

# Revision of the genus *Gentiana* L. (Gentianaceae) in Taiwan

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**Abstract.** Based on intensive morphological study of the genus *Gentiana* from Taiwan, eleven species and two varieties are recognized. All but *G. davidii* var. *formosana* T. N. Ho. are endemic to Taiwan. Two new species (*G. kaohsiungensis* C. H. Chen & J. C. Wang and *G. tarokoensis* C. H. Chen & J. C. Wang) and one new variety (*G. flavomaculata* var. *yuanyanghuensis* C. H. Chen & J. C. Wang) are published in this paper. *Gentiana taiwanica* T. N. Ho (= *Gentiana angusta* (Masamune) Liu & Kuo) and *G. kaoi* Shimizu are reduced to the synonym of *G. scabrida* Hayata and *G. tentyoensis* Masamune, respectively. *Gentiana loureirii* (G. Don) Grisebach, *G. manshurica* Kitagawa, and *G. yakushimensis* Makino are treated as excluded species. Calyx-lobe shape and corolla color are the most useful characters for classification of Taiwanese species. A key to the taxa, description, taxonomic character, geographical distribution, classification notes, and specimens examined is provided for each taxon.

**Keywords:** *Gentiana*; Gentianaceae; Revision; Taiwan; Taxonomy.

## Introduction

*Gentiana* (Gentianaceae), a subcosmopolitan genus, consists of about 360 species (Ho and Pringle, 1995). Grisebach was the first to study the infrageneric taxonomy of *Gentiana*, establishing 12 sections. Later, he added three sections (Grisebach, 1845). Among these 15 sections, eight sections were transferred to the genus *Gentianella* Moench. (Ho, 1985). Infrageneric surveys or treatments were conducted (Ho, 1985, 1988; Ho and Liu, 1990; Ho and Pringle, 1995; Ho et al., 1996; Pringle, 1978; Smith, 1961, 1965; Yuan et al., 1996). In Taiwan, the first infrageneric treatment was made by Liu and Kuo (1974) who classified Taiwanese species into three sections, but one of these sections has been transferred to *Tripterospermum* Blume (Nilsson, 1967). Based on Ho's (1988) study of Chinese *Gentiana*, the species of Taiwan were classified into two sections and six series.

The Taiwanese *Gentiana* have been studied by Japanese taxonomists, such as Hayata (1908, 1917), Yamamoto (1936), and Masamune (1943), who published most of the older taxa. The first revision was made by Liu and Kuo (1970). Liu and Kuo (1978) recorded 12 taxa in the Flora of Taiwan, of which most were endemic. Ho (1988) revised the genus distributed in China (including Taiwan). Her treatment differed from that of Liu and Kuo's (1978) concerning several taxa of the genus in Taiwan, especially the new record of *G. yakushimensis* Makino. The treatment of Ying (1989), who made many new combinations, differed from those of Liu and Kuo (1978) and Ho (1988). In a more recent study by Ho and Pringle (1995), *G. manshurica* Kitagawa was recorded in Taiwan. Although there have

been few taxonomists conducting studies on Taiwanese *Gentiana*, the treatments differed greatly.

*Gentiana parvifolia* was published by Hayata (1911) and adopted by Liu and Kuo (1970, 1974, 1978) and Ying (1989). However, the name is a later homonym and this taxon has been transferred to the genus *Tripterospermum* Blume by Smith (see Nilsson, 1967), and renamed as *T. microphyllum* H. Smith since the species has unequal and curved stamens, nectaries forming a collar-like disc around the gynophore, and obvious petioles.

## Materials and Methods

Materials used in the present studies were collected from the field throughout Taiwan, pressed and dried for voucher specimens, and deposited in the Herbarium of TNU. In addition, specimens from the following herbaria were examined: HAST, NTUF, PPI, TAI, TAI, and Department of Forestry, National Chung Hsing University (NCUF). Type specimens preserved in the Japanese herbaria KYO and TI were also examined.

Seeds for scanning electron microscopic (SEM) study were collected from fresh capsules when they were dehisced. The seed size was measured by using no fewer than 10 seeds for each taxon. The seeds were dried to the critical point, coated with gold, and examined under an ABT DS-180S scanning electron microscope.

## Taxonomic Characters

The taxonomic characters have been well documented by Ho and Liu (1990), especially the main application to the section and the series level. They will therefore not be repeated here in detail. Previous studies (e. g., Liu and Kuo, 1974; Ho, 1988; Ying, 1989) showed that corolla color,

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calyx-lobe shape, and seedcoat exterior decoration are valuable morphological characters for the taxonomy of Taiwanese species in the genus. Based on detailed comparisons on these and other characters, this study presents a taxonomic revision of the genus. The concise descriptions of taxonomic characters used for the present study are shown in the following categories.

### Habit

In Taiwan the majority of the taxa are annual herbs, except *Gentiana davidii* var. *formosana* and *G. arisanensis* which are perennial herbs. Both of these perennial species have thicker and more robust roots than the annual ones. Lower parts of the plants persist through the snow season in high mountains, and the lateral branches of the main stems usually elongate when the plants bloom and then wither after capsules dehiscence. Most plants of the genus in Taiwan are usually less than 15 cm tall, except *Gentiana itzershanensis* and *G. scabrida* var. *punctulata*, which are sometimes up to 20 cm.

### Stem

The Taiwanese *Gentiana* can be divided into two types based on the morphology of the stem from Ho and Liu's (1990) concept. The first type, found in *G. davidii* var. *formosana*, is the sympodial branching type. The second type, found in other species, is the monopodial branching type. The second type can be split into two subtypes. The first subtypes, found in *Gentiana arisanensis*, branches from the stem base rather than on the upper part of the stem. The second subtype, found in most of other species, branches from the stem base to the upper part of stems. The length of internode is to some extent related to their habitat. In general, individuals growing in exposed areas usually exhibit shorter internodes than those growing in shady areas or in grasslands.

### Leaves

Leaves are simple, sessile or short-petiolate. Two opposite leaves encircle the stem and form a basal sheath. The length of sheath for Taiwanese species is usually less than 2 mm, except *Gentiana davidii* var. *formosana* which is longer than 3 mm. All of the Taiwanese species, with an exception of *G. arisanensis*, produce two kinds of leaves, radical and cauline. The radical leaves are more or less larger than the cauline ones.

Leaf shape can be divided into three types. The first type is chisel-like. Only one species, *Gentiana arisanensis* has this type. The second leaf type is linear-lanceolate to narrow lanceolate, including *G. davidii* var. *formosana* and *G. itzershanensis* (cauline leaves). The third type is lanceolate to ovate or broadly ovate and includes most of the Taiwanese taxa.

In addition to the above categorization, plicate and closely crowded leaves on lower stems of *Gentiana arisanensis* are easily distinguished from those of any other Taiwanese taxa.

### Inflorescence

The inflorescence of Taiwanese species is terminal and solitary, except for *Gentiana davidii* var. *formosana* whose flowers are clustered at the end of branches with several to ten flowers per branch. Careful examination shows the flowers of *Gentiana davidii* var. *formosana* to be sessile and axillary, and form a head-like clusters being the result of extremely short internode and small bract-like leaves. The other Taiwanese species have distinct pedicels that elongate during maturation when blooming. Finally, the pedicels usually increase to as long as internodes of stems.

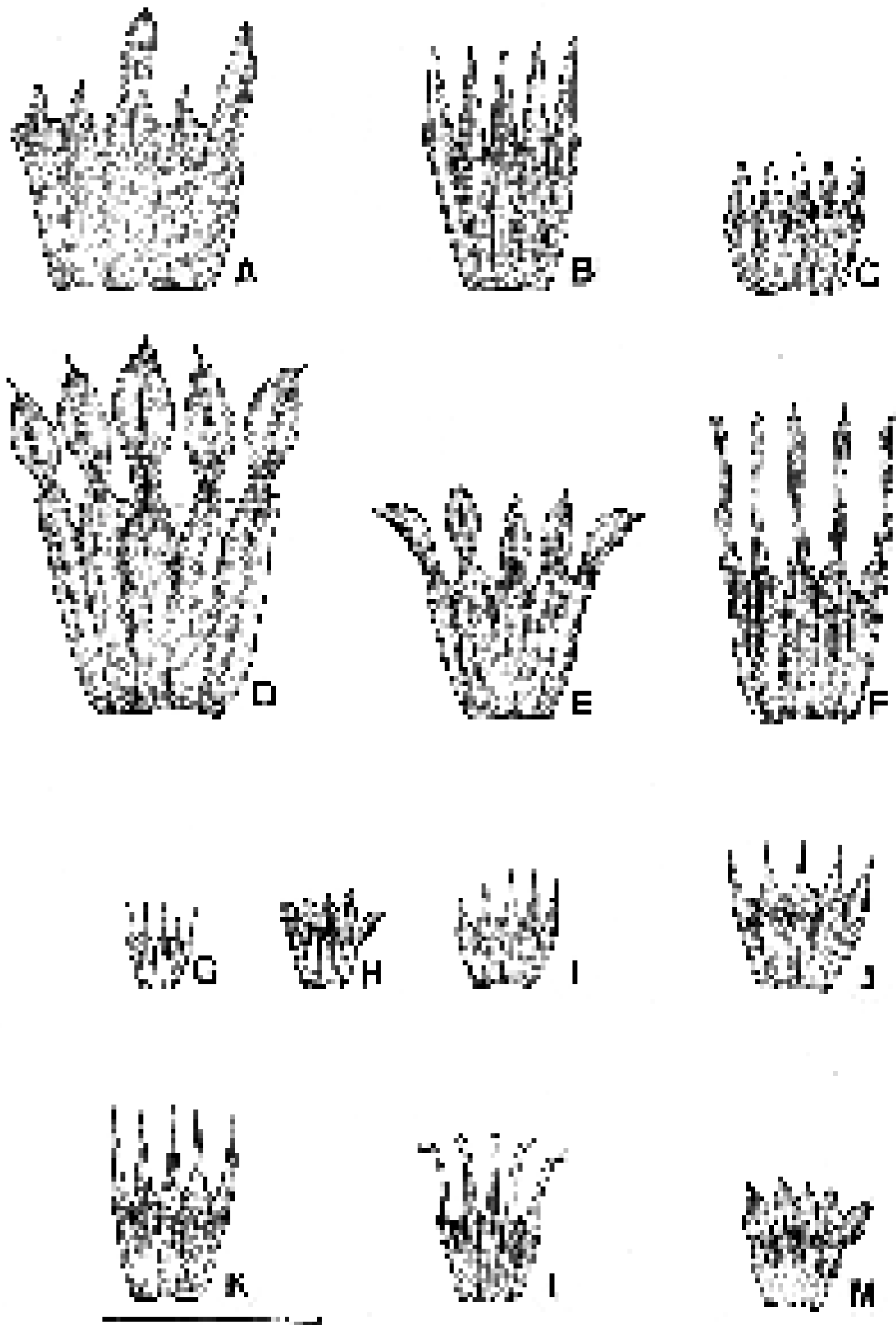
### Calyx

The calyx is an obvious and extremely useful diagnostic character of the genus in Taiwan. The calyx becomes a campanulate calyx-tube on the lower portion and has five (sometimes four on *Gentiana tenuissima*) lobes on the upper portion. Because the shapes of calyx-lobes vary widely in Taiwanese species (Figure 1), earlier botanists (Liu and Kuo, 1974, 1978; Ho, 1988; Ying, 1989) used them as an important diagnostic feature. *Gentiana davidii* var. *formosana* is easily distinguished from the remainder of the Taiwanese species because of the variable (linear, triangle, or lanceolate) and unequal lobes (two are obviously larger than other three). Liu and Kuo (1974, 1978) reported that *G. scabrida* could be distinguished from *G. angusta* by having unequal calyx-lobe lengths. However, both of them have calyx-lobes that are almost equal or just slightly unequal as shown by the examination of both specimens.

Of the species in Taiwan, except *Gentiana davidii* var. *formosana* which is placed in Sect. *Kudoa* (Masamune) Satake & Toyokuni ex Toyokuni (Ho and Pringle, 1995), all other taxa are included in Sect. *Chondrophylla* Bunge (Liu and Kuo, 1974; Ho, 1988; Ho and Pringle, 1995). In Sect. *Chondrophylla*, the shapes of calyx-lobes are considered as useful characters to distinguish the series of Taiwanese species (Ho, 1988). They can be approximately divided into four types—ovate, linear, triangular, and linear-triangular (Figure 1 and Table 1). The ovate type is serrulate along both margins but almost entire near the base, with erose costae which usually extends near the base of calyx-tubes. The linear type also has prolonged erose costae but is entire along the middle part. Only near the apex and base of the calyx-lobe have subtle serrations (only distinctly seen under a magnifying lens). Both the triangular and linear-triangular types are completely entire as well as lacking erose costae.

The calyx characters can be conveniently used for identifying most of the Taiwan species, but several taxa can be precisely distinguished by adding characters from other structures. A key based on calyx characters is given below to distinguish each Taiwanese taxa.

1. Calyx-lobes variable, with two lobes obviously larger than the other three ..... 2. *G. davidii* var. *formosana*
1. Calyx-lobes almost equal in size.



**Figure 1.** The calyx shape of *Gentiana* species in Taiwan. A, *G. davidii* var. *formosana*; B, *G. arisanensis*; C, *G. tentyoensis*; D, *G. scabrada* var. *punctulata*; E, *G. scabrada* var. *scabrada*; F, *G. itzershanensis*; G, *G. tatakensis*; H, *G. horaimontana*; I, *G. flavomaculata* var. *yuanyanghuensis*; J, *G. flavomaculata* var. *flavomaculata*; K, *G. kaohsiungensis*; L, *G. tarokoensis*; M, *G. tenuissima*. Bar = 10 mm.

**Table 1.** A comparison of taxonomic characters among *Gentiana* L. of Taiwan.

Taxa	Shapes of calyx-lobes	Colors of corolla	Spots colors in corolla
<i>G. arisanensis</i>	Triangular	Blue or purplish blue	Brown or black
<i>G. davidii</i> var. <i>formosana</i>	Irregular	Light blue	None
<i>G. flavomaculata</i> var. <i>flavomaculata</i>	Linear-triangular	White	Yellow or greenish yellow
<i>G. flavomaculata</i> var. <i>yuanyanghuensis</i>	Linear-triangular	White	Yellow or greenish yellow
<i>G. horaimontana</i>	Ovate	Yellow	Brown
<i>G. itzershanensis</i>	Linear	Yellow	Brown or black
<i>G. kaohsiungensis</i>	Linear-triangular	Light yellow	Brown
<i>G. scabrida</i> var. <i>scabrida</i>	Ovate	Yellow	Brown or dark brown
<i>G. scabrida</i> var. <i>punctulata</i>	Ovate	Yellow	Dark brown or black
<i>G. tarokoensis</i>	Linear <sup>a</sup>	White	Yellow or greenish yellow
<i>G. tatakensis</i>	Linear-triangular	White	Light brown
<i>G. tentyoensis</i>	Triangular	Blue	Brown or black
<i>G. tenuissima</i>	Ovate	Light blue	Brown

<sup>a</sup>Denote somewhat narrow lanceolate.

2. Calyx-lobes ovate or narrow ovate.
3. Calyx-tube more than 6 mm long ..... 7. *G. scabrida*
3. Calyx-tube less than 5 mm long.
  4. Calyx green ..... 11. *G. tenuissima*
  4. Calyx yellowish green ..... 4. *G. horaimontana*
2. Calyx-lobes triangular, linear-triangular, or linear.
  5. Calyx-lobes triangular or narrow triangular.
    6. Calyx-lobes triangular 10. *G. tentyoensis*
    6. Calyx-lobes narrow triangular ..... 1. *G. arisanensis*
  5. Calyx-lobes linear or linear-triangular.
    7. Calyx-lobes linear.
      8. Calyx-lobes as long as calyx-tube, ca. 4 mm long ..... 8. *G. tarokoensis*
      8. Calyx-lobes longer than calyx-tube, ca. 7 mm long ..... 5. *G. itzershanensis*
    7. Calyx-lobes linear-triangular.
      9. Length of calyx-lobe plus calyx-tube more than 9 mm long. 6. *G. kaohsiungensis*
      9. Length of calyx-lobe plus calyx-tube less than 9 mm long.
        10. Calyx-tube 2–3 mm long ..... 9. *G. tatakensis*
        10. Calyx-tube 3–5 mm long ..... 3. *G. flavomaculata*

### Corolla

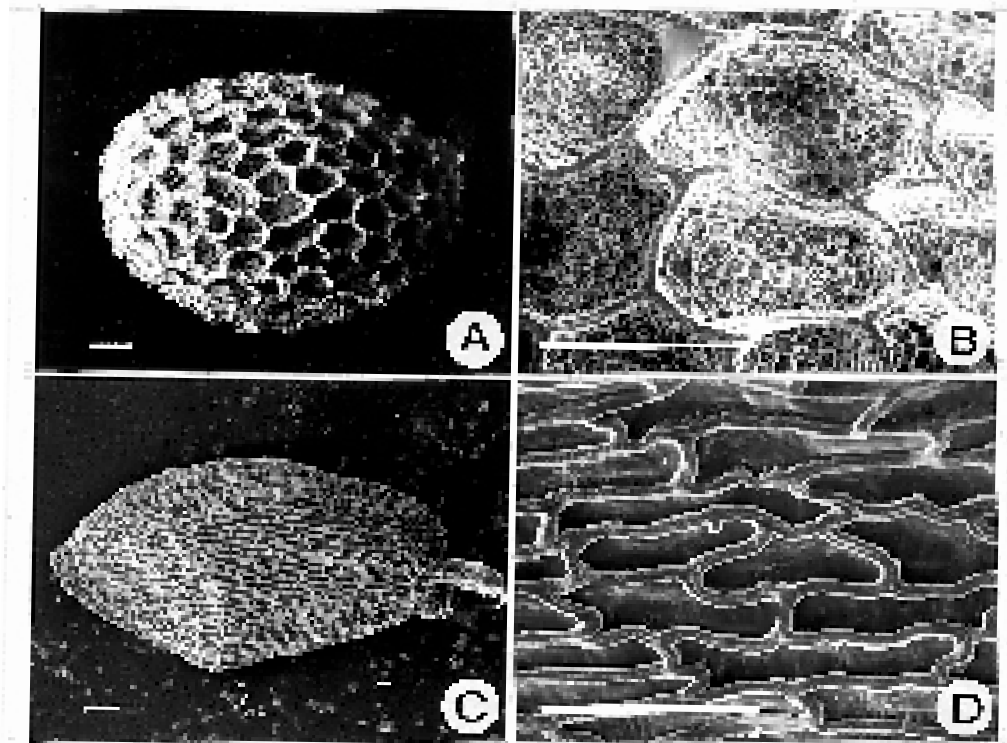
The corolla of *Gentiana davidii* var. *formosana* is urceolate and the corolla of the other species in Taiwan are tubular-campanulate. The corolla has five (sometimes four on *G. tenuissima*) lobes and the same number of corolla appendages (plicae) in sinuses between the lobes. The appendages of all the Taiwanese taxa are symmetrical. The shapes of the corolla-lobes and appendages have been used to distinguish Taiwanese species (Liu and Kuo, 1974, 1978). According to the authors' field observation, however, these structures display an unstable variation

among Taiwanese species as well as within an individual. The colors of corolla provide a convenient and useful character for Taiwanese species and can approximately be divided into five types—blue or purplish blue, light blue, yellow, light yellow, and white (Table 1). The authors found that there are various spots in the middle part or near the corolla and the throat of the color of the spots is somehow related to the color type of the corolla (Table 1).

### Fruits and Seeds

In Taiwan, the capsules of all taxa are cylindrical to ellipsoid or obovoid, dehisce by 2-valved and are exerted beyond the persistent corolla. Liu and Kuo (1974, 1978) reported that ovary of *Gentiana itzershanensis* with serulate wings is unique for the Taiwanese species. However, according to detailed observations of the ovaries and capsules of Taiwanese species, the authors found that most taxa (except *G. davidii* var. *formosana*) exhibit this character. It exists from ovary to capsule stage and becomes more and more obvious when the capsule is mature.

Through scanning electron microscopic (SEM) study of seedcoat, Ho and Liu (1990) and Yuan (1993) described great diversity between the sections of *Gentiana*. For Taiwanese species, only descriptive characters have been reported by Liu and Kuo (1970; 1974; 1978). They also recorded that the seeds are winged in some species. Our SEM observations on seed micromorphology of the Taiwanese species, the seeds are all ovoid and can be classified into two types by the external sculpture. The first type appears in one species only — *Gentiana davidii* var. *formosana*, with honeycomb-like supercellular pits (Figure 4A–B). The second type includes all other Taiwanese species and exhibit minutely longitudinal reticulate-striae with varied shapes and sizes of the meshes (Figure 4C–D; *G. horaimontana* as an example). The sizes and shapes of seeds do not differ obviously among species of the second type, except the seeds of *G. tenuissima* are smaller. The authors did not find seeds with wings or obviously wing-like structure in Taiwanese species. Thus, our SEM observation of seeds differs from the description reported by Liu and Kuo (1974, 1978), but is similar to those reported by Yuan (1993) at the sectional level.



**Figure 2.** SEM-micrographs of seedcoats of *Gentiana*. A–B: *G. davidii* var. *formosana*. C–D: *G. horaimontana*. Bars = 0.1 mm.

## Distribution

Among the species in Taiwan, *Gentiana davidii* var. *formosana* is the most widespread (Figure 3), ranging from low to high elevations throughout the island. This species also occurs in the southeastern part of Mainland China. Remaining species are all endemic to Taiwan.

Three species (*Gentiana tenuissima*, *G. tentyoensis*, and *G. tarokoensis*) are found only in the eastern part of Central Mountain Range of Taiwan (Figure 5) and the other Taiwanese species are found in the Central Mountain Range and Hsuehshan Mountain Range. (Figure 4, 6–7).

## Systematic Treatment

### *Gentiana* L.

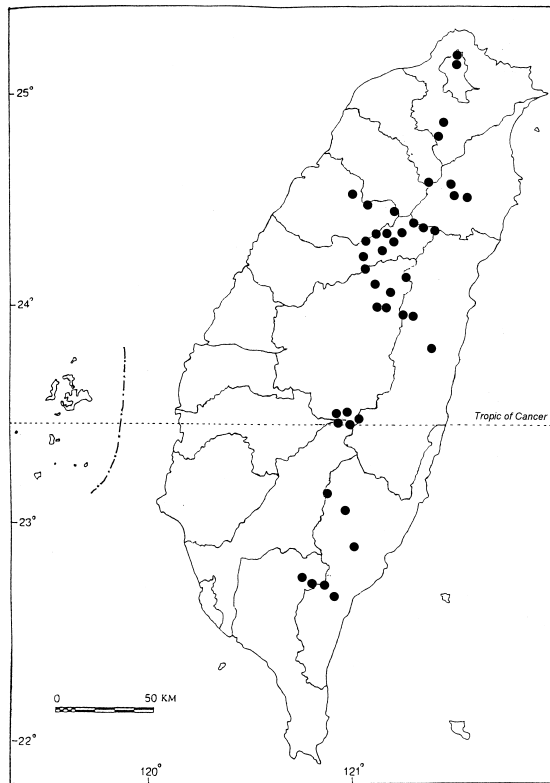
Herbs, annual, biennial, or perennial. Stems ascending to erect. Leaves opposite, rarely verticillate, sometimes forming a basal rosette, sessile or short-petiolate. Inflorescence axillary or terminal, 1-few-flowered cyme, sometimes in terminal clusters and/or axillary whorls. Flowers (4- or 5-merous; calyx-lobes filiform to ovate; corolla tubular, salverform, funnellform, obconic, or urceolate; tube usually much longer than lobes; with appendages (plicae) between lobes; stamens inserted on corolla tube; filaments basally winged or not; anthers free or rarely contiguous; glands 5–10 at ovary base; pistil sessile or on a long gynophore; style usually short, linear, less often long and filiform; stigma bilobed, lobes free or connate, usually oblong to linear, spirally recurved at anthesis. Capsule cy-

lindric to ellipsoid and wingless or narrowly obovoid to obovoid and winged, many seeded. Seeds wingless or winged, seedcoat minutely reticulate, rugose, simply areolate, or with complex spongy areolation.

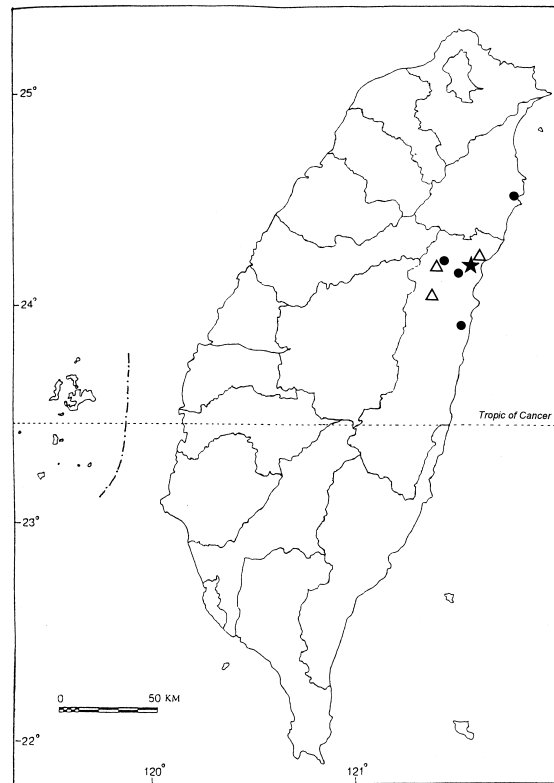
About 360 species: NW Africa (Morocco), America, Asia, E Australia, Europe. Eleven species and two varieties are found in Taiwan.

### Key to the Taxa of Taiwanese *Gentiana*

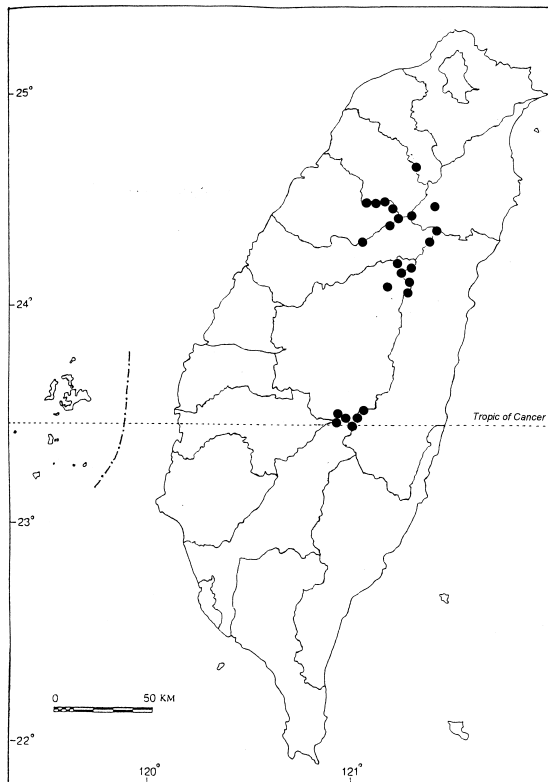
1. Branching sympodial, without flowers on main stem; corolla urceolate; leaves linear-lanceolate to elliptic-lanceolate ..... 2. *G. davidii* var. *formosana*
1. Branching monopodial, flowers on both main stem and branches; corolla tubular- campanulate; leaves plicate or ovate, lanceolate to narrow-lanceolate.
  2. Radical leaves indistinct ..... 1. *G. arisanensis*
  2. Radical leaves distinct.
    3. Corolla light blue, blue, or purplish blue.
      4. Calyx-lobes ovate ..... 11. *G. tenuissima*
      4. Calyx-lobes triangular ..... 10. *G. tentyoensis*
    3. Corolla white, light yellow, or yellow.
      5. Calyx-lobes ovate or narrow ovate.
        6. Plants very minute, less than 3 cm tall; stems yellow; flowers less than 10 mm long ..... 4. *G. horaimontana*
        6. Plants taller than above, up to 15 cm tall; stems dark brown or purple; flowers more than 16 mm long.



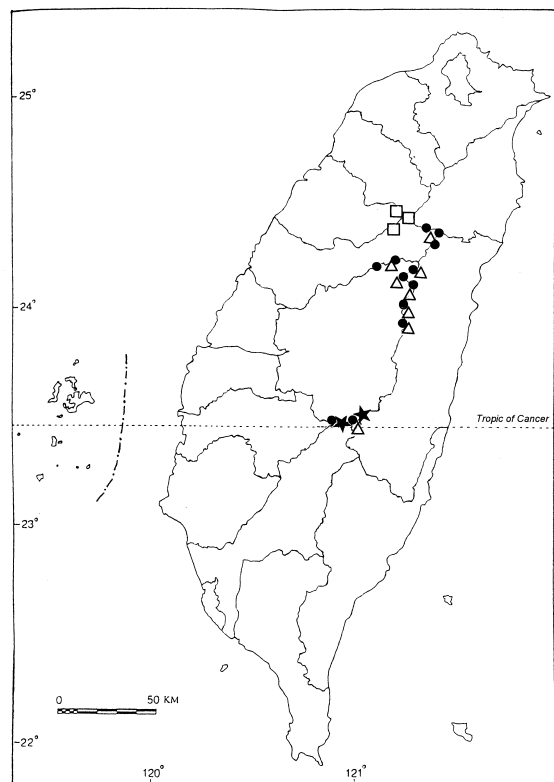
**Figure 3.** Distribution of *Gentiana davidii* var. *formosana* in Taiwan.



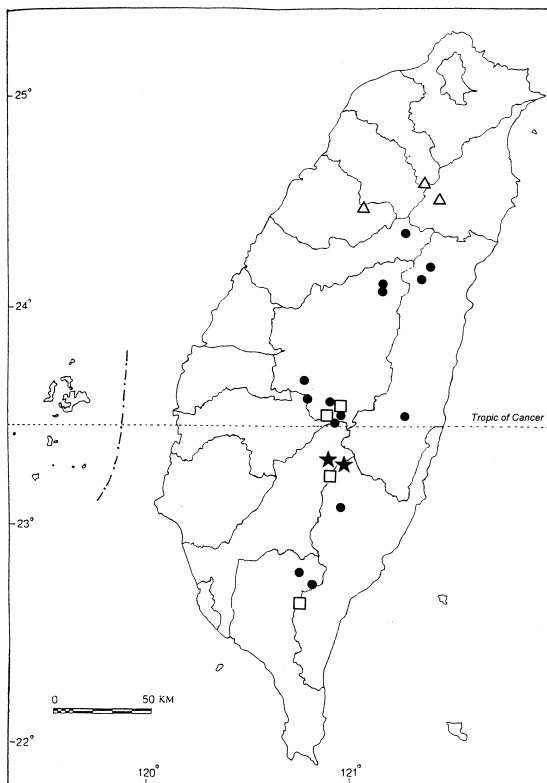
**Figure 4.** Distribution of *Gentiana tenuissima* (circles), *G. tentyoensis* (triangles), and *G. tarokoensis* (star).



**Figure 5.** Distribution of *Gentiana arisanensis*.



**Figure 6.** Distribution of *Gentiana scabrada* var. *scabrada* (circles), *G. scabrada* var. *punctulata* (triangles), *G. horaimotana* (stars), and *G. itzershanensis* (squares).



**Figure 7.** Distribution of *Gentiana flavomaculata* var. *flavomaculata* (circles), *G. flavomaculata* var. *yuanyanghuensis* (triangles), *G. kaohsiungensis* (stars), and *G. tatakensis* (squares).

7. Cauline leaves lanceolate to narrowly lanceolate; calyx lobes ovate to narrowly ovate; flowers 17–23 mm long .....  
..... 7a. *G. scabrida* var. *scabrida*
7. Cauline leaves ovate to lanceolate; calyx lobes ovate; flowers 20–28 mm long .....  
..... 7b. *G. scabrida* var. *punctulata*
5. Calyx-lobes linear or linear-triangular.
8. Calyx-lobes linear, their apices slightly recurved, very minutely scabrous-serrulate at base.
9. Flowers more than 18 mm long; corolla yellow ..... 5. *G. itzershanensis*
9. Flowers less than 15 mm long; corolla white ..... 8. *G. tarokoensis*
8. Calyx-lobes linear-triangular, margins entire.
10. Flowers 7–8 mm long .. 9. *G. tatakensis*
10. Flowers more than 10 mm long.
11. Corolla light yellow; flowers 17–20 mm long ..... 6. *G. kaohsiungensis*
11. Corolla white; flowers 12–18 mm long.
12. Anthers yellow to light pink .....  
3a. *G. flavomaculata* var. *flavomaculata*

12. Anthers pink to light red .....  
3b. *G. flavomaculata* var. *yuanyanghuensis*

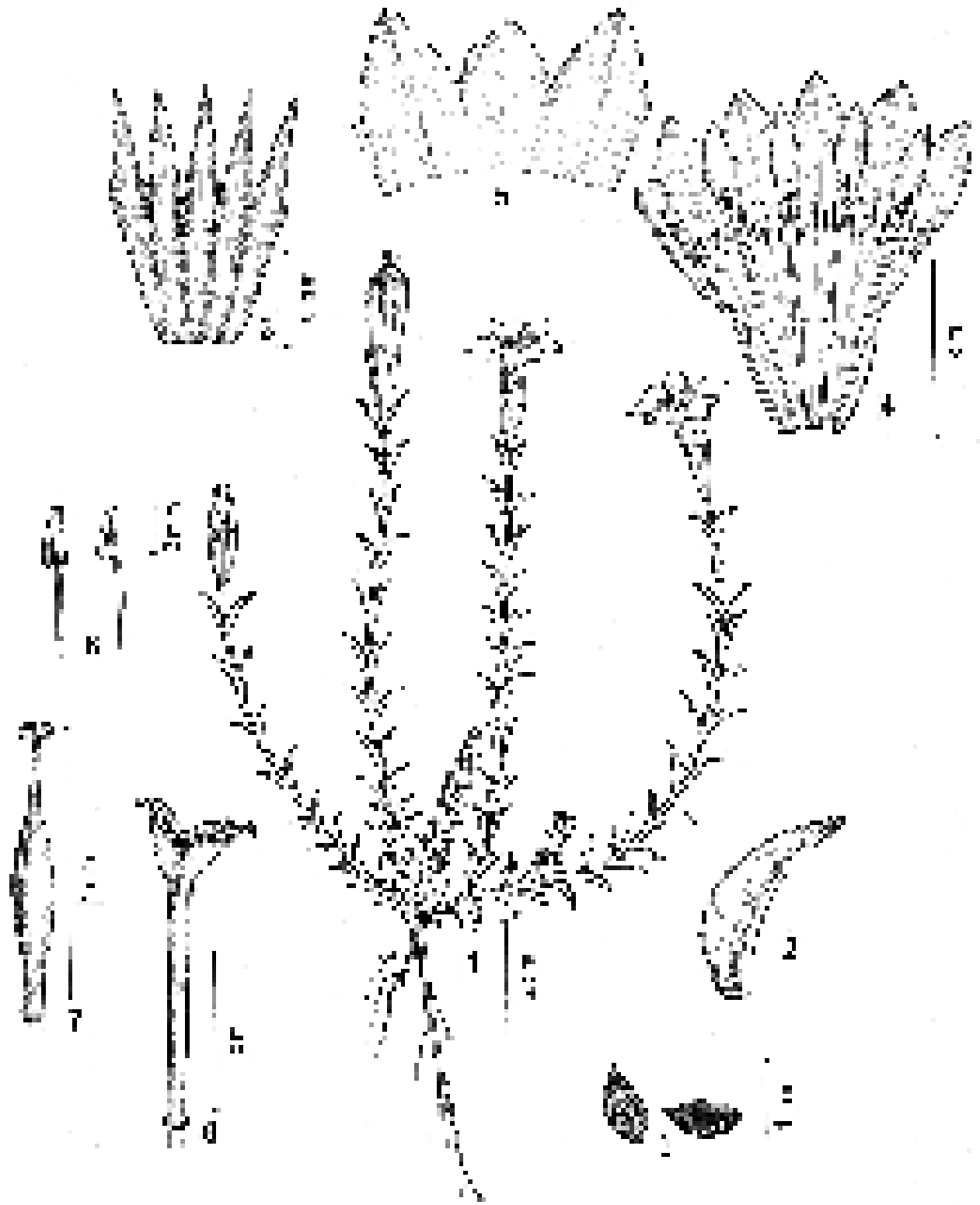
**1. *Gentiana arisanensis*** Hayata, Gen. Ind. Fl. Formosa 48. 1917; Suzuki, Ann. Rep. Taihoku Bot. Gard. 1: 169. 1931; Liu & Kuo, Ann. Taiwan Mus. 13: 103. 1970; Liu & Kuo, Bull. Exp. Forest Natl. Taiwan Univ. 114: 178, pl. 5. 1974; Liu & Kuo in Li *et al.*, Fl. Taiwan 4: 165. 1978; Ho, Fl. Reipubl. Popul. Sin. 62: 205. 1988; Ho & Pringle in Wu & Raven, Fl. China 16: 97. 1995. 阿里山龍膽 Figure 8

*Gentiana caespitosa* Hayata, J. Coll. Sci. Imp. Univ. Tokyo 25(19): 165. 1908 (Fl. Mont. Formos.) *non* Mart. & Gal. (1844); Hayata, J. Coll. Sci. Imp. Univ. Tokyo 30(1): 201. 1911 (Mater. Fl. Formosa). — TYPE: Formosa. Monte Morrison, ad 12500 ped. alt., Oct 1906, *T. Kawakami et U. Mori* 2242 (holotype: TI!; isotype: TAIF!).

*Gentiana aristata* *auct. non* Maxim. (1880); Ying, Quart. J. Exp. Forest Natl. Taiwan Univ. 3(2): 91. 1989.

Perennial herbs. Stems usually branched in the upper part, ascending, usually caespitose, 3–5 cm tall, usually elongated when flowering, up to 13 cm tall. Leaves plicate, closely crowded on stem, especially stems bearing no flowers, 7–8 mm long, 2–3 mm wide, aristate-acuminate at apex, the costae prominent beneath, almost entire along margin, slightly scabrous near leaves base, sheaths about 2 mm long. Flowers pedicellate, solitary and terminal; pedicels 2–5 mm long. Calyx-tube campanulate, ca. 8 mm long, with 5 smooth costae, 5-lobed; lobes narrow triangular, ca. 4 mm long, acuminate at apices, almost smooth along margins. Corolla blue or purplish blue, tubular-campanulate, 18–22 mm long, with 5 lobes; the lobes acutely ovate, ca. 4 mm long, aristate-acuminate at apices; sinuses plicate with ovate-triangular appendages; appendages apically acute or cuspidate, almost entire near both extremes; stamens 5, anthers pink, 2–2.5 mm long; filaments about 12 mm long, attached slightly above the lower-part of corolla-tube. Ovary shortly stipitate, lanceolate to narrow ovate, 10–12 mm long, 3–4 mm wide; stipe 3–4 mm long; style 3–4 mm long; stigma bifurcate and spirally recurved when flowering. Capsules 5–7 mm long, the stipe 10–17 mm long, 2-valved, dehiscent, valves denticulate near apices, exserted beyond the persistent corolla. Seeds ovoid, with minutely longitudinal reticulate-striae, ca. 0.9 mm long and 0.5 mm wide.

*Additional specimens examined.* **TAIWAN.** HSINCHU HSIEN: Kuanwu, *Huang* 6692 (TAI); Itzershan, elev. ca. 3250–3300 m, *Huang* 94 (HAST); Tapachienshan, elev. 3200–3400 m, *Chen* 1441 (TNU); same loc., elev. ca. 2900 m, *Ying* 4149 (NTUF). MIAOLI HSIEN: Luchangtashan, *Fukuyama* 3497 (TAI). TAICHUNG HSIEN: Yupolanshan, *Chuang* 44 (PPI); Tahsuehshan, *Lu* 323 (NCUF); Chungshueshan, elev. ca. 2800m, 22 May 1958, *Kuo s. n.* (TAI); Hsinta Lodge to Pintianshan, elev. 3200–3536 m, *Wang* 4030 (TAI); Chikashanchuang, elev. ca. 3100 m, *Hsu* 697 (HAST); same loc., elev. 2500–3000 m, *Peng* 7890 (HAST); Chikashanchuang to Sanliuchiushanchuang, *Hsu*



**Figure 8.** *Gentiana arisanensis* Hayata. 1, Habit; 2, Leaf; 3, Calyx; 4, Corolla and stamens; 5, Enlarged corolla-lobes; 6, Stamen; 7, Pistil; 8, Capsule; 9, Seeds. (C. H. Chen 1000).



14644 (TAI); same loc., *Huang 7158* (TAI); Taoshan, elev. ca. 3300 m, *Hosokawa 2293* (NTUF); same loc., elev. ca. 3100 m, *Peng 12049* (HAST); Anmashan to Hsiaohsuehshan, *Wang 4969* (TAI); Sungling, 24 May 1930, *Fujita s. n.* (TNU); Nanhutashan, elev. 2600–2800 m, *Chen 1000* (TNU); same loc., elev. ca. 9000 feet, 23 Jul 1922, *Sasaki s. n.* (TAIF); Hsiaohsuehshan, elev. ca. 3000 m, *Liu 314* (TAI); same loc., *Huang 10289* (TAI); Hsuehshan, *Kao 3955* (NCUF); same loc., 24 Aug 1995, *Yang s. n.* (TAIF); same loc., elev. ca. 3800 m, *Ying 3834* (NTUF); same loc., elev. 3300–3500 m, *Chen 1422* (TNU); NANTOU HSIEN: Wuling, elev. 3200–3250 m, *Peng 14470* (HAST); Kuanyuan to Hohuanshan, *Su 3392* (NTUF); Tienluanchih, *Chuang 362* (PPI); Patungkuang, 8 Aug 1923, *Sasaki s. n.* (TAI); Wushe, *Chuang 4248* (TAI); Tashuikushan, elev. 3625–3725 m, *Lee 8* (HAST); Hohuanshan, elev. 3050–3150 m, *Chen 1266* (TNU); same loc., *Tseng 9706* (NCUF); same loc., *Kao 7816* (TAI); Paiyangchinkuang, elev. 3200–3600 m, *Chen 124* (HAST); Nengkaoshan, 15 Jul 1931, *Masamune s. n.* (TAI); Nengkao, 15 Jul 1930, *Kudo s. n.* (TAI); Tienchih to Nengkao, *Huang 5812* (TAI); Mapolaszushan, 4 Oct 1926, *Sasaki s. n.* (TAI). CHIAYI HSIEN: Paiyunshanchuang, *Lu 3733* (NCUF); Paiyunshanchuang to Yushan, *Hsu 6295* (TAI); Yushan, 9 Oct 1908, *Sasaki s. n.* (TAIF); same loc., *Ying 1445* (NTUF). ILAN HSIEN: Taipingshan, 15 Aug 1925, *Suzuki s. n.* (TAI); same loc., Aug 1957, *Huang s. n.* (TNU). HUALIEN HSIEN: Patolushan, *Wang 364* (HAST); Tayuling to Hohuanshan, elev. 2565–3250 m, *Hsu 3817* (TAI).

*Distribution.* Endemic to Taiwan, at sunny places in grasslands or exposed rocky places in high mountains. Usually found in the northern and central parts of the Central Mountain Range from 2,500 to 3,900 m in elevation. Flowering and fruiting Jun–Dec.

*Notes.* *Gentiana arisanensis* Hayata was treated as the synonymy of *G. aristata* Maxim. by Ying (1989). However, the treatment is incorrect, because the latter is an annual herb with obvious radical leaves.

**2. *Gentiana davidii* var. *formosana*** (Hayata) T. N. Ho, Fl. Reipubl. Popul. Sin. 62: 103. 1988; Ho & Pringle in Wu & Raven, Fl. China 16: 40. 1995. 台灣龍膽 Figure 9

*Gentiana formosana* Hayata, J. Coll. Sci. Imp. Univ. Tokyo 22: 242. 1906 (Enum. Pl. Formos.); Hayata, J. Coll. Sci. Imp. Univ. Tokyo 25(19): 167. 1908 (Fl. Mont. Formos.); Hayata, Gen. Ind. Fl. Formosa 49. 1917. — TYPE: Formosa, in monte Shichiseitonzan, 1900, *B. Hayata, s. n.* (lectotype: TI!, here designated; remaining syntype: Monte Shichiseitonzan, 1905, *G. Nakahara, s. n.*, TI!).

*Gentiana fasciculata* Hayata, J. Coll. Sci. Imp. Univ. Tokyo 25(19): 165. 1908 (Fl. Mont. Formos.); Hayata, Gen. Ind. Fl. Formosa 49. 1917. — TYPE: Formosa. Seizan, in montibus Morrison, ad 11707 ped. Alt., Nov. 1905, *S. Nagasawa 624* (holotype: TI!).

*Gentiana atkinsonii* var. *formosana* (Hayata) Yamamoto, J. Soc. Trop. Agr. 8: 70. 1936; Liu & Kuo, Ann. Taiwan

Mus. 13: 103. 1970; Liu & Kuo, Bull. Exp. Forest Natl. Taiwan Univ. 114:172, pl. 2. 1974; Liu & Kuo in Li *et al.*, Fl. Taiwan 4: 167. 1978.

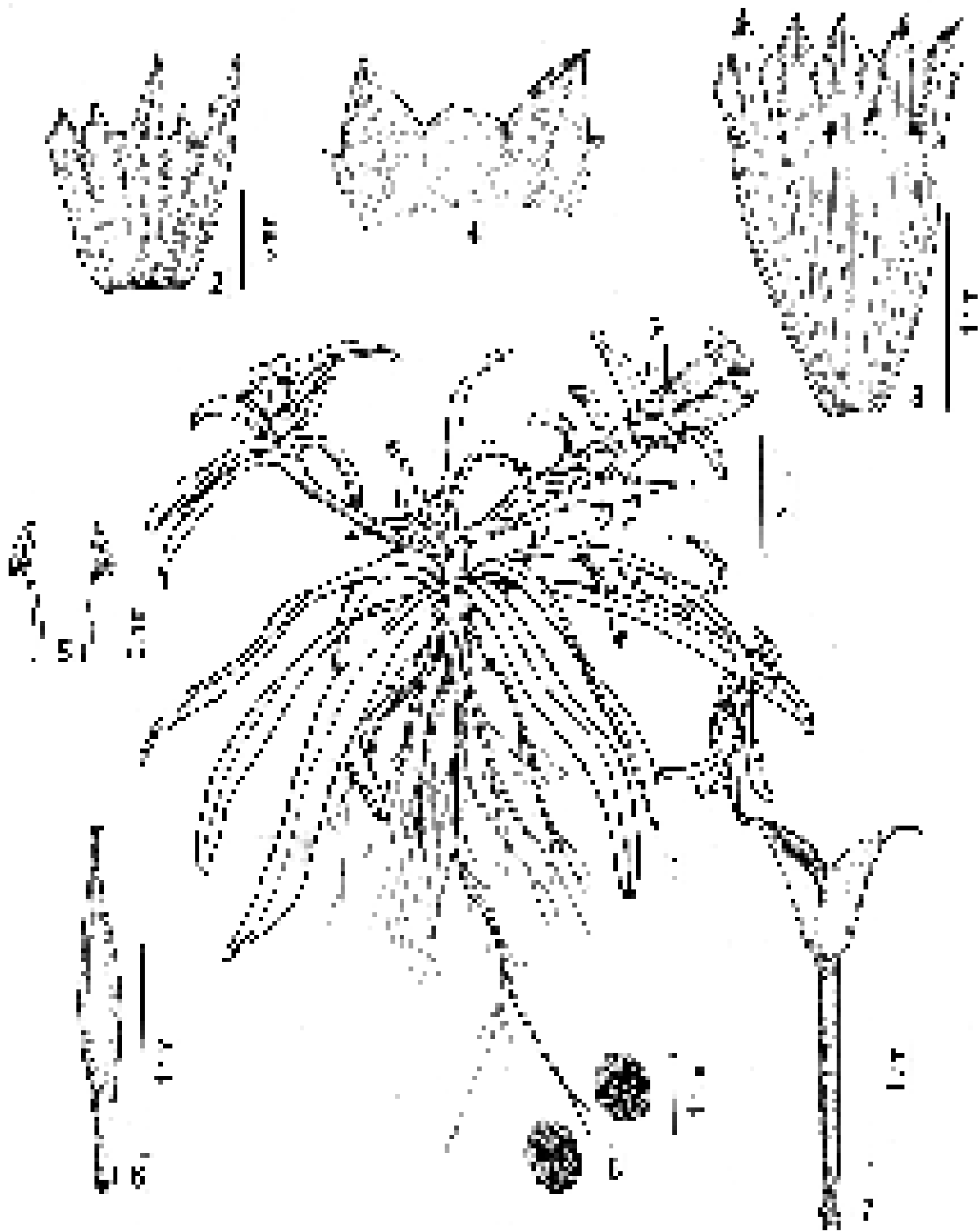
*Gentiana davidii* auct. non Franch. (1884): Ying, Quart. J. Exp. Forest Natl. Taiwan Univ. 3(2): 91. 1989.

*Gentiana davidii* var. *fukienensis* (Ling) T. N. Ho, Novon 4: 370. 1994; Ho & Pringle in Wu & Raven, Fl. China 16: 40. 1995. syn. nov.

*Gentiana fukienensis* Ling, Contr. Inst. Bot. Natl. Acad. Peiping 6(4): 217. 1949. — TYPE: China. Fujian: Shanghan, Chutsaotung, southern slope, 1350–1500 m, *Y. Ling 4604*, 20 Oct. 1945 (holotype: PE). syn. nov.

Perennial herbs. Stems almost entire, usually branched in the upper part, ascending, usually caespitose, up to 12 cm tall. Leaves obtuse at apices, uninerve, almost entire along margin; radical leaves linear-lanceolate to narrow lanceolate, 3–6 cm long, 6–8 mm wide; cauline leaves usually closely crowded near upper stems, 2.5–4 cm long; sheaths about 2–3 mm long. Flowers sessile, axillary, usually fasciculate on the end of branches. Calyx-tube tubuliform, 8–10 mm long, smooth, 5 lobed, lobes unequal, linear triangle or lanceolate, the 3 shorter lobes about 2–3 mm long, the others 4–10 mm long, the apex acuminate, sinuses truncate. Corolla urceolate, light blue, 15–23 mm long, 5 lobed, lobes ovate-triangular, 3–4 mm long, aristate-acuminate at apices, sinuses plicate with 5 short appendages; appendages broadly triangular. Stamens 5, the anthers narrow, about 2 mm long, the filaments about 15 mm long, attached to the middle part of the corolla-tube. Ovary long-ovoid, 5–7 mm long, stipe 4–5 mm long; style 7–8 mm long; stigma bifurcate with coiled tip. Capsules oblong to ovate, 8–10 mm long, stipe 6–8 mm long, 2-valved, dehiscent, valves almost entire near apices, exerted beyond the persistent corolla. Seeds ovoid, with honeycomb-like supercellular pits, 0.9–1 mm long and 0.6–0.7 mm wide.

*Additional specimens examined.* TAIWAN. TAIPEI CITY: Yangmingshan, elev. 650–750 m, *Chen 1204* (TNU); Tatunshan, *Kawakami s. n.*, Jul. 1909 (TAIF); Chihshingshan, *Chang 1122* (TAI); same loc., *Hsu 3189* (TAI); Tsaoshan, 30 Dec 1935, *Sasaki s. n.* (TAI); Menghuanhu, *Yang 1378* (TAI); Fuling, *Yang 518* (TAI). TAIPEI HSIEN: Peichatienshan, *Shie 2077* (TAIF); same loc., *Yen 6707* (HAST); Lalashan, 27 Jul 1918, *Mazuda s. n.* (TAIF). HSINCHU HSIEN: Yuanyanghu, elev. ca. 1650 m, *Peng 15157* (HAST); same loc., *Chen 158* (HAST); Tapachienshan, 19 Jul 1932, *Sasaki s. n.*, (TAI); same loc., elev. 2700–3500 m, *Chang 2027* (TAI); Kuanwu, *Huang 6617* (TAI). MIAOLI HSIEN: Luchangtashan, 11 Jul 1932, *Fukuyama 3496* (TAI); same loc., 7 Oct 1908, *Mori s. n.* (TAIF). TAICHUNG HSIEN: Chikashanchuang to Sanliuchiushanchuang, elev. 2400–3100 m, *Chen 1324* (TNU); Tachienshan, *Chuang 46* (PPI); Chikashanchung to Sanliuchiushanchung, *Huang 7179* (TAI); same loc., *Hsu 14642* (TAI); same loc., elev. ca. 2900 m, *Peng 9619* (HAST); Hsuehshan, elev. 3300–3500 m, *Chen 1421* (TNU); Hsiaohsuehshan, elev. ca. 2400 m, *Huang 10290* (TAI); same loc., *Kuo 2184* (NTUF) Pahsienshan, 18 Aug 1927,



**Figure 9.** *Gentiana davidii* var. *formosana* T. N. Ho. 1, Habit; 2, calyx; 3, Corolla and stamens; 4, Enlarged corolla-lobes; 5, Stamens; 6, Pistil; 7, Capsule; 8, Seeds. (C. H. Chen 1204).

*Kanehira s. n.* (TAIF); same loc., *Chuang 2665* (TAI); Anmashan, *Huang 1816* (TAI); Wuling farm, elev. 1900–3200m, *Wang 3965* (TAI); Nanhutashan, elev. ca. 2600–2800 m, *Chen 990* (TNU); same loc., 21 Aug 1969, *Yamazaki s. n.* (TAI). NANTOU HSIEN: Nengkaoshan, 7 Aug 1911, *Mazuda s. n.* (TAIF); Peitungyenshan, elev. 2000–2100 m, *Chen 887* (TNU); Kuantaohsi, 22 Nov 1931, *Sasao s. n.* (NCUF); Patungkuang, *Suzuki 13317* (TAI); same loc., *Lee 25* (HAST); same loc., elev. 2650–3000 m, *Peng 8199* (HAST); Hohuanshan, *Kuo 6906* (TAI); Yunhai to Tienchih, elev. 2360–2860 m, *Ho 586* (HAST); same loc., elev. ca. 2000 m, *Huang 1201* (TAI); same loc., elev. 2346–2840 m, *Kao 5866* (TAI); same loc., 30 Jun 1959, *Leu & Kuo s. n.* (NTUF); Shanlinhsi, elev. 1600–1750 m, *Shen 190* (HAST); Tashuikushan, 2 Oct 1926, *Sasaki s. n.* (TAI); Tungpu, *Jeng 2880* (TAI); Tsuifeng to Sunghsuehlou, elev. 2500–3100 m, *Hsu 11096* (TAI); Tsuifeng to Sungkang, *Hsu 11096* (TAI); same loc., *Hsu 13995* (TAI); Tsuifeng to Meifeng, elev. 2000–2200 m, *Yang 121* (TAI); Tunyuan to Yunhai, *Huang 5678* (TAI); Kuankao to Chungyangchinkuang, elev. 2600–2900 m, *Chen 103* (HAST). CHIAYI HSIEN: Alishan to Tungpu, *Chang 16377* (PPI); Tatachiaanpu to Paiyunshanchung, elev. 2600–3550 m, *Hsu 6239* (TAI); Alishan, *Chang 16228* (PPI); same loc., elev. ca. 2400m, *Kuoh 7483* (TAI); same loc., *Ying 1715* (NTUF); same loc., *Mori 3649* (TAIF); Yushan, *Suzuki 13230* (TAI); same loc., elev. ca. 3200 m, *Hsu 5138* (TAI); same loc., 10 Dec 1908, *Kawakamii s. n.* (TAIF); Tataka, elev. 2800–3200 m, *Chen 1401* (TNU); Paiyunshanchung, *Huang 4578* (TAI); same loc., elev. ca. 3100 m, 19 Nov 1967, *Hsu s. n.* (TAI). KAOHSIUNG HSIEN: Kuaiku, *Lu 3310* (NCUF); Chuyunshan, elev. 2225–2324 m, *Ho 897* (HAST); Chishan, 12 Aug 1940, *Yamamoto s. n.* (TAI); Kuanshan, elev. ca. 3000 m, 12 Jul 1935, *Fujiyama s. n.* (TAI). PINGTUNG HSIEN: Hsiaokueihu, *Kuo 2370* (NTUF), same loc., *Yang 25455* (PPI); Tawushan, 20 Nov 1918, *Mazuda s. n.* (TAIF); same loc., elev. 1600–2100 m, *Huang 13629* (TAI). ILAN HSIEN: Tsuifenghu, elev. ca. 1790 m, *Lin 60* (HAST); Tayenshan, *Ou 2697* (NCUF); same loc., elev. 1400–1800 m, *Kao 3246* (HAST, TAI); Taipingshan, elev. ca. 2100 m, *Chen 959* (TNU); same loc., *Ou 2654* (NCUF); same loc., 5 Aug 1928, *Suzuki s. n.* (TAI); same loc., *Kao 4799* (HAST); Nanshan to Chiliting, elev. 1200–2550 m, *Hsu 5874* (TAI). HUALIEN HSIEN: Kuanyuan, *Lu 1218* (NCUF); Tayuling, elev. ca. 2600 m, *Chuang 4433* (TAI); Lintienshan, *Kuo 3217* (NTUF). TAITUNG HSIEN: Meinaitienshan, *Ou 1955* (NCUF); Takuanshan, elev. 2600–3200 m, *Peng 11722* (HAST); Litao, *Mazuda 1506* (TAI); Chihpen 22th Forest Station, elev. ca. 2000 m, *Hsu 3309* (TAI).

*Distribution.* Southeastern China (Fujian and Guangdong) and Taiwan. In Taiwan, commonly found on the Central Mountain Range, mostly in exposed places and often on shady grasslands or roadsides from 1,000 to 3,500 m in elevation. Also found at ca. 500 m on mountains near Taipei (in Yangmingshan National Park). Flowering Jun–Oct, Fruiting Jul–Nov.

*Notes.* The species is easily distinguished from other Taiwanese species by its linear-lanceolate to narrow lan-

ceolate leaves and urceolate corolla. Ho & Pringle (1995) considered that there are two varieties—*Gentiana davidii* var. *formosana* (Hayata) T. N. Ho and *G. davidii* var. *fukienensis* (Ling) T. N. Ho in Taiwan. The obvious and stable characters to distinguish them is the former with triangular corolla plicae and the latter with truncate corolla appendages (Ho, 1994; Ho and Pringle, 1995). According to authors' inspecting of Taiwanese specimens in the species, the corolla plicae shapes are somewhat subtruncate to triangular. There is no definite difference between those two shapes. Therefore, they are treated here as the same variety.

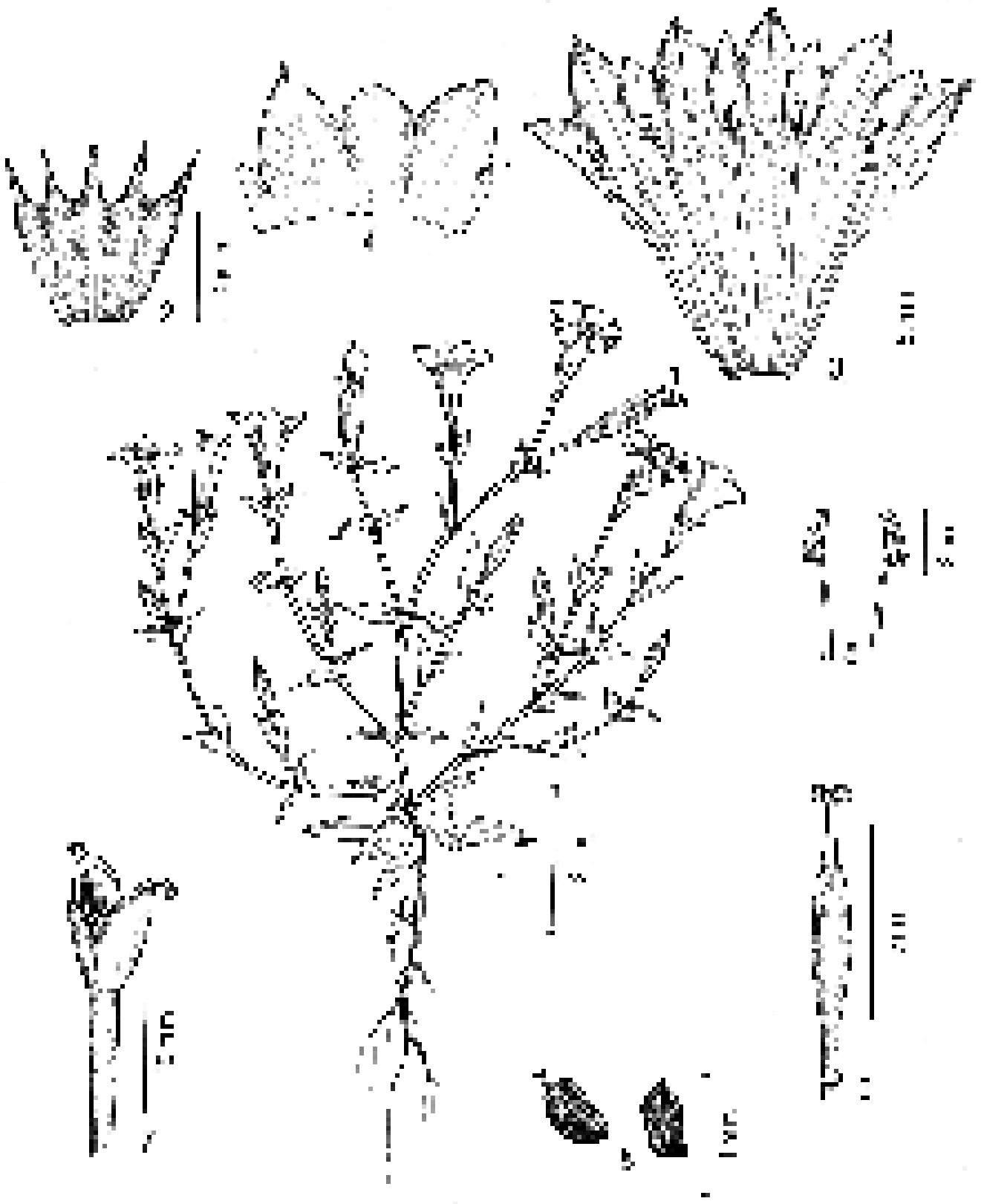
**3. *Gentiana flavomaculata* Hayata, Gen. Ind. Fl. Formosa 49. 1917.**

**3a. *Gentiana flavomaculata* Hayata var. *flavomaculata*, Gen. Ind. Fl. Formosa 49. 1917; Liu & Kuo, Ann. Taiwan. Mus. 13: 105. 1970; Liu & Kuo, Bull. Exp. Forest Natl. Taiwan Univ. 114: 180, pl. 6. 1974; Liu & Kuo in Li *et al.*, Fl. Taiwan 4: 170, pl. 953. 1978; Ho, Fl. Reipubl. Popul. Sin. 62: 179. 1988; Ho & Pringle in Wu & Raven, Fl. China 16: 73. 1995. 黃斑龍膽 Figure 10**

*Gentiana flavescens* Hayata, J. Coll. Sci. Imp. Univ. Tokyo 25(19): 166. 1908 (Fl. Mont. Formos.), *non* Schur. (1866) — TYPE: Formosa, Ganzan, in isdem montibus, ad 9141 ped. alt. *S. Nagasawa 690* (lectotype: TI!, here designated; remaining syntype: Suizan, in montibus Morrison, ad 7702 ped. alt. *S. Nagasawa 646*, TI!).

*Gentiana scabrida* var. *flavomaculata* (Hayata) Ying, Quart. J. Exp. Forest Natl. Taiwan Univ. 3(2): 94. 1989.

Annual herbs. Stems usually branched, brown, brownish purple or purple, densely scabrous, 6–10 cm tall. Leaves aristate-acuminate at apices, slightly scabrous along margins; radical leaves lanceolate to ovate, 2–2.5 cm long, 7–8 mm wide; cauline-leaves shape almost same to radical-leaves but smaller in size, 6–10 mm long, 3–4 mm wide; sheaths short, usually less than 1 mm long. Flowers pedicellate, solitary on terminal branches. Pedicels 2–4 mm long, extending to 10 mm long in fruit. Calyx-tube campanulate, 4–5 mm long, with 5 slightly scabrous costae, 5-lobed, lobes linear-triangular, 2–3 mm long, with obscurely erose costae, almost entire along margins. Corolla tubular-campanulate, white with yellow or greenish yellow spots in the middle part, 12–18 mm long, with 5 lobes, lobes acutely ovate, 3 mm long, aristate-acuminate at apices; appendages acute or cuspidate near apices, almost entire near both extremes. Stamens 5; anthers oblong, yellow to light pink, 1.5–2 mm long, filaments 6–8 mm long, attached slightly on the lower part of corolla-tube. Ovary stipitate, lanceolate to narrow ovate, 6–7 mm long, 2–3 mm wide, stipe 2–3 mm long. Style 2–3 mm long, stigma bifurcate and spirally recursive at bloom. Capsules obovoid, ca. 6 mm long, 3 mm wide, with long stipes about 15 mm long, 2-valved, dehiscent, valves obscurely dentate near apices, exerted beyond the persistent corolla. Seeds ovoid, with minutely longitudinal reticulate-striae, about 0.7 mm long and 0.4–0.5 mm wide.



**Figure 10.** *Gentiana flavomaculata* Hayata var. *flavomaculata*. 1, Habit; 2, Calyx; 3, Corolla and stamens; 4, Enlarged corolla-lobes; 5, Stamens; 6, Pistil; 7, Capsule; 8, Seeds. (C. H. Chen 1206).

*Additional specimens examined.* **TAIWAN.** TAICHUNG HSIEN: Central Cross Island Road Branch, elev. 2100–2340 m, *Shen 475* (HAST). NANTOU HSIEN: Patungkuan, elev. ca. 2800 m, 12 Jul 1993, *Yang s. n.* (TAI); Yushan en route from Panaiyike lodge to Patungkuan elev. 2900–2770 m, *Lee 26* (HAST); Kunyang, elev. 2100–2600 m, *Chen 1059* (TNU); Tungpu, *Chang 16378* (PPI); Shanlinhsi, elev. ca. 1700 m, *Hsiao 1130* (HAST); Jenai, *Lu 1472* (TNU); Meifeng, elev. 2100–2300 m, *Chen 497* (HAST); Kuankao to Patungkuan, 28 Jul 1935, *Suzuki s. n.* (TAI); same loc., elev. 2650–3000 m, *Peng 8142, 8143* (HAST); Kuankao to Chungyangchinkuang, elev. 2600–2900 m, *Chen 95* (HAST). CHIAYI HSIEN: Tungpushanchung to Tatchiaanpu, elev. 2500–2900 m, *Leu 1203* (HAST); Alishan, *Chang 17228* (PPI); same loc., Jan 1912, *Hayata & Sasaki s. n.* (TAIF); same loc., elev. ca. 2600 m, *Ying 1669*(NTUF); same loc., elev. 2300 m, *Peng 4626* (HAST); same loc., *Wang 6322* (TNU); Alishan to Tashan, elev. ca. 2600 m, *Ying 1715* (NTUF); Yushan, 23 May 1992, *Ying s. n.* (NTUF). PINGTUNG HSIEN: Hsiaokueihu, *Yang 5060* (PPI), same loc., *Yang 25454* (PPI); Wutai, *Lin 405* (TAIF). HUALIEN HSIEN: Tunyuan to Yunhai, elev. 2000–2400 m, *Liao 1523* (HAST); Kuanyuan to Pilu, elev. 2250–2350 m, *Peng 9226* (HAST). TAITUNG HSIEN: Chihpen 22th Forest Station, elev. 1600–2000 m, *Hsu 3312* (TAI).

*Distribution.* Endemic to Taiwan, frequently found in semishady grasslands or moist slope, in the Central Mountain Range from 1,800 to 3,000 m in elevation. Flowering and fruiting Jun-Sep.

*Note:* Hayata (1908) first described this taxon and named it *Gentiana flavescens* Hayata, but this is a later homonym and he later (1917) renamed it. Ying (1988) treated this species as a variety of *G. scabrida*. According to our observation, colors of corolla, sizes of plants, and shapes of calyx-lobes are very different between the two taxa, and they should be treated as separate species.

**3b. *Gentiana flavomaculata* var. *yuanyanghuensis*** C. H. Chen & J. C. Wang var. nov. —TYPE: Taiwan, Hsinchu Hsien: Chienshih Hsiang: Yuanyanghu (a lake) Nature Preserve, 16 May 1996, *C. H. Chen 1707* (holotype: TNU; isotype: HAST, TNU). 鴛鴦湖龍膽 Figure 11

Species *G. flavomaculata* Hayata affinis, sed plantae et flores parvus, plantae 4–8 cm altae, calyx campanulatus 3.5–5 mm longus 5-lobatus, lobis 1.5–2.5 mm longus. Stamina roseus differt.

*Annual herbs.* Stems usually branched, brown, brownish purple to purple, densely scabrous, 4–8 cm tall. Leaves aristate-acuminate at apices, slightly scabrous along margins; radical leaves lanceolate or ovate, about 2 cm long, 7–8 mm wide; cauline leaves similar to radical leaves but smaller in size, 5–10 mm long, 3–4 mm wide. Flowers pedicellate, solitary on terminal branches. Pedicels 2–4 mm long, extending to 10 mm long in fruit. Calyx-tube campanulate, 3.5–5 mm long, with 5 slightly scabrous costae, 5-lobed, lobes linear, 1.5–2.5 mm long, with obscurely erose costae, nearly entire along margins. Corolla tubular-

campanulate, white with yellow or greenish yellow spots in the middle part, 12–16 mm long, sinuses plicate with ovate-triangular appendages, appendages apices acute or cuspidate, nearly entire near both extremes. Anthers pink to light red, 1.5–2 mm long. Filaments 6–8 mm long, attached slightly above the lower part of corolla-tube. Ovary stipitate, lanceolate to narrow ovate, 6–7 mm long, 2–3 mm wide; stipe 2–3 mm long; style 2–3 mm long; stigma bifurcate and spirally recurved when flowering. Capsules obovate, about 6 mm long, 3 mm wide, with long stipes about 15 mm long, 2-valved, valves slightly dentate near apices, exerted beyond the persistent corolla. Seeds ovoid, with minutely longitudinal reticulate-striae, ca. 0.7 mm long and 0.4–0.5 mm wide.

*Additional specimens examined.* **TAIWAN.** MIAOLI HSIEN: Kuanwu, *Huang 1901* (TNU), same loc., *Wang 9264* (TNU). same loc., ca. 1800 m, *Chen 801* (TNU). HSINCHU HSIEN: Yuanyanghu, elev. ca. 1670 m, *Chen 845, 965* (TNU); same loc., *Chen 180* (HAST); same loc., *Wang 1313* (HAST). ILAN HSIEN: Taipingshan, elev. ca. 2100 m, *Chen 960, 1657* (TNU); same loc., elev. ca. 1970 m, *Huang 10774* (TAI); same loc., elev. ca. 1950 m, *Peng 7858* (HAST); same loc., elev. ca. 1970 m, *Yang 10774* (TAI).

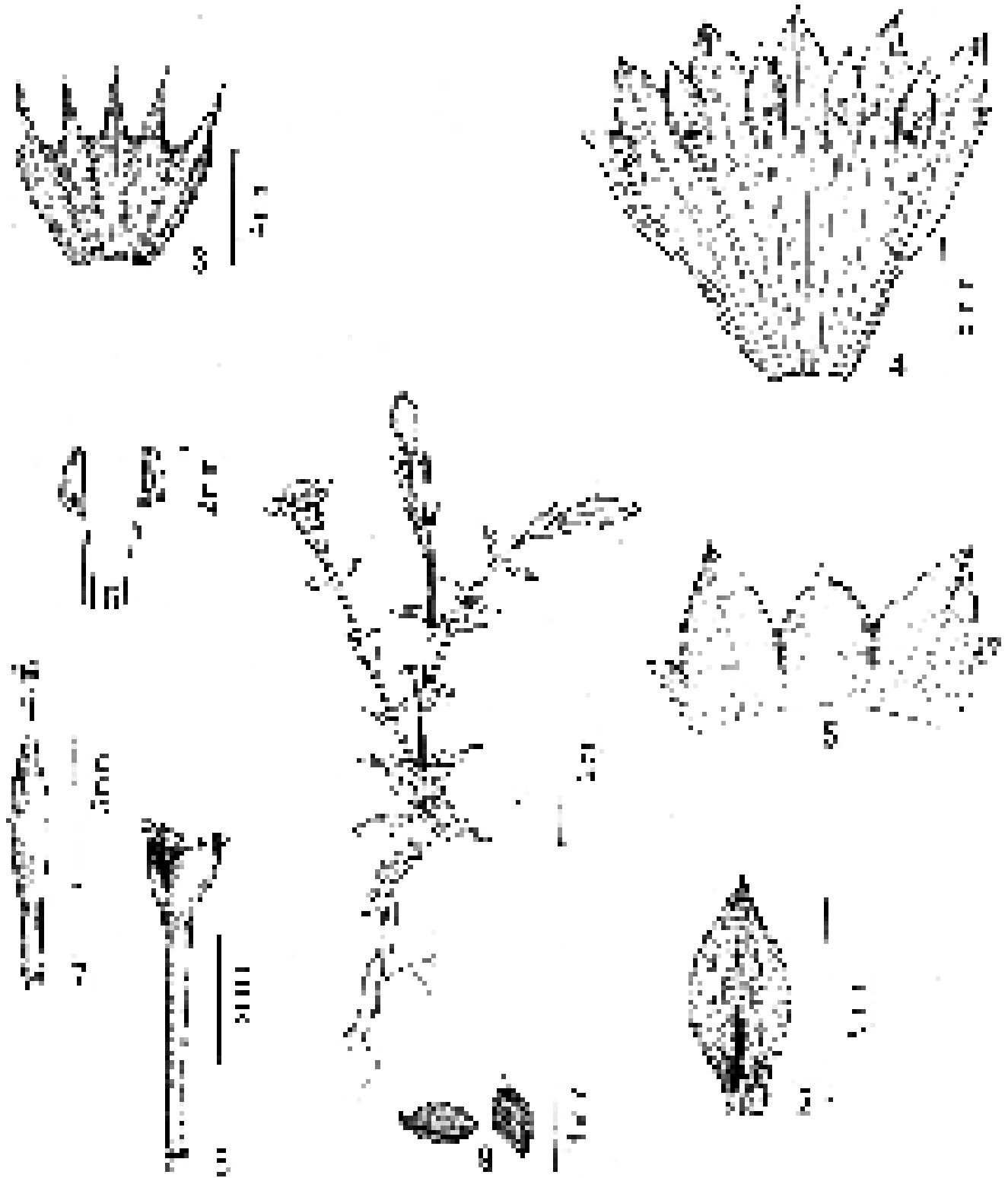
*Distribution.* Endemic to Taiwan, frequently found on shady grasslands or roadsides in northern part of the Central Mountain Range from 1,600 to 2,200 m in elevation. Flowering and fruiting Jun-Sep.

*Notes.* The taxon has been found in the northern part of Central Mountain Range and was previously treated as *G. flavomaculata* Hayata. The gross morphology of this variety is similar to var. *flavomaculata* occurring in the central and southern part of the Central Mountain Range. Detailed comparison demonstrates that the variety differs from the var. *flavomaculata* in that the anther color is pink to light red, plant is smaller, and corolla tube is slightly shorter.

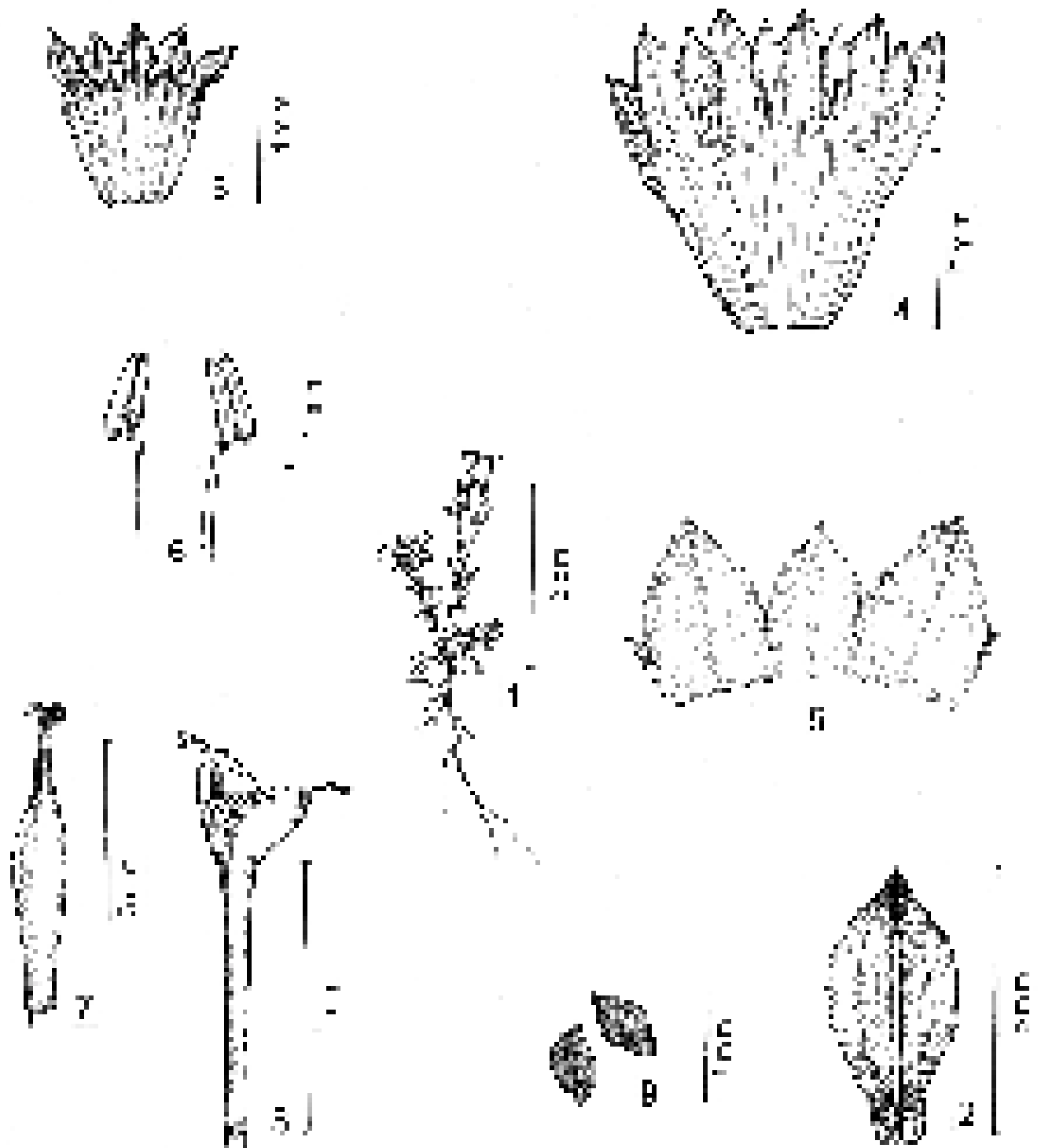
**4. *Gentiana horaimontana*** Masamune, Trans. Nat. Hist. Soc. Formos. 26: 56. 1936; Liu & Kuo, Ann. Taiwan Mus. 13: 107. 1970. —TYPE: Taiwan, Taityu-syu: In umbrosis juniperetorum montis Maborasu-san, *Suzuki-T 13630*, 3 Aug. 1935 (holotype: TAI!). 高山龍膽 Figure 12

*Gentiana scabrida* var. *horaimontana* (Masamune) Liu & Kuo, Bull. Exp. Forest Natl. Taiwan Univ. 114: 188, pl. 10. 1974; Liu & Kuo in Li *et al.*, Fl. Taiwan 4: 178. 1978; Ho, Fl. Reipubl. Popularis Sin. 62: 243. 1988; Ying, Quart. J. Exp. Forest Natl. Taiwan Univ. 3(2): 94. 1989; Ho & Pringle in Wu & Raven, Fl. China 16: 77. 1995.

*Annual herbs.* Stems usually branched, greenish yellow to brownish yellow, caespitose glabrous, 3–5 cm tall. Leaves apically aristate-acuminate, slightly scabrous along margins; radical leaves lanceolate or ovate, 3–10 mm long, 2–4 mm wide; cauline leaves lanceolate to narrowly lanceolate, 3–5 mm long; sheaths less than 1 mm long. Flowers pedicellate, solitary on terminal branches. Calyx-tube campanulate, 3 mm long, with 5 scabrous costae, 5-lobed, ovate, aristate-acuminate at apex, about 2 mm long.



**Figure 11.** *Gentiana flavomaculata* Hayata var. *yuanyanghuensis* C. H. Chen & J. C. Wang var. nov. 1, Habit; 2, Cauline leaf, abaxial view; 3, Calyx; 4, Corolla and stamens; 5, Enlarged corolla-lobes; 6, Stamens; 7, Pistil; 8, Capsule; 9, Seeds. (C. H. Chen 960).



**Figure 12.** *Gentiana horaimontana* Masamune. 1, Habit; 2, Cauline leaf, abaxial view; 3, Calyx; 4, Corolla and stamens; 5, Enlarged corolla-lobes; 6, Stamens; 7, Pistil; 8, Capsule; 9, Seeds. (Peng 14373).

Corolla tubular-campanulate, yellow with brown spots in the middle, 9–10 mm long, with 5 lobes; lobes acutely ovate, about 2 mm long; appendages acute or cuspidate near apices. Stamens 5, anthers narrow, 0.5–1 mm long; filaments about 4 mm long, attached slightly above the lower-part of corolla-tube. Ovary shortly stipitate, lanceolate to narrow ovate, 2–3 mm long, about 1 mm wide; stipe ca. 1 mm long; style 2–3 mm long; stigma bifurcate and spirally recurved when flowering. Capsules obovate, 2–3 mm long, exerted beyond the persistent corolla. Seeds ovoid, with minutely longitudinal reticulate-striae, 1–1.2 mm long and 0.5–0.6 mm wide.

*Additional specimens examined.* **TAIWAN.** CHIAYI HSIEN: Paiyuanshanchuang, *Lu 3692* (NCUF); same loc., *Lu 3750* (NCUF); Payuanshanchuang to Mt. peak of Yushan, elev. 3700–3800 m, *Chen 2237* (TNU), same loc., *Peng 14373* (HAST). PINGTUNG HSIEN: Pingtung to Tawushan, *Huang 13676* (TAI).

*Distribution.* Endemic to Taiwan, rare at the high altitude of the Central Mountain Range from 3,600 to 3,900 m in elevation. Found with *Juniperus* on shady limestone bedrock or moss covered slopes. Flowering Sep–Oct, fruiting Sep–Nov.

*Notes.* This taxon was treated as a distinct species by Masamune (1936), but was reduced to a variety of *Gentiana scabrida* by Liu & Kuo (1974). According to Liu & Kuo, this taxon is close to *G. scabrida* Hayata, but differs from the latter by having the glabrous leaves, the appendages entire and cuspidate-acute at the apex, a minute plant body, and occurrence at high altitude up to 3800 m. However, from authors' field experience and detailed comparison, in addition to the differences described above, this species has a yellowish plant body and occurs in a shadier habitat. Based upon the features mentioned above, it seems appropriate to treat this taxon as a distinct species.

**5. *Gentiana itzershanensis*** Liu & Kuo, Bull. Exp. Forest Natl. Taiwan Univ. 114: 181. pl. 7. 1974; Liu & Kuo in Li *et al.*, Fl. Taiwan 4: 172, pl. 954. 1978; Ho, Fl. Reipubl. Popularis Sin. 62: 175. 1988; Ho & Pringle in Wu & Raven, Fl. China 16: 73. 1995. — TYPE: Taiwan. Hsinchu Hsien: Itzershan, in the central ranges, *SH 512*, 15 July 1935 (holotype: TAI!). 伊澤山龍膽 Figure 13

*Gentiana scabrida* var. *itzershanensis* (Liu & Kuo) Ying, Quart. J. Exp. Forest Natl. Taiwan Univ. 3(2): 94. 1989.

Annual herbs. Stems usually branched, purple to dark purple, densely scabrous, 10–25 cm tall. Leaves apically aristate-acuminate, slightly scabrous along margins; radical leaves lanceolate to narrow lanceolate, 10–20 mm long, 5–8 mm wide; cauline leaves narrow-lanceolate to linear-lanceolate, 12–15 mm long, 3–4 mm wide; sheaths 2–3 mm long. Flowers pedicellate, solitary on terminal branches; pedicels 4–10 mm long. Calyx-tube campanulate, 5–7 mm long, with 5 prominent scabrous costae, 5-lobed; lobes linear, longer than calyx-tubes, 8–10 mm long, aristate at apices, with obscurely scabrous-serrulate near apices, dilated and very minutely scabrous-serrulate at base, middle-part

entire. Corolla tubular-campanulate, yellow, with brown or dark brown spots in the middle, 18–24 mm long, with 5 lobes; lobes acutely ovate, 3–5 mm long, aristate-acuminate at apices, sinuses plicate with ovate-triangular appendages; appendages acute or cuspidate near apices. Stamens 5, anthers narrow, 2.5 mm long, filaments 15–17 mm long, attached slightly above the lower-part of corolla-tube. Ovary shortly stipitate, lanceolate to narrow ovate, 8–10 mm long, 4–6 mm wide; stipe 2–3 mm long; style 6–7 mm long; stigma bifurcate and spiral. Capsules obovate or elliptical, 5–6 mm long. Stipe 16–18 mm long, with serrulate wings, exerted beyond the persistent corolla. Seeds ovoid, with minutely longitudinal reticulate-striae, 0.8–0.9 mm long and ca. 0.5 mm wide.

*Additional specimens examined.* **TAIWAN.** HSINCHU HSIEN: Tapachienshan, elev. 3200–3400 m, *Chen 1443* (TNU); same loc., elev. 2700–3500 m, *Kuoh 3278* (TAI); same loc., 5 Jul 1934, *Suzuki s. n.* (TAI); same loc., elev. ca. 3400 m, *Ying 4207* (NTUF). MIAOLI HSIEN: Chiuchiushanchuang to Tapachienshan, elev. 2700–2900 m, *Peng 8486* (HAST); same loc., *Wang 1274* (TNU); Itzershan, loc. elev. 3250–3300 m, *Huang 105* (HAST). TAICHUNG HSIEN: Chikashanchuang to Sanliuchiushanchuang, elev. 2400–3100 m, *Chen 1337* (TNU); Hsuehshan, 23 Aug 1995, *Yang s. n.* (TAIF); same loc., elev. 3150–3850 m, *Chen 1370* (TNU); same loc., *Huang 1602* (TNU); Wuling lodge to Taoshan, elev. 2900–3000 m, *Peng 12032* (HAST); Sanliuchiushanchuang to Tsuichih, elev. 3200–3884 m, *Wang 4419* (TNU); Taoshan, elev. ca. 10000 feet, *Hosokawa 2281* (TAI).

*Distribution.* Endemic to Taiwan, in exposed grasslands or bedrock areas in the Hsuehshan Mountain Range from 2,800 to 3,800 m in elevation. Flowering Jul–Oct, fruiting Aug–Nov.

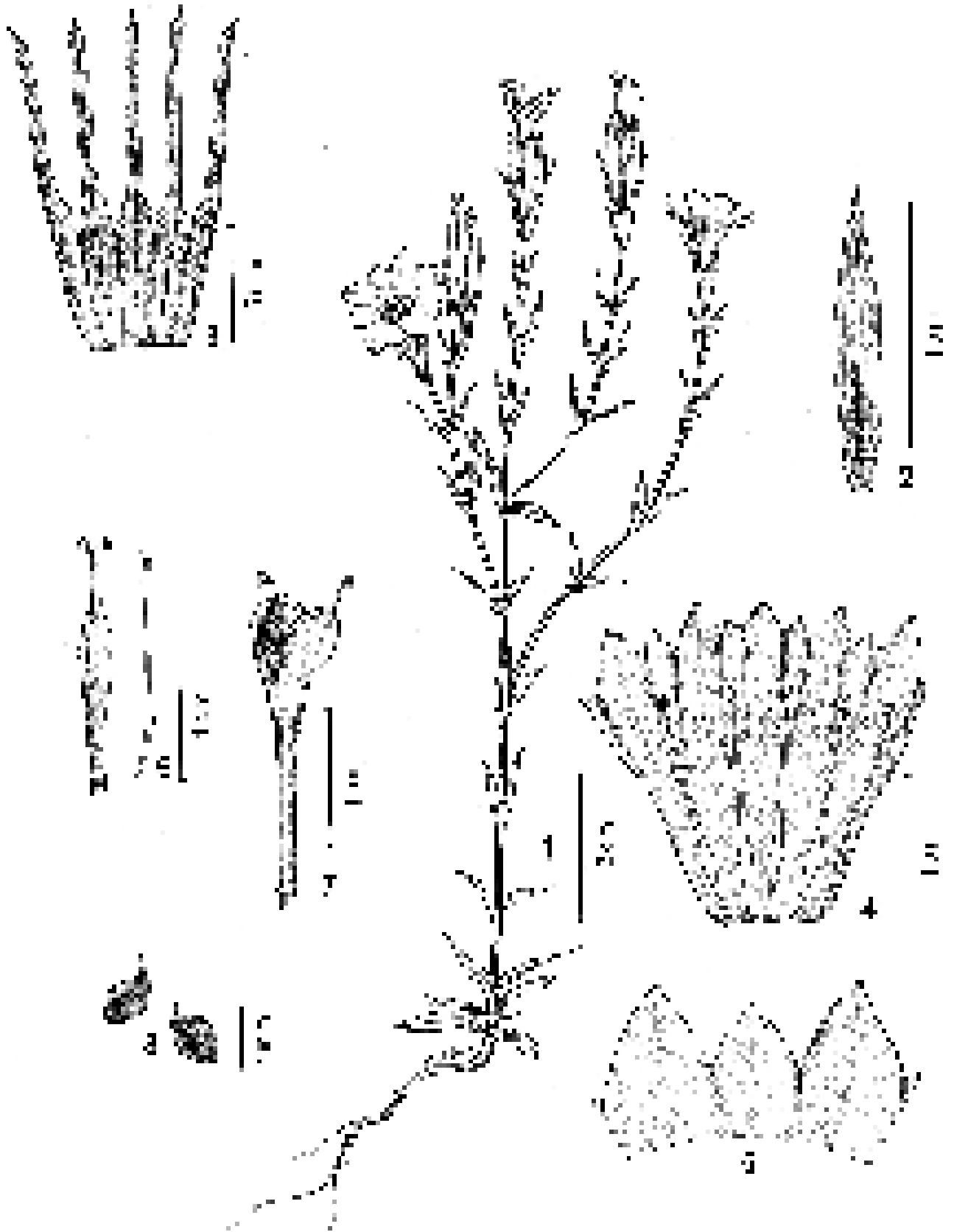
*Note.* *Gentiana itzershanensis* is readily separated from its congeners in Taiwan by its linear calyx-lobes and narrow-lanceolate to linear-lanceolate cauline leaves.

**6. *Gentiana kaohsiungensis*** C. H. Chen & J. C. Wang sp. nov. — TYPE: Taiwan. Kaohsiung Hsien: Kuaiku, *C. H. Chen 1624*, 16 Mar. 1996 (holotype: TNU; isotype: HAST, TNU). 高雄龍膽 Figure 14

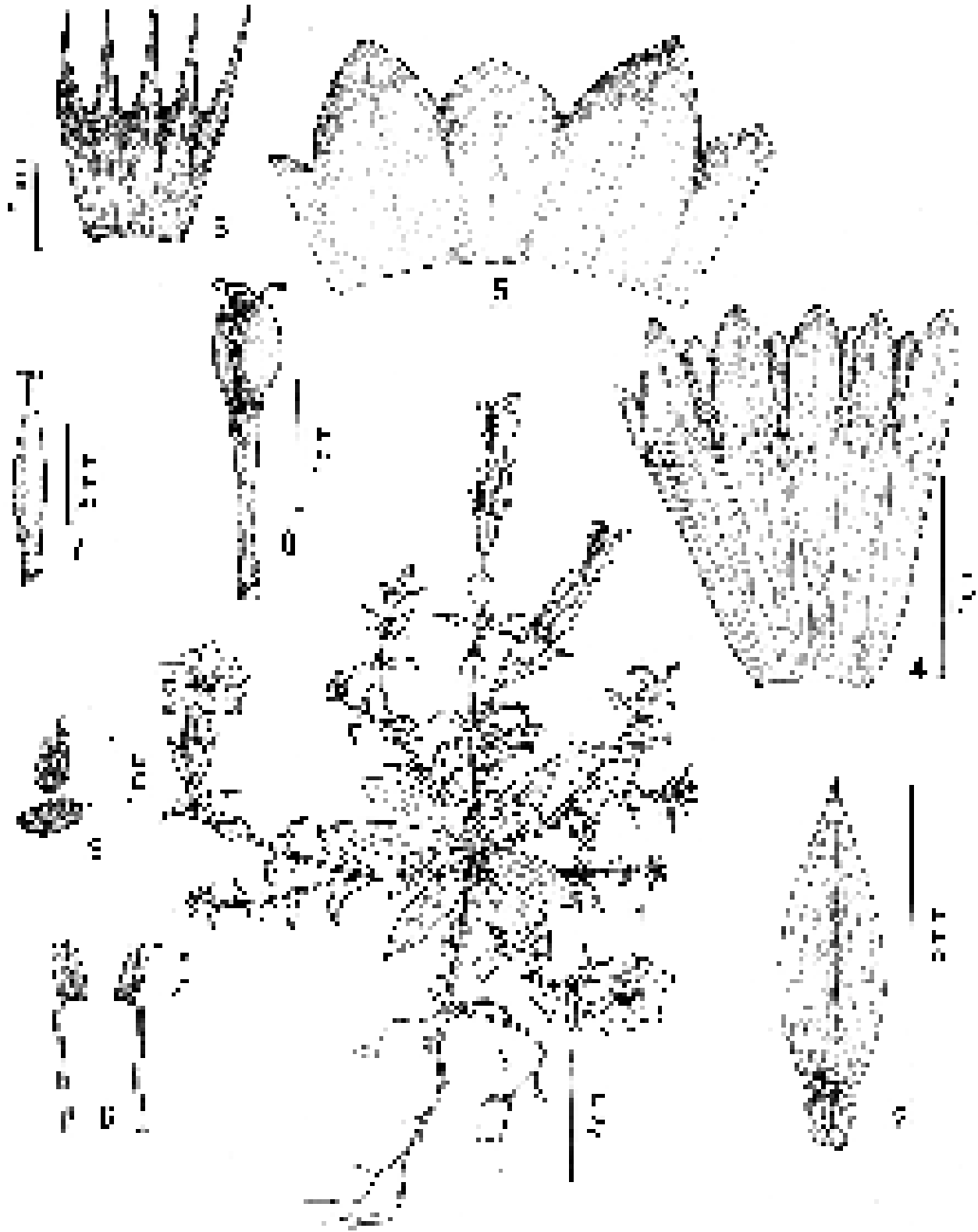
Species *G. flavomaculata* Hayata affinis, sed plantae scaberrimus, plantae et flores plus grandis, corolla paullo flavus fauce brunneus macula differt.

Annual herbs. Stems usually branched, brownish purple to reddish purple, densely scabrous, 8–15 cm tall. Leaves aristate-acuminate at apices, slightly scabrous along margins; radical leaves lanceolate or ovate, 15–22 mm long, 6–7 mm wide; cauline-leaves shape similar to radical-leaves but smaller in size, 6–9 mm long, 2–3 mm wide; sheaths 1–2 mm long. Flowers pedicellate, solitary on terminal branches; pedicels 5–7 mm long. Calyx-tube campanulate, about 5 mm long, with 5 slightly scabrous costae, 5-lobed, lobes linear-triangular, 4–5 mm long, with obscurely erose costae, marginally nearly entire. Corolla tubular-campanulate, light yellow, with brown spots in the middle part, 17–20 mm long, with 5 lobes; lobes acutely ovate, 3–





**Figure 13.** *Gentiana itzershanensis* Liu & Kuo. 1, Habit; 2, Cauline leaf, abaxial view; 3, Calyx; 4, Corolla and stamens; 5, Enlarged corolla-lobes; 6, Pistil & stamen; 7, Capsule; 8, Seeds. (C. H. Chen 1337).



**Figure 14.** *Gentiana kaohsiungensis* C. H. Chen & J. C. Wang sp. nov. 1, Habit; 2, Cauline leaf, abaxial view; 3, Calyx; 4, Corolla and stamens; 5, Enlarged corolla-lobes; 6, Stamens; 7, Pistil; 8, Capsule; 9, Seeds. (C. H. Chen 1624).

4 mm long, aristate-acuminate, sinuses plicate with ovate-triangular appendages; appendages acute or cuspidate near apices. Stamens 5, anthers oblong, about 2 mm long, filaments about 1 cm long, attached slightly above the lower-part of corolla-tube. Ovary stipitate, lanceolate to narrow ovate, 7–9 mm long, 2–4 mm wide; stipe 2–3 mm long; style 2–4 mm long; stigma bifurcate and spirally recurved at anthesis. Capsules obovate, about 7 mm long, 4 mm wide, with long stipes about 1.5–2 cm long, 2-valved, dehiscent; valves apically obscurely dentate. Seeds ovoid, with minutely longitudinal reticulate-striae, ca. 0.8 mm long and 0.4–0.5 mm wide.

*Additional specimens examined.* **TAIWAN.** KAOHSIUNG HSIEN: Kuanshanling, *Chung 754* (PPI); Shiangyangshan, *Huang 1115* (TNU); Kuaiku, elev. ca. 2580 m, *Wang 1086* (HAST); Tienchih, 8 Jul 1974, *Chang s. n.* (PPI); same loc., elev. ca. 2200 m, *Wang 1155* (HAST); Tienchih to Yakou, *Huang 8924* (TNU); Takuanshan, elev. 2400–2500 m, *Huang 3611* (TAI); Chinching Bridge to Takuanshan entrance, elev. 2400–2500 m, *Huang 3611* (TAI). TAITUNG HSIEN: Juglans natural reserve area, *Yang 30177* (PPI); Yakou to Hsiangyang, *Chen 13774* (HAST).

*Distribution.* Endemic to Taiwan, from 2,400 to 3,200 m in the southern part of the Central Mountain Range. Found on semishady to exposed rocky slopes and in opened grasslands. Flowering and fruiting Jul–Nov.

*Notes.* The taxa resembles *Gentiana flavomaculata* Hayata but it differs from the latter in the larger plant body, larger corolla, longer calyx, and light yellow corolla. Compared with other Taiwanese species, the characters of *G. kaohsiungensis* are also similar to *G. scabrida* Hayata, but distinct from the latter in its smaller flowers, linear-triangular calyx-lobes, and light yellow corolla. In other words, the morphological characters of this taxon are intermediate between *G. flavomaculata* Hayata and *G. scabrida* Hayata.

**7. *Gentiana scabrida*** Hayata, J. Coll. Sci. Imp. Univ. Tokyo 25(19): 168. 1908 (Fl. Mont. Formos.).

**7a. *Gentiana scabrida*** Hayata var. **scabrida**, J. Coll. Sci. Imp. Univ. Tokyo 25(19): 168. 1908 (Fl. Mont. Formos.); Hayata, J. Coll. Sci. Imp. Univ. Tokyo 30(1): 202. 1911 (Mater. Fl. Formosa); Hayata, Gen. Ind. Fl. Formosa 49. 1917; Liu & Kuo, Ann. Taiwan Mus. 13: 111. 1970, pro parte; Liu & Kuo, Bull. Exp. Forest. Natl. Taiwan Univ. 114: 185. 1974, pro parte; Liu & Kuo in Li *et al.*, Fl. Taiwan 4: 176. 1978, pro parte; Ho, Fl. Reipubl. Popul. Sin. 62: 242. 1988 pro parte; Ying, Quart. J. Exp. Forest Natl. Taiwan Univ. 3(2): 93. 1989; Ho & Pringle in Wu & Raven, Fl. China 16: 77. 1995, pro parte — TYPE: Taiwan, in monte Morrison, *Kawakami & Mori 2275* (syntype: TAIIF!); Ganzan, in montibus Morrison, ad 9141. alt., *S. Nagasawa 701 et 702* (syntype: TI, not seen). 玉山龍膽 Figure 15

*Gentiana scabrida* var. *angusta* Masamune, Trans. Nat. Hist. Soc. Formos. 29: 64. 1939; Ying, Quart. J. Exp. Forest Natl. Taiwan Univ. 3(2): 94. 1989. — TYPE: Taiwan,

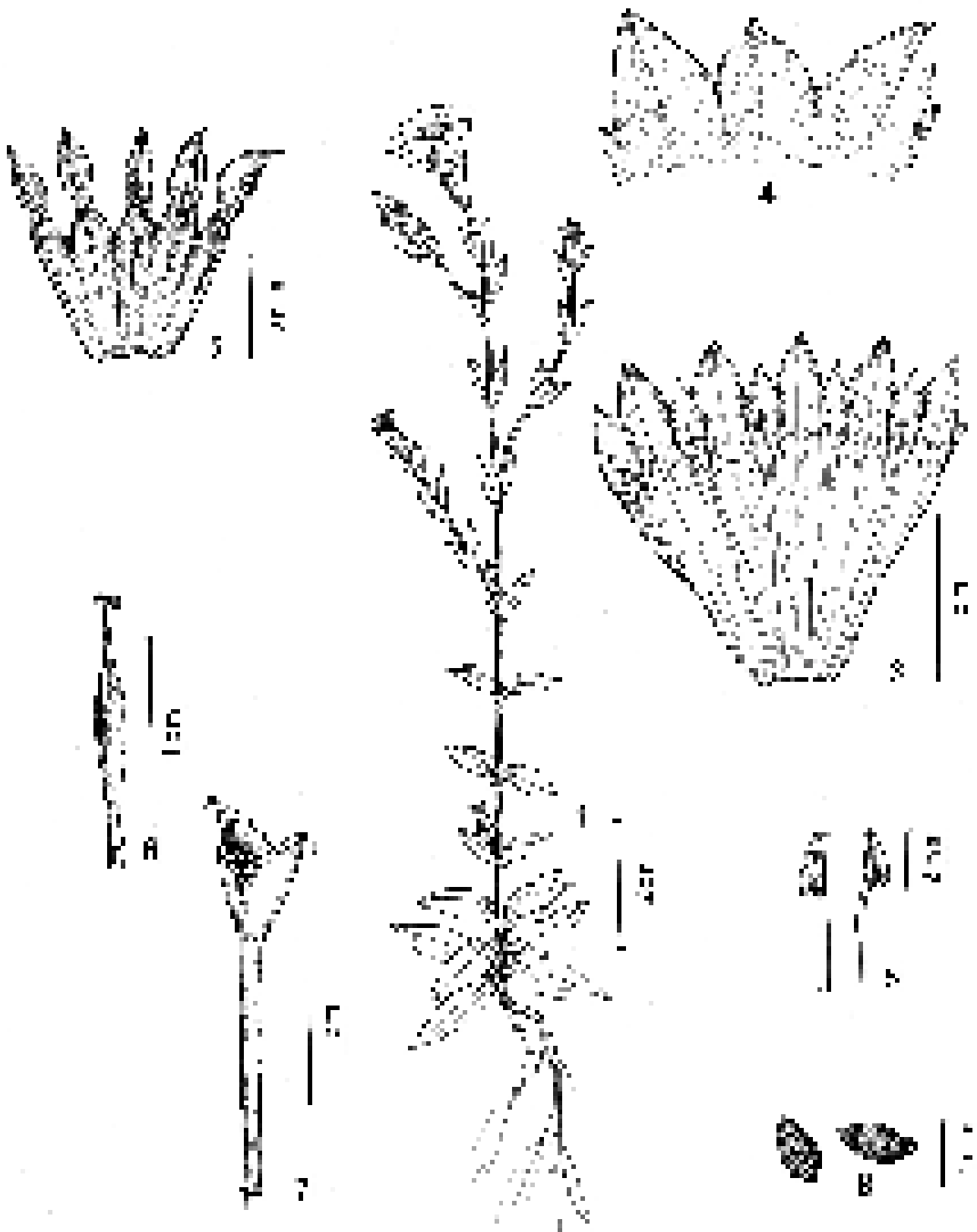
Kotaizan, 15 Jul, 1931, *Masamune & Mori s. n.* (holotype: TAI!). syn. nov.

*Gentiana angusta* (Masamune) Liu & Kuo, Bull. Exp. Forest Natl. Taiwan Univ. 114: 176, pl. 4. 1974 non Jones (1908); Liu & Kuo in Li *et al.*, Fl. Taiwan 4: 165. 1978; Ho, Fl. Reipubl. Popul. Sin. 62: 243. 1988. syn. nov.

*Gentiana taiwanica* T. N. Ho, Bull. Nat. Hist. Mus. London (Bot.) 23: 59. 1993; Ho & Pringle in Wu & Raven, Fl. China 16: 92. 1995. syn. nov.

Annual herbs. Stems usually branched, purple or dark purple, densely scabrous, 10–15 cm tall. Leaves aristate-acuminate, slightly scabrous along margins; radical leaves lanceolate or ovate, 10–22 mm long, 4–7 mm wide; cauline leaves lanceolate to narrow-lanceolate, 6–13 mm long, 3–5 mm wide; sheaths about 2 mm long. Flowers pedicellate, solitary on terminal branches; pedicels 2–10 mm long. Calyx-tube campanulate, 6–7 mm long, with 5 scabrous costae, 5-lobed; lobes slightly unequal in size, especially on buds, narrowly lanceolate to narrowly ovate, aristate-acuminate at apex, 4–6 mm long with erose costae, minutely aculeate along margins. Corolla tubular-campanulate, light-yellow to yellow, with brown or dark brown spots in the middle, 18–22 mm long, with 5 lobes; lobes acutely ovate, ca. 5 mm long, aristate-acuminate at apices, sinuses plicate with ovate-triangular appendages; appendages acute or cuspidate near apices. Stamens 5, anthers narrow, 2 mm long; filaments ca. 14 mm long. Ovary shortly stipitate, lanceolate to narrow ovate, 10–14 mm long, 4–6 mm wide; stipe 2–3 mm long; style 6–7 mm long. Capsules obovoid, 6–8 mm long; stipe 17–20 mm long, 2-valved, dehiscent; valves denticulate near upper part, exerted beyond the persistent corolla. Seeds ovoid, with minutely longitudinal reticulate-striae, 1–1.1 mm long and ca. 0.6 mm wide.

*Additional specimens examined.* **TAIWAN.** TAICHUNG HSIEN: Nanhutashan to Shenmachenshan, *Ying 2071* (NTUF); Sungling, 24 May 1933, *Fujita s. n.* (TNU); Pahsienshan, *Chuang 2700* (TAI); Nanhutashan, 14 Jul 1931, *Masamune s. n.* (TAI); same loc., elev. 2,450–3,530 m, *Wang 3654* (TAI); same loc., elev. 3,200–3,500 m, *Kao 5231* (TAI, NTUF); Nanhupeishan to Shenmachenshan, *Ying 2037* (NTUF); Hsiaohsuehsan, *Huang 10287* (TAI), same loc., elev. 2,000–2,400 m, *Wang 4968* (TAI); Lishan, *Kao 4609* (TAI). NANTOU HSIEN: Piluhsi, *Ou 5247* (NCUF); Hohuanshan, *Kao 7797* (TAI), same loc., elev. 2,750–2,850 m, *Peng 8321* (HAST); Tunyuan to Yunhai, elev. 2,000–2,400 m, *Liao 1294* (HAST); Kuankuao to Chungyangchinkuang, elev. 2,600–2,900 m, *Chen 96* (HAST); Tashuiku, 2 Oct 1926, *Sasaki s. n.* (TAI); Tungnengkao to Nengkao, 23 Aug 1929, *Sasaki s. n.* (TAI); Yunhai to Tienchih, elev. 2,340–2,840 m, *Kao 5824* (TAI); Chilaishan, *Jeng 1819* (TAI). CHIAYI HSIEN: Yushan, same loc., *Huang 1667* (TNU); Lulinshan, 30 Jul 1933, *Yento s. n.*, (TNU); Tungpushanchung to Tatachiaanpu, elev. ca. 2,500–2,900 m, *Leu 1201, 1202* (HAST); Tatachiaanpu to Paiyunshanchuang, elev. 2,800–3,500 m, *Peng 14362* (HAST); Tataka, elev. 2,650–3,500 m, *Chen 1061, 1062* (TNU); same loc., elev. ca. 2,600 m, *Yamazaki 776* (TAI); Monroe Cliff to Tungpu, elev. 2,400–



**Figure 15.** *Gentiana scabrida* Hayata var. *scabrida*. 1, Habit; 2, Calyx; 3, Corolla and stamens; 4, Enlarged corolla-lobes; 5, Stamens; 6, Pistil; 7, Capsule; 8, Seeds. (C. H. Chen 1060).

2,800 m, *Hsu 5363* (TAI). ILAN HSIEN: Chiliehting, *Huang 7784* (TAI). HUALIEN HSIEN: Tayuling to Hohuanshan, elev. 2,565–3,250 m, *Hsu 3801* (TAI).

*Distribution.* Endemic to Taiwan, in the northern and central parts of the Central Mountain Range from 2,400 to 3200 m in elevation. Flowering Jun-Sep, fruiting Jul-Oct.

*Notes.* *Gentiana scabrida* Hayata was first published in 1908. Masamune (1939) recognized a variety as *G. scabrida* var. *angusta*. Masamune's variety supposedly differed from var. *scabrida* by its linear-lanceolate calyx-lobes with acute to acuminate apices and a non-contracted base and ovate-lanceolate to linear-lanceolate leaves. Later, Liu & Kuo (1974) raised the variety to species but this created a later homonym to a species published by Jones in 1908. Our detailed comparison demonstrate that there are no stable or separable characters differentiating the two taxa. Detailed examination of specimens in Taiwanese herbaria demonstrated two taxa within the complex *G. scabrida* var. *scabrida*, and another is similar to *G. scabrida* var. *punctulata* described by Ying (1978).

**7b. *Gentiana scabrida* var. *punctulata*** Ying, Alp. Pl. Taiwan Col. 2: 215, photo. 61, pl. 53. 1978; Ying, Quart. J. Exp. Forest Natl. Taiwan Univ. 3(2): 95. 1989 (“*punctata*”). — TYPE: Taiwan. Nantou Hsien: Hohuanshan, 26 Jul 1976, *Ying 4890* (holotype: NTUF!). 黑斑龍膽 Figure 16

*Gentiana scabrida* auct. non Hayata: Liu & Kuo, Ann. Taiwan Mus. 13: 111. 1970, pro. parte; Liu & Kuo, Bull. Exp. Forest Natl. Taiwan Univ. 114: 185, pl. 9. 1974, pro parte; Liu & Kuo in Li *et al.*, Fl. Taiwan 4: 176. 1978, pro parte; Ho, Fl. Reipubl. Popul. Sin. 62: 242. 1988, pro parte; Ho & Pringle in Wu & Raven, Fl. China 16: 77. 1995, pro parte.

Annual herbs. Stems usually branched, dark purple, densely scabrous, up to 20 cm tall. Leaves aristate-acuminate, slightly scabrous along margins; radical leaves lanceolate or ovate, 10–25 mm long, 4–7 mm wide; cauline leaves lanceolate to narrow-lanceolate, 6–13 mm long, 3–6 mm wide; sheaths ca. 2 mm long. Flowers pedicellate, solitary on terminal branches; pedicels 2–10 mm long. Calyx-tube campanulate, 9–11 mm long, with 5 scabrous costae, 5-lobed; lobes unequal in size, especially on buds, ovate to narrowly ovate, aristate-acuminate, 5–7 mm long, ca. 3 mm wide; lobes with erose costae, marginally minutely aculeate. Corolla tubular-campanulate, yellow, with dark brown or black spots in the middle, 20–28 mm long, the 5 lobes acutely ovate, ca. 5 mm long, aristate-acuminate, sinuses plicate with ovate-triangular appendages; appendages acute or cuspidate near apices. Stamens 5, anthers narrow, 2.5–3 mm long; filaments ca. 18 mm long, attached slightly above the lower-part of corolla-tube. Ovary shortly stipitate, lanceolate to narrow ovate, 12–14 mm long, 4–6 mm wide; stipe 2–3 mm long; style 6–7 mm long; stigma bifurcate and spirally recurved when flowering. Capsules obovoid, ca. 9 mm long, 6 mm wide; stipe 18–20 mm long, 2-valved, dehiscent; valves denticulate near upper-part. Seeds ovoid, with minutely longitudinal reticulate-striae, 1.2–1.3 mm long and 0.6–0.7 mm wide.

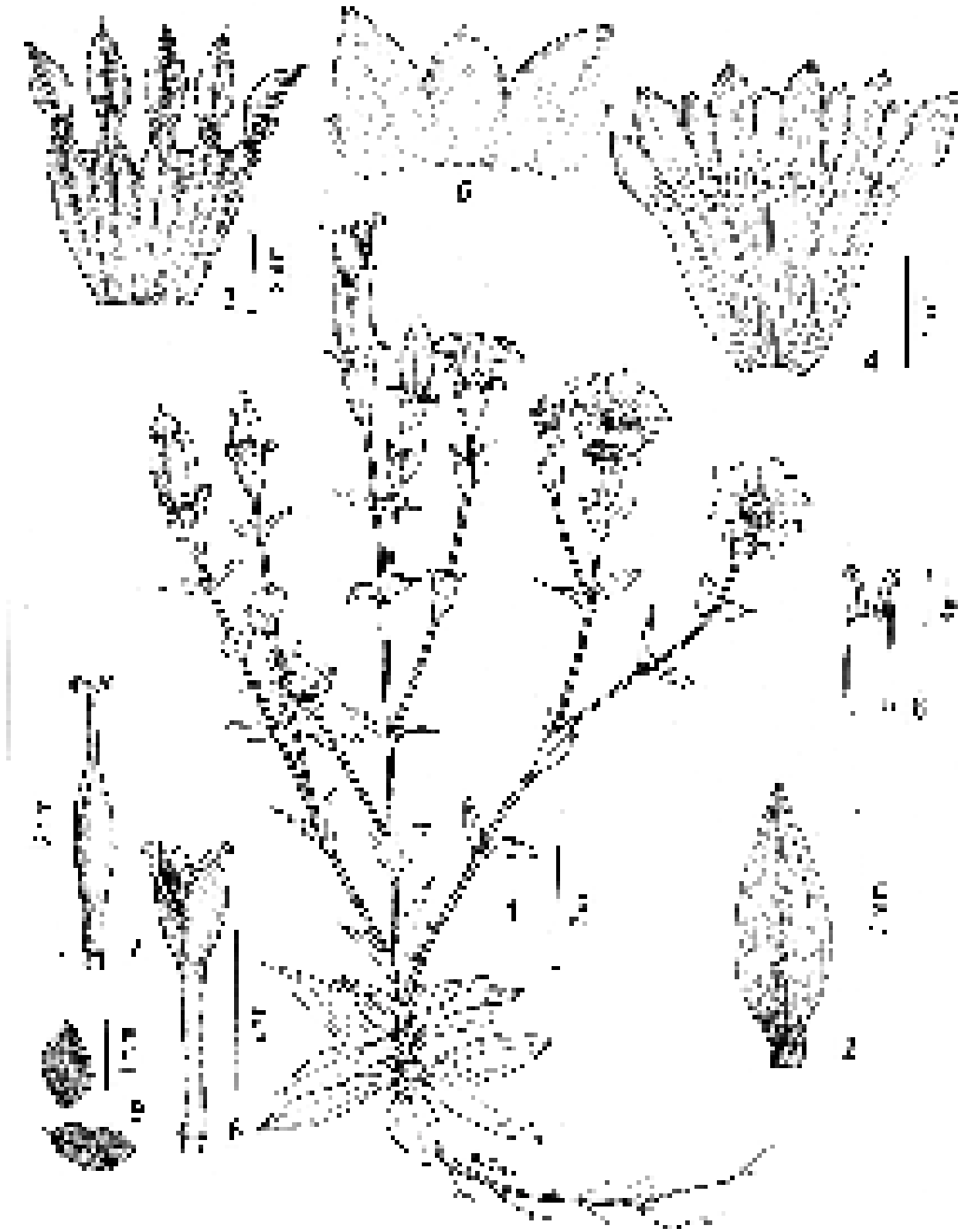
*Additional specimens examined.* TAIWAN. TAICHUNG HSIEN: Nanhutashan, *Wang 922* (HAST); same loc., 15 Jul 1933, *Fujita s. n.* (TNU); same loc., elev. 3300–3700 m, *Huang 787* (TAI); Lishan to Hohuanshan, Jeng 1718 (TAI); 27 Jul 1922, Sungling, *Sasaki s. n.* (TAIF). NANTOU HSIEN: Nengkaoshan, 7 Aug 1919, *Mazuda s. n.* (TAI, TAIF); Tungnengkao to Nengkao, 28 Aug 1929, *Sasaki s. n.* (TAI); Weishang, 22 Oct 1932, *Sasao s. n.* (NCUF); Wuling, elev. 3200–3250 m, *Peng 14489* (HAST); Sunghsuehlou, *Huang 2658* (TNU); Patungkuan, elev. ca. 2850 m, *Lee 10* (HAST); same loc., *Huang 1538* (TNU); same loc., elev. ca. 2800 m, 12 Jul 1993, *Yang s. n.* (TAI); Hohuanshan, elev. ca. 2600 m, *Chen 1060* (TNU); same loc., elev. 2600–2700 m, *Chen 1203* (TNU); same loc., elev. 3050–3150 m, *Chen 1266* (TNU); same loc., elev. ca. 2800 m, *Lu 12745* (TAIF); same loc., *Ou 9152* (TAI); same loc., elev. 2600–3200 m, *Kuo 2655* (NTUF); Kuankao to Patungkuan, elev. 2650–3000 m, *Peng 8136* (HAST); Chilaichunanfeng, *Sasaki 2363* (TAI); same loc., *Sasaki 2416* (TAI); same loc., 24 Aug 1929, *Suzuki s. n.* (TAI); Mabolashushan, *Suzuki 13621* (TAI); Tienchih to Nengkao, *Huang 5791* (TAI); Yunhai to Tienchih, elev. 2340–2860 m, *Kuo 1028* (NTUF). CHIAYI HSIEN: Yushan, *Suzuki 13231* (TAI); same loc., *Huang 14321* (TAI). HUALIEN HSIEN: Chilaishan, elev. 2910–3000 m, *Shen 9* (HAST); Miyasan, 8 Mar 1923, *Sasaki s. n.* (TAI); Tayuling, *Huang 4468* (TAI); Hohuanshan to Tayuling, elev. 2650–3200 m, 20 Jun 1983, *Lin s. n.* (TAIF); same loc., elev. ca. 3000 m, *Ying 1284* (NTUF); Tayuling to Piliu, elev. 2400–2650 m, 21 Jun 1983, *Lin s. n.* (TAIF).

*Distribution.* Endemic to Taiwan, in the northern and central parts of the Central Mountain Range from 2,600 to 3,500 m in elevation. Commonly found on exposed rocky slopes and grasslands. Flowering and fruiting Jul-Nov.

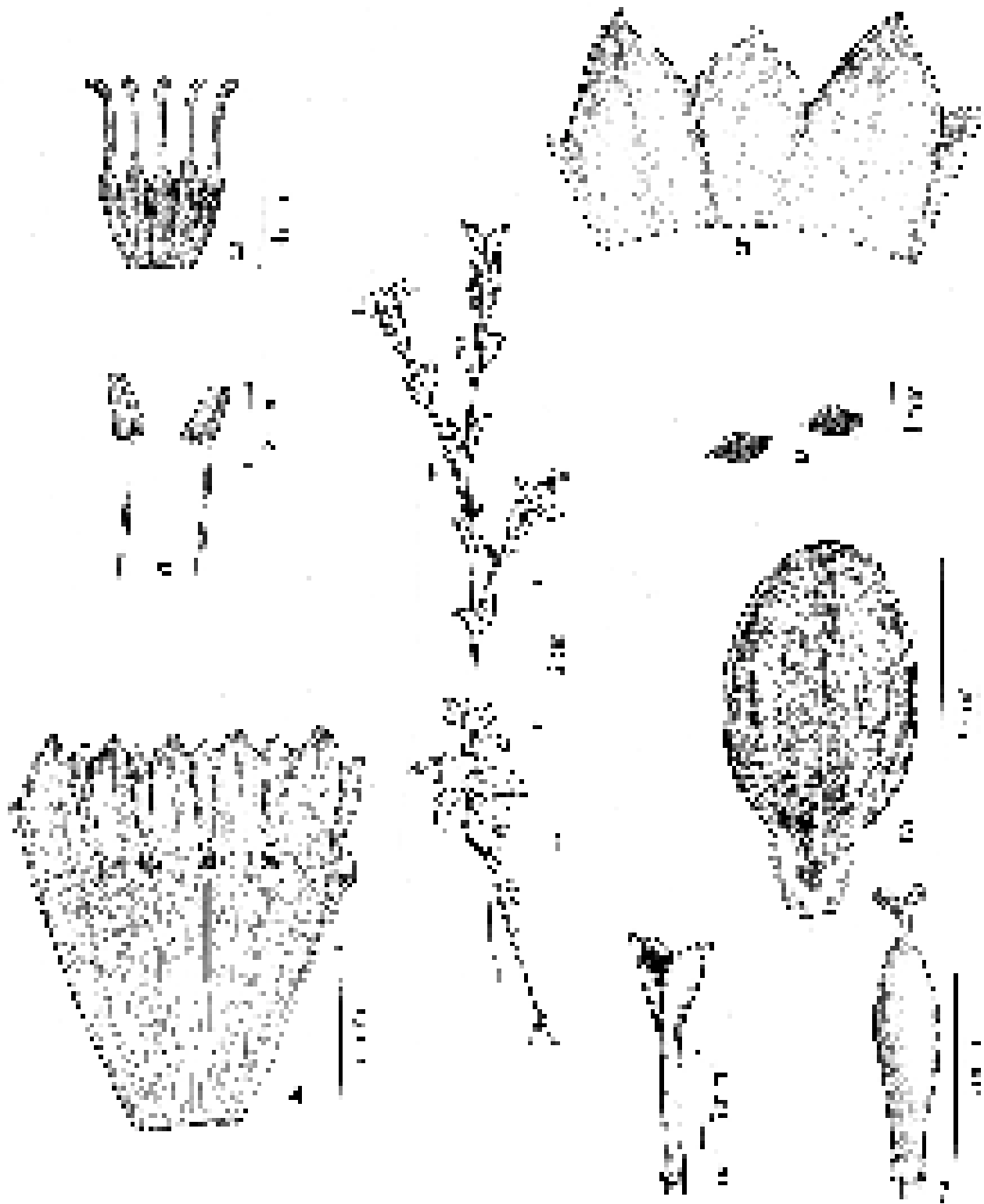
**8. *Gentiana tarokoensis*** C. H. Chen & J. C. Wang sp. nov.— TYPE: Taiwan. Hualien Hsien: Chingshuishan, 23 Apr 1995, *C. H. Chen 931* (holotype: TNU; isotype: HAST, TNU). 太魯閣龍膽 Figure 17

Species *G. itzershanensis* Liu & Kuo affinis, sed plantae parvus, prope basin vix ramifer, flores albi parvus 12 mm long, calyx lobis ad marginem vix scaberrimus differt.

Annual herbs. Stems erect or usually 2–3 branched in the upper part, greenish yellow to brownish yellow, caespitose glabrous, 7–9 cm tall. Leaves aristate-acuminate at apices, slightly scabrous along margins; radical lanceolate, ca. 12 mm long, 8 mm wide; cauline leaves lanceolate to narrow-lanceolate, ca. 6 mm long, 3–4 mm wide; sheaths ca. 1 mm long. Flowers pedicellate, solitary on terminal branches; pedicels 1–4 mm long. Calyx-tube campanulate, ca. 4 mm long, with 5 prominent scabrous costae, 5-lobed; lobes linear or somewhat narrowly lanceolate, almost equal to calyx-tubes in length, roll slightly at apex, with obscurely scabrous-serrulate near apex, dilated and very minutely scabrous-serrulate at base, middle-part entire. Corolla tubular-campanulate, white, with yellow or greenish yellow spots in the middle, ca. 12 mm long, with 5 lobes; lobes acutely ovate, ca. 3 mm long,



**Figure 16.** *Gentiana scabrida* var. *punctulata* Ying. 1, Habit; 2, Culine leaf, abaxial view; 3, Calyx; 4, Corolla and stamens; 5, Enlarged corolla-lobes; 6, Stamens; 7, Pistil; 8, Capsule; 9, Seeds. (C. H. Chen 1266).



**Figure 17.** *Gentiana tarokoensis* C. H. Chen & J. C. Wang sp. nov. 1, Habit; 2, Cauline leaf, abaxial view; 3, Calyx; 4, Corolla and stamens; 5, Enlarged corolla-lobes; 6, Stamens; 7, Pistil; 8, Capsule; 9, Seeds. (C. H. Chen 2083).

aristate-acuminate at apices; sinuses plicate with ovate-triangular appendages; appendages acute to cuspidate near apices, almost entire near both extremes. Stamens 5, anthers narrow, 1.5 mm long, filaments 7–8 mm long, attached slightly above the lower-part of corolla-tube. Ovary shortly stipitate, lanceolate to narrow ovate, 3–5 mm long, 1–2 mm wide; stipe 1–2 mm long; style ca. 2 mm long; stigma bifurcate and spirally recurved at anthesis. Capsules obovoid or elliptical, 5–6 mm long, 2-valved, dehiscent, with serrulate wings on upper-part, exerted beyond the persistent corolla. Seeds ovoid, with minutely longitudinal reticulate-striae, 0.9–1.2 mm long and 0.5–0.7 mm wide.

*Distribution.* Endemic to Taiwan, at about 2,000 to 2,400 m in elevation. Only found under shady *Juniperus* woods and semishady grasslands or in mixed situations in Chingshuishan. Rare. Flowering Apr–May, fruiting May–Jun.

*Notes.* To date, only one population has been found on the mountain-peak of Chingshuishan (in Taroko National Park). This species is similar to *Gentiana itzershanensis* Liu & Kuo, but differs from the latter in the smaller plant (7–9 cm), fewer branches, shorter flowers (ca. 12 mm), and white corolla. The latter has bigger plant (10–25 cm), more branches, longer flowers (18–24 mm), and yellow corolla.

**9. *Gentiana tatakensis*** Masamune, Trans. Nat. Hist. Soc. Formos. 33: 110. 1943; Liu & Kuo, Ann. Taiwan Mus. 13: 112. 1970; Liu & Kuo, Bull. Exp. Forest Natl. Taiwan Univ. 114: 189, pl. 11. 1974; Liu & Kuo in Li *et al.*, Fl. Taiwan 4: 178. 1978; Ho, Fl. Reipubl. Popularis Sin. 62: 181. 1988; Ho & Pringle in Wu & Raven, Fl. China 16: 74. 1995. — TYPE: Taiwan, ca. Tataka, inter Rokurinsan et Niitaka-sita, 1924, *Masamune 3759* (holotype: TAI!). 塔塔加龍膽 Figure 18

*Gentiana squarrosa* var. *tatakensis* (Masamune) Ying, Quart. J. Exp. Forest Natl. Taiwan Univ. 3(2): 94. 1989.

Annual herbs. Stems usually branched, brownish purple to reddish purple, densely scabrous, 2–7 cm tall. Leaves aristate-acuminate at apices, slightly scabrous along margins; radical leaves ovate, 7–10 mm long, 4–5 mm wide; cauline-leave shape similar to radical-leave but smaller in size, 3–4 mm long, 2–3 mm wide; sheaths about 0.5 mm long. Flowers pedicellate, solitary on terminal branches; pedicels short, usually less than 2 mm long. Calyx-tube campanulate, 2–3 mm long, with 5 slightly scabrous costae, 5-lobed; lobes linear, 1–1.5 mm long, with obscurely erose costae, almost entire along margins. Corolla tubular-campanulate, white or slightly purplish white, with light brown spots in the throat, 7–8 mm long, with 5 lobes; lobes acutely ovate, 2 mm long, aristate-acuminate at apices; sinuses plicate with ovate-triangular appendages; appendages acute or cuspidate near apices. Stamens 5, anthers oblong, ca. 1 mm long; filaments 4–5 mm long, attached slightly above the lower-part of corolla-tube. Ovary stipitate, lanceolate to narrow ovate, 3–4 mm long, 1–1.5 mm wide; stipe ca. 1 mm long; style ca. 1 mm long; stigma

bifurcate and spirally recurved when flowering. Capsules obovoid, ca. 4 mm long, 3 mm wide, with long stipes 8–12 mm long, partly exerted beyond the persistent corolla. Seeds ovoid, with minutely longitudinal reticulate-striae, ca. 0.9 mm long and 0.5 mm wide.

*Additional specimens examined.* TAIWAN. NANTOU HSIEN: Kuankao to Patungkuan, elev. 2650–3000 m, *Peng 8132* (HAST); Patungkuan, *Huang 1539* (TNU); same loc., elev. ca. 2800 m, 12 Jul 1993, *Yang s. n.* (TAI). CHIAYI HSIEN: Yushan, *Chang 26890* (PPI); Tataka, *Masamune 3808* (TAI); same loc., *Masamune 3822* (TAI); Tatchiaianpu, *Huang 2218* (TNU); en route to Yushan, elev. 2700–3400 m, *Huang 14258* (TAI); same loc., elev. 3400–3900 m, *Huang 14290* (TAI); Paiyunshanchuang, *Hsu 6257*; Tataka to Paiyunshanchuang, *Yamazaki 837* (TAI); Tatchiaianpu to Paiyunshanchuang, same loc., elev. 3300–3550 m, *Chen 1397* (TNU); same loc., elev. 3300–3500 m, *Chen 1419* (TNU). TAITUNG HSIEN: Takuanshan, elev. 2600–3200 m, *Peng 11752* (HAST). PINGTUNG HSIEN: Peitawushan, elev. 3000m, Aug 1997, *Wang s. n.* (TNU).

*Distribution.* Endemic to Taiwan, widely scattered in shady to semishady grasslands in the central and southern part of Central Mountain Range, at elevations from 2,500 to 3,500 m. Flowering and fruiting Jul–Sep.

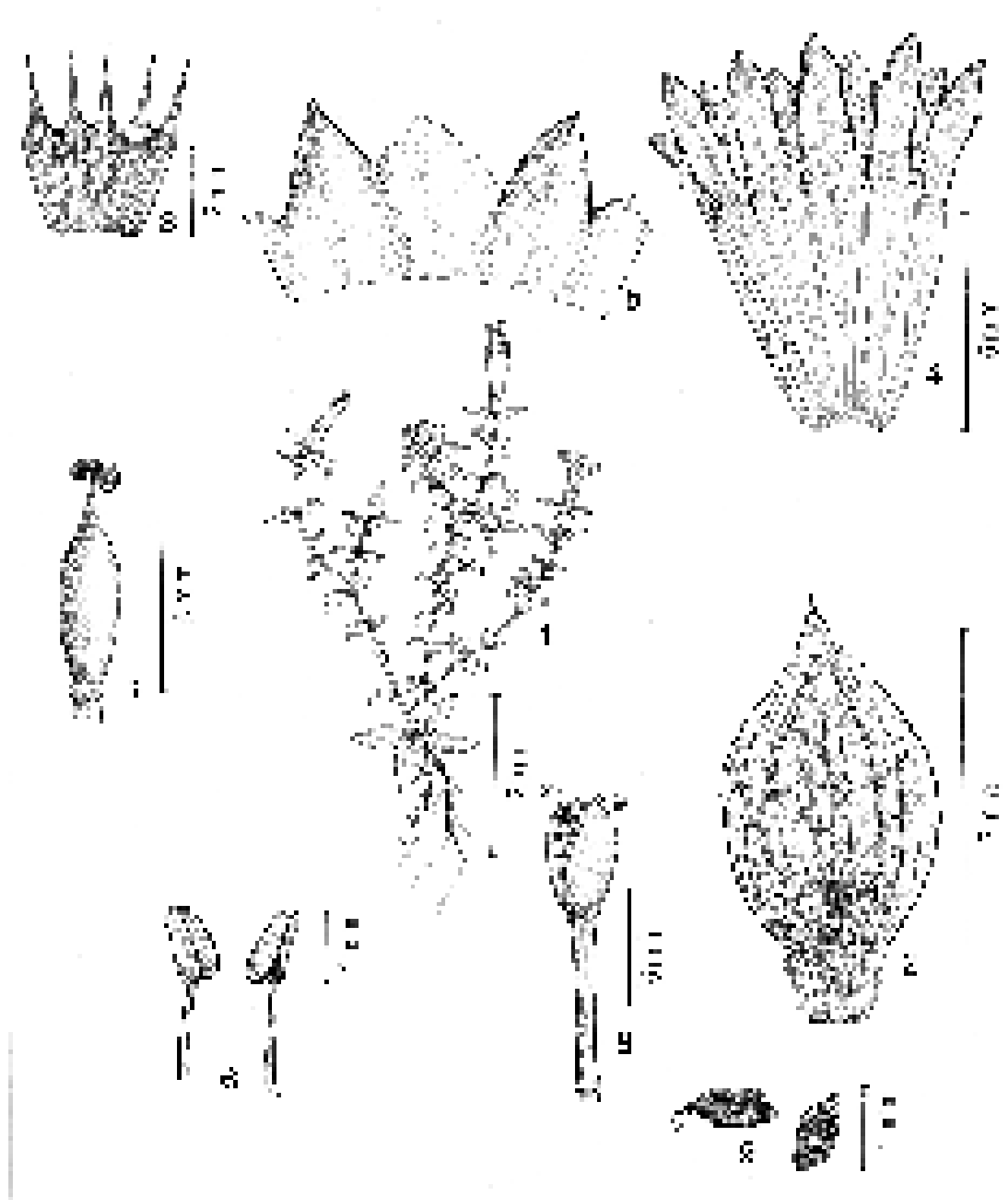
*Notes.* According to the description of Masamune (1943), the species had numerous branches which gathered densely and had campanulate corolla that was pale purple inside. From experiences of field, these characters are unstable. The branches usually elongate when it grows in grassland and the color of corolla is slightly pale purple to nearly white especially in shady area. However, a combination of small plant size, tiny flowers, linear-triangular calyx-lobes, and narrower corolla tube could distinguish this species from remainder of Taiwanese *Gentiana*.

Only one collecting locality with no altitude data was reported by Masamune (1943). Liu & Kuo (1974, 1978) considered that the range of altitude was from 1400 to 2400m. Our examination of specimens from Taiwanese herbaria reveals that the distribution of the species is almost higher than 2500 m at elevation.

**10. *Gentiana tentyoensis*** Masamune, Trans. Nat. Hist. Soc. Formos. 32: 1. 1942; Liu & Kuo, Ann. Taiwan Mus. 13: 114. 1970; Liu & Kuo, Bull. Exp. Forest Natl. Taiwan Univ. 114: 190, pl. 12. 1974; Liu & Kuo in Li *et al.*, Fl. Taiwan 4: 176. 1978; Ho, Fl. Reipubl. Popul. Sin. 62: 242. 1988; Ho & Pringle in Wu & Raven, Fl. China 16: 95. 1995.— TYPE: Taiwan, Pref. Hualien: Tienchang Cliffs, 27 Dec 1940, *Nangen s. n.* (holotype: TAI!). 厚葉龍膽 Figure 19

*Gentiana kaoi* Shimizu, J. Fac. Text. Sci. & Techn., Shinshu Univ. Ser. Biol. 12: 54. 1963; Shimizu, Acta Phytotax. Geobot. 21:27. 1964; Liu & Kuo in Li *et al.*, Fl. Taiwan 4: 181. 1978 (as excluded species); Ying, Quart. J. Exp. Forest Natl. Taiwan Univ. 3(2): 96. 1989 (as uncertain species).— TYPE: Taiwan, Pref. Hualien: Mt. Chingshui,





**Figure 18.** *Gentiana tatakensis* Masamune. 1, Habit; 2, Cauline leaf, abaxial view; 3, Calyx; 4, Corolla and stamens; 5, Enlarged corolla-lobes; 6, Stamens; 7, Pistil; 8, Capsule; 9, Seeds. (C. H. Chen 1419).

1 May 1961, *T. Shimizu 12535* (holotype: KYO!). syn. nov.

*Gentiana squarrosa* auct. non Ledeb. (1812): Ying, Quart. J. Exp. Forest Natl. Taiwan Univ. 3(2): 95. 1989.

Annual herbs. Stems erect or usually 2–3 branched in the upper part, brown to purplish brown, caespitose, glabrous, low herb. Stems up to 13 cm tall. Leaves aristate-acuminate at apex, costae prominent beneath, almost entire along margin; radical leaves ovate, 10–11 mm long, 7–8 mm wide; cauline leaves widely ovate, 3–6 mm long, 3–5 mm wide, slightly scabrous near leaves base; sheaths ca. 1 mm long. Flowers pedicellate, solitary and terminal; pedicels 1–4 mm long. Calyx-tube campanulate, ca. 4 mm long, with 5 smooth costae, 5-lobed; lobes narrow triangular, 3–4 mm long, acuminate at apices. Corolla tubular-campanulate, blue, with brown to black spot in the throat, 11–12 mm long, with 5 lobes; lobes acutely ovate, 2–3 mm long, aristate-acuminate at apices; sinuses plicate with ovate-triangular appendages; appendages acute or cuspidate near apices. Stamens 5, anthers pink, narrow, ca. 1.5 mm long; filaments 7–8 mm long, slightly attached on the lower-part of corolla-tube. Ovary shortly stipitate, lanceolate to narrow-ovate, 4–6 mm long, ca. 2 mm wide; stipe ca. 2 mm long, style ca. 2 mm long; stigma bifurcate and spirally recurved at anthesis flowering. Capsules obovoid, 5–6 mm long, 3–4 mm wide, 2-valved, dehiscent, exserted beyond the persistent corolla, with denticulate margin near upper part. Seeds ovoid, with minutely longitudinal reticulate-striae, ca. 0.8 mm long and 0.4–0.5 mm wide.

*Additional specimens examined. TAIWAN.* HUALIEN HSIEN: Chingshuishan, elev. 2300–2408 m, *Chen 930* (TNU); Tzuen, elev. 1800–2000 m, *Chen 2056* (TNU).

*Distribution.* Endemic to Taiwan, on semishady moist slopes or exposed rocky slopes in the northeast part of the island. Only found in the east part of Central Cross-Island Highway at ca. 2,000 m, Tienchang cliffs (type locality) and Chingshuishan at 1,500–2,400 m. in elevation. Rare. Flowering and fruiting Apr–May.

*Notes.* Masamune (1942) regarded *Gentiana tentyoensis*, *G. squarrosa*, and *G. zollingerii* as similar taxa. According to authors' examination, *G. tentyoensis* differs from *G. squarrosa* in nearly no branch and differs from *G. zollingerii* in flourishing radical leaves. Shimizu (1963) treated the specimens found on Chingshuishan (a mountain in Taroko National Park) as new species, *Gentiana kaoi*. Based on authors' examination, the only difference between *G. tentyoensis* and *G. kaoi* is that the stem of the specimens collected by Shimizu extended when blooming. It is reasonable to treat these two as the same species.

**11. *Gentiana tenuissima*** Hayata, J. Coll. Sci. Imp. Univ. Tokyo 25(19): 167. 1908 (Fl. Mont. Formos.); Hayata, Gen. Ind. Fl. Formosa 49. 1917; Liu & Kuo, Ann. Taiwan Mus. 13: 115. 1970; Liu & Kuo, Bull. Exp. Forest Natl. Taiwan Univ. 114: 191, pl. 13. 1974; Liu & Kuo in Li *et al.*, Fl. Taiwan 4: 180. 1978. — TYPE: Hualien: Wuchuan Cheng, Apr 1907, *T. Kawakami s. n.* (lectotype:

TAIF!, here designated; remaining syntype: Hualien: Wuchuan Cheng, Apr 1907, *T. Kawakami s. n.*, T1!). 台東龍膽 Figure 20

*Gentiana squarrosa* auct. non Ledeb. (1812): Kitamura, Acta Phytotax. Geobot. 10: 183. 1941; Ying, Quart. J. Exp. Forest Natl. Taiwan Univ. 3(2): 95. 1989.

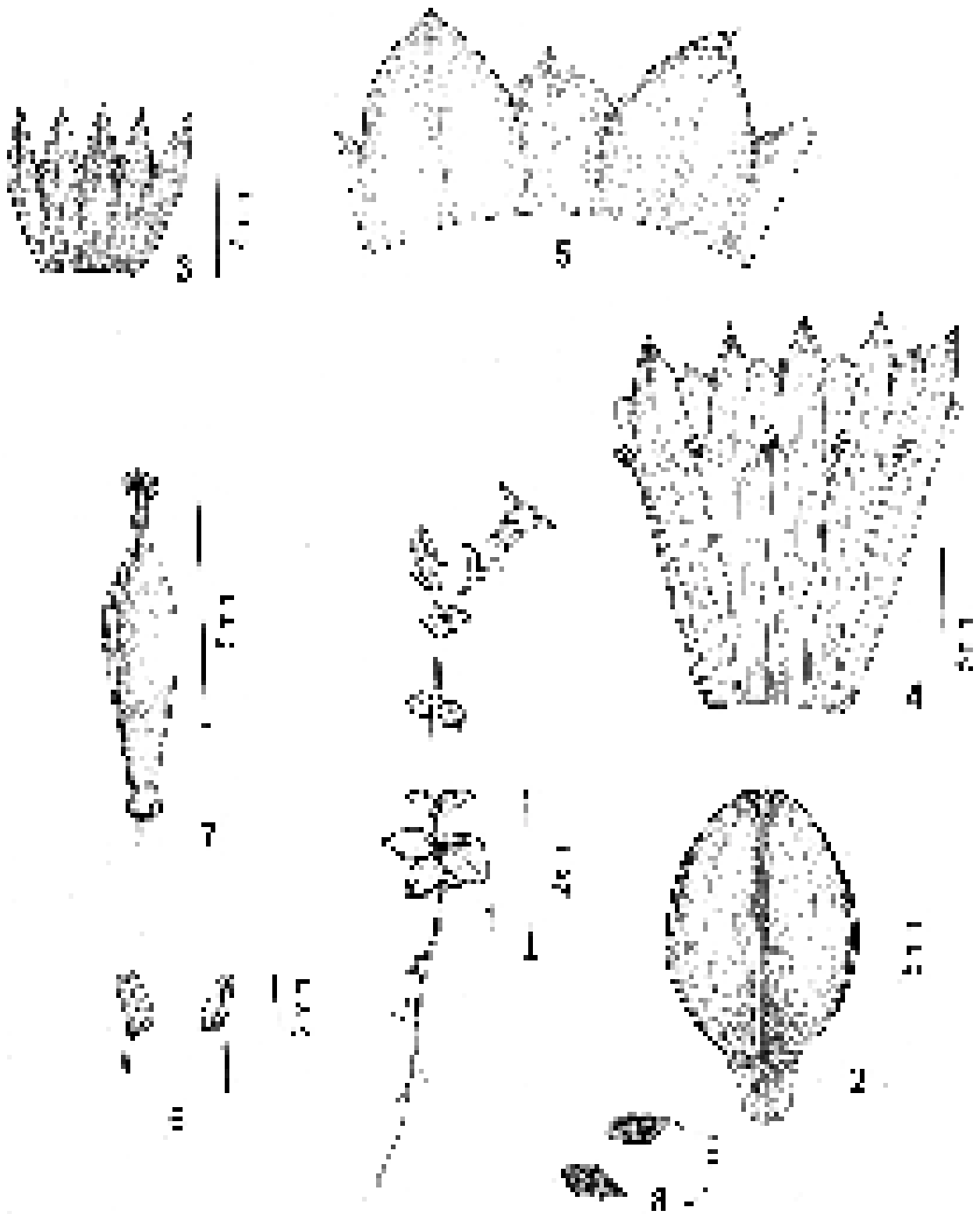
*Gentiana yokusai* auct. non Burk. (1906): Ho, Fl. Reipubl. Popul. Sin. 62: 234. 1988; Ho & Pringle in Wu & Raven, Fl. China 16: 78. 1995.

Annual herbs. Stems usually branched, yellowish green, caespitose glabrous, up to 6–8 cm tall. Leaves aristate-acuminate at apices, slightly scabrous along margins; radical leaves lanceolate or ovate, 7–8 mm long, 4–5 mm wide; cauline leaves lanceolate to narrow-ovate, ca. 5 mm long, 3 mm wide; sheaths 1–2 mm long. Flowers pedicellate, solitary on terminal branches; pedicels 2–6 mm long. Calyx-tube campanulate, 2–3 mm long, with 4 or 5 scabrous costae, 4 or 5-lobed; lobes broadly ovate, aristate-acuminate at apex, ca. 2 mm long, with erose costae, minute aculeus along margins. Corolla tubular-campanulate, light blue, with brown bands or spots in the middle, ca. 7 mm long, with 4 or 5 lobes; the lobes acutely ovate, 1–2 mm long, aristate-acuminate at apices; sinuses plicate with ovate-triangular appendages, appendages acute or cuspidate near apices. Stamens 4 or 5, anthers oblong, 0.4–0.6 mm long, filaments about 3–4 mm long, attached slightly above the lower-part of corolla-tube. Ovary shortly stipitate, lanceolate to narrow ovate, 2–3 mm long, ca. 1 mm wide; stipe ca. 1 mm long; style ca. 1 mm long; stigma bifurcate and spirally recurved when flowering. Capsules obovoid, ca. 4 mm long, 3 mm wide; stipe 3–6 mm long, 2-valved, dehiscent; valves denticulate along margin. Seeds ovoid, with minutely longitudinal reticulate-striae, 0.5–0.6 mm long and 0.3–0.4 mm wide.

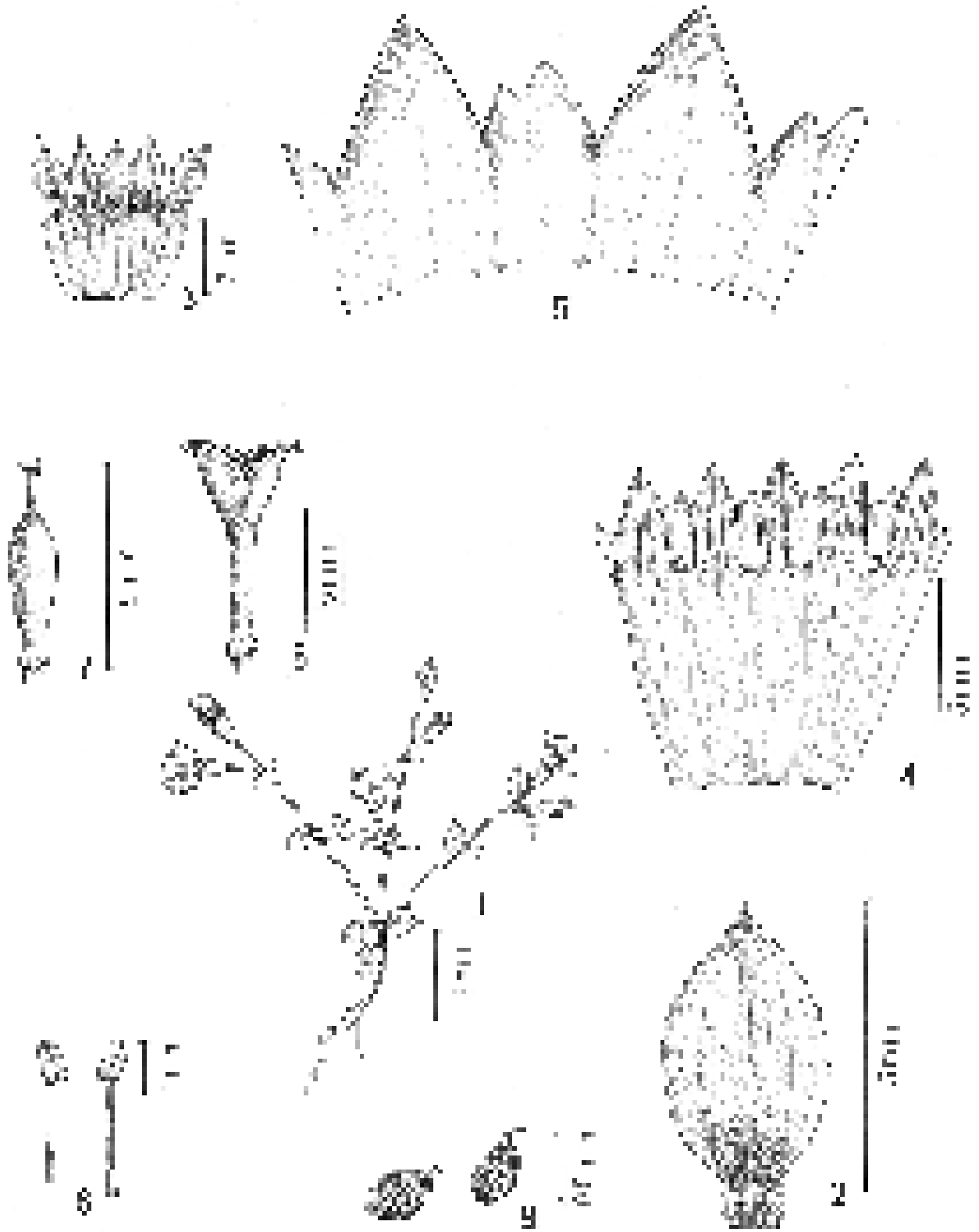
*Additional specimens examined. TAIWAN.* ILAN HSIEN: Tungao, elev. ca. 100 m, *Huang 3706* (TAI). HUALIEN HSIEN: Loshao, elev. 1900–2100 m, *Chen 1603* (TNU); Yenhaulintao, elev. 650–1200 m, *Chen 1195* (TNU); same loc., *Chen 1196* (TNU); same loc., *Wang 6807* (TNU); same loc., *Wang 7664* (TNU).

*Distribution.* Endemic to Taiwan, distributed in semishady grasslands or roadsides in northeast part of Taiwan. At mountain ranges from 50 to 2,100 m in elevation. Flowering and fruiting Mar–Jun.

*Notes.* This species resembles *Gentiana tentyoensis*, but distinct in having ovate calyx-lobes. *G. tenuissima* is quite different from other species distributed in the central and west part of the Central Mountain Range in Taiwan. Ho (1988) compared the *G. yokusai* distributed in mainland China with *G. tenuissima* of Taiwan and found that the two species differ only in sizes of plants, flowers, and leaves. Thus, she treated them as conspecific. However, taking the original description and some specimens of *G. yokusai* and *G. tenuissima* into consideration, the size-range of plants and flowers of *G. tenuissima* is obviously smaller than that of *G. yokusai*. In addition, *G. tenuissima* sometimes has 4-merous flowers but *G. yokusai* does not.



**Figure 19.** *Gentiana tentyoensis* Masamune. 1, Habit; 2, Cauline leaf, abaxial view; 3, Calyx; 4, Corolla and stamens; 5, Enlarged corolla-lobes; 6, Stamens; 7, Capsule; 8, Seeds. (C. H. Chen 930).



**Figure 20.** *Gentiana tenuissima* Hayata. 1, Habit; 2, Cauline leaf, abaxial view; 3, Calyx; 4, Corolla and stamens; 5, Enlarged corolla lobes; 6, Stamens; 7, Pistil; 8, Capsule; 9, Seeds. (C. H. Chen 1196).

## Excluded species

**1. *Gentiana loureirii*** (G. Don) Grisebach, in A. DC., Prodr. 9: 108. 1845; Yamamoto, J. Soc. Trop. Agric. 8: 71. 1936; Liu & Kuo, Bull. Exp. Forest Natl. Taiwan Univ. 114: 183, pl. 8. 1974; Liu & Kuo in Li *et al.*, Fl. Taiwan 4: 174. 1978; Ho, Fl. Reipubl. Popul. Sin. 62: 254. 1988; Ying, Quart. J. Exp. Forest Natl. Taiwan Univ. 3(2): 92. 1989; Ho & Pringle in Wu & Raven, Fl. China 16: 97. 1995.

*Notes.* Hayata (1908) recorded *Gentiana humilis* Stev. with distributions in Yushan, Alishan and Nengkaoshan. Yamamoto (1936) compared these specimens collected from Alishan with specimens of *G. humilis* Stev. deposited in herbarium of New York Botanical Garden. He recognized that the former is different from the latter but similar to *G. loureirii* (G. Don) Grisebach which is distributed in the southeast part of mainland China. The treatment of Yamamoto was adopted by Liu & Kuo (1974, 1978), Ho (1988), Ying (1989), and Ho & Pringle (1995). The authors did not find the specimen (collected by T. Shikano on Pingtung Hsien, Tawushan in March 1929, in TAI herbarium cited by Liu & Kuo (1974), or any specimen similar to *G. loureirii* in Taiwanese herbaria. Prof. Ho also agrees that this species does not occur in Taiwan (pers. comm.).

**2. *Gentiana manshurica*** Kitagawa, Bot. Mag. (Tokyo) 48: 103. 1934; Ho & Pringle in Wu & Raven, Fl. China 16: 54. 1995.

*Notes.* The species is distributed in mainland China and Korea (Ho, 1988). Nevertheless, Ho & Pringle (1995) mentioned that this species also occurred in Taiwan. After a thorough examination of specimens in Taiwanese herbaria, we did not find any specimen similar to this species. Prof. Ho agrees this species does not occur in Taiwan recently (pers. comm.).

**3. *Gentiana yakushimensis*** Makino, Bot. Mag. (Tokyo) 23: 252. 1909; Ho, Fl. Reipubl. Popul. Sin. 62: 82. 1988; Ho & Pringle in Wu & Raven, Fl. China 16: 43. 1995. (type: Prov. Osumi: Summit of Mt. Miyanouradake in Yakushima, Sep 1909, *Y. Kudo s. n.*, TAI!)

*Notes.* Ho (1988) recorded the occurrence of the species in Taiwan, based on a specimen at PE (No. 81854). The first author examined this specimen cited by Ho. It was a specimen stamped as from Taiwan, but without collection label. However, there is no other specimen collected from Taiwan except the type specimen at TAI, which was collected from Japan.

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## 台灣龍膽屬之分類訂正

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本文依據外部形態之詳細研究對台灣產龍膽屬植物進行分類訂正，結果將台灣產種類區分為十一種及二變種，除台灣龍膽 (*Gentiana davidii* var. *formosana* T. N. Ho) 外，其餘均為台灣特有种；本研究發現二新種—高雄龍膽 (*G. kaohsiungensis* C. H. Chen & J. C. Wang) 及太魯閣龍膽 (*G. tarokoensis* C. H. Chen & J. C. Wang)，以及一新變種—無葉湖龍膽 (*G. flavomaculata* var. *yuanyanghuensis* C. H. Chen & J. C. Wang)；將狹瓣龍膽 (*G. taiwanica* T. N. Ho = *G. angusta* (Masamune) Liu & Kuo) 併入玉山龍膽 [*G. scabrida* Hayata var. *scabrida*]，將原先台灣植物誌記載為排除種之高氏龍膽 (*G. kaoi* Shimizu) 併併為厚葉龍膽 (*G. textyocensis* Masamune)；另將以往文獻曾記載產於台灣之盧氏龍膽 (*G. loweirii* Griseb.)、傅華龍膽 (*G. maxshurica* Kitagawa) 及台灣輪葉龍膽 (*G. yakushimensis* Makino) 處理為排除種。本研究顯示花萼裂片的形狀以及花冠筒的顏色，提供台灣產種類重要之分類依據，本文並提供種之檢索表，各分類群的描述、繪圖、地理分布及分類註釋。

關鍵詞：龍膽屬；龍膽科；分類訂正；植物分類；台灣。