treated with 2 mM 8-hydroxyquinoline below 4 °C for 8 h, then fixed with Carnoy’s solution (absolute ethanol:acetic acid, 3:1, v:v) for at least 24 h at 0 °C. The fixed roots were then stained with 2% aceto-orcein for 24 h at room temperature, squashed, and the slides were examined using an optical microscope (Accu-Scope 3025) equipped with a CCD camera (ProgRes C14 plus). Information about voucher materials is presented in Table 1.

Distribution map

A distribution map was generated using QGIS ver. 3.4 from the package developed by Lin (2018). Geographical climatic regions and altitudinal vegetation zones of Taiwan were indicated following Su (1984, 1985) (Fig. 4). The geographical range of each species was determined from information on herbarium specimens.

Data analysis

The values of the quantitative morphological and palynological traits were determined and their means and standard deviations were calculated (Table 2). Differences between taxa were analyzed using a one-way ANOVA, followed by Tukey’s HSD multiple-range test (*p* ≤ 0.05) (Zar 1984). All analyses were performed using the PASW Statistics ver. 18 software (Sarma and Vardhan 2018).
Table 1. Voucher material for *Cirsium* Mill. subsect. *Australicirsium* Kitam. pollen morphology and karyotype analysis.

| Taxa           | Location                                                                 | Altitude | Coordinate (WGS84)               | Collecting date | Voucher number | Pollen morphology | Karyotype analysis |
|----------------|---------------------------------------------------------------------------|----------|----------------------------------|-----------------|-----------------|--------------------|--------------------|
| *C. arisanense* | Taiwan, Hualien County, Xiulin Township, Hsiaofengkou                    | 2,996 m  | 24.16245°N, 121.28716°E          | 26 June 2015    | C. Y. Chang 602 | ●                  | ●                  |
|                | Taiwan, Taichung City, Heping District, Mt. Syue trail 8.9 km             | 3,399 m  | 24.39229°N, 121.24166°E          | 3 Sept. 2015    | C. Y. Chang 756 | ●                  | ●                  |
|                | Taiwan, Nantou County, Ren’ai Township, Rueiyian river pipes road 2 km     | 2,215 m  | 24.11398°N, 121.20746°E          | 27 May 2016     | C. Y. Chang 1275| ●                  | ●                  |
|                | Taiwan, Nantou County, Sini Township, Tataka                               | 2,609 m  | 24.47692°N, 120.89841°E          | 9 Feb. 2020     |                 | ●                  | ●                  |
| *C. hosokawae* | Taiwan, Taichung City, Heping District, Mt. Syue trail, Kupo to Mt.      | 3,168 m  | 24.38882°N, 121.27348°E          | 8 Nov. 2015     | C. Y. Chang 870 | ●                  | ●                  |
|                | Syue East Peak                                                            |          |                                  |                 |                 |                    |                    |
|                | Taiwan, Hualien County, Xiulin Township, Shangyuankuti, Mt. Nanhutashan   | 3,586 m  | 24.36402°N, 121.43713°E          | 5 Sept. 2016    | C. Y. Chang 1432| ●                  | ●                  |
|                | Taiwan, Ilan County, Datong Township, Mt. Nanhutashan trail, near Mt.     | 2,761 m  | 24.36801°N, 121.37971°E          | 11 Aug. 2018    | C. Y. Chang 2023| ●                  | ●                  |
|                | Tochiatun                                                                |          |                                  |                 |                 |                    |                    |
|                | Taiwan, Taichung City, Heping District, Mt. Nanhutashan, Sungfengling    | 2,648 m  | 24.36973°N, 121.37167°E          | 27 July 2019    | C. Y. Chang 2477| ●                  | ●                  |
|                | Taiwan, Taichung City, Heping District, Mt. Nanhutashan trail 8.5 km     | 2,707 m  | 24.36850°N, 121.37350°E          | 31 July 2019    | C. Y. Chang 2499| ●                  | ●                  |
| *C. taiwanense*| Taiwan, Taichung City, Heping District, Mt. Syue trail 0.9 km             | 2,398 m  | 24.38520°N, 121.29254°E          | 3 July 2015     | C. Y. Chang 620 | ●                  | ●                  |
|                | Taiwan, Nantou County, Ren’ai Township, Provincial Rd. No. 14A 21.5 km    | 2,657 m  | 24.11381°N, 121.22401°E          | 2 Oct. 2015     | C. Y. Chang 772 | ●                  | ●                  |
|                | Taiwan, Taichung City, Heping District, Mt. Syue trail 0–1 km             | 2,353 m  | 24.38486°N, 121.29519°E          | 24 Apr. 2016    | C. Y. Chang 1230| ●                  | ●                  |
|                | Taiwan, Taichung City, Heping District, Mt. Tao                           | 2,648 m  | 24.41766°N, 121.30693°E          | 22 July 2018    | C. Y. Chang 1926, 2133 | (TCF)             | ●                  |

Results

Macro-morphological differences

The abaxial leaf surface of the members of subsect. *Australicirsium* in Taiwan displays two types of indumentum. Both *C. hosokawae* and *C. taiwanense* are densely covered with cobwebby hairs, whereas *C. arisanense* is without cobwebby indumentum. The angle between the midrib and the lateral veins of the leaves of *C. hosokawae* is often almost 90°, (60–)82–90°, which differs significantly \( p \leq 0.05 \) from that of *C. arisanense*, (49–)57–78° and *C. taiwanense* (44–)52–73° (Fig. 1, Table 2). In addition, the mature capitula of *C. arisanense* are erect and rarely nodding, whereas those of *C. hosokawae* and *C. taiwanense* are usually nodding. *Cirsium taiwanense* has significantly \( p \leq 0.05 \) more florets in a capitulum (101–135–194) than *C. arisanense* (78–137) and *C. hosokawae* (54–111), and a larger number of phyllaries: 90–127 vs. 66–100 for *C. arisanense* and 68–109 for *C. hosokawae*. (Fig. 1, Table 2). Further,
**Table 2.** Summary of diagnostic characters of *Cirsium* Mill. subsect. *Australicirsium* Kitam. in Taiwan.

| Characters | *C. arisanense* | *C. hosokawae* | *C. taiwanense* |
|-----------|----------------|----------------|----------------|
| Rosette leaves | Size (cm): 31.32 ± 13.71× 5.55 ± 1.27<sup>a</sup> | 19.69 ± 3.79× 4.42 ± 1.02<sup>a</sup> | 26.05 ± 6.18× 5.55 ± 1.27<sup>a</sup> |
| | Shape: narrowly elliptic | narrowly elliptic to oblanceolate | narrowly elliptic to oblanceolate |
| | Angle between midrib and lateral vein (°): 68.78 ± 5.12<sup>a</sup> | 83.05 ± 9.88<sup>a</sup> | 63.04 ± 12.00<sup>a</sup> |
| | Cobwebby hairs on abaxial leaf surface: Absent | present | present |
| Cauline leaves | Size (cm): 12.70 ± 5.84× 4.10 ± 2.95<sup>a</sup> | 17.88 ± 0.78× 5.26 ± 0.74<sup>a</sup> | 16.17 ± 5.01× 4.85 ± 1.56<sup>a</sup> |
| | Angle between midrib and lateral vein (°): 65.31 ± 9.06<sup>a</sup> | 83.73 ± 9.53<sup>a</sup> | 62.30 ± 10.71<sup>a</sup> |
| | Cobwebby hairs on abaxial leaf surface: Absent | present | present |
| Capitula | Mature capitula: erect or sometimes nodding | nodding | nodding |
| | Size (cm): 3.05 ± 0.22× 1.42 ± 0.25<sup>a</sup> | 2.60 ± 0.66× 1.18 ± 0.32<sup>a</sup> | 3.03 ± 0.22× 1.61 ± 0.17<sup>a</sup> |
| Phyllaries | Length ratio (inner vs. outer): 2.05 ± 0.75<sup>a</sup> | 1.46 ± 0.33<sup>a</sup> | 2.91 ± 0.73<sup>a</sup> |
| | Length of the reflexed part of the phyllaries (mm): 4.88 ± 1.23<sup>a</sup> | 2.33 ± 0.80<sup>a</sup> | 2.30 ± 0.18<sup>a</sup> |
| | Number: 81.3 ± 11.5<sup>b</sup> | 86.3 ± 12.0<sup>b</sup> | 111.7 ± 13.3<sup>b</sup> |
| Florets | Length (cm): 2.54 ± 0.15<sup>a</sup> | 2.46 ± 0.21<sup>a</sup> | 2.63 ± 0.21<sup>a</sup> |
| | Inflated part of corolla tube length (mm): 4.39 ± 0.63<sup>a</sup> | 4.41 ± 0.46<sup>a</sup> | 5.11 ± 0.70<sup>a</sup> |
| | Corolla color: Yellow | vivid purplish red | yellow |
| | Corolla lobes: Revolute | erect | erect |
| | Anther length (mm): 6.02 ± 0.78<sup>a</sup> | 6.10 ± 0.51<sup>b</sup> | 6.86 ± 0.80<sup>b</sup> |
| | Number: 102.7 ± 24.1<sup>a</sup> | 84.6 ± 19.5<sup>b</sup> | 129.7 ± 30.1<sup>b</sup> |
| Achene | Size (mm): 3.77 ± 0.16× 1.49 ± 0.06<sup>b</sup> | 3.95 ± 0.13× 1.37 ± 0.05<sup>b</sup> | 3.97 ± 0.18× 1.65 ± 0.07<sup>b</sup> |
| | Pappus length (cm): 1.66 ± 0.04<sup>a</sup> | 1.29 ± 0.04<sup>a</sup> | 1.60 ± 0.05<sup>a</sup> |
| Pollen | Pollen size (P/E, μm): 47.61 ± 0.80× 46.37 ± 1.00<sup>a</sup> | 41.40 ± 0.60× 41.15 ± 0.75<sup>a</sup> | 48.50 ± 0.80× 47.00 ± 1.00<sup>a</sup> |
| | Pollen spine length (μm): 4.25 ± 0.18<sup>a</sup> | 3.91 ± 0.14<sup>a</sup> | 3.20 ± 0.18<sup>a</sup> |
| | Pollen spine base width (μm): 4.44 ± 0.26<sup>a</sup> | 5.33 ± 0.19<sup>a</sup> | 4.74 ± 0.26<sup>a</sup> |
| Chromosome number | 2n = 34<sup>a</sup> | 2n = 34<sup>a</sup> | 2n = 32<sup>a</sup> |
| Distribution | Endemic to Taiwan; widely distributed in open mountain areas at 1500–3800 m a.s.l. (Chang et al. 2019). | Endemic to Taiwan; open areas at 1400–3600 m a.s.l. in central-northern Taiwan. | Endemic to Taiwan; open areas at 1400–3400 m a.s.l. in central-northern Taiwan. |

<sup>a</sup>Means in the same row followed by the same letter are not significantly different (p ≤ 0.05; Tukey’s HSD test).

the corolla of *C. taiwanense* and *C. arisanense* is yellow, but that of *C. hosokawae* is vivid purplish red. Although the color of the corolla of *C. hosokawae* could not be determined from its type specimen, it is described as red in the protologue (Kitamura 1932). The populations described here have yellow corollas and are therefore regarded as *C. taiwanense*. Moreover, the corolla lobes of *C. arisanense* are revolute, whereas the two other species have erect corolla lobes (Fig. 1, Table 2). Finally, the pappus of the...
achene of *C. hosokawae* is significantly (*p* ≤ 0.05) shorter (1.02–1.48 cm) than that of *C. arisanense* (1.44–1.73 cm) and *C. taiwanense* (1.55–1.66 cm) (Fig. 1, Table 2). In general, the leaves of *C. taiwanense* and *C. hosokawae* are similar, as the abaxial leaf
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Surfaces of both species are covered with dense cobwebby hairs. Therefore, herbarium specimens are often misidentified. Our field observations however suggest that the color of the corolla and the angle between the midrib and the lateral veins of the leaves are reliable characters for distinguishing the two species.

**Pollen morphology**

The pollen grains of Taiwanese species of subsect. *Australicirsium* are tricolporate, spheroidal and of medium size. The pollen grains of *C. taiwanense* (43.5–51.8 μm) and *C. arisanense* (42.9–53.0 μm) have a significantly ($p \leq 0.05$) larger diameter than those of *C. hosokawae* (36–46 μm) (Fig. 2B). *Cirsium arisanense* has significantly ($p \leq 0.05$) longer pollen spines (2.9–5.1 μm) (Fig. 2A) than *C. taiwanense* (2.8–3.6 μm), but these are not significantly ($p \leq 0.05$) longer than those of *C. hosokawae* (3.2–4.9 μm) (Fig. 2C, Table 2).

**Figure 2.** Comparison of the pollen morphology of *Cirsium* Mill. subsect. *Australicirsium* Kitam

A *C. arisanense* Kitam

B *C. hosokawae* Kitam

C *C. taiwanense* Y.H.Tseng & Chih Y.Chang

1 polar view

2 equatorial view

3 colporate view. Scale bar: 30 μm.
Chromosome cytology

The most common chromosome number of *Cirsium* species is \(2n = 34\) (Hsu 1970; Funk et al. 2009; Chen and Yeh 2010a, 2010b). Our cytological investigation also shows that the chromosome numbers of both *C. arisanense* and *C. hosokawae* are \(2n = 34\) (Fig. 3A, B). In contrast, the chromosome number of *C. taiwanense* is \(2n = 32\) (Fig. 3C).

Although the chromosomes of the three taxa were too short to determine their karyotypic formula, satellites and secondary constrictions could be observed in longer chromosomes. Satellites were observed in *C. arisanense* for the 3rd, 6th and 7th pairs (Fig. 3A), in *C. hosokawae* for the 1st, 2nd and 5th pairs (Fig. 3B), and in *C. taiwanense* for the 5th and 7th pairs (Fig. 3C). In addition, only the 1st and 2nd pairs of *C. taiwanense* have secondary constrictions (arrows in Fig. 3C). Our results show that each taxon of subsect. *Australicirsium* in Taiwan has a clearly different karyotype (Fig. 3).

Distribution

*Cirsium arisanense* is the most common *Cirsium* species in high altitude regions in Taiwan (see distribution map in Chang et al. 2019). In comparison, *C. hosokawae* and *C. taiwanense* are less common and widespread. Both *C. hosokawae* and *C. taiwanense* occupy similar
habitats and altitudes, often occurring in open areas such as in wide roadsides and forest margins at 1400–3600 m a.s.l. However, the latitudinal distributions of the two species are different. *Cirsium hosokawae* and *C. taiwanense* are mainly found in the northwest inland region (Su 1985). However, *C. hosokawae* is absent from the central west inland region, whereas *C. taiwanense* is found less frequently near the western boundary of the north section of the east region. In general, the distribution of *C. taiwanense* is concentrated in the southwest and *C. hosokawae* is in the northeast of their combined distribution area (Fig. 4). The climate of the *C. hosokawae* habitat is usually more humid than that of *C. taiwanense*.

**Discussion**

The differences and the taxonomic status of the unknown *Cirsium*

*Cirsium taiwanense* has a unique combination of morphological characteristics: its corolla lobes are erect and yellow, and the abaxial surface of the leaves is densely covered with cobwebby hairs (Fig. 1C). Additionally, *C. taiwanense* has the largest pollen grains and shortest pollen spines of the three species of subsect. *Australicirsium* in Taiwan (Fig. 2, Table 2). The chromosome number of *C. taiwanense* is 2n = 32 (Fig. 3C), which is different from the other known *Cirsium* species in Taiwan (Hsu 1970; Peng and Hsu 1978; Chen and Yeh 2010a, 2010b; Chang et al. 2019). Also, the 1st and 2nd pairs of chromosomes in its karyotype have secondary constrictions, which is different from other subsect. *Australicirsium* species (Fig. 3). Based on the above comparison, *C. taiwanense* is clearly different from other known congeners. We therefore here describe *C. taiwanense* as a new species.

**Key to the 14 wild *Cirsium* taxa of Taiwan** (modified from Chang et al. (2019), Chang and Tseng (2019), and Chang and Tseng (2020))

1 Biennial herb; leaves villose; involucre cylindrical or urceolate ...............2
2 Stem without wings; mature capitula nodding; involucre cylindrical..................*C. ferum*
2* Stem with spiny wings; mature capitula erect; involucre urceolate.................*C. vulgar*1
1* Perennial herb; leaves glabrous, pubescent or densely cobwebby; involucre urceolate or cupuliform..........................3
3 All leaves cauline, basal rosette leaves absent............................4
4 Leaves densely cobwebby on abaxial surface; mature capitula erect, involucre urceolate; apical parts of inner phyllaries inflated, obtuse; outer phyllaries lanceolate, apex acute without a spine; corolla lobes obviously longer than the inflated part of corolla tube..........................*C. lineare*

1 naturalized species.
4* Leaves glabrous on both surfaces; mature capitula nodding, involucre cupuliform; apical parts of inner phyllaries acute or acuminate; outer phyllaries elliptical with a long spine at the apex; corolla lobes as long as the inflated part of corolla tube .......................................................... 5

5 Corollas white; leaves pinnatisect or bipinnatisect, lobes > 1.5 cm wide........

5* Corollas purple; leaves mainly pinnatisect, lobes < 1.2 cm wide................

C. kawakamii 

3* Leaves in both a basal rosette and cauline............................................. 6

6 Reflexed part of the phyllaries blade-like; corolla lobes as long as the inflated part of corolla tube .......................................................... 7

7 Corollas white or light purple ................................................................. 8

8 Corollas white; inner and outer phyllaries similar in length; stems cauline, without rhizome .............................................................. C. brevicaule
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8* Corollas light purple; inner and outer phyllaries distinctly different in length; stems both cauline and rhizomatous .............................. C. morii
7* Corollas yellow or vivid purplish red............................................................. 9
9 Abaxial leaf surface without cobwebby indumentum; mature capitula erect or nodding; corolla lobes revolute .............................................. C. arisanense
9* Abaxial leaf surface densely cobwebby; mature capitula nodding; corolla lobes erect................................................................. 10
10 Corolla vivid purplish red; angle between midvein and lateral veins of leaf (60–)82–90° ................................................................. C. hosokawae
10* Corolla yellow; angle between midvein and lateral veins of leaf (44–)52–73° .................................................................................. C. taiwanense
6* Reflexed part of the phyllaries spine-like; corolla lobes shorter than the inflated part of corolla tube............................................. 11
11 Abaxial leaf surface densely cobwebby; mature capitula nodding ... C. suzukii
11* Leaf surfaces pubescent, but not cobwebby; mature capitula erect...... 12
12 Corolla white; leaves glabrescent ......................................................... C. japonicum var. takaense
12* Corolla purple; leaves villose, not glabrescent .................................... 13
13 Apical spines of phyllaries shorter than 2 mm; leaves pinnatifid to pinnatisect ............................................................. C. japonicum var. australis
13* Apical spines of phyllaries longer than 3 mm; leaves pinnatifid to pinnatisect ............................................................. C. japonicum var. fukienense

Taxonomic treatment

Cirsium taiwanense Y.H. Tseng & Chih Y. Chang, sp. nov.
urn:lsid:ipni.org:names:77220552-1
Figures 1C, 2C, 3C, 5, 6

Diagnosis. Differs from C. hosokawae in having a yellow corolla (vs. vivid purplish red corolla), a narrower angle between the midrib and lateral veins of the cauline leaves ((44–)52–73° vs. 82–90°), and usually more florets (101–135(–194) vs. 54–111) and phyllaries (90–127 vs. 68–109) per capitulum. Differs from C. arisanense by its nodding mature capitula (vs. erect), erect corolla lobes (vs. revolute), and a densely cobwebby abaxial leaf surface (vs. without cobwebby indumentum).

Type. Taiwan. Nantou County, Ren’ai Township, Provincial Rd. No. 14A 21 km, 2605 m alt., 24.11438°N, 121.21821°E, 15 July 2020. C. Y. Chang 2976 (holotype: TCF; isotype: TNM, PPI).

Description. Perennial herbs, stems 0.5–1.0 m tall, internodes terete. Leaves pinnatifid or pinnatisect, space between pinnae V-shaped, adaxial surface puberulent or cobwebby, abaxial surface densely cobwebby, margin spinose; rosette leaves narrowly elliptic to oblanceolate, base cuneate to attenuate, apex narrowly acute, 19.5–34.1 × 4.1–7.4 cm, angle between the midrib and the lateral veins (40–)55–76°; pinnae 7–11 pairs, 0.9–2.6 ×1.2–2.1 mm, space between pinnae 0.4–1.2 cm, petiole 1.5–4.0 cm; cauline
leaves narrowly elliptic to narrowly triangular, base cordate, apex narrowly acute, 9.0–25.5 × 2.2–6.9 cm, angle between the midrib and the lateral veins (44–)52–73°; pinnae 5–8 pairs, 1.3–2.1 × 0.8–1.9 cm, space between pinnae 0.6–1.5 cm, sessile. Capitula

Figure 5. Line drawings of *Cirsium taiwanense* Y.H. Tseng & Chih Y. Chang  
A habit  
B rosette leaf  
C cauline leaf  
D capitulum  
E floret  
E' floret (pappus removed)  
F phyllaries  
G style branches  
H achene.
Figure 6. *Cirsium taiwanense* Y.H. Tseng & Chih Y. Chang A habitat B habit C basal rosette D variations of rosette leaves E variations of cauline leaves F inflorescences G, H capitulum I floret I’ floret (pappus removed) J achenes.
solitary or 2–6 arranged into racemes or panicles, mature capitula nodding. Involucre urceolate, more or less cobwebby, 2.8–3.4 × 1.4–1.9 cm; phyllaries 90–127, in 5–7 series, apex acute, midrib distinct, (0.3–)0.5–1.4 × 1.5–2.1 mm, length ratio of inner and outer phyllaries 2.2–3.6, the reflexed part of the phyllaries 1.5–3.1 mm long. Receptacle flat, densely bristly. Florets 101–135(–194), 2.2–3.1 cm long, with yellow corolla, corolla lobes 5, linear, erect, 3.0–5.1 × 0.4–0.7 mm, corolla tube fistulose with 2 sections, the inflated section of corolla tube 4.1–5.8 mm long; synantherous stamens 5, anthers brown, 5.9–8.3 mm long, base with caudate extensions, filaments 3.0–4.5 mm long with irregular protuberances; stigmas bifid, styles 2.0–2.5 cm long, style arm 2.6–2.7 mm long, ovaries (1.6–)3.2–4.1 mm long. Achenes oblong, base acute, apex truncate, beige, 3.5–4.5 × 1.5–1.8 mm, compressed, 4-angled, ribbed, beak heart-shaped; pappus copious, plumose, bristles in many series, 1.55–1.65 cm long, forming basal ring, easily shed.

**Phenology.** Flowering between June and October and fruiting between July and November.

**Distribution and habitat.** Endemic species of Taiwan. *Cirsium taiwanense* grows in open areas between *Querus* forest and *Abies* forest at 1400–3400 m a.s.l. in central-northern Taiwan. *Cirsium taiwanense* usually grows at sunny sites. Common companion species are *Artemisia murrisonensis* Hayata (Compositae), *Lilium formosanum* Wallace (Liliaceae), *Salix fulvopubescens* Hayata (Salicaceae) and *Rubus pectinellus* Maxim. (Rosaceae).

**Chinese name.** Tai-wan-ji (臺灣薊).

**Chromosome number.** $2n = 32$ (Fig. 3B).

**Palynology.** Pollen grains are tricolporate, spheroidal, micro-reticulate and 46.6–51.8 × 43.5–50.7 μm (P/E ratio: 0.9–1.1). The surface is densely covered with spines that are 2.8–3.6 μm long and 3.9–6.0 μm wide at the base. The distance between spines is 8.2–11.8 μm (Fig. 2C).

**Conservation status.** *Cirsium taiwanense* is common in north-central Taiwan (Fig. 4). The populations often grow in high mountain areas and experience limited disturbance by humans. Following the International Union for Conservation of Nature (IUCN) Categories and Criteria (IUCN 2019), we regard this species as of Least Concern (LC).

**Additional specimens examined.** TAIWAN. Hsinchu County, Jianshi Township, Mt. Itsashan, 7 Sept. 1993. *C. L. Huang* 78 (HAST!). Miaoli County, Taian Township, en route from 99 lodge to Mt. Tapachienshan, 11 Aug. 1985. *C. I Peng 8492, 8542, 8543, 8544, 8545, 8546* (HAST!); same loc., 2 Nov. 1996. *C. M. Wang 2384* (TNM!); Taian, 13 Sept. 1996. *C. H. Chen 1870* (TAIE!); 99 Lodge, 2780 m alt., 2 Nov. 1996. *C. M. Wang 2384* (HAST!); Mt. Hsishihshan, 27 Oct. 1976. *B. P. Yang 81* (TAIF!). Taichung City, Heping District, Mt. Nanhutashan, 21 Sept. 1969. *T. Yamazaki 281* (TI!); Yunleng cabin to Mt. Duojiatunshan, 26 June 1994. *C. M. Wang 1026* (TNM!); en route from entrance to Yunleng cabin, 27 July 2019. *C. Y. Chang 2478* (TCF); Derji, 3 July 1974. *C. I Peng 15* (TAI!); en route from entrance to Chika Lodge, 1 June 2003. *C. M. Wang 6908* (TNM!); same loc., 19 June 2009. *C. M. Wang 13025* (TNM!); same loc., 20 Jun. 2011. *C. I Huang 5273* (HAST!); same loc., 16 July 2009. *Y. H. Tseng 4697*
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