



New addition and a review of *Neottia* in Taiwan

Fang-Mei HSIEH¹, Ching-Hwang LIU², Tsan-Piao LIN^{3,*}

1. Sanxing Elementary School, no. 55, Chencuoliao, Minxiong Township, Chiayi County, Taiwan. Email: juliya5088@gmail.com, 2. Chinese Culture Univ., Dept. of Atmospheric Sciences, No. 55, Hua-Kung Road, Taipei, Taiwan. Email: ching_hwang@yahoo.com, 3. Institute of Plant Biology, National Taiwan University, 1 Roosevelt Rd., Sec. 4, Taipei 106, Taiwan. *Corresponding author's emails: tpl@ntu.edu.tw

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ABSTRACT: A new orchid species of Taiwan, *Neottia ruisuiensis* T.P. Lin., is described and illustrated. A brief taxonomical review of all other species, and a dichotomous key for *Neottia* in Taiwan is presented. Also, an appraisal on the *Neottia* phylogeny, possible species hybridization and intraspecific variations are discussed.

KEY WORDS: *Listera*, *Neottia hohuanshanensis*, *Neottia nankomontana*, *Neottia ruisuiensis*, new species, Orchidaceae, Taiwan.

INTRODUCTION

The genus *Neottia* Guett. (including *Listera* R.Br.), along with 5 other genera, belongs to the tribe Neottieae, which is the basal group of the large subfamily Epidendroideae (Chase *et al.*, 2015; Zhang *et al.*, 2023). According to the Plants of the World Online database (<https://powo.science.kew.org/about>), the native range of *Neottia* includes subarctic, temperate and partly tropical zones of the Northern Hemisphere within North America, Eurasia, and NW Africa. This genus includes 84 accepted species (POWO, 2024). More than 55% of them (48 species) were recorded in China (Jin and Li, 2007; Jin, 2014; Jin and Pang, 2016; Zhou *et al.*, 2016; Mu *et al.*, 2020; Chen and Jin, 2021; Cai *et al.*, 2023; Lei *et al.*, 2023; Wang *et al.*, 2023). Ten species of *Listera* and *Neottia* are known from Japan (Iwatsuki *et al.*, 2016). Fifteen species were reported in Taiwan (Lin, 2019), and 40% of them (6/15) were discovered in the last 15 years. The diversity of this genus in Taiwan may be largely explained by altitudinal speciation in different mountain systems. Some mountain systems may still harbor undescribed species belonging to this and other orchid genera. To the data, all species of *Neottia* which were described from Taiwan, were discovered on the western side of the Central Mountain Range (CMR), excluding the new species described here.

MATERIAL AND METHODS

The morphological description is based on plants collected from the wild in summer 2024. Floral morphological characteristics were examined under stereoscopic zoom microscope (The Greenough stereo microscope, Leica S8 APO, Germany) and measured with a caliper. Ecology and phenological data of the new species are based on field observations. Plants were collected from the mountain at about 2300 m, Ruisui township, Hualien

County, Taiwan. The voucher herbarium specimens were gathered by the authors and are housed at the herbarium of the Taiwan University (TAI, <https://tai2.ntu.edu.tw/>).

TAXONOMIC TREATMENT

Neottia ruisuiensis T.P. Lin, *sp. nov.* 瑞穗雙葉蘭 Fig. 1

Type: Taiwan: Hualien Co.: Ruisui, 2300 m, July 5, 2024, Fang-Mei Hsieh *s.n.* (holotype TAI289924).

Diagnosis: *Neottia ruisuiensis* differs from all other 15 species of this genus of Taiwan by the shape of its lip, which is oblanceolate in outline, with two acute lobes on its apex. Its possible closest relative is *N. hohuanshanensis*, which differs by rounded apex of the lip lobes and larger flowers. To some extent, new species is also similar to *N. nankomontana*, from which new species can be distinguished by much narrower opening of the distal part of the lip. Sepals, petals, column, stigma, anther and vegetative parts of new species are not diagnostic, being similar in appearance with many other species of *Neottia* in Taiwan.

Description: Terrestrial. **Stems** green, slender, arising from horizontal or vertical short rhizome, ridged, 7–11 cm long. **Roots** sparse, filiform, spreading horizontally. **Leaves** 2, opposite, ovate-triangular, 1.5–1.7 × 1.5–2.0 cm, acute, green, paler below. **Inflorescence** terminal, 5.0–8.5 cm long; scape green, minutely hairy; inflorescence rachis 2.5–3 cm long hairy, with 5–8 flowers. Floral bracts ovate-lanceolate, ca. 3 mm long, Pedicel and ovary 3–4 mm long, glabrous. **Flowers** greenish, ca. 1.1–1.3 cm long, 6.3–6.8 mm across, sepals and petals translucent; upper sepal lanceolate, 3–3.4 × 1.2 mm, acute or obtuse; lateral sepals obliquely falcate, 3.2–3.5 × 1.4 mm, obtuse; petals narrowly lanceolate, somewhat incurved, ca. 3.3 × 0.7 mm, acute or obtuse. **Lip** green, often with a fine light-greenish rim, oblanceolate in outline, cuneate at base, 6.5–8.5 × 3.7–4.0 mm, apex deeply 2-lobed; lobes slightly divergent, triangular, tapering to a pointed apex, ca. 2.4–2.7 mm long;

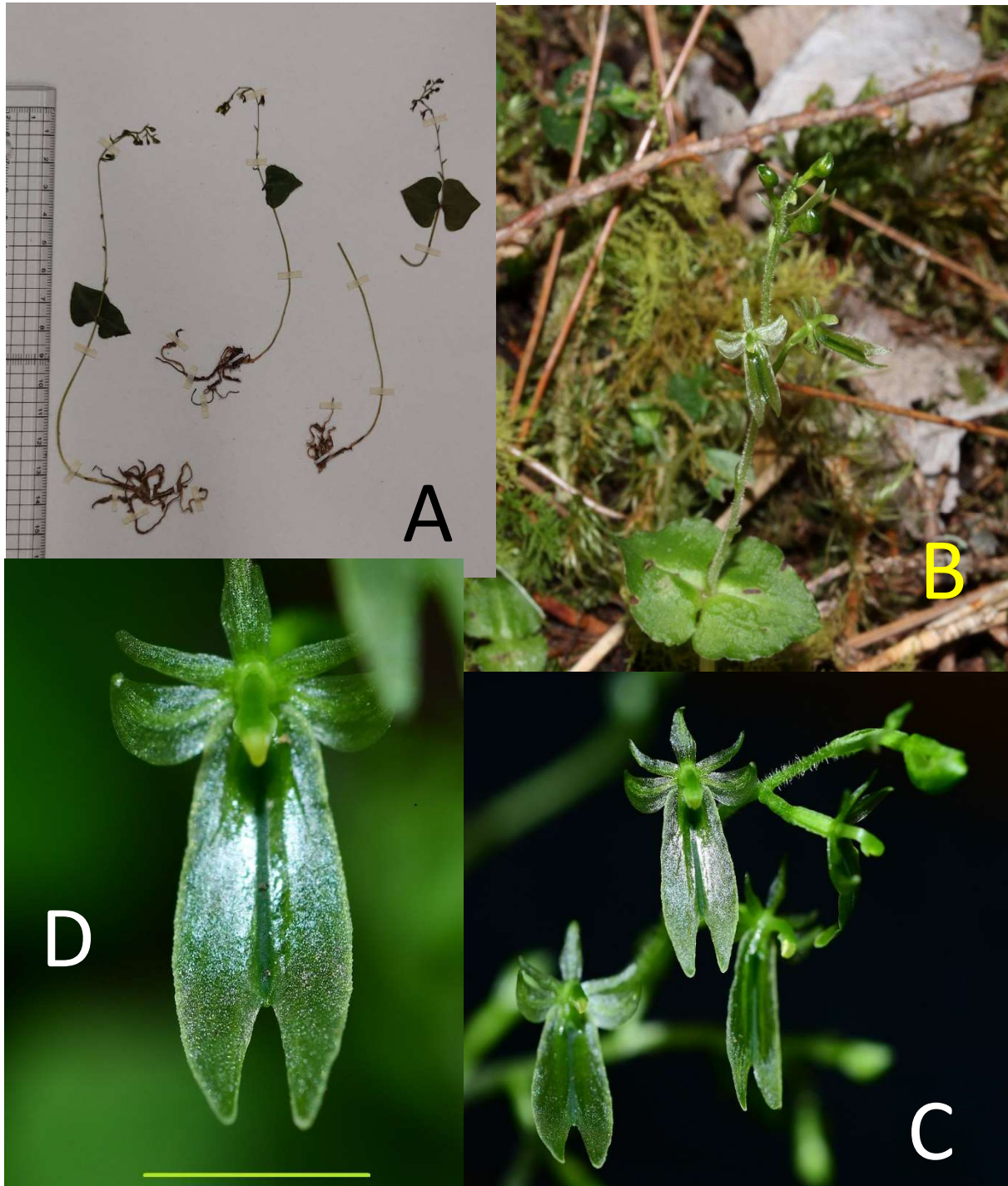


Fig. 1. *Neottia ruisuiensis* T.P. Lin. **A.** holotype TAI289924. Scale, 15 cm. **B & C.** Two individual plants in their native habitat. **D.** Frontal view of flower. Scale, 5 mm. A, Taken by Show-Yu Yang. B, Taken by Hsiao-Ling Su. C, D, Taken by Ching-Hwang Liu.

central disc with a linear dark-green thickened area, situated between 2 lustrous elevations. **Column** green, arcuate, ca. 2.5 mm long, semi-terete, apex slightly dilated. Rostellum protruding, nearly semicircular, whitish. Stigma flat and wide. Anther-cap ovate, firmly attached to column; pollinia 2, large, each bipartite, attached to a round viscidium.

Flowering time: June–July.

Distribution and Ecology: Endemic to Taiwan. Currently known from one locality only in Hualien County, at the eastern side of CMR facing the Pacific Ocean, at an elevation of about 2300 m. Found in a forest of *Chamaecyparis* and *Pinus*, on the slope or bank of a dried alpine creek where the stones are covered with moss.



Etymology: The specific epithet “ruisuiensis” refers to the name of locality where this species was found.

Notes: The only known population of *N. ruisuiensis* seems very small, with only a few individuals discovered.

DISCUSSION

A dichotomous key for *Neottia* of Taiwan

1. Mycoheterotrophic plants, lacking green color. *N. acuminata*
Autotrophic green plants 2
2. Column apex clearly differentiated into dilated hood; anther borne inside it 3
Column apex not forming a dilated hood; anther borne on apex of column. 5
3. Lip with small auricles not embracing column *N. suzukii*
Lip with distinct basal auricles and embracing column 4
4. Perianth not widely opening; lip lobes wide, 1–1.5 mm *N. atayalica*
Perianth widely open; lip lobes narrow, to 1 mm *N. japonica*
5. Lip with 2 small lateral lobes near base *N. pseudonipponica*
Lip without distinct lateral lobes near base 6
6. Lip emarginate or shallowly 2-lobed at the apex 7
Lip distinctly 2-lobed at the apex 9
7. Leaves orbicular-ovate *N. morrisonicola*
Leaves deltoid or ovate-deltoid 8
8. Flowers greenish, lip tinged brown toward apical part, not ciliate *N. taizanensis*
Flowers greenish, lip ciliate (more obvious microscopically)
..... *N. meifongensis*
9. Lip shortly stipitate at base 10
Lip not stipitate at base 12
10. Lobes of lip broad and truncate at the apex *N. shenlengiana*
Lobes of lip linear and rounded at the apex 11
11. Lip with 2 divergent and linear lobes *N. kuanshanensis*
Lip with 2 parallel and oblanceolate lobes *N. hohuanshanensis*
12. Flower larger, lip 1.1–2 cm long 13
Flower smaller, lip 6–9 mm long 14
13. Lobes of the lip like a forked tail, sinus broad *N. piluchiensis*
Lobes of the lip with a broad end, sinus narrow *N. wardii*
14. Lobes of the lip rounded *N. cinsbuensis*
Lobes of the lip acute 15
15. Lip profile oblanceolate *N. ruisuiensis*
Lip profile triangular *N. nankomontana*

Taxonomy of *Neottia* of Taiwan

Neottia acuminata Schltr., Acta Hort. Gothob. 1: 141. 1924; Yang et al., Manual Taiwan Vasc. Pl. 5: 271. 2002; Lin et al., Taiwania 61(2): 108. 2016; Lin et al., Ill. Native Taiwan. Orch. 534, f.340. 2022. **Type:** China: Szechuan, Dongrergo, *K.A.H. Smith 3859* (holotype UPS: BOT: V-140218). Taiwan: Yilan: in lauri-aciculi-silvie ad Kiritto, Mt. Nankotaizan, Jun. 2, 1938, *K. Segawa s.n.* (KPM, TIG00638). **Note:** The plant in Taiwan has not been formally published, and the Yilan collection is about 16 cm tall above the tuberoid. 鳥巢蘭

Neottia atayalica T.C. Hsu, In Chung & Hsu, Ill. Fl. Taiwan 2: 120. 2016. **Type:** Taiwan: Hsinchu, between Mayangchih and Chungpaping, July 4, 2007, *T.C. Hsu 878* (holotype TAI 496965). 泰雅雙葉蘭 **Note:** supposably, *N. atayalica* is just a variation of *N. japonica*. (Fig. 2A)

Neottia cinsbuensis T.P. Lin & D.M. Huang, Taiwania 62(4): 351, f.1D, E, 3. 2017. **Type:** Taiwan:

Hsinchu Co., Cinsbu, 2450 m, July 8, 2017, *H.C. Tsai s.n.* (holotype TAI 286832). (Fig. 2B) 鎮西堡雙葉蘭

Neottia hohuanshanensis T.P. Lin & Shu H. Wu, Taiwania 57(4): 381, f.1D, 4. 2012. **Type:** Taiwan: Hohuanshan, July 23, 2012, *T.P. Lin s.n.* (holotype TAI 281320). (Fig. 2C) 合歡山雙葉蘭

Neottia japonica (Blume) Szlach., Fragm. Florist. Geobot., Suppl. 3: 117. 1995; Lin, Orch. Fl. Taiwan 673, f.325. 2019. *Listera japonica* Blume, Coll. Orch. 136, pl.38, f.2, pl.48. 1859; Masam., Pl. Jpn. 8: 200. 1969. *Diphryllum japonicum* (Blume) Kuntze, Revis. Gen. Pl. 2: 659. 1891. *Ophrys japonica* (Blume) Makino, J. Jpn. Bot. 6: 33. 1929. **Type:** Not located. Described from Japan after Siebold's collection. 小雙葉蘭 **Note:** Masamune (1969) indicated that *Listera japonica* occurs in Taiwan. The labellum of this species exhibits a lot of variation. (Fig. 2D)

Neottia kuanshanensis (H.J. Su) T.C. Hsu & S.W. Chung, Taiwania 54(1): 83. 2009; Lin, Orch. Fl. Taiwan 674, f.326. 2019. *Listera kuanshanensis* H.J. Su, Q. J. Exp. For. Natl. Taiwan Univ. 13(3): 206. 1999. **Type:** Taiwan: Kaohsiung, Kuanshan 2650 m, Aug. 19, 1998, *C.C. Chen s.n.* (holotype HAST 106478). (Fig. 2E) 關山雙葉蘭

Neottia meifongensis (H.J. Su & C.Y. Hu) T.C. Hsu & S.W. Chung, Taiwania 54(1): 83. 2009; Lin, Orch. Fl. Taiwan 680, f.327. 2019. *Listera meifongensis* H.J. Su & C.Y. Hu, Taiwania 45(3): 240, pl.1. 2000. **Type:** Taiwan: Nantou, Meifong, 2700 m, June 27, 1999, *C.Y. Hu 226* (holotype HAST 105322); Hualien, Hohuanshan, 3000 m, July 25, 1999, *H.J. Su & C.Y. Hu 9592* (paratype NTUF). (Fig. 2F) 梅峰雙葉蘭

Neottia morrisonicola (Hayata) Szlach., Fragm. Florist. Geobot. Suppl. 3: 118. 1995; Lin, Orch. Fl. Taiwan 680, f.328. 2019. *Listera morrisonicola* Hayata, Icon. Pl. Formosan. 2: 140. 1912; Masam., J. Geobot. 14(4): pl.117. 1966. *Ophrys morrisonicola* (Hayata) Makino, J. Jpn. Bot. 6: 34. 1929. **Type:** Taiwan: Mt. Morrison, 11,000 ped., Oct. 9, 1909, *T. Kawakami et S. Sasaki s.n.* (holotype TI, photo T00998 in PoT (<https://tai2.ntu.edu.tw/>); isotype TAI 6867). (Fig. 2G) 玉山雙葉蘭

Neottia nankomontana (Fukuy.) Szlach., Fragm. Florist. Geobot., Suppl. 3: 118. 1995; Lin, Orch. Fl. Taiwan 680, f.329. 2019. *Listera nankomontana* Fukuy., Bot. Mag. (Tokyo) 49(581): 291. 1935. **Type:** Taiwan: Nankotaizan, inter Kiritto (2570 m) et Bunakkei (3500 m), July 1933, *J. Ohwi, N. Fukuyama 4139* (holotype KPM-NA 0105561 without Fukuyama's no., photo T00068 in PoT). Taiwan: Taichu, inter Matsumine at Hakka, July 12, 1930, *S. Suzuki 5600*. (Fig. 2H) 南湖雙葉蘭

Neottia piluchiensis T.P. Lin, Taiwania 60(4): 169, f.3, 4A. 2015. **Type:** Taiwan: Nantou, Piluchi, 2400 m, June 22, 2011, *T.P. Lin s.n.* (holotype TAI 277369). (Fig. 2J) 碧綠溪雙葉蘭

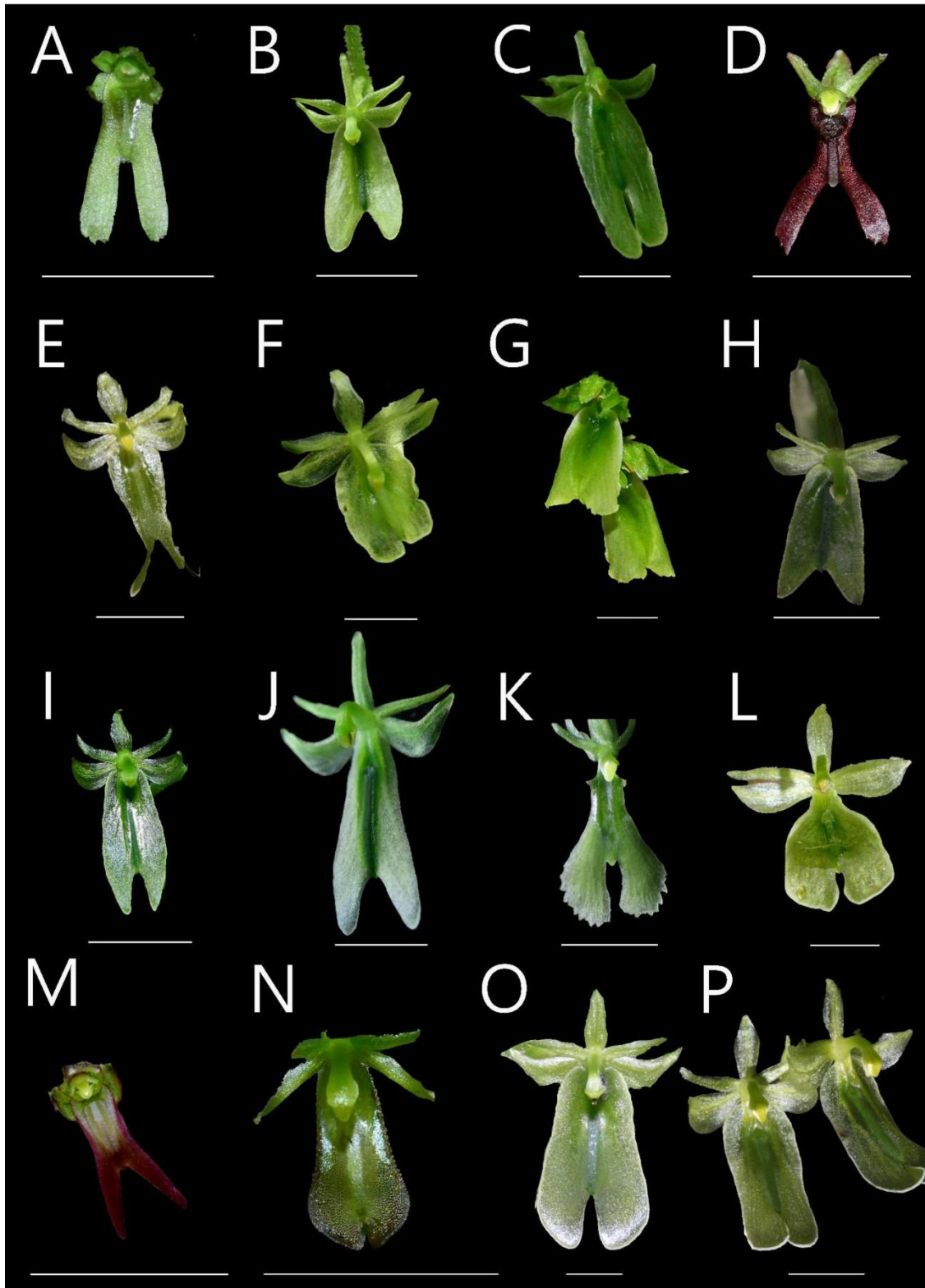


Fig. 2. *Neottia* species of Taiwan. **A.** *N. atayalica*. **B.** *N. cinsbuensis*, taken by Sheng-Kun Yu. **C.** *N. hohuanshanensis*. **D.** *N. japonica*, taken by Ching-Hwang Liu. **E.** *N. kuanshanensis*. **F.** *N. meifongensis*. **G.** *N. morrisonicola*, taken by Ching-Hwang Liu. **H.** *N. nankomontana*. **I.** *N. ruisuiensis*, taken by Ching-Hwang Liu. **J.** *N. piluchiensis*. **K.** *N. pseudonipponica*, taken by Kuo-Chu Yueh. **L.** *N. shenlengiana*, taken by Kuo-Chu Yueh. **M.** *N. suzukii*, taken by Hsi-Chi Tsai. **N.** *N. taizanensis*, taken by Ching-Hwang Liu. **O.** *N. wardii*, taken by Hsin-Hsiung Lin. **P.** *N. wardii*, taken by Po-Neng Shen (P was named *N. tatakaensis*). A, C, E, F, H, and J, taken by Tsan-Piao Lin. Scale, 5 mm.



Neottia pseudonipponica (Fukuy.) Szlach., *Fragm. Florist. Geobot.*, Suppl. 3: 118. 1995; Lin, *Orch. Fl. Taiwan* 681, f.331. 2019. *Listera pseudonipponica* Fukuy., *Bot. Mag. (Tokyo)* 49(586): 665. 1935; S.W. Chung, *Orch. Taiwan* 87. 2008. **Type:** Taiwan: Tosei-gun, Seki-heki-ko, Jan. 1934, *Nakazawa 4686* (holotype TAI118732) flower is missing. (Fig. 2K) 裂唇雙葉蘭/假日本雙葉蘭 **Note:** *Neottia fugongensis* (X.H. Jin) J.M.H. Shaw, according to the original description and figure (Jin and Li, 2007) and later data (Jin and Pang, 2016), is almost identical to *N. pseudonipponica*.

Neottia ruisuiensis T.P. Lin, *sp. nov.* **Type:** Taiwan: Hualien Co.: Ruisui, 2300 m, July 5, 2024, *Fang-Mei Hsieh s.n.* (holotype TAI289924). 瑞穗雙葉蘭

Neottia shenlengiana T.C. Hsu, In Chung & Hsu, *Ill. Fl. Taiwan* 2: 129. 2016; Lin, *Orch. Fl. Taiwan* 688, f.332. 2019. **Type:** Hsinchu, Takechin Stream, 2900–3100 m, July 23, 2012, *T.C. Hsu 6075* (holotype TAI 496949). (Fig. 2L) 聖陵雙葉蘭

Neottia suzukii (Masam.) Szlach., *Fragm. Florist. Geobot.*, Suppl. 3: 119. 1995; Lin, *Orch. Fl. Taiwan* 688, f.333. 2019. *Listera suzukii* Masam., *Trop. Hort.* 3: 42. April 1933. *nom. nud.*; Masam., *Trans. Nat. Hist. Soc. Formosa* 23(126): 209. Aug. 1933 (description and 2 specimens were provided); Masam., *J. Geobot.* 19(4): 11, pl.174. 1971. **Syntype:** Taiwan: Taiheizan, *S. Suzuki s.n.*; Taito, Kaimosu, *Segawa s.n.* Neither one found. (Fig. 2M) 三角雙葉蘭

Neottia taizanensis (Fukuy.) Szlach., *Fragm. Florist. Geobot.*, Suppl. 3: 119. 1995; T.P. Lin, *Orch. Fl. Taiwan* 695, f.334. 2019. *Listera taizanensis* Fukuy., *Bot. Mag. (Tokyo)* 48(571): 431. 1934. **Type:** Taiwan: Nankotaizan, inter Kirittoei et Bunakkei, July 1933, *N. Fukuyama 4123* (holotype KPM-NA0105562 without Fukuyama's no., photo T00069 in PoT). (Fig. 2N) 大山雙葉蘭

Neottia wardii (Rolfe) Szlach., *Fragm. Florist. Geobot.*, Suppl. 3: 119. 1995; T.P. Lin, *Orch. Fl. Taiwan* 695, f.335. 2019. *Listera wardii* Rolfe, *Notes Roy. Bot. Gard. Edinburgh* 8: 127. 1913. *Listera grandiflora* Rolfe, *Bull. Misc. Inform. Kew* 1896: 200. 1896. *Neottia grandiflora* (Rolfe) Szlach., *Fragm. Florist. Geobot.*, Suppl. 3: 117. 1995, not Hooker (1830), nor (A. Richard) Kuntze (1891), nor Schlechter (1912). **Type:** China: N.W. Yunnan, Salwen, Mekong divide, E. slope, 1000 ft, June 1911, *F. Kingdon-Ward 149* (holotype E00383567). (Fig. 2O) 大花雙葉蘭

Notes on *Neottia* in Taiwan

The phylogenetic analysis based on an internal transcribed (ITS) sequence and *matK* of chloroplast DNA of 22 taxa (So and Lee, 2020) revealed 2 major clades of *Neottia*. Clade 1 has a basal species, *N. ovata*, which is sister to a group of species formed by *N. meifengensis*, *N. grandiflora*, *N. fugongensis*, mycoheterotrophic taxa, and other species. Clade 2 has a basal species, *N. cordata*,

which is sister to a group of species formed by only *N. japonica* and *N. suzukii*. Both *Neottia ovata* and *N. cordata* are taxa with very wide distribution. While *Neottia ovata* has its native range in the Old World (Europe, Russia, western Siberia, Turkey, Pakistan, and the western Himalayas), *N. cordata* has a circumpolar distribution (North America, Greenland, Europe, Russia, Turkey, and Asia eastwards up to Japan). The phylogenetic analyses of protein coding genes of mitochondrial genomes and plastome genomes of *Neottia* also showed that *N. ovata* is basal to all other *Neottia* species that were studied (Shao *et al.*, 2023).

Among the 16 *Neottia* species in Taiwan, *N. acuminata*, *N. japonica*, *N. pseudonipponica*, and *N. wardii* are considered widely distributed. *Neottia acuminata* is widely distributed in temperate Asia (Russia, Mongolia, China, the Himalayas, and Japan). *Neottia wardii* occurs in Tibet and south-central China, while *N. japonica* is found in southeastern China, Japan, and Korea. *Neottia* in Taiwan appears to have originated from Japan and China.

Neottia japonica in Taiwan is morphologically strongly variable, and in Japan as well. In fact, *N. atayalica* (Chung and Hsu, 2016; Fig. 2A) may be an intraspecific variation of *N. japonica*. *Neottia japonica* stands rather closely also with *N. suzukii*, because both share relatively similar lip morphology with 2 small auricles at the lip base and 2 long lobes (Lin, 2019). They also have a hood structure near the column apex. A hood is formed in the column apex, and the anther is borne deep inside the column hood. Among Taiwan's *Neottia*, this special column structure is only found in *N. suzukii*, *N. japonica* and *N. atayalica* (Lin, 2019). Unlike other species, this group also occurs at much lower altitudes. The lip of *N. suzukii* is also similar to that of *N. cordata*, being divided more than halfway into 2 sharply pointed lobes (Fig. 2M). Phylogenetic analyses based on complete plastomes and the nuclear ITS showed that *N. japonica* + *N. suzukii* form a tight clade (Zhu *et al.*, 2019). The data given above argue that *N. suzukii* might have evolved from *N. japonica* in Taiwan.

Neottia wardii is another highly polymorphic species in Taiwan. From different localities in the alpine mountains of Taiwan, it was described several times: viz., *Listera macrantha* (Fukuyama, 1933), *N. fukuyamae* (Hsu and Chung, 2009), *Listera longiflora* (Lin, 2014: 618), *Neottia fukuyamae* var. *chilaiensis* (Chung and Hsu, 2016: 123), *N. breviscapa* (Chung and Hsu, 2016: 121), and *N. tatakaensis* (Chung and Hsu, 2016: 130, fig. 2P). Based on our observations, only a few morphotypes of Taiwan overlap with those of China, indicating that *N. wardii* has evolved in different directions at mainland and island localities.

Another important driving force of diversification of *Neottia* in Taiwan may be connected with hybridization, which was discovered in several localities. A prominent



example was discovered at Cinsbu, Hsinchu Co., at an elevation of 2450 m on the western side of the CMR, where *Neottia cinsbuensis*, *N. nankomontana* and several morphotypes intermediate between them were discovered growing alongside in one place. This case needs in-depth studies, including phylogenetic analyses.

Seventy-five percent of Taiwan's *Neottia* species are endemic. These species are mainly scattered in alpine mountains at elevations of 2500–3300 m. Most of our alpine species of terrestrial genera of *Cypripedium*, *Platanthera*, and *Ponerorchis* are also indigenous. These high-elevation areas are disproportionately important for plant biodiversity when richness and endemism are standardized by available land (Jump *et al.*, 2012). Roughly, 55% of species of vascular plants at the highest elevations are endemic to Taiwan. Endemism of alpine plants was similarly reported in SW Alps (Guerrina *et al.*, 2024), with elevation range as one of the factors positively correlating with endemic richness. What is the driving force of the lip evolution in alpine mountains that creates so many species of *Neottia*? Prof. Chun-Neng Wang of Taiwan University has observed different pollinators visiting different species of *Neottia* in alpine region of Hohuan Mt., central Taiwan (pers. comm.). This possible differentiation mechanism warrants further investigation.

At present, the number of species of *Neottia* in Taiwan makes it one of the largest terrestrial genera, only after *Calanthe*, *Gastrodia* and *Goodyera*. Orchid exploration by orchid hobbyists has the potential to find new *Neottia* species native to the eastern part of the CMR.

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