

# *Phacellanthus* (Orobanchaceae), a newly recorded genus in Taiwan

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**ABSTRACT.** A heretofore unrecorded holoparasite *Phacellanthus tubiflorus* Siebold & Zucc. (Orobanchaceae) was recently discovered in Taiwan. It represents a new genus for the island and is distinguishable from related holoparasitic taxa such as *Aeginetia*, *Christisonia*, *Boschniakia*, and *Orobanche* by a combination of characters: stems with many scale-like leaves, inflorescence subcapitate or subcorymbose with 4-6 flowers, corolla white, and elongate, slender corolla-tube. *Phacellanthus tubiflorus* is rare on Taiwan, with no more than two dozen individuals occurring in the cloud zone of a mixed *Chamaecyparis*/broadleaved forest at 1,800-2,000 m elevation. This paper provides a taxonomic account of *Phacellanthus* and illustrations to aid in identification.

**Keywords:** Holoparasitic plant; New Record; Orobanchaceae; *Phacellanthus tubiflorus*; Rare plant; Taiwan.

## INTRODUCTION

*Phacellanthus* (Orobanchaceae) comprises a single holoparasitic species, *P. tubiflorus* Siebold & Zucc., distributed in eastern China, Japan, Korea, and Russia (Tuyama, 1947; Zhang and Tzvelev, 1998). During one of our recent botanical surveys, *P. tubiflorus* was discovered in the northern part of the Central Mountain Range in northeastern Taiwan. Our collection represents the first discovery for both the genus and species for Taiwan, and a southern range extension from Japan. We hereby provide a taxonomic account of this rare species, which was unknown

when the Flora of Taiwan (Yang and Lu, 1998; Boufford et al., 2003) was published. Since the completion of the six volumes of the Flora of Taiwan, 2<sup>nd</sup> edition, many additional genera, unknown from Taiwan at the time, have been discovered, e.g. *Lomatogonium* (Gentianaceae; Chen and Wang, 2000), *Thismia* (Burmanniaceae; Yang et al., 2002), *Saccolabiopsis* (Orchidaceae; Chung et al., 2006), *Phryma* (Phrymaceae; Jung et al., 2005), and *Chikusichloa* (Poaceae; Jung et al., 2007). Such discoveries provide evidence for the importance of sustained inventory in areas not easily accessible or rarely botanized.

## Key to holoparasitic species of Orobanchaceae in Taiwan

1. Calyx spathe-like; pedicels more than 5 cm long ..... *Aeginetia indica*
1. Calyx absent or 5-lobed, not spathe-like; pedicels less than 2 cm long.
  2. Stems usually above ground; inflorescence spicate or racemose, borne well above soil surface.
    3. Plants villose; lower lip of corolla subequal to upper lip; stamens included in corolla ..... *Orobanche coerulescens*
    3. Plants glabrous; lower lip of corolla much shorter than upper lip; stamens exerted from corolla.....  
..... *Boschniakia himalaica*
  2. Stems usually underground; inflorescence subcapitate or subcorymbose, near soil surface.
    4. Calyx absent; corolla tube 2.8-3.2 cm long, 2.5-3 mm across; fertile stamens 4 ..... *Phacellanthus tubiflorus*
    4. Calyx lobes 5, persistent; corolla tube 4-6 cm long, 4-5 mm across; fertile stamens 2..... *Christisonia hookeri*

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## MATERIALS AND METHODS

Fresh materials of *Phacellanthus tubiflorus* were collected from Taiwan. Voucher specimens have been preserved in the Herbarium of Taiwan Forestry Research Institute (TAIF).

### Scanning electron microscopy

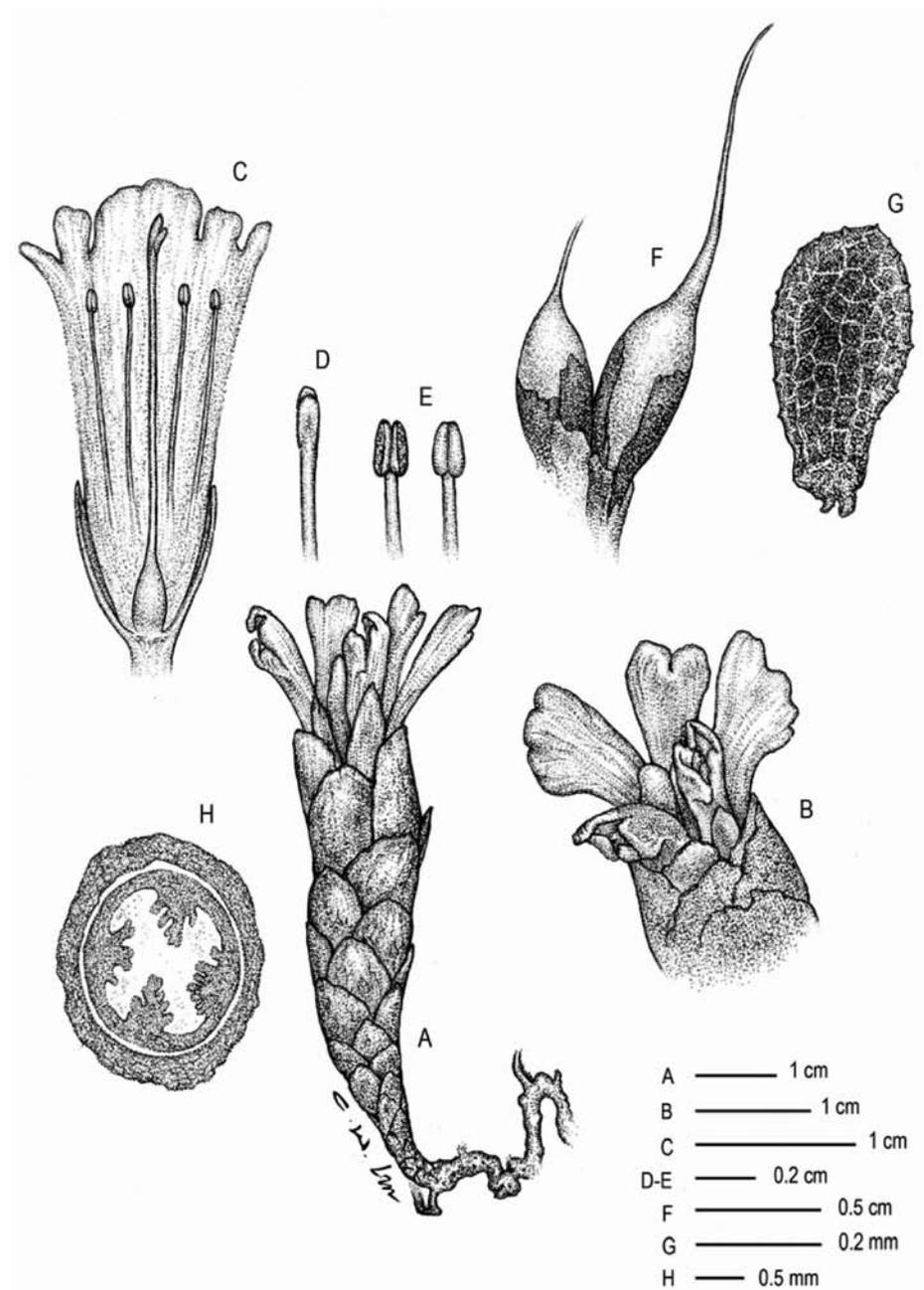
Samples were fixed in FAA (18:1:1—50% ethanol, glacial acetic acid, formalin). After dehydration in an alcohol-acetone series, samples were critical point dried, sputter coated with platinum, and observed under a scanning electron microscope with an accelerating voltage of 18 kV.

### Light microscopy

Samples were dissected and gradually dehydrated in an alcohol/tert-Butanol series, slowly infiltrated/embedded in paraffin, and then sectioned on a microtome. Sections (8  $\mu$ m) were stained with Safranin O/Fast Green and examined/imaged on a Leica compound microscope.

### Karyology

Root tips were pretreated for 3-4 h in a mixture of 70 ppm cycloheximide and 250 ppm 8-hydroxyquinoline (1:1) at 18-20°C. They were then fixed for 1-3 h in a mixture of 45% acetic acid and absolute ethanol (1:3) at about 20°C, then preserved in 70% ethanol at 4°C. They



**Figure 1.** *Phacellanthus tubiflorus*. A, Habit; B, Inflorescence; C, Flower, dissected; D, Pistil, upper portion; E, Stamens; F, Capsules; G, Seed; H, Corolla and ovary, cross section showing parietal placentation.

were macerated for 1-3 min in 1 M HCL at 60°C, washed for 10 s, and then digested for 1-2 h in 4% pectinase. Finally, the root tips were squashed in modified Sharma's solution (Sharma, 1982). Chromosome spreads were observed under a Leica compound microscope.

### Species description

***phacellanthus tubiflorus*** Siebold & Zucc., Abh. Mat.-Phys. Baier. Akad. Wiss. 4(3): 142. 1846; Zhang and Tzvelev, Fl. China 18: 243. 1998; Wu and Raven, Fl. China Illstr. 18: 267. f. 267. 2000. 黃筒花 Figures 1, 2  
*Phacellanthus continentalis* Komarov, Bull. Acad. Sci. URSS 7: 267, f. 1-4. 1930. *Tienmuia triandra* Hu, Bull. Fan. Mem. Inst. Biol. Bot. 9: 6. 1939.

Herbs, perennial, holoparasitic. Stem terete, glabrescent, solitary, unbranched, 4-8 cm long. Leaves scale-like, spirally arranged, ovate to ovate-triangular, involute, margin slightly membranous, apex acute or obtuse, 5-20 mm long, glabrous. Inflorescence subcapitate or subcorymbose, 4-6-flowered. Bracts scale-like, elliptic, entire or fringed, apex rounded, white, 20-25 mm long, 7-12 mm wide, glabrous. Corolla white, tubular, bilabiate, usually curved, glabrous; tube slender, 28-32 mm long, 2.5-3 mm across; upper lip orbicular, ca. 4 mm long; lower lip ca. 3 mm long, deeply 3-lobed, lobes elliptic, obtuse. Stamens 4, included, adnate to lower half of corolla tube, 10-16 mm long, glabrous, anthers ovate, ca. 1 mm long, 2-locular. Style filiform, 10-20 mm long, glabrous. Ovary superior, ellipsoid-globose, ca. 4 mm long; placentas 4,



**Figure 2.** *Phacellanthus tubiflorus*. A, Habit and habitat; B, Root; C, Flowering individual; D, Fruiting individual; E, Habit and fruits; F, seed; G, H, Pollen SEM microphotographs. Scale bar equals 1 cm in A-E and 200  $\mu$ m in F-H.

parietal; ovules numerous. Capsule ellipsoid, apex acute, ca. 7 mm long, 4 mm across, glabrous; style persistent. Seeds minute, ovoid, testa reticulate.

**Distribution.** Russia (Far East), China (Gansu, Hubei, Hunan, Jilin, Shaanxi, Zhejiang), Japan, Korea (Zhang and Tzvelev, 1998). Our collection represents a new record for both the genus and the species in Taiwan, and a southern range extension (Figure 3).

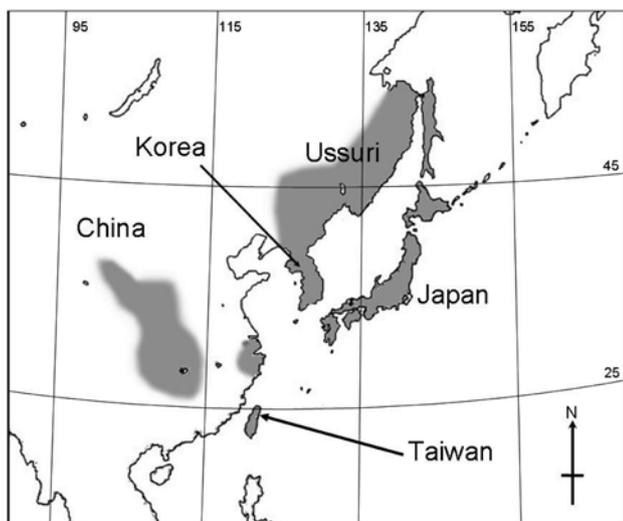
**Specimen examined.** TAIWAN. Ilan Co., Tatong Township, Taipingshan, Santieh Waterfall. 5 June 2005, S. W. Chung and T. C. Hsu 9897 (TAIF).

**Phenology.** Flowering in early June; fruiting from June to July.

**Habitat and ecology.** *Phacellanthus tubiflorus* was recently discovered in the northern part of the Central Mountain Range in northeastern Taiwan. It occurs in the cloud zone in a mixed *Chamaecyparis*/broadleaved forest at 1,800-2,000 m elevation and is apparently very rare (Figure 4). No more than two dozen individuals were found on slopes and along trails. In addition to its rarity, *Phacellanthus* may have escaped attention because of its small size, seasonality, resemblance to a fungus and specific microhabitat requirements. The host of the parasite in Taiwan is *Machilus pseudolongifolia*, *Fraxinus* spp. on the Chinese mainland (Zhang and Tzvelev, 1998) and *Ulmus lacinata*, *Cornus controversa*, *Morus bombycis*, *Kalopanax ricinifolium* and *Picrasma quassioides* in Japan (Matsuura and Toyohuku, 1937) have also been reported as hosts.

**Pollen and seed morphology.** Pollen tricolpate, subglobose, 300-310  $\mu\text{m}$  in polar axis and 320-330  $\mu\text{m}$  in equatorial diameter (Figure 2G, H). Seed ovoid, testa reticulate (Figure 2F).

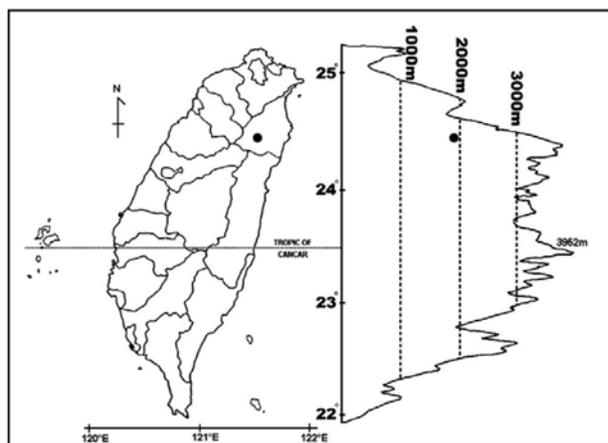
**Floral anatomy.** Inflorescence 4- to 6-flowered; ovary unilocular with 4 parietal placentas; ovules numerous (Figure 5).



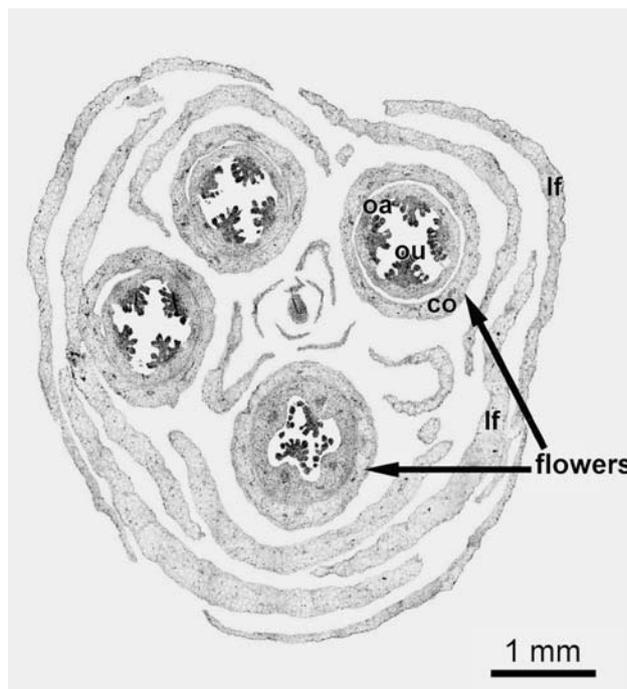
**Figure 3.** Global distribution of the genus *Phacellanthus* (Asia, in shade).

**Chromosome number.** Cytological examination of somatic chromosomes of *Phacellanthus tubiflorus* in Taiwan revealed  $2n = 42$  (Figure 6). Gametic chromosome numbers of  $n = 19, 21, 26, 35, 38, 39$  and  $42$  were reported for various populations from Japan (Matsuura and Toyohuku, 1937). *Phacellanthus tubiflorus* appears to be highly polymorphic karyologically.

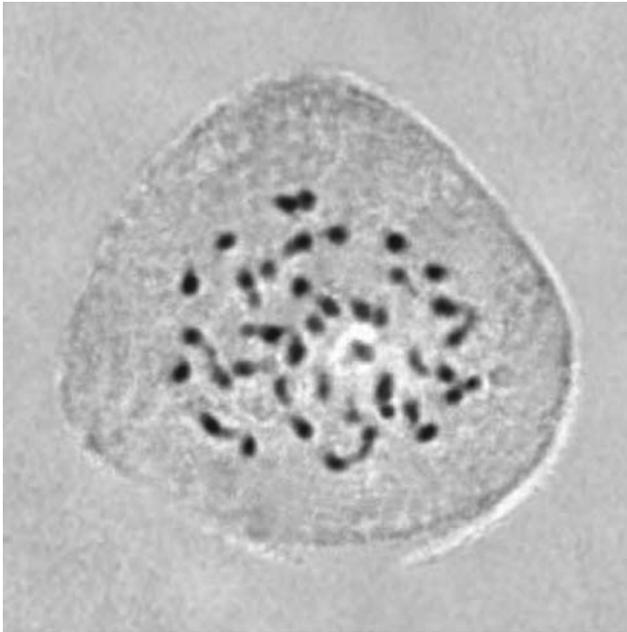
**Morphological Notes.** The morphology of the plants in Taiwan does not conform well to descriptions of *Phacellanthus tubiflorus* from mainland China (Zhang and Tzvelev, 1998) and Japan (Yamazaki, 2003). Yamazaki (2003) described the Japanese plants as having densely puberulent stems, but the stems of the plants from Taiwan are



**Figure 4.** Distribution and altitudinal maps of *Phacellanthus tubiflorus* (●) in Taiwan.



**Figure 5.** *Phacellanthus tubiflorus*. Inflorescence, cross section. lf = Leaf; co = Corolla; oa = Ovary; ou = Ovules.



**Figure 6.** *Phacellanthus tubiflorus*. Somatic chromosomes at metaphase,  $2n = 42$ .

glabrous. The stamen filaments are sparsely pubescent basally in mainland plants (Zhang and Tzvelev, 1998) while they are glabrous in Taiwan. Considering the diversity of chromosome numbers and the wide geographic distribution of *P. tubiflorus* in Asia (Takasi, 1947), we are inclined to treat the plants from Taiwan as conspecific.

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## 台灣新記錄屬植物：黃筒花屬

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本文描述台灣新記錄之列當科寄生植物黃筒花 (*Phacellanthus tubiflorus* Siebold & Zucc.)；黃筒花屬 (*Phacellanthus*) 亦為台灣之新記錄屬。本文並報導其花部解剖及種子、花粉顯微構造與染色體數 ( $2n = 42$ )。黃筒花之族群發現於台灣東北部中海拔針闊葉樹混合林，其植株密被多數鱗狀葉，花序繖房狀，花 4-6 朵，白色，花筒細長管狀，而與台灣列當科其他全寄生植物如：野菰屬 (*Aeginetia*)，草蓯蓉屬 (*Boschniakia*)，假野菰屬 (*Cistanche*) 和列當屬 (*Orobanche*) 容易區別。

**關鍵詞：**全寄生植物；新記錄屬；列當科；黃筒花屬；黃筒花；稀有植物；台灣。