

Gentiana bambuseti (Gentianaceae), a new species from Taiwan

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ABSTRACT. *Gentiana bambuseti* T. Y. Hsieh, T. C. Hsu, S. M. Ku & C.-I. Peng, a new species from Taiwan, is described and illustrated. This new species resembles *G. zollingerii* Fawcett, differing in the radical leaves not cordate, flowers shorter (ca. 9-12 mm long); branches from middle or above; lower half of stem simple and leafless; leaf margins cartilaginous and scabrescent; and apex of calyx lobes aristate-acuminate. This species occur spradically in the Alishan Range at 1,400-1,700 m altitude in central Taiwan. It is remarkably distinct from all congeners in Taiwan in the long, simple, leafless stem base. A somatic chromosome number of $2n = 60$ was determined and the karyotype was analyzed for *G. bambuseti*. A color plate, line drawings, distribution map, and SEM microphotographs of seeds and pollen are documented for this new species. *Gentiana bambuseti* is highly vulnerable to heavy disturbance during harvesting in the bamboo forests.

Keywords: Chromosome cytology; *Gentiana bambuseti*; *Gentiana zollingerii*; Karyotype analysis; New species; Rare species; Taiwan; Taxonomy.

INTRODUCTION

Gentiana, the largest genus of Gentianaceae, contains about 360 species, mainly in temperate Asia but also common in Europe and North America (Ho and Liu, 2001). Gentians are traditionally used as herbal medicines in Taiwan and mainland China. Many of them bear attractive flowers of great horticultural value. Eleven species and two additional varieties of *Gentiana* are known in Taiwan (Wang and Chen, 1998; Chen and Wang, 1999), mainly in grasslands on high mountains (to 3,900 m). All but one variety are endemic. Shortly after the treatment of Gentianaceae was published in the 2nd edition of Flora of Taiwan (Wang and Chen, 1998), *Lomatogonium chilaiensis*, representing a newly recorded genus and a new species (Chen and Wang, 2000), and *Tripterospermum lilungensis*, a new species (Chen et al., 2006), were reported from this island.

During our botanical surveys in 2006, we collected a unique *Gentiana* that was not identifiable to any species known in Taiwan. After consulting relevant floras and literature (Hayata, 1908, 1917; Yamamoto, 1936; Masamune, 1943; Liu and Kuo, 1970, 1978; Ho, 1988; Ying, 1989; Chen and Wang, 1999; Ho and Pringle, 1995; Ho and Liu, 2001; Li et al., 2001) and abundant herbarium specimens, we are convinced that it is a new species, which we describe and illustrate here.

NEW SPECIES

Gentiana bambuseti T. Y. Hsieh, T. C. Hsu, S. M. Ku & C.-I. Peng, sp. nov.—TYPE: TAIWAN. Chiayi County, Chuchi Hsiang, Fenchihu, in bamboo forests, ca. 1,500 m, 5 Feb 2006, *Tung-Yu Hsieh 101* (holotype: HAST; isotypes: A, MO). 竹林龍膽 Figures 1, 2

Haec species affinis *Gentianae zollingerii* Fawcett, sed differt herba bienni, foliis basi haud cordatis, margine scabris et cartilaginosis (vs. anguste membranaceis), floribus minoribus, ca. 9-12 mm (vs. 14-17 mm) longis, caule a medio (vs. basi) ramoso, inferne aphylo (vs. folioso), calicis lobis apice aristato-acuminatis (vs. acutis).

Biennial herb. Roots fibrous, dark brown. Stem solitary; lower part covered by leaf litter on bamboo forest floor, simple, leafless, glabrous, whitish, 3-14 cm long, 0.8-1.5 mm across; upper stem erect, 2.5-5 cm long, glabrous, simple to much branched from middle, internodes short, distally with many leaves. Leaves fringed, margins white cartilaginous, apex aristate-acuminate, cartilaginous, scabrous; lower leaves larger, suborbiculate to elliptic, 1.5-2.3 cm long, 1-1.3 cm wide; upper leaves gradually smaller, narrowly elliptic, lanceolate or linear-oblancheolate, to 2 cm long. Inflorescences terminal and axillary, dense, capitulum-like or sometimes cyme-like. Flowers (1-)3-9(-13), subsessile; calyx tube tubular-campanulate, ca. 6 mm long, costae 4 or 5, scabrescent; calyx lobes 4 or 5, ca. 2.5 mm long, 1 mm wide, lanceolate, margins slightly scabrous, cartilaginous, apex

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aristate-acuminate; corolla urceolate-tubular, 9-12 mm long, 4- or 5-lobed, lobes triangular, ca. 1.5 mm long, apex of lobes white tinged blue or bluish, apex aristate-acuminate; margins of plicae entire, apically 2-cleft or erose. Stamens 4 or 5, anthers lanceolate, ca. 1 mm long, light yellow, filaments 5-6 mm long, attached slightly

above base of corolla tube. Ovary shortly stipitate, obovoid-ellipsoid, ca. 5-5.5 mm long, 1.3-3 mm wide; style ca. 2 mm long; stigma bifurcate and spirally recurved at anthesis. Capsules obovoid to ellipsoid, 10-11 mm long, 2-valved, with obscure serrulate wings along sutures, exerted beyond persistent corolla. Seeds numerous, ovoid,

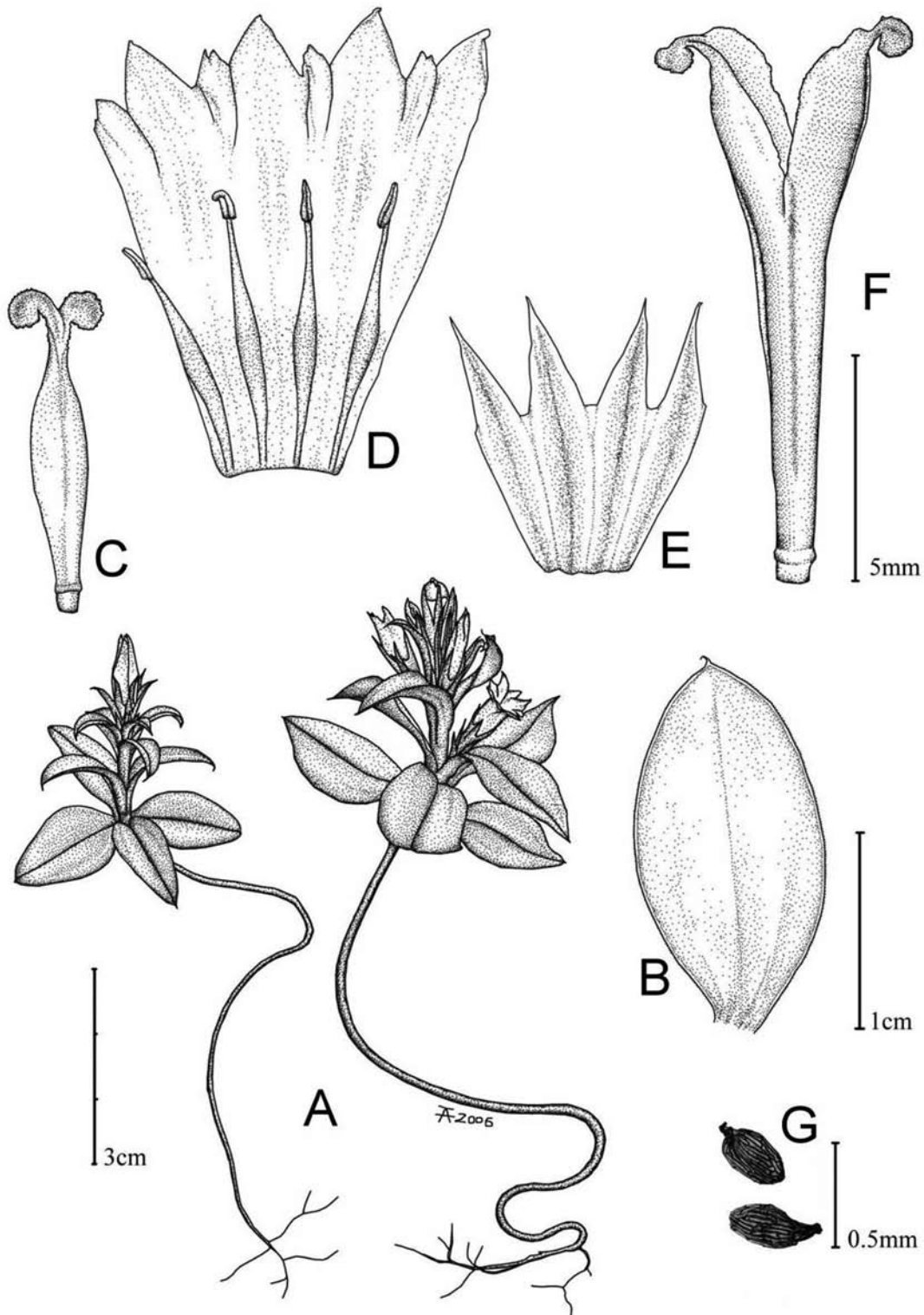


Figure 1. *Gentiana bambuseti*. A, Habit; B, Leaf; C, Pistil; D, Corolla and stamen; E, Calyx; F, Dehiscent capsule; G, Seeds.

minutely longitudinally reticulate, 0.4-0.45 mm long, 0.2-0.25 mm wide, dark brown.

Additional specimens examined. TAIWAN. CHIAYI HSIEN: Meishan Hsiang, Reili, in bamboo forest, ca. 1,450 m, 5 Feb 2006, *Tung-Yu Hsieh 118* (HAST); Fen-Rui Ancient Trail, in bamboo forest, ca. 1,600 m alt., 5

Feb 2006, *Tien-Chuan Hsu 394* (TAIF); Meishan Hsiang, Changshuhu, in bamboo forest, ca. 1,650 m alt., 9 Apr 2006, *Tung-Yu Hsieh 541* (HAST); in bamboo forest, ca. 1,600 m alt., 9 Apr 2006, *Tien-Chuan Hsu 875* (TAI); Chuchi Hsiang, Chicho, in bamboo forest, ca. 1,450 m alt., 25 Dec 2006, *Tung-Yu Hsieh 932* (HAST); same loc., *Tien-*

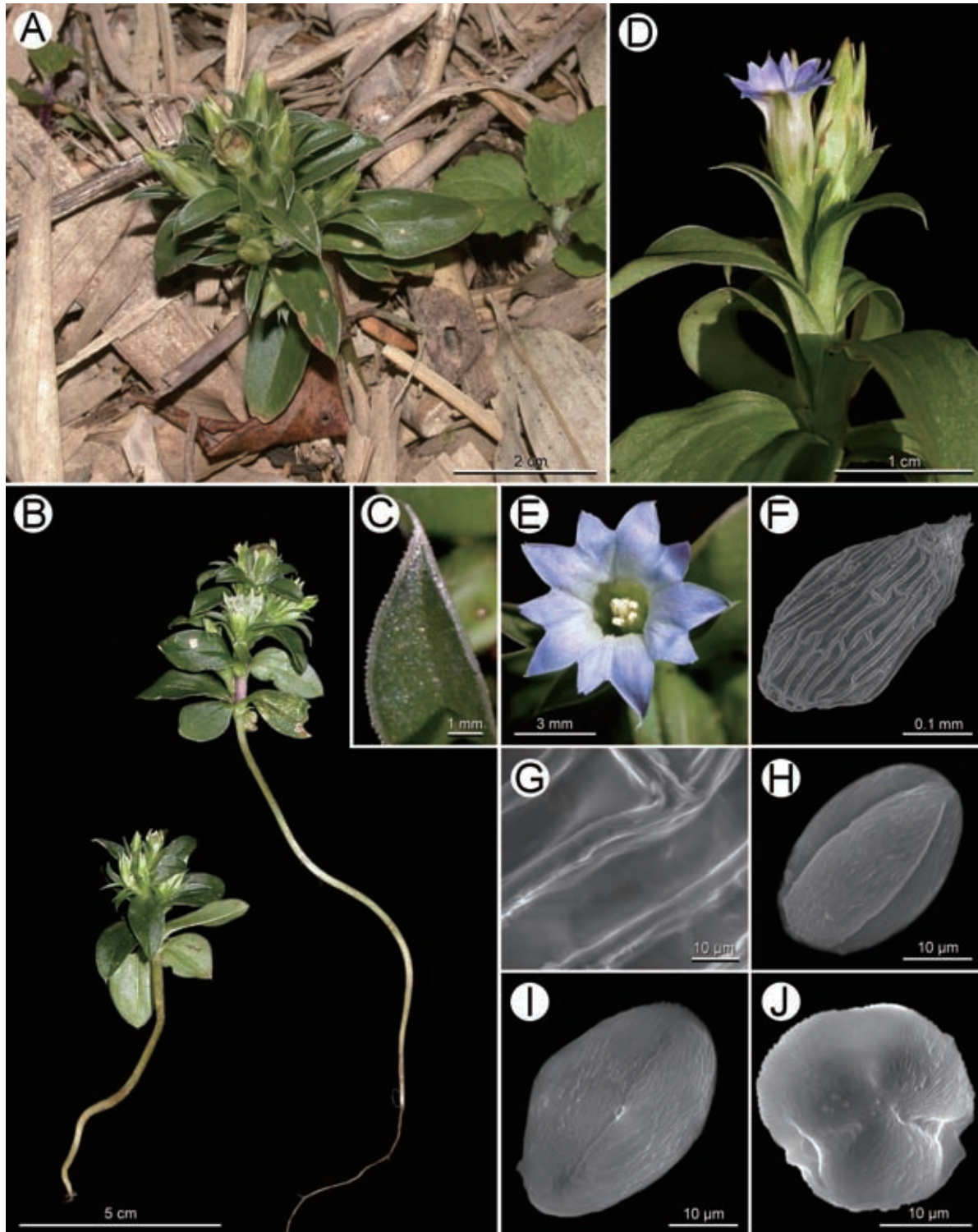


Figure 2. *Gentiana bambuseti*. A, Habit and habitat; B, Whole plants; C, Leaf, showing the scaberrulous margin with white-colored fringe, and aristate-acuminate apex; D, Upper portion of a flowering plant; E, Flower, viewed from above. F, G, Seed, SEM microphotograph; H-J, Pollen, SEM microphotograph.

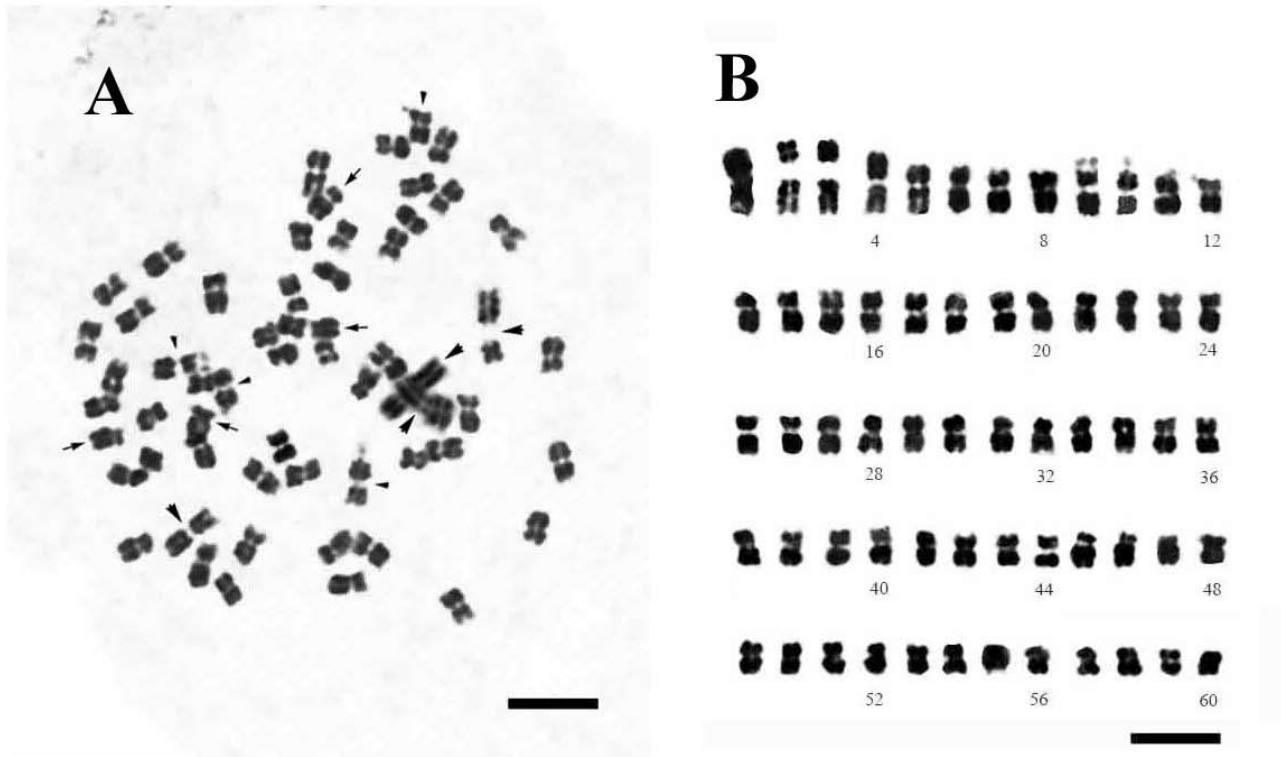


Figure 3. Somatic chromosomes at mitotic metaphase in *Gentiana bambuseti* ($2n = 60$). A, Large arrowheads indicate longer metacentric chromosomes. Small arrowheads indicate metacentric chromosomes with satellites. Arrows indicate submetacentric chromosomes. Scale bar = 5 μm . B, Serial arrangement of chromosomes at mitotic metaphase by chromosome length. Scale bar = 5 μm .

Chuan Hsu 876 (TAIF); Alishan Hsiang, Huti, in bamboo forest, ca. 1,550 m alt., 25 Dec 2006, *Tung-Yu Hsieh 939* (HAST); Alishan Hsiang, Dinhu, in bamboo forest, ca. 1,660 m alt., 31 Dec 2006, *Tung-Yu Hsieh 945* (HAST). NANTOU COUNTY: Hsinyi Hsiang, Hoshe, ca. 3 km to Shenmu village, in bamboo forest, ca. 1,650 m alt., 28 Dec 2006. *Tung-Yu Hsieh 943* (HAST).

Pollen morphology. Pollen grains of *Gentiana bambuseti* are prolate in equatorial view, trilobate-circular in polar view, 36–38 \times 23–26 μm , 3-colporate, colpi long, narrow, with obscurely thickened margins.

Etymology. The specific epithet ‘*bambuseti*’ means ‘dweller in bamboo forest’.

Phenology. Seedlings appearing late July. Flowering October to May; fruiting November to June.

Chromosome Cytology. For chromosome observations, pretreatment, fixation and staining of chromosomes followed Oginuma and Nakata (1988). Classification of chromosome morphology on the basis of the position of centromere followed Levan et al. (1964). Somatic chromosomes at mitotic metaphase of *Gentiana bambuseti* are $2n = 60$, showing a bimodal karyotype (Figure 3). Four of the 60 chromosomes have median centromeres and are longer (ca. 3.3–3.8 μm) than the rest of the chromosomes in the complement. The remaining 56 chromosomes, ranging from 1.3 to 2.7 μm long, show a gradual change in length. Of the 56 chromosomes, four have submedian centromeres

and the rest have median centromeres. Satellites were observed in the distal regions of the short arms of four metacentric chromosomes. The karyotype formula is $2n = 60 = 52m + 4m^{\text{SAT}} + 4sm$ (Figure 3). The chromosome complement with $2n = 60$ contains a set of four longer chromosomes in addition to sets of four submetacentric and metacentric chromosomes with satellites, which suggests that *G. bambuseti* may be a tetraploid derived from a diploid with $2n = 30 = 26m + 2m^{\text{SAT}} + 2sm$.

In *Gentiana* section *Chondrophyllae* (163 species: Ho and Liu, 2001) to which this new species belongs (see below), somatic chromosome numbers of $2n = 12, 14, 18, 20, 24, 26, 32, 36, 38, 40, 44, 48, 60, 72, 76, 96-98$ have been reported (Chuang et al., 1962; Löve and Löve, 1975; Shigenobu, 1982; Küpfer and Yuan, 1996; Ho et al., 1997; Yuan et al., 1998; Ho and Liu, 2001). Species with $2n = 30$, however, has not been reported so far for any member of this section. A somatic chromosome number of $2n = 60$ was known only for one species, *G. micantiformis* (Yuan et al., 1998), but its karyotype was not reported. In sect. *Chondrophyllae*, karyotypes of species with $2n = 20$ have been reported as $2n = 20 = 18m + 2sm$ for *G. haynaldii*; $2n = 20 = 18m + 2m^{\text{SAT}}$ for *G. alsinoides*, *G. anisostemon*, *G. asterocalyx*, *G. prattii*, *G. spathulifolia*; $2n = 20 = 16m + 2m^{\text{SAT}} + 2sm$ for *G. pseudoaquitica*; $2n = 20 = 12m + 2sm^{\text{SAT}} + 6sm$ for *G. pseudosquarrosa* (Küpfer and Yuan, 1996; Yuan et al., 1998). Thus, although *G. bambuseti* ($2n = 60$) may be a tetraploid derived from $x = 15$ as stated

above, it is also possible that it represents a hexaploid derived from $x = 10$. After $2n = 60$ was established by polyploidization from complements such as $2n = 20 = 16m + 2m^{\text{SAT}} + 2sm$, chromosomal changes in the complement of $2n = 60$ may have been caused by translocation via chromosome fission and subsequent fusion, resulting in the $2n = 60 = 52m + 4m^{\text{SAT}} + 4sm$ in *G. bambuseti*. Further cytological studies are necessary to elucidate the chromosomal evolution in members of *Gentiana* sect. *Chondrophyllae*.

Distribution. Endemic to central Taiwan in the Alishan Range at 1,400–1,700 m (Figure 4). All populations were found on the floor of bamboo forests, a habitat different from the open alpine meadows where all other congeners in Taiwan are frequently encountered. The oversight of this new species over the years suggests the necessity of more thorough inventory in bamboo forests in Taiwan, which generally have poor biodiversity due to the allelopathic potential of bamboo vegetation (Chou and Hou, 1981). *Gentiana bambuseti* is highly vulnerable to heavy disturbance during harvesting in the bamboo forests.

Notes. According to the classification in Flora of China (Ho and Pringle, 1995), *Gentiana bambuseti* belongs to sect. *Chondrophyllae*, as do 10 of the other 11 species of *Gentiana* in Taiwan. Within section *Chondrophyllae*, *Gentiana bambuseti* resembles *Gentiana zollingerii* Fawcett, differing from the latter in the radical leaves never cordate, flowers smaller (9–12 mm vs. 14–17 mm long); branches from middle (vs. from base), with (vs. without) leafless lower stem, leaf margins scabrous cartilaginous (vs. narrowly membranous) and apex of calyx lobe aristate-acuminate (vs. acute). *Gentiana bambuseti*, characterized by the simple, leafless lower stem and upper stem with very short internodes and apically many-leaved, and with flowering branches crowded into a dense capitulum, is sharply distinct from all 11 known species of *Gentiana* in Taiwan. A detailed morphological comparison among *G. bambuseti*, *G. zollingerii* and related species is shown in Table 1.

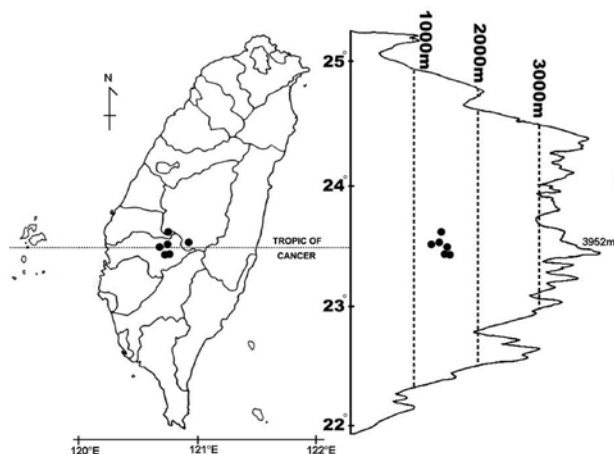


Figure 4. Distribution of *Gentiana bambuseti* (dots) in Taiwan.

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Table 1. Comparison of *Gentiana bambuseti*, *G. xingrenensis*, *G. alii*, *G. globosa*, *G. perpusilla*, *G. hesseltiana* and *G. zollingeri* (based mainly on Ho and Liu, 2001).

	<i>G. bambuseti</i>	<i>G. xingrenensis</i>	<i>G. alii</i>	<i>G. globosa</i>	<i>G. perpusilla</i>	<i>G. hesseltiana</i>	<i>G. zollingeri</i>
Habit	Biennial	Annual	Biennial	Annual	Annual	Annual	Annual
Stem	Glabrous	Glabrous	Pubescent	Glabrous	Glabrous	Glabrous	Glabrous
Branching position	Middle	Middle	Middle	Middle	Middle	Middle	Base
Lower stem	Leafless	Leafless	Leafless	Leafless	Leafless	Leafless	Leafy
Leaf							
Size (cm)	1.5-2.3×1-1.3	0.5-2×0.1-1.6	0.75-1.75×0.3-0.6	0.2-0.6×0.2-0.4	0.3-1×0.1-0.38	1-5×0.2-1.5	0.7-1.3×1.5-0.8
Margin	Scabrous cartilaginous	Cartilaginous	Cartilaginous	Distinctly cartilaginous	Cartilaginous	Cartilaginous	Narrowly membranous
Calyx lobe							
Shape	Lanceolate	Subulate	Oblong, reflexed	Suborbicular	Triangular	Narrowly triangular, subulate or ovate	Narrowly triangular to ovate-elliptic
Length (mm)	ca. 2.5	2.5-3	2.5-5	2-2.5	1-1.2	5-7	3.5-4.5
Margin	Slightly scabrous cartilaginous	Ciliate and cartilaginous	Cartilaginous	Markedly cartilaginous	Cartilaginous	Smooth and cartilaginous	Smooth and narrowly membranous
Apex	Aristate-acuminate	Acuminate and awned	Obtuse and mucronate	Rounded and cuspidate	Acute	Acute	Acute
Corolla							
Color	White tinged blue or bluish toward lobe apex	Pale yellow-green outside and pale blue inside	Blue to pale blue	Blue with a pale yellow-white base	Pale blue to blue	Blue	Pale blue with pale yellow base
Length (mm)	9-12	8-10	8-12	8-10	5-9.5	14-15	14-17
Seed							
Shape	Ovoid	Data not available	Data not available	Data not available	Ovoid-ellipsoid	Fusiform to ellipsoid	Ellipsoid
Size (mm)	0.4-0.45×0.2-0.25	Data not available	Data not available	Data not available	0.75×0.5	0.4-0.6	0.3-0.5
Chromosome number	2n = 60	Data not available	Data not available	Data not available	Data not available	Data not available	2n = 20
Distribution	Taiwan	China	Pakistan	China; Nepal	Mexico	Thailand; Vietnam	China; E. Russia; Korea; Japan

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台灣產龍膽屬新種植物—竹林龍膽

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本文描述台灣產龍膽屬植物一新種—竹林龍膽 (*Gentiana bambuseti* T. Y. Hsieh, T. C. Hsu, S. M. Ku & C.-I. Peng)。本新種略似東亞產之筆龍膽 (*G. zollingerii* Fawcett)，不同在於竹林龍膽下部莖單一而無葉，莖上部分枝；葉片基部非心形，葉緣具細粗糙狀軟骨邊；花較小，長約 9-12 mm；萼裂片先端為芒狀漸尖。竹林龍膽具單一且無葉的下部莖，易與台灣其他龍膽物種區別。本文提供竹林龍膽的彩色圖版、線繪圖、分布圖以及花粉和種子的電顯圖；報導其體染色體數 ($2n = 60$)，並經由核型分析探討可能之多倍體起源。竹林龍膽相當稀有，目前僅知零星分布於中台灣阿里山山區海拔約 1,400-1,700 m 的竹林邊緣，受到人工採收竹筍的嚴重干擾。

關鍵詞：染色體細胞學；竹林龍膽；筆龍膽；核型分析；新種；稀有植物；台灣；分類學。

