Cremastra saprophytica (Orchidaceae: Epidendroideae), a new leafless autonomously self-pollinating orchid species from Gifu Prefecture, Japan

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Abstract

A new species of Cremastra (Orchidaceae), *C. saprophytica*, is described from Gifu Prefecture, Japan. The new species is similar to *C. aphylla* in having a leafless and mycoheterotrophic habit. However, it is distinguishable from *C. aphylla* by its green stem, more closed perianth tube, smaller lateral lobes of lip, smaller callus of lip positioned at base of the midlobe and absence of a rostellum and viscidium. An illustration and ecological information on the new species are provided. A key to the *Cremastra* species is also provided.

Keywords: Calypsoinae, Japanese flora, mycorrhiza, mycoheterotrophy, new species, self-pollination, taxonomy

Introduction

Cremastra Lindley (1833: 172; Orchidaceae) is a small genus of five species consisting of both leafless and leafy species distributed from Nepal to Japan (Hu et al. 2013). *Cremastra* is characterized by an underground pseudobulb, a racemose inflorescence arising directly from the apex of the pseudobulb, flowers with a clawed lip and lip callus (Lund 1988, Hu et al. 2013, Watthana et al. 2015). Based on molecular phylogenetic classification, *Cremastra* has been placed in subtribe Calypsoinae, tribe Epidendreae (Epidendroideae; Chase et al. 2015). Lund (1988) revised *Cremastra* and recognised two species, *C. appendiculata* (Don 1825: 36) Makino (1904: 24) and *C. unguiculata* (Finet 1896: 698) Finet (1897: 235); in *C. appendiculata*, he also recognized two varieties, var. *appendiculata* and var. *variabilis* (Blume 1849: 48) Lund (1988: 201). After this, three new species, *C. aphylla* Yukawa (1999: 59), *C. guizhouensis* Chen & Chen (2003) and *C. malipoensis* Hu in Hu et al. (2013: 64) have been described. Given that recent floral surveys have revealed several new species and new records in the genus (Chen & Chen 2003, Hu et al. 2013, Watthana et al. 2015), it is likely that the diversity of *Cremastra* species remains underestimated. As expected, a leafless but green *Cremastra* species with significantly different morphology compared to the other species was discovered during recent botanical surveys on Gifu Prefecture, Japan.

Taxonomic treatment

*Cremastra saprophytica* Suetsugu, sp. nov. (Figs 1, 2)

Type:—JAPAN. Gifu Pref.: Ibi County, Ibigawa Town, Kasugakawai, 5 Jun 2021, Suetsugu Sa52 (holotype: KYO!, spirit collection).

*Cremastra saprophytica* is similar to *C. aphylla* but differs by its more closed perianth tube, smaller lateral lip lobes, smaller callus positioned at base of the midlobe and lack of rostellum and viscidium.

Terrestrial, leafless herbs, 28–48 cm tall with subterranean tuberous pseudobulbs, creeping rhizomes and sometimes coralloid mycorhizal rhizomes. Roots fibrous, whitish, densely hairy, spreading from the base of the pseudobulb. Inflorescence erect from the upper part of pseudobulb, 25–45 cm long, slightly purplish green with 2–3...
nodes, each node with a tubular sheathing scale, the sheath 2.5–6.0 cm long, rachis 7–15 cm long, 5–22-flowered, secund, floral bracts narrowly elliptic to lanceolate, obtuse, 0.5–1.0 cm long, green. Pedicel and ovary ca. 2 times longer than floral bract, up to 24 mm, dark purple. Flowers pendulous, hardly opening, rose-purple to orange-brown, narrowly campanulate. Dorsal sepal oblanceolate-spathulate, 26.0–30.0 × 3.1–3.9 mm at the widest part, apex acute to acuminate. Lateral sepals oblanceolate-spathulate, slightly oblique, 26.0–30.0 × 3.1–3.9 mm at the widest part, apex acute to acuminate. Petals oblanceolate-spathulate 24.5–27.0 × 2.7–3.2 mm at the widest part, apex obtuse. Lip 26.0–30.0 mm long, divided into epichile and hypochile, hypochile linear, shallowly saccate at base involute and furrowed, 18–21 mm lon, epichile trilobed from base, lateral lobes extending from inrolled margins of hypochile, 2.5–3.5 mm long, apex never exceeding column, midlobe ovate to narrowly oblong, 8.0–9.0 mm long, apex acute or obtuse; base of epichile with a smooth callus, 2.0–3.0 mm long, 0.5–1.0 mm in diameter. Column straight, 24.0–26.5 mm long, without narrow ventral wings below anther, dilated at apex, light purple, purple surrounding stigma cavity and along midrib on ventral surface, stigma orbicular, rostellum absent, anther cap joined with column, triangular, yellow, apex thickened, pollinia 4, yellow, compressed, in 2 groups, viscidium absent. Capsules pendent, ellipsoid-cylindric, 30–33 mm long.

These measurements above are based on several specimens from the type locality and may not entirely represent the diversity present in the species when more specimens are found in the future.

**Additional specimens examined:**—JAPAN. Gifu Pref.: Ibi County, Ibigawa Town, Kasugakawai, 18 Dec 2020, Nishida 20201218 (Lake Biwa Museum!)

**Distribution and phenology:**—Cremastra saprophytica is only known from the type locality. Flowering occurred from late May to early June, and fruiting from late June to early October.

**Taxonomic notes:**—Cremastra saprophytica is the second completely leafless species in the genus. It is superficially similar to *C. aphylla* due to their leafless and mycoheterotrophic habit (Yukawa 1999). However, *C. saprophytica* can be easily distinguished from *C. aphylla* by its green stem, more closed perianth tube, smaller lateral lobes of lip, smaller callus of lip positioned at base of the midlobe, and absence of a rostellum and viscidium (Figs 1–3 and Table 1).

**TABLE 1.** Morphological comparison of Cremastra saprophytica and *C. aphylla*.

<table>
<thead>
<tr>
<th>characters</th>
<th><em>C. saprophytica</em></th>
<th><em>C. aphylla</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>stem colour</td>
<td>green</td>
<td>dark brownish purple</td>
</tr>
<tr>
<td>flower colour</td>
<td>rose-purple to orange-brown</td>
<td>brownish black</td>
</tr>
<tr>
<td>floral condition</td>
<td>almost closed</td>
<td>weakly open</td>
</tr>
<tr>
<td>length of lateral sepals</td>
<td>26–30 mm</td>
<td>32–36 mm</td>
</tr>
<tr>
<td>length of lateral lip lobes</td>
<td>2.5–3.5 mm long, never exceeding column</td>
<td>more than 5.0 mm long, consistently exceeding column</td>
</tr>
<tr>
<td>lip callus condition</td>
<td>linear or acute, smooth, 2.0–3.0 mm long, 0.5–1.0 mm in diameter and height</td>
<td>clavate, verruculose, ca. 5.0 mm long, 2.5 mm in diameter and height</td>
</tr>
<tr>
<td>anther cap condition</td>
<td>joined with column</td>
<td>free</td>
</tr>
<tr>
<td>rostellum condition</td>
<td>absent</td>
<td>flat, deeply cleft after removing pollinarium</td>
</tr>
<tr>
<td>viscidium condition</td>
<td>absent</td>
<td>large, folded</td>
</tr>
</tbody>
</table>

In Cremastra, except in the two leafless species, the leaf emerges in the autumn and persists through the winter, withering at flowering (Freudenstein et al. 2017). Therefore, because leafy Cremastra species often lack leaves when flowering, *C. saprophytica* may be confused with two varieties of *C. appendiculata* with relatively similar floral morphology. However, apart from its leafless habit, *C. saprophytica* can be distinguished from *C. appendiculata* var. appendiculata by the floral morphological characters mentioned above because *C. aphylla* and *C. appendiculata* var. appendiculata have identical floral structures (Lund 1988, Yukawa 1999). In addition, although *C. saprophytica* is somewhat similar to *C. appendiculata* var. variabilis in having a small smooth lip callus on the base of midlobe (Lund
1988), *C. saprophytica* can be distinguished by the other floral morphological characters mentioned above as well as its column wing condition (absent vs. a narrow ventral wing below anther).

**FIGURE 1.** *Cremastra saprophytica* from the type locality. A–C. Flowering plant. D. Flower, dorsal view. E. Flower, lateral view. F. Flower, front view. Central arrow points to a small smooth callus of lip positioned at the base of midlobe, whereas the other arrows point to the inconspicuous lateral lobes. G. Fruiting plants. H. Fruiting body of *Coprinellus disseminates*, one of the associated fungi of *C. saprophytica*. 

A NEW SPECIES OF *CREMASTRA SAPROPHYTICA*  
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FIGURE 2. *Cremastra saprophytica* (holotype). A. Habit. B. Pseudobulb with roots and a coralloid mycorhizal rhizome; arrow points to mycorhizome. C. Flower, dorsal view. D. Lip. E. Dorsal sepals. F. Lateral sepals. G. Column (lateral, ventral and dorsal views). H. Close-up of the upper part of the column (lateral, ventral and dorsal views); arrow points to contact between pollinia and stigma. Scale bars: A = 10 cm; B–H = 1 cm; I–J = 5 mm.
FIGURE 3. Cremastra aphylla from Hokkaido. A. Flowering plant. B. Flowers; central arrow points to a large verruculose callus of lip positioned at the base of midlobe, whereas the other arrows point to the conspicuous lateral lobes. C. Close-up of the upper part of the lip and column, lateral view. D. Close-up of the upper part of the lip, dorsal view. E. Close-up of the upper part of column and anther cap (lateral and ventral views); arrow points to a large, folded viscidium attached to pollinia. A–B: Y. Sugawara KS872 (KYO). C–D: Suetsugu & Horie KS411 (KYO). All scale bars = 5 mm.
Reproductive notes:—Cremastra saprophytica possesses an effective self-pollination system, and the fruit set is nearly 100% (Fig. 1G). In other Cremastra species, a well-developed rostellum/viscidium acts as a barrier to self-pollination (Fig. 3E; Chung & Chung 2003). In contrast, there is no rostellum and viscidium in C. saprophytica, resulting in contact between the pollinia and stigma (Fig. 2I) and allowing autonomous self-pollination. In addition, given that the viscidium acts as a glue to bind the pollinia to insect visitors, its lack must decrease the likelihood of insect pollination. Therefore, autogamy is likely the dominant, if not exclusive, reproductive strategy in C. saprophytica. As mentioned above, C. saprophytica can be distinguished from C. aphylla by not only column morphology but also smaller flower size and more closed perianth tube (Fig. 1, 3) probably associated with its autonomous self-pollination system.

Self-pollination is thought to be an adaptive response that provides reproductive assurance under conditions of pollinator limitation (Suetsugu 2013b), which is reported to be widespread among orchids (Tremblay et al. 2004). The fruit set of entomophilous Cremastra species is far lower than average in Orchidaceae (ca. 30%; Tremblay et al. 2004), with C. appendiculata in a Korean population exhibiting only 1.3–2.0% fruit set under natural conditions, even though artificial self- and cross-pollination both resulted in nearly 100% fruit set (Chung & Chung 2003). Therefore, it is likely that pollinator limitation severely affects the reproductive success of Cremastra species. It is also noteworthy that autonomous self-pollination has been suggested to be favourable for mycoheterotrophic plants because they are restricted to dark shaded forest understory with few pollinators (Leake 1994, Zhou et al. 2012, Suetsugu 2013a, 2015).

Ecological notes and etymology:—Mycoheterotrophic plants have often been misrepresented by many botanists as a form of saprophytism (Leake 1994). However, despite their leafless nature, they do not directly obtain carbon from decaying organic matter. Instead, most mycoheterotrophic plants depend on the photosynthate of adjacent autotrophic plants through shared mycorrhizal networks (Martos et al. 2009, Suetsugu et al. 2020). However, recent studies have shown that several mycoheterotrophic orchids obtain carbon from dead wood via saprotrophic fungi (Martos et al. 2009, Suetsugu et al. 2020). Therefore, even though the term “mycoheterotroph” has replaced the formerly misapplied term “saprophyte”, some mycoheterotrophic plants are indirectly saprotrophic (Martos et al. 2009). The genus Cremastra is one of such examples exploiting wood-decaying Psathyrellaceae (Suetsugu et al. 2021). Cremastra saprophytica is also associated with Psathyrellaceae fungi, and the fruiting bodies of Coprinellus disseminates, one of the mycobionts, could be observed on decayed fallen trees near C. saprophytica plants (Fig. 1H). The new species is named after its indirectly saprophytic habit.

However, it should be noted that C. saprophytica accumulates more chlorophyll than C. aphylla in the shoot (Fig. 1A–C and 1G), although it is arguably at a late stage in the evolutionary development toward complete mycoheterotrophy due to its leafless habit. Given that recent studies have shown that the stems of these leafless orchids have been shown to provide some photosynthetic carbon to the plants (Zimmer et al. 2008, Suetsugu et al. 2018, Kobayashi et al. 2021), it is likely that C. saprophytica is a partially mycoheterotrophic species rather than fully mycoheterotrophic. In particular, because the green colour deepens during fruit maturation (Fig. 1G), its photosynthetic ability may significantly contribute to fruit and seed production. Notably, the underground parts of C. aphylla always consisted of pseudobulbs, roots and coralloid mycorhizomes, whereas not all C. saprophytica plants formed coralloid mycorhizomes. Because the main area of mycorrhizal colonization is coralloid rhizomes in Cremastra (Yagame et al. 2013, Suetsugu et al. 2021), occasional lack of coralloid rhizomes might reflect some autotrophic carbon gain. Thus, comparative studies in C. saprophytica, C. aphylla and C. appendiculata could be an ideal model to understand how the photosynthetic apparatus functions in chlorophyllous but highly mycoheterotrophic orchids.

Preliminary conservation status:—Cremastra saprophytica is currently known only from a single population. The population comprises roughly ten mature plants, and at present we are not aware of any other locality where this species persists.

Key to the species of Cremastra (based on Chen et al. 2013)

1. Mycoheterotrophic plants without foliage leaves..................................................................................................................2

- Apparently autotrophic plants with normal leaves..................................................................................................................3

2. Stem dark brownish purple; flower weakly open, dark brownish purple; lip lateral lobes consistently exceeding column; lip callus positioned at the base of midlobe, clavate, verruculose, ca. 5.0 mm long, 2.5 mm in diameter and height, rostellum flat, deeply cleft after removing pollinarium, viscidium large, folded.................................................................C. aphylla

- Stem green; flower almost closed, rose-purple to orange-brown, lip lateral lobes never exceeding column, lip callus positioned at the base of midlobe, linear or acute, smooth, 2.0–3.0 mm long, 0.5–1.0 mm diameter, rostellum absent, viscidium absent..................................................................................................................................................C. saprophytica

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3. Creeping rhizome between pseudobulbs 3–4 cm long, leaves green with purple blotches, flowers suberect, opening widely, lip 16–20 mm, midlobe strongly reflexed.................................................................C. unguiculata
- Creeping rhizome between pseudobulbs ca. 1 cm long, leaves green without purple blotches; flowers pendulous or horizontal on rachis, not opening widely, lip 25–35 mm, mid-lobes straight to slightly reflexed.................................................................C. guizhouensis
4. Pseudobulbs broadly cylindric, 10.0–14.0 cm, lip callus midway along midlobe ....................................................C. guizhouensis
- Pseudobulbs ovoid or subglobose, 1.5–3.0 cm, lip callus at base of midlobe ........................................................................C. appendiculata
5. Inflorescence sparsely 4–7-flowered, flowers horizontal to slightly pendulous, lip lateral lobes geniculate and twisted 90° at the base, midlobe slightly reflexed, rhombic to broadly ovoid.................................................................C. unguiculata
- Inflorescence compact to densely (5–)8–32-flowered, flowers pendulous, lip lateral lobes straight, midlobe ovate to narrowly oblong...................................................................................................................................................
6. Lip callus clavate, verruculose, ca. 5.0 mm long, 2.5 mm in diameter, column with a narrow ventral wing below anther ............C. appendiculata
- Lip callus linear, smooth, 2.0–4.0 mm long, 1.0–2.0 mm in diameter, column wing absent.....................C. appendiculata var. variabilis

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