Morphological Variation in the Species of *Cephalanthera* (Orchidaceae) in Japan

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We report four examples of morphological variation in the species of *Cephalanthera* (Orchidaceae) in Japan. We recognized a new peloric form, *C. subaphylla* Miyabe & Kudo f. *conformis* Hiros. Hayak. The new form has a tepal-like lip morphology. We also report variegation mutants of *C. erecta* (Thunb.) Blume var. *erecta*, which are albinos-like in appearance. The above-ground parts of the mutants were withered at the immature seed stage during the end of June. We also observed variegated individuals of *C. falcata* (Thunb.) Blume f. *falcata* and *C. falcata* f. *albescens* S. Kobay. Finally, we discovered individuals of *C. falcata* f. *falcata* with a malformed flower at the top of an inflorescence with normal flowers in other parts of the same inflorescence from two localities.

Key words: Flower, Lip, Peloria, Radial symmetry, Zygomorphic

*Cephalanthera* Rich. (Orchidaceae) comprises approximately 16 mixotrophic or holomycotrophic species in Europe, northern Africa, eastern Asia, southeast Asia, and western North America (Luer 1975, Satomi 1982, Chen *et al*. 2010, Nuraliev *et al*. 2014). Five species, one variety, and three forms are known to occur in Japan (Yonekura & Kajita 2003 onwards, Yukawa 2015). Additionally, an unknown species of *Cephalanthera* has been reported from Hokkaido in northern Japan (Yukawa 2009). During our field and herbarium observations, we found variation in species of *Cephalanthera* that has not been formally recognized. Some of these morphological variants occur by mutation of gene(s) during speciation rather than as transient mutants. Thus, it is important to understand the morphological variations in each species of *Cephalanthera*. In the present study, we report four examples of morphological variation *Cephalanthera*.

*Cephalanthera subaphylla* f. *conformis: a new peloric mutant of C. subaphylla*

*Cephalanthera subaphylla* Miyabe & Kudo is a mixotrophic orchid distributed in Japan and in the southern part of the Korean peninsula (Hashimoto & Kanda 1981, Satomi 1982, Yukawa 2015, Fig. 1C). The plants are 10–15 cm tall, and their most characteristic feature is the presence of 1 or 2 small leaves, each 3 cm long and 1–1.5 cm wide. Flowering occurs from April to June. Two to five white flowers are borne on each inflorescence. The lip has a relatively long spur (3–4 mm) and 3 brown lamellae.

We discovered two individuals of *Cephalanthera subaphylla* with no differentiation between the lip and tepals. One was collected from Mt. Ontake, Kagoshima Prefecture, Japan (Fig. 1A–
B), and the other from Imose-yama, Okino-shima, Kochi Prefecture, Japan. This mutation, in which the lip is undifferentiated from the tepals, is called peloria (Rudall & Bateman 2002, 2003). Five peloric mutants have been recognized in Cephalanthera (Chen et al. 2010, Jin et al. 2011, Hayakawa et al. 2014). Thus, peloria may repeatedly occur in Cephalanthera under natural conditions. Although peloria in orchid flowers has been categorized into several types (Rudall & Bateman 2002, 2003; Mondragón-Palomio & Theißen 2009), we could not determine the exact type of peloria (especially type-B, type-C, or type-B pseudopeloria) that applies to this case, since old, pressed herbarium specimens were insufficient for determining detailed floral morphology. Based on the lip morphology, we describe the peloric mutant as a new form: Cephalanthera subaphylla Miyabe & Kudo f. conformis. Hayak.

Cephalanthera subaphylla Miyabe & Kudo f. conformis. Hayak., forma nov.—Figs. 1A & B.

This form differs from Cephalanthera subaphylla f. subaphylla in lip morphology. The lip is tepal-like, entire, and without lamellae or a spur.

Japanese name. Ontake-Yushunran, nov.


Fig. 1. Voucher specimens of Cephalanthera subaphylla f. conformis (TI; holotypus) (A-B) and C. subaphylla f. subaphylla (TNS; 531112) (C).
Variegation mutants of Cephalanthera erecta var. erecta

We found mutants of Cephalanthera erecta (Thunb.) Blume var. erecta (Fig. 2A), with substantial variegation in the leaves, such that they were albino-like in appearance. As species of Cephalanthera are nutritionally mixotrophic, and have a tripartite symbiotic relationship with ectomycorrhizal fungi and trees (e.g., Yagame & Yamato 2013, Sakamoto et al. 2015), the presence of the albino-like mutants suggests that C. erecta var. erecta can grow and flower without photosynthesis, similar to the holomycotrophic mode of nutrition known in C. falcata (Thunb.) Blume (Yukawa 2015). The immature seeds of C. falcata f. falcata express maximum germination rate at 70 days after pollination under asymbiotic culture conditions (Yamazaki & Miyoshi 2006). The seeds then matured and dormancy was induced (Yamazaki & Miyoshi 2006). The variegated mutants withered before late June, resulting in senescence of fruits with seeds that may not germinate. During our observations, the above-ground parts of the variegated mutants appeared only during a few years, although it is unknown whether the variegated plants observed each year grew from the same rhizomes. The absence in
some years could simply be due to withering, or long-term vegetative dormancy. Therefore, the variegated mutants exhibited an extremely low fitness, similar to the albino mutant of *Cephalanthera falcata* f. *falcata* described by Suetsugu & Kato (2014) and Suetsugu (2015a, b).

**Cephalanthera falcata** f. *falcata* and f. *albescens* with variegated leaves

*Cephalanthera falcata* f. *falcata*, with leaves that display longitudinal stripes of white or yellow are called “Suji-Kinran” in Japanese (Satomi 1982). To our knowledge, the mutant has not been formally documented with voucher specimens. We found the mutants not only in *C. falcata* f. *falcata* (Fig. 2B), but also in *C. falcata* f. *albescens* S. Kobay., a form with yellowish white flowers (Fig. 2C).

**terminal flower mutant of Cephalanthera falcata** f. *falcata*

We discovered individuals of *Cephalanthera falcata* f. *falcata* with a unique flower at the top of the inflorescence, and with normal flowers in other parts of the same inflorescence, in Tsukuba, Ibaraki, and Machida, Tokyo (Fig. 2D–E). The modified flowers of the mutants had approximately six stamen-like structures (columns without stigmas), more than six tepals, without ovaries, and floral components that directly arose from the floral axis. Additionally, the column-like structures are hollow in this complex flower. The morphology of the mutant is similar to a flower mutation in *Arabidopsis thaliana* (L.) Heynh. (Alvarez *et al.* 1992) induced by the terminal flower gene, which affects inflorescence development. Thus, the mutant could be controlled by mutation of the same or similar developmental regulatory gene(s).

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APPENDIX; Voucher specimens used in this study

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