



## New natural hybrid in the genus *Gastrodia*: *Gastrodia* × *nippo-uraiensis* (Orchidaceae) from Yakushima Island, Japan

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**ABSTRACT:** We describe a new taxon of *Gastrodia* (Orchidaceae), *G. × nippo-uraiensis* from Yakushima Island. *Gastrodia × nippo-uraiensis* shows similar outer appearances with both *G. nipponica* and *G. uraiensis*. It could, however, be easily recognized by the 13–16 mm long perianth tube which is distinctly smaller than *G. nipponica* (Honda) Tuyama and distinctly larger than *G. uraiensis* T.C. Hsu & C.M. Kuo. In addition, *G. nippo-uraiensis* bears mixed or intermediate floral morphological characters between *G. nipponica* and *G. uraiensis*. Therefore, this taxon can be considered as a natural hybrid between *G. nipponica* and *G. uraiensis*. The morphological characteristics and illustrations of the new taxon, *G. nipponica* and *G. uraiensis* are provided.

**KEY WORDS:** *Gastrodia*, Japan, Mycoheterotroph, Natural hybrid, Orchidaceae, Ryukyu, Taxonomy.

### INTRODUCTION

*Gastrodia* Brown (Orchidaceae), a genus of mycoheterotrophic orchids, is distributed throughout temperate and tropical regions of Asia, Oceania, Madagascar and Africa (Cribb *et al.* 2010). *Gastrodia* is characterized by fleshy tubers, the absence of normal leaves, united sepals and petals and two, mealy pollinia that lack caudicles. Several recent studies re-examined the diversity of *Gastrodia* in various Asian countries (Hsu & Kuo 2010; Hsu & Kuo 2011; Hsu *et al.* 2012; Hsu *et al.* 2016; Huang *et al.* 2015; Metusala & Supriatna 2017; Ong & O'Byrne 2012; Pelter *et al.* 2016; Suetsugu 2013; Suetsugu 2014; Suetsugu 2016; Suetsugu 2017b; Tan *et al.* 2012; Tsukaya & Hidayat 2016; Yeh *et al.* 2011). Consequently, *Gastrodia* now comprises more than 90 species, making it the most diverse genus of mycoheterotrophic vascular plants (Hsu *et al.* 2016; Suetsugu 2017b).

The genus *Gastrodia* exhibits extraordinary morphological diversity, with some species of section *Gastrodia* (sensu Schlechter 1911), such as *G. elata* Blume reaching 60–100 cm in height during the flowering season, while many species of section *Codonanthus* (Schlechter 1911; Tuyama 1967), as represented by *G. verrucosa* Blume have inflorescences that are only 3–20 cm long at flowering (Chung & Hsu 2006). Consequently, the distribution and species diversity of section *Codonanthus* remains somewhat unclear, since these species are easily overlooked in the wild due to their short flowering season and dwarf habits (Suetsugu 2016, 2017). The flora of Japan is particularly rich in mycoheterotrophic plants, harboring ca. 60 species, and recent botanical surveys have resulted in the

discovery of several new taxa and distributional records in this region (Ohashi *et al.* 2008; Suetsugu & Fukunaga 2018; Suetsugu & Ishida 2011; Suetsugu *et al.* 2012; Suetsugu 2012; Suetsugu *et al.* 2013; Suetsugu 2013; Suetsugu & Yagame 2014; Suetsugu *et al.* 2014; Suetsugu 2014; Suetsugu 2015; Suetsugu & Fukunaga 2016; Suetsugu *et al.* 2016; Suetsugu 2016; Suetsugu & Nishioka 2017; Suetsugu 2017a; Suetsugu 2017b; Yahara & Tsukaya 2008).

During botanical survey in Yakushima Island, Japan in mid-April 2018, we collected an unknown taxon that belong to section *Codonanthus*. There are only two chasmogamous *Gastrodia* species (i.e. *Gastrodia nipponica* and *G. uraiensis*) that bloom in this season in Yakushima Island. Detailed morphological examination revealed that this plant exhibited intermediate morphological characters between *Gastrodia nipponica* and *G. uraiensis* (Hsu & Kuo 2010; Suetsugu 2013). Therefore, this unknown taxon can be considered as a natural hybrid of them. Here describe *G. × nippo-uraiensis*, which is named after the parental taxa *G. nipponica* and *G. uraiensis*. As far as we know, this is the first report of interspecific hybridization in the genus *Gastrodia*.

### TAXONOMIC TREATMENTS

*Gastrodia × nippo-uraiensis* Suetsugu & T. C. Hsu, *sp. nov.*  
Figs 1 & 2.

**Type:** JAPAN. Ryukyu: Kagoshima Pref., Yakushima Island, near the Tashiro Coast, 10 April 2018, Kenji Suetsugu KS238 (holotype: TNS)

Japanese name: Hime-haruzaki-yatsushiro-ran, *nov.*



**Fig. 1.** *Gastrodia* × *nippo-uraiensis* Suetsugu & T. C. Hsu (from the holotype). **A.** Flowering plant. **B.** Flower, front view. Scale bar: **A** = 3 cm.

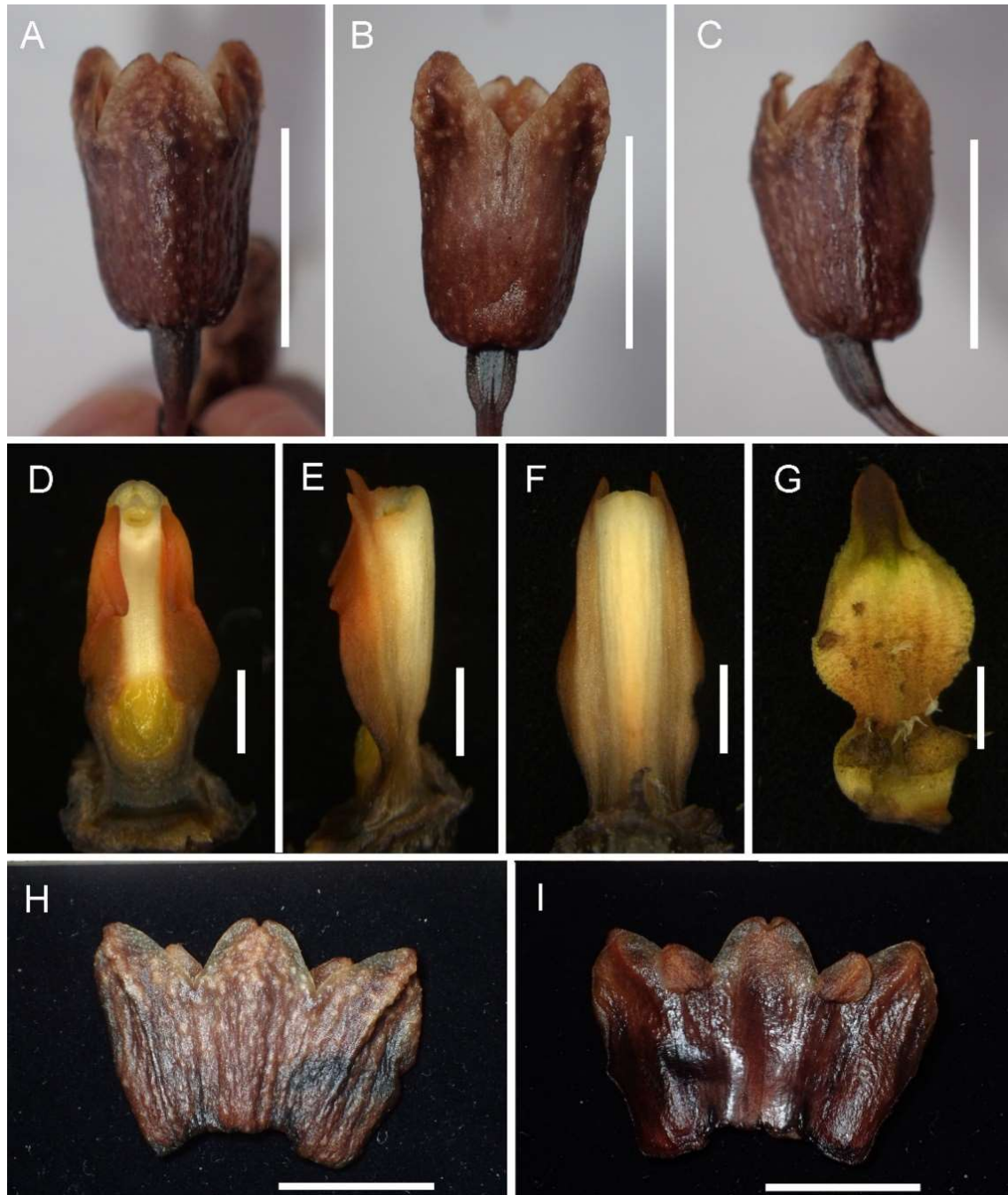
Terrestrial, mycoheterotrophic herb. Rhizome tuberous, fusiform or cylindrical, 2–6 cm long, 3–7 mm in diameter, yellowish brown, covered with numerous scales. Stem erect, pale brown, 2–5 cm long, 2–3 mm in diameter. Bracts ovate, ca. 4 mm long. Pedicel and ovary 7–12 mm long. Flowers 1–3, bellshaped, slightly nodding or angled slightly upward, resupinate, 13–16(–17) mm long, 8–10(–11) mm in diameter. Sepals and petals united, forming a 5-lobed perianth tube. Sepals subsimilar, fleshy, 13–15 mm long, connate ca. 2/3 the length of the petals, lateral sepals connate ca. 3/5 their length with each other, outer surface dark brown, verrucose, margins entire; free portion of dorsal sepal straight, ovate-triangular, ca. 4 mm long, 6 mm wide, apex retuse; free lobes of lateral sepals ovate-triangular, ca. 4 mm long, 6 mm wide apex obtuse. Free lobes of petals ovate or elliptic, ca. 3 mm long, 2 mm wide. Lip adnate to column foot, ca. 8 mm long, 4 mm wide; hypochile with 2 pale-orangish white globose calli; epichile pale-orangish to pale-greenish white, ovate-orbicular, base contracted, margin slightly undulate, apex portion ligulate, dark red, ca. 1.2 mm wide, obtuse at tip; disc bearing 4(–6) ridges arising around the middle of epichile and uniting into 2 ridges toward the ligulate apex. Column straight, terete, 7.5–8.0 mm long, 2.5 mm wide, white tinged and reddish brown at base; column foot well developed; lateral wings narrow, red, edges parallel to column, base slightly angled, apex acute; rostellum ca. 0.7 mm long; stigma located at base. Anther hemispheric, 1.1–1.3 mm in diameter, pollinia 2. Fruits not seen.

**Distribution:** The population discovered to date was located near the Tashiro Coast, Yakushima Island, Japan. The population is located in humid evergreen broad-leaved forests dominated by *Castanopsis sieboldii*, *Distylium racemosum* and *Machilus thunbergii* with sparse herbaceous understories. The population

consisted of ca. 10 flowering *G.* × *nippo-uraiensis* individuals at an elevation of ca. 10–30 m. The new hybrid is not completely sympatric with parental taxa (i.e., *G. nipponica* and *G. uraiensis*, while these two species can be observed within a few kilometers square.

**Note:** *Gastrodia* × *nippo-uraiensis* shows similar outer appearances with both *G. nipponica* (Fig. 3) and *G. uraiensis* (Fig. 4). It could, however, be easily recognized by the 13–16 mm long perianth tube which is distinctly smaller than *G. nipponica* and distinctly larger than *G. uraiensis*. There are also significant differences in the detailed lip structure among the three species (Fig. 5). In *G. nipponica*, the lip bears 6 distinct ridges (and sometimes additional 1 or 2 obscure outer ones) arising from base of epichile. All ridges are subparallel and not uniting below the ligulate apex. In *G. nippo-uraiensis*, the lip bears 4 distinct ridges (and sometimes additional 1 or 2 obscure ones) arising from middle of the epichile and uniting below the ligulate apex. While in *G. uraiensis*, the lip bears 2 distinct outer ridges and 2 obscure inner ones arising from middle of epichile and uniting below ligulate apex. In general, *G. nippo-uraiensis* bears mixed or intermediate morphological characters between *G. nipponica* and *G. uraiensis* (Table 1) and is thus presumed as a natural hybrid between *G. nipponica* and *G. uraiensis*. Similar to its congeners (Martos *et al.* 2015; Suetsugu 2018), both *G. nipponica* and *G. uraiensis* deceptively attract *Drosophila* pollinators by emitting fermented scents (Suetsugu, unpublished data). Therefore, the sharing of *Drosophila* pollinators will be the mechanism of the hybridization.

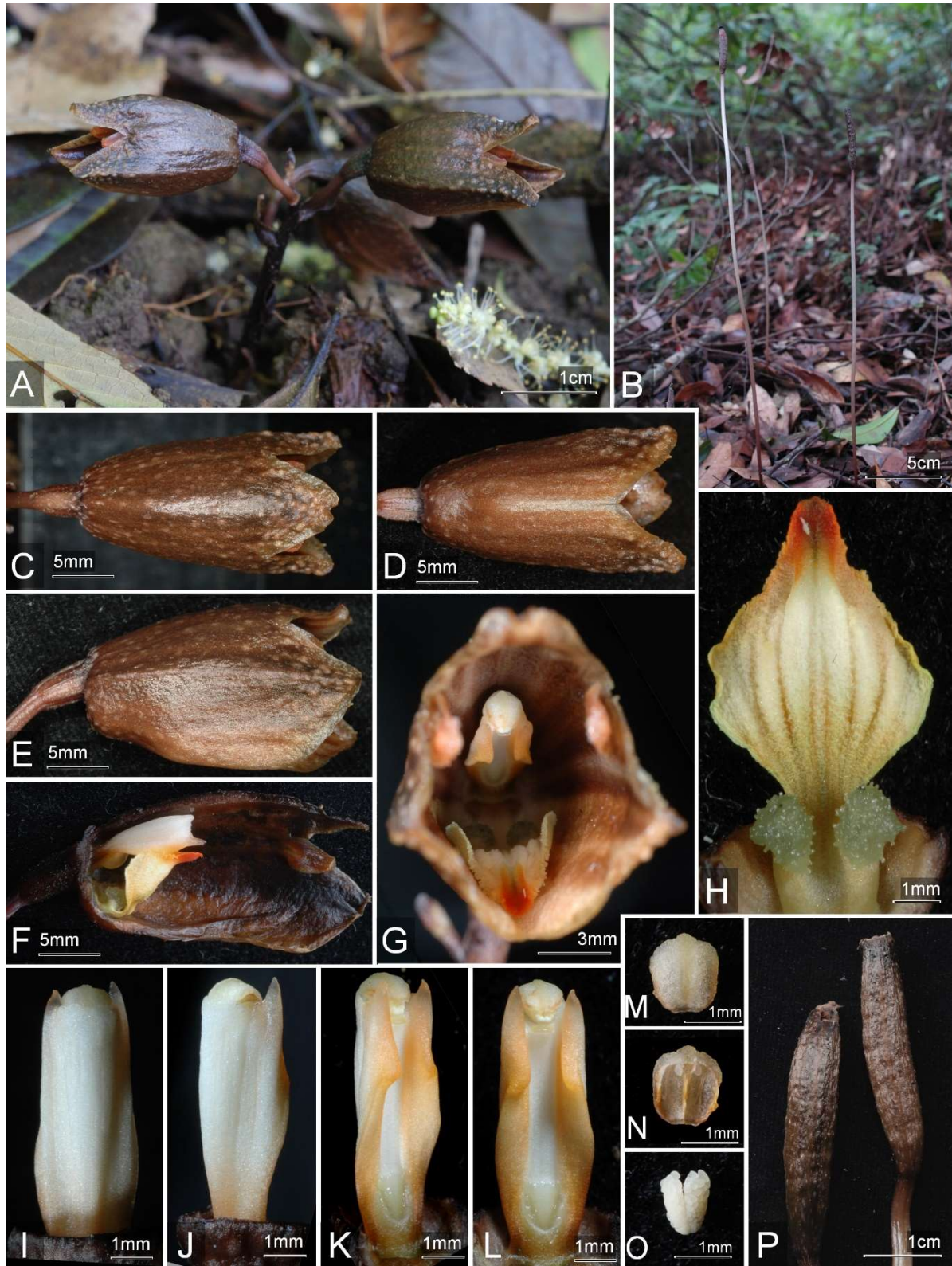
The new hybrid is not completely sympatric with parental taxa (i.e., *G. nipponica* and *G. uraiensis*) in the type locality. The result may suggest they are capable of establishing lineage that persists for long time. In addition, it is even possible that introgressive hybridization between *G. nipponica* and *G. uraiensis*



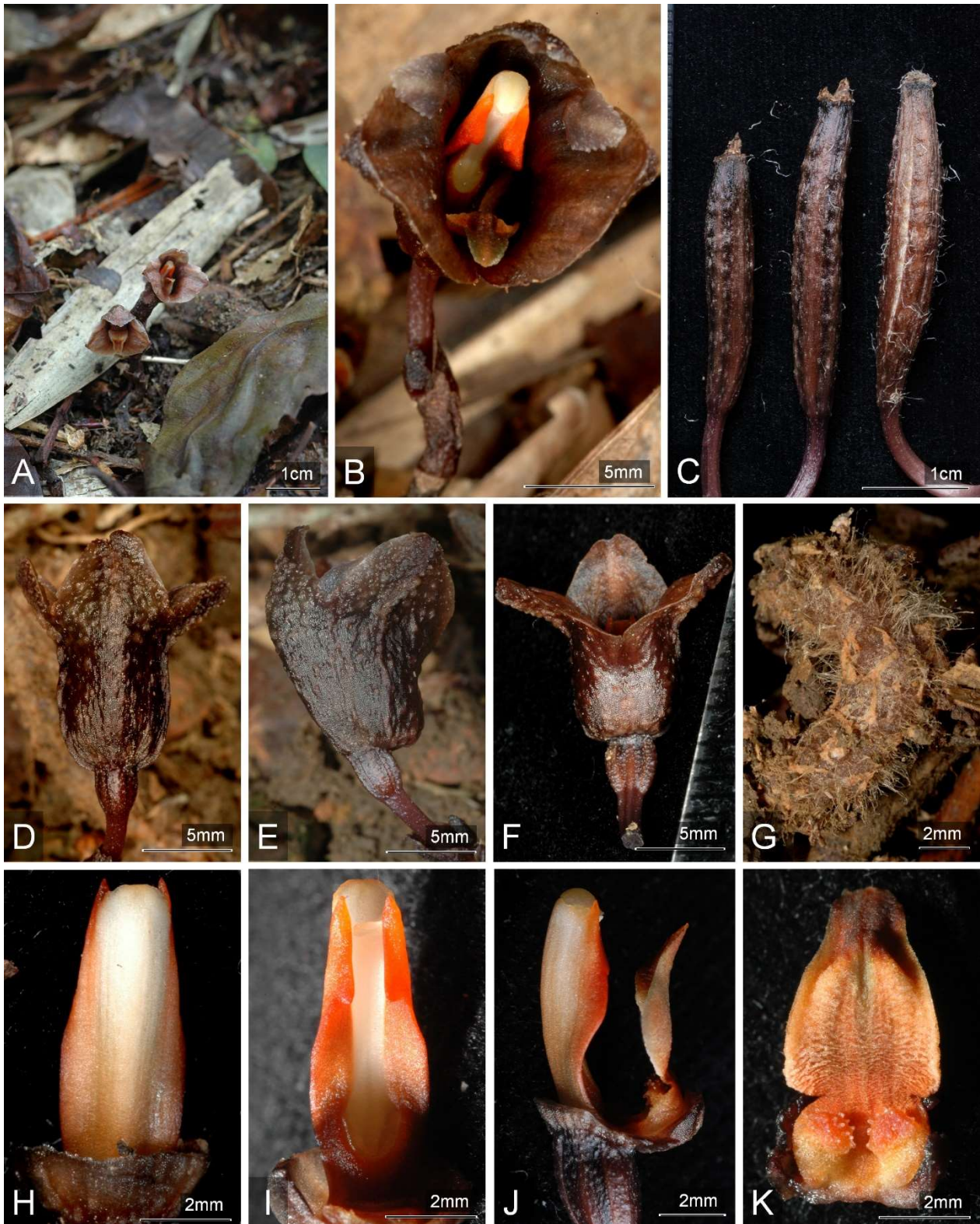
**Fig. 2.** *Gastrodia* × *nippo-uraiensis* Suetsugu & T. C. Hsu (from the holotype). **A–C.** Flower (**A.** Upper view. **B.** Lower view. **C.** Side view). **D–F.** Column (**D.** Lower view **E.** Side view. **F.** Upper view.). **G.** Lip. **H–I.** Flattened perianth tube (**H.** Outer view. **I.** Inner View). Scale bar: A–C = 1 cm. D–G = 2 mm. C–F = 1 mm. H–I = 1 cm.

occur widely in Yakushima Island, because *G. nipponica* and *G. uraiensis* are sometimes sympatrically distributed, with similar flowering phenology. Actually, *G. uraiensis* previously recorded in Yakushima Island is slightly different from that in Taiwan in the shape of corolla tube and coloration of lip (Suetsugu 2015), while the hybridization with *G. nipponica* is not as apparent as the plants we recorded here. In contrast, while *G. nipponica*

and *G. uraiensis* are also sometimes sympatric in Taiwan, *G. nipponica* generally flowers ca. two weeks later than *G. uraiensis*. Therefore, hybridization between *G. nipponica* and *G. uraiensis* is less likely in Taiwan. Future molecular investigation such as microsatellite markers will reveal the pattern and degree of hybridization between *G. nipponica* and *G. uraiensis* in Yakushima Island and Taiwan.



**Fig. 3.** *Gastrodia nipponica* (Honda) Tuyama. **A.** Flowering plant. **B.** Fruiting plants. **C–G.** Flower (**C.** Upper view. **D.** Lower view. **E.** Side view. **F.** Side view, partial floral tube removed. **G.** Front view). **H.** Lip. **I–L.** Column (**I.** Upper view. **J.** Side view. **K.** Oblique lower view. **L.** Lower view). **M–N.** Anther cap (**M.** Upper view. **N.** Lower view). **O.** Pollinia (Upper view). **P.** Fruits. **A** on 29 Mar 2008 from *Hsu 1319* (TAIF); **B** on 6 May 2006 from *Hsu 502* (TAIF); **C–O** on 18 Mar 2007 from *Hsu 732* (TAIF); **P** on 15 Apr 2008 from *Hsu 1331* (TAIF). All but **B** from Wulai District, New Taipei City, Taiwan. **B** from Fusing District, Taoyuan City, Taiwan.

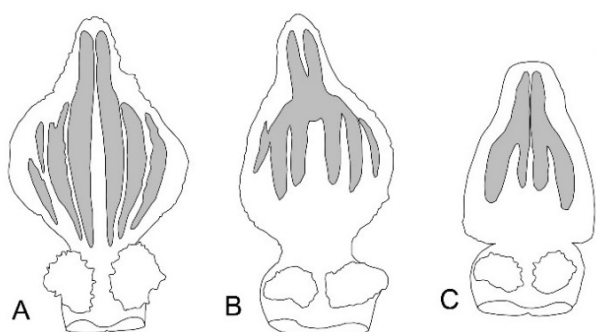


**Fig. 4.** *Gastrodia uraiensis* T.C. Hsu & C.M. Kuo. **A–B.** Flowering plant. **C.** Fruits. **D–F.** Flower (**D.** Upper view. **E.** Side view. **F.** Lower view.). **G.** Rhizome. **H–I.** Column (**H.** Upper view. **I.** Lower view). **J.** Column and Lip. **K.** Lip. **B & D–K** on 15 Feb 2007 from Hsu 715 (TAIF; isotype); **C** on 29 Mar 2008 from Hsu 1316 (TAIF). All from Wulai District, New Taipei City, Taiwan.

**Table 1.** Morphological comparison among *G. × nippo-uraiensis*, *G. nipponica* and *G. uraiensis*.

Character	<i>G. × nippo-uraiensis</i>	<i>G. nipponica</i>	<i>G. uraiensis</i>
Plant height	2–6 cm	3–8 cm	1–4 cm
Perianth tube size	13–16(–17) mm long	18–24 mm long	9–13 mm long
Perianth tube coloration	both outer and inner surface dark brown	outer surface dark brown, inner surface stripes of dark brown and pale brown	both outer and inner surface dark brown
Sepal shape	13–15 mm long, connate ca. 2/3 the length of the petals, lateral sepals connate ca. 3/5 their length with each other	18–24 mm long, connate ca. 3/4 their length with petals, lateral ones connate ca. 2/3 with each other	9–13 mm long, connate ca. 2/3 their length with petals, lateral ones connate ca. 3/5 their length with each other
Free lobes of petals	ca. 3 × 2 mm	ca. 4 × 3.5 mm	ca. 3 × 1.5 mm
Free lobes of sepals	ca. 4 × 6 mm	ca. 7 × 6 mm	ca. 5 × 4 mm
Openness of free portions of lateral sepals	not widely open	not widely open	widely open
Lip size	ca. 8 mm long	ca. 8 mm long	6–7 mm long
Lip coloration	pale-orange to pale-greenish white with reddish apex	pale-yellowish white with reddish apex	reddish brown
Epichile shape	ovate-orbicular	ovate-orbicular	ovate-triangular
Number of ridges on the epichile	4 distinct plus 0–2 obscure	6 distinct plus 0–2 obscure	2 distinct plus 2 obscure
Structure and location of ridges on the epichile	arising from base of epichile and subparallel	arising from middle of epichile and unting below the ligulate apex	arising from middle of epichile and unting below the ligulate apex
Column size	7.5–8.0 × ca. 2.5 mm	ca. 8 × 2.5 mm	6–7 × ca. 2 mm
Lateral wings coloration	red	pale orange	red

Data of related species from Hsu *et al.* (2010) and Suetsugu (2013)



**Fig. 5.** Lip morphology of *Gastrodia nipponica* (A; from Hsu 732), *G. nippo-uraiensis* (B; from Suetsugu KS238) and *G. uraiensis* (C; from Hsu 715). Scale bar = 2 mm.

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