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8 Title: First record of the mycoheterotrophic plant *Sciaphila corniculata* (Triuridaceae)

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10 in particular on stylar characteristics

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13 Running title: Suetsugu & Sugimoto | *Sciaphila corniculata*, new to Japan.

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Short Communication

First Record of the Mycoheterotrophic Plant *Sciaphila corniculata* (Triuridaceae) from Ishigaki Island, Ryukyu Islands, Japan, with updated description of its morphology, in particular on stylar characteristics

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1 We report three new localities of the mycoheterotrophic plant *Sciaphila corniculata*
2 (Triuridaceae) from Ishigaki Island, Ryukyu Islands, Japan. Previously, *S. corniculata*
3 was reported only from Kolombangara Island (Solomon Islands), Waigeo Island (New
4 Guinea) and Obi and Aru islands (the Moluccas). We also update a description of its
5 morphology, in particular on styler characteristics based on new materials. A key to the
6 Japanese species of *Sciaphila* based on total flower and styler characteristics is also
7 provided for easy identification of these rare mycoheterotrophic plants.

8

9 Key words: Distribution, mycoheterotrophy, *Sciaphila*, taxonomy, Triuridaceae

10

11 The Triuridaceae comprise fully mycoheterotrophic plants that mainly grow in deep shade
12 understory in ever-wet forests in the tropics and subtropics worldwide, reaching their
13 northernmost limits in temperate regions of Japan (van de Meerendonk 1984). The
14 mycoheterotrophic *Sciaphila* Blume consists of ca. 40 species and is the largest genus in
15 the family (van de Meerendonk 1984).

16 In taxonomic studies of *Sciaphila* (van de Meerendonk 1984, Hsieh *et al.* 2003,
17 Chantanaorrapint & Thaithong 2004, Averyanov 2007, Ohashi *et al.* 2008, Xu *et al.* 2011,
18 Tsukaya & Okada 2013, Tsukaya & Suetsugu 2014, Suetsugu *et al.* 2016a, Suetsugu &
19 Nishioka 2017), the following floral traits have been used as key characters for species
20 discrimination: bisexual or unisexual flowers, number and shape of the stamens and
21 perianth segments, shape of the apical perianth segments, and shape and length of the
22 styles. As with most mycoheterotrophs, the plants are small, up to 40 cm tall, recognizable
23 only during the reproductive season and usually occur in small populations. Consequently,
24 they have scarcely been collected and their morphological traits rarely described in detail.
25 In addition, key characteristics of the staminate flowers, which are crucial for precise

1 identification, have not been documented in some species, particularly in individuals too
2 young at the time of collection or because staminate flowers are often limited (Tsukaya
3 & Okada 2013, Tsukaya & Suetsugu 2014). Given the difficulty of precise identification,
4 the taxonomy of *Sciaphila* remains to be revised.

5 Japan is known for its great diversity of *Sciaphila*, harboring seven species
6 (Suetsugu *et al.* 2016a, Suetsugu & Nishioka 2017). In fact, the flora of Japan is
7 particularly rich in mycoheterotrophic plants, harboring ca. 50 species. Recent botanical
8 surveys of mycoheterotrophic plants in Japan have resulted in the discovery of several
9 new distributional records and new taxa (Ohashi *et al.* 2008, Yagame *et al.* 2008, Yahara
10 & Tsukaya 2008, Suetsugu 2012a, b, 2013, 2014, 2015a, b, 2016a, b, c, d, 2017, Suetsugu
11 & Ishida 2011, Suetsugu *et al.* 2012, 2013, 2014b, 2016a, b, Suetsugu & Yagame 2014,
12 Suetsugu & Fukunaga 2016). Of particular interest are the lowland forests of the Ryukyu
13 Islands, which are known to be a hotspot for endemic mycoheterotrophic taxa such as
14 *Sciaphila yakushimensis* Suetsugu, Tsukaya & H. Ohashi, *Gastrodia takeshimensis*
15 Suetsugu and *Gastrodia flexistyloides* Suetsugu.

16 A detailed botanical survey of the Ryukyu Islands would likely provide more
17 precise data regarding the diversity and distribution of mycoheterotrophs. As anticipated,
18 during a recent botanical survey, we collected unknown plants of *Sciaphila* in lowland
19 evergreen forests on Ishigaki Island, Ryukyu Islands. After a detailed morphological
20 investigation, we determined them to be *Sciaphila corniculata* Becc. (Fig. 1). Here we
21 report the first occurrence of that species in Japan. We also provide a description based
22 on the plants from Ishigaki Island, because there are a few minor differences between
23 previous descriptions and the plants on Ishigaki Island.

24
25 ***Sciaphila corniculata*** Becc., Malesia 3: 336. (1890) — Figs. 1–2.

1

2 **Specimen examined:** JAPAN. Ryukyu. Okinawa Pref., Ishigaki City, Nosoko, alt
3 ca. 10 m, 18 October 2015, *T. Sugimoto s.n.* (KYO); JAPAN. Ryukyu. Okinawa Pref.,
4 Ishigaki City, Nosoko, alt ca. 20 m, 15 October 2016, *T. Sugimoto s.n.* (KYO); JAPAN.
5 Okinawa Pref., Ishigaki City, Miyara, alt. ca. 80 m, 21 October 2016, *T. Sugimoto s.n.*
6 (OSA); JAPAN. Okinawa Pref., Ishigaki City, Nosoko, alt ca. 10 m, 30 September 2016,
7 *T. Nishioka s.n.* (OSA); JAPAN. Okinawa Pref., Ishigaki City, Ibaruma, alt ca. 170 m, 30
8 September 2016, *T. Nishioka s.n.* (OSA).

9

10 Herbs, monoecious, mycoheterotrophic, perennial, erect, carmine or scarlet, non-
11 branched; underground parts white. Roots filiform, with few hairs. Inflorescences
12 glabrous, 1.5–6 cm tall, ca. 0.8 mm thick. Scale leaves acute, ca. 1.5 mm long.
13 Inflorescences racemose, rachis ca. 0.5–2 cm long, densely 3–11 flowered, staminate
14 flowers distal. Pedicels ca. 0.7–1.5 mm long, straight, shorter than flower, divergent at
15 60–90°; bracts linear, acute, ca. 1 mm long, appressed to the pedicel. Staminate flowers
16 1.6–1.8 mm across, perianth segments 6, opening flat, equal in size, connate at base,
17 segments ovate to triangular, glabrous, apex acute, long-bearded. Stamens 3, without
18 filaments. Anthers 4-lobed. Carpellate flowers: 1.8–2.1 mm across; perianth segments 6,
19 equal in size, connate at base, segments ovate to triangular, glabrous, apex obtuse or acute,
20 without particular structures. Carpels numerous, ellipsoidal, ca. 0.2–0.3 mm long, apex
21 rounded; style and stigma clavate with dense cylindrical papillae or rarely subulate with
22 inconspicuous cylindrical papillae, laterally inserted at base of ovary; free portion of style
23 and stigma ca. 0.6–0.7 mm long.

24

25 **Taxonomic note:** The staminate flowers of *Sciaphila* on Ishigaki Island bear

1 unisexual flowers with six equal-sized perianth segments, indicating that they belong to
2 *Sciaphila* sect. *Oliganthera* subsect. *Quadrilobatae* (van de Meerendonk 1984).
3 Subsection *Quadrilobatae* contains several species, including *S. corniculata* Beccari, *S.*
4 *secundiflora* Thwaites ex Bentham, *S. stellata* Aver., *S. thaidanica* K. Larsen and *S. alba*
5 Tsukaya and Suetsugu. However, our material differs from *S. secundiflora*, *S. stellata*, *S.*
6 *thaidanica* and *S. alba* in having a long beard at the apex of all 6 staminate perianth
7 segments. The characteristics of the plants on Ishigaki Island closely match the
8 description of *S. corniculata* (van de Meerendonk 1984). Based on morphological
9 similarities of the other floral organs, we determined our material to be *S. corniculata*.

10 Despite the similarities, there are a few minor differences between the plants on
11 Ishigaki Island and previous descriptions and illustrations of *S. corniculata*. For example,
12 *S. corniculata* was often described as having a subulate style, with a glabrous apex
13 (Schlechter 1912, van de Meerendonk 1984). In contrast, plants in the Ishigaki population
14 always have a clavate style with dense, cylindrical papillae (Fig. 1A). Our observations
15 of the Ishigaki plants revealed that the style tends to shrink from the apex during the late
16 flowering stage and appears to be subulate (Fig. 1B). Clavate styles with dense cylindrical
17 papillae were noticed in some plant of *S. corniculata* on Waigeo Island (New Guinea; H.
18 Tsukaya, personal communication). We consider the differences to most likely represent
19 intraspecific variation, mainly due to floral conditions.

20

21 **Distribution and phenology:** *Sciaphila corniculata* has been reported only from
22 Kolombangara Island (Solomon Islands), Waigeo Island (New Guinea) and Obi and Aru
23 islands (the Moluccas); the Japanese populations represent the northernmost occurrence
24 of the species.

25 The *S. corniculata* populations in Japan appear to be restricted to three locations

1 separated by at least 1 kilometers on central Ishigaki Island, Ryukyu Islands, Japan. They
 2 occur at approximately 10–170 m elevation within a humid evergreen broadleaved forest
 3 dominated by *Castanopsis sieboldii* (Makino) Hatus. ex T. Yamaz. & Mashiba, *Distylium*
 4 *racemosum* Siebold et Zucc, and *Neolitsea aciculata* (Blume) Koidz. *Sciaphila*
 5 *corniculata* flowers from mid-September to mid-October. Each location consisted of
 6 dozens of individuals, together totaling less than 50 flowering plants. We are not aware
 7 of any other localities for *S. corniculata* on Ishigaki Island.

8 Given that mycoheterotrophic plants are highly dependent on the activities of both
 9 the fungi and the trees that sustain them (e.g., Suetsugu *et al.* 2014a), they are particularly
 10 sensitive to environmental destruction. Careful conservation is requested for these
 11 populations. It should also be noted that *S. corniculata* may be found more widely,
 12 considering that these mycoheterotrophic plants are easily overlooked. Further
 13 exploration is needed to elucidate the full distribution of *S. corniculata* in Japan.

14

15 **A. Key to the Species of *Sciaphila* in Japan based on general floral characteristics**

16 **(modified after Suetsugu & Nishioka 2017)**

17

- 18 1. Plants with bisexual and unisexual flowers..... *S. tenella*
 19 1. Plants with unisexual flowers.....2
 20 2. Staminate flowers located between carpellate flowers..... *S. multiflora*
 21 2. Staminate flowers located above carpellate flowers.....3
 22 3. Segments of staminate flower equal4
 23 3. Segments of staminate flowers unequal, 3 large alternating with 3 small...5
 24 4. Staminate flowers ca. 6–7 mm across..... *S. secundiflora*
 25 4. Staminate flowers ca. 1.5–2 mm across..... 6
 26 5. Apex of all 6 staminate perianth segments with globose knob..... *S. sugimotoi*
 27 5. Apex of only 3 smaller staminate perianth segments with globose knob.....7
 28 6. Staminate perianth segments without beard..... *S. ramosa*
 29 6. Staminate perianth segments with apical beard *S. corniculata*
 30 7. Style subulate, apex smooth, glabrous *S. nana*
 31 7. Style club-shaped, papillate..... *S. yakushimensis*
 32

1 **B. Key to the Species of *Sciaphila* in Japan based primarily on stylar characteristics**

2 **(modified after Suetsugu & Nishioka 2017)**

- 3
- 4 1. Style of carpellate flowers club-shaped, apex papillate 2
- 5 1. Style of carpellate flowers subulate, apex glabrous 6
- 6 2. Flowers staminate and bisexual; apex of perianth bearded *S. tenella*
- 7 2. Flowers unisexual 3
- 8 3. Staminate flowers located between carpellate flowers..... *S. multiflora*
- 9 3. Staminate flowers above carpellate lowers..... 4
- 10 4. Staminate flowers 6–7 mm across; carpellate flowers ca. 5 mm across; perianth
- 11 segments of staminate flowers narrowly triangular to linear-triangular, equal, apex
- 12 without appendage; plants reddish purple or brownish pink..... *S.*
- 13 *secundiflora*
- 14 4. Staminate and carpellate flowers of same size, less than 2.5 mm across; perianth
- 15 segments of staminate flowers narrowly ovate to triangular, 5
- 16 5. Staminate flowers, ca. 1.5 mm across; perianth segments dimorphic, 3 broader
- 17 alternating with 3 narrower; apex of narrower segments with globose knob; plants
- 18 blackish purple *S. yakushimensis*
- 19 5. Staminate perianth segments, ca. 2 mm across, equal in size; apex of all segments
- 20 bearded; plants carmine to scarlet..... *S. corniculata*
- 21 6. Perianth segments monomorphic; apex of perianth without appendages..... *S. ramosa*
- 22 6. Perianth segments dimorphic, 3 broader alternating with 3 narrower; apex of perianth
- 23 segments with globose knob..... 7
- 24 7. Connective exceeding anthers; apex of 3 narrower staminate perianth segments with
- 25 globose knob *S. nana*
- 26 7. Connective not exceeding anthers; apex of all staminate perianth segments with
- 27 globose knob *S. sugimotoi*

28

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30 the field study. The beautiful, very helpful line drawings were prepared by Ms. Kumi

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34

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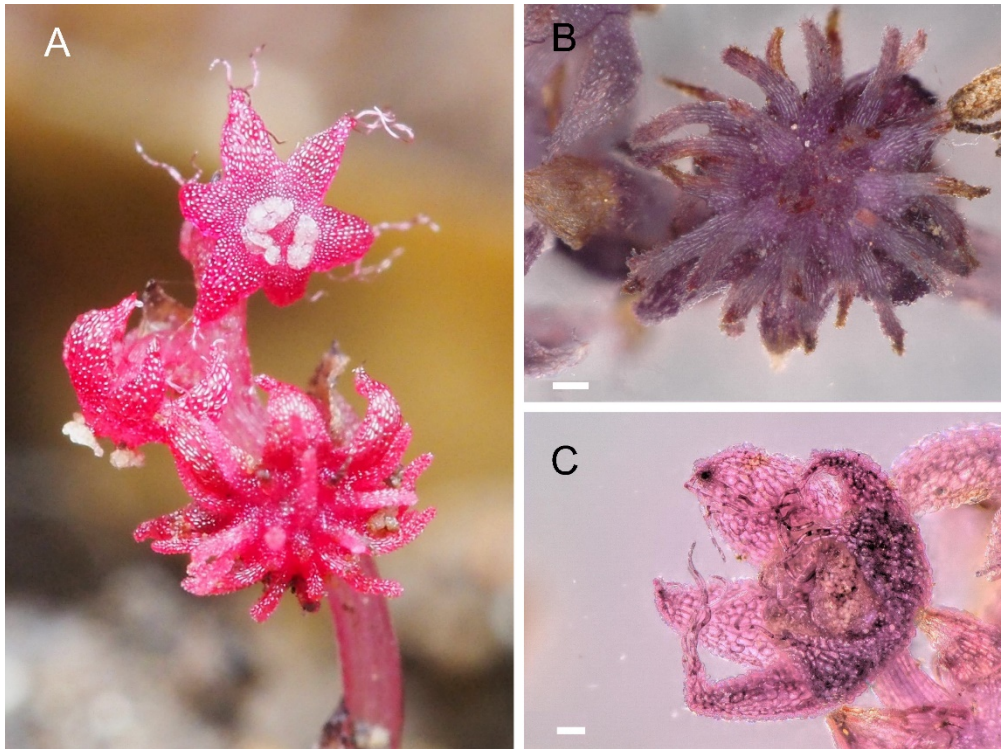
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24 **Figure legend**

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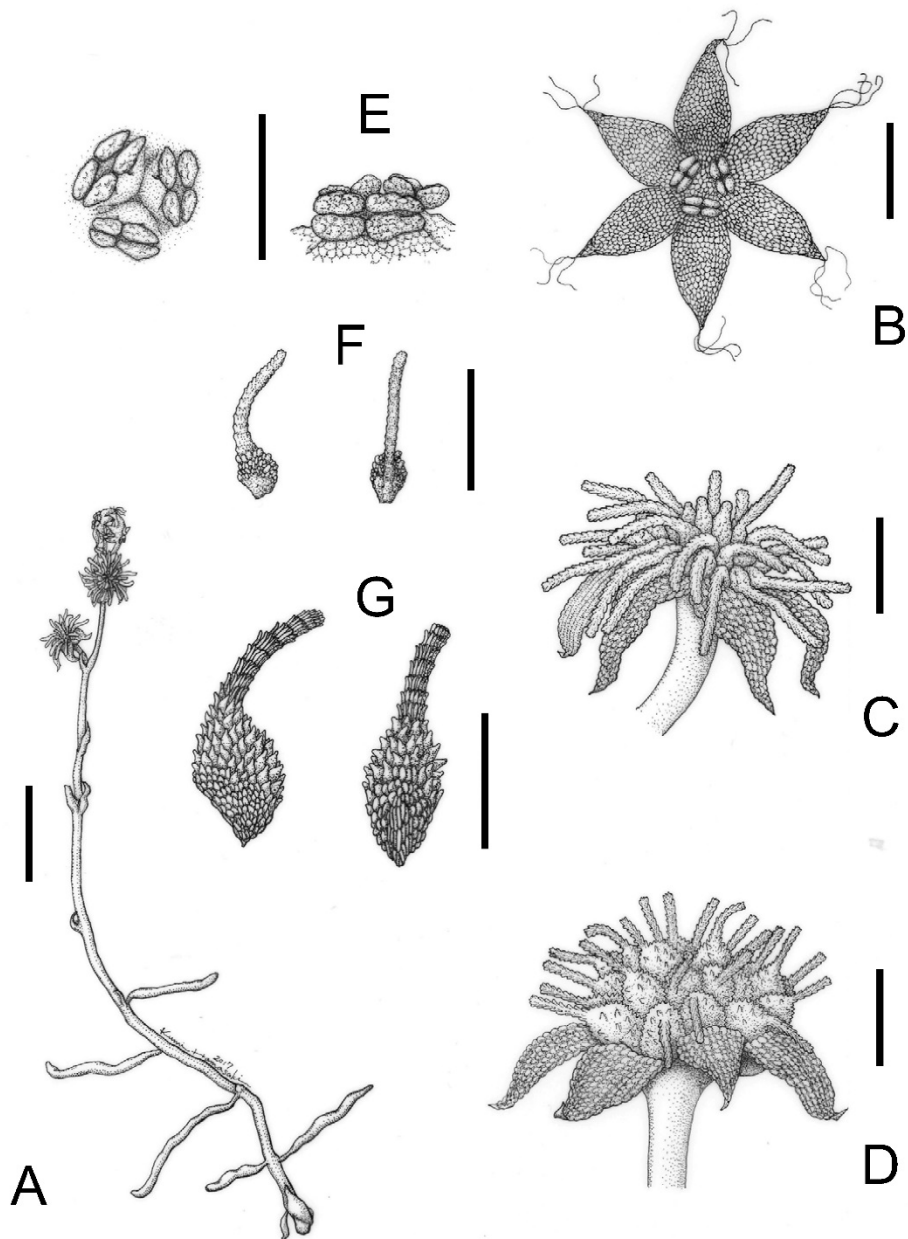


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3 **Figure 1.** Habit and microscopic images of *Sciaphila corniculata* on Ishigaki Island. A.
4 Flowering plant. B. Carpellate flower. C. Staminate flower. Bar = 0.2 mm (B), 0.1 mm
5 (C).

6

7



1

2 **Figure 2.** *Sciaphila corniculata* on Ishigaki Island A. Flowering plant, B. Staminate
 3 flower, C. Carpellate flower. D. Carpellate flower in fruit with persistent perianth
 4 segments. E. Anthers with floral disc. F. Immature carpel with stigma. G. Immature
 5 fruit. Bar = 5 mm (A), 0.5 mm (B–G). Drawn by Kumi Hamasaki.

6