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SALVIA DAIGUII (LAMIACEAE): A NEW SPECIES FROM WEST HUNAN, CHINA

Y. K. Wei[1], C. A. Pendry[2], D. G. Zhang[3] & Y. B. Huang[1]

Salvia daiguii Y.K.Wei & Y.B.Huang, a new species from China, is described. *Salvia daiguii* belongs to *Salvia* subg. *Glutinaria* (Raf.) G.X.Hu, C.L.Xiang & B.T.Drew, sect. *Sobiso* (Raf.) G.X.Hu, A.Takano & B.T.Drew, and is distinguished from morphologically similar species by differences in its habit, leaves, inflorescences and flowers. It has a narrow distribution in a karst region of Yongding District, Hunan Province, central China. A key to the Chinese species of section *Sobiso* is also presented.

Keywords. Chinese endemic species, Nepetoideae, *Salvia*, section *Sobiso*.

Introduction

All species of *Salvia* native to China belong to the East Asia clade of *Salvia* (Wei *et al*., 2015; Hu *et al*., 2018), and 70 of them are endemic to China. The high diversity of *Salvia* in China is probably a result of the country's wide range of geological and climatic conditions, and the genus is most prominent in the Qinghai–Tibet Plateau, the Hengduan Mountains, and the karst regions found across the country.

Several new *Salvia* species have been described from China in recent years (Su *et al*., 1984; Hu *et al*., 2014, 2017), but there is still a lack of comprehensive studies in areas such as the provinces of Yunnan, Sichuan, Guizhou, Guangxi and Hunan, and the collection of specimens across the Himalayas is much needed (Li & Hedge, 1994). The existing taxonomy of *Salvia* (Wu & Li, 1977) is based purely on morphology, and it is currently being revised in the light of new molecular evidence and detailed field investigations (Will *et al*., 2015; Drew *et al*., 2017; Will & Claßen-Bockhoff, 2017; Hu *et al*., 2018). In the present study we describe a new species of *Salvia* from Hunan Province and discuss its placement within the revised classification of *Salvia*.

In 2007, Zhang Daigui collected a *Salvia* in western Hunan, China, and initially identified it as the widespread Chinese species *Salvia cavaleriei* H.Lév., following the account in the *Flora of China* (Li & Hedge, 1994). Further investigations in the field and comparison with herbarium material of *Salvia cavaleriei* and the morphologically similar *S. prionitis* Hance (Table), found in South Central and East China, have confirmed that Zhang's collection represents a new species, and it is described and illustrated below. The new species is superficially similar to *Salvia japonica* Thunb. and *S. scapiformis* Hance,

[1] Shanghai Chenshan Botanical Garden, 3888 Chenhua Road, Shanghai 201602, China.
[2] Royal Botanic Garden Edinburgh, 20A Inverleith Row, Edinburgh EH3 5LR, Scotland, UK. Author for correspondence. E-mail: cpendry@rbge.ac.uk
[3] Key Laboratory of Plant Resources Conservation and Utilization, College of Biology and Environmental Sciences, Jishou University, Jishou, Hunan 416000, China.

TABLE. Morphological comparison of *Salvia daiguii*, *S. cavaleriei* and *S. prionitis*[a]

Feature	*Salvia daiguii*	*Salvia cavaleriei*	*Salvia prionitis*
Plant height (cm)	13–21 (mean, 16.1) ($n = 10$)	36–63 (mean, 44.1) ($n = 6$)	28–59 (mean, 41.9) ($n = 8$)
Number of tillers	2–5	0 or 1	0
Indumentum	Petioles, veins and stem puberlous; inflorescence tomentose	Whole plant almost glabrous	Whole plant densely puberlous
Leaf position	All basal	Usually with 1 or 2 cauline leaves	Usually with 1 or 2 cauline leaves
Leaf division	Entire or trifoliolate	Basal leaf entire or trifoliolate, cauline leaf usually trifoliolate	Entire or trifoliolate
Leaf size (cm)	2–5.9 × 1.2–2.9	2.9–7.3 × 1.5–3.6	3.4–7 × 1.7–4
Leaf shape	Obovate, ovate to broadly elliptic	Ovate, elliptic	Elliptic, ovate
Leaf apex	Obtuse to rounded	Acuminate to acute	Acute, obtuse to rounded
Leaf base	Cuneate to rounded	Cordate	Cordate to truncate
Leaf colour	Dark green	Green and usually with purplish red lower surface	Green
Leaf texture	Shiny, subglabrous, subleathery	Subglabrous, papery	Coarse, thick papery
Inflorescences	Compound verticillaster	Single verticillaster	Compound verticillaster
Inflorescence length (cm)	8.0–15.5 (mean, 11.4) ($n = 10$)	11.0–23.4 (mean, 16.7) ($n = 7$)	7.8–30.5 (mean, 21.3) ($n = 8$)
Calyx length (mm)	4–6 (mean, 5.13) ($n = 11$)	4–7 (mean, 5.27) ($n = 10$)	3–6 (mean, 4.81) ($n = 18$)
Calyx indumentum on throat inside	Sparsely strigillose in upper part, exannulate	Sparsely strigillose in upper part, exannulate	Obviously and densely strigose, annulate
Corolla colour	White	Pale purple	Pale blue-purple
Corolla length (mm)	8–11 (mean, 9.60) ($n = 27$)	6–8 (mean, 7.28) ($n = 10$)	9–12 (mean, 9.96) ($n = 20$)

TABLE. *(Continued)*

Feature	*Salvia daiguii*	*Salvia cavaleriei*	*Salvia prionitis*
Corolla width (mm)	4–7 (mean, 5.60) ($n = 21$)	3–5 (mean, 3.85) ($n = 10$)	5–7 (mean, 5.63) ($n = 18$)
Corolla height (mm)	8–11 (mean, 9.59) ($n = 27$)	6–8 (mean, 6.98) ($n = 10$)	8–12 (mean, 10.1) ($n = 20$)
Corolla upper lip	Upright	Spreading	Upright
Corolla lower lip	Middle lobe obcordate, apex bilobed	Middle lobe obcordate, apex emarginate	Middle lobe rounded, apex bilobed
Annulus position	Close to throat	Middle of corolla tube	Close to throat
Stamen exsertion	Exserted from corolla	Partially included within corolla	Exserted from corolla
Filament length (mm)	2.6–3.2 (mean, 2.82) ($n = 27$)	2.1–2.9 (mean, 2.58) ($n = 10$)	2.0–3.4 (mean, 2.49) ($n = 20$)
Stamen connective length (mm)	4.2–5.7 (mean, 4.91) ($n = 27$)	4.3–5.9 (mean, 5.18) ($n = 10$)	3.5–7.3 (mean, 4.78) ($n = 20$)
Pistil length (mm)	11.7–14.1 (mean, 12.6) ($n = 27$)	8.5–12.0 (mean, 10.5) ($n = 10$)	8.5–12.0 (mean, 10.8) ($n = 20$)
Pollen polar axis (PA) (μm)	31.6–36.0 (mean, 33.2) ($n = 12$)	39.7–43.2 (mean, 41.0) ($n = 12$)	43.7–46.9 (mean, 44.7) ($n = 12$)
Pollen equatorial diameter (ED) (μm)	30.3–34.1 (mean, 31.6) ($n = 12$)	32.3–36.9 (mean, 34.5) ($n = 12$)	35.2–38.5 (mean, 34.2) ($n = 12$)
Pollen equatorial breadth (μm)	26.4	14.4	9.32
Shape of pollen	Prolate-spheroidal	Subprolate	Subprolate
(PA/ED) × 100	105	119	131
Nutlet size (mm)	1.8–2.2 × 0.9–1.1 ($n = 8$)	1.5–2 × 0.8–1.1 ($n = 12$)	1.3–1.7 × 0.8–0.9 ($n = 12$)
Flowering time	June to July	April to May	May to June

[a] Where mean values are given, this refers to measurements taken from different plants.

which are also found in South Central and East China, but readily distinguished from both by the prominent, fused, boot-shaped lower arms of its stamens in contrast to the very reduced and free lower arms of the latter species.

Material and Methods

Stems, leaves, flowers and fruits were measured on herbarium specimens or living plants. Pollen micromorphology was examined for *Salvia daiguii*, *S. cavaleriei* and *S. prionitis* by using scanning electron microscopy (SEM). Pollen grains were transferred directly onto SEM stubs with double-sided adhesive tape, sputter-coated and examined with a Quanta 250 scanning electron microscope (FEI, Hillsboro, Oregon, USA). Pollen polar axis, pollen equatorial diameter and pollen equatorial breadth were measured for 12 individual pollen grains from each species by using Adobe Photoshop CS3's ruler tool (Adobe Systems, San Jose, California, USA).

Salvia daiguii Y.K.Wei & Y.B.Huang **sp. nov.**

Salvia daiguii differs from *S. cavaleriei* H.Lév. and *S. prionitis* Hance in having white corollas and only basal leaves whereas the latter species have pale blue-purple or pale purple corollas and cauline leaves; furthermore, its leaves are subleathery, whereas the other two species have papery leaves. It is distinguished from *Salvia japonica* Thunb. and *S. scapiformis* Hance by the boot-shaped, united lower arms of its stamens whereas the lower arms of stamens in the latter species are reduced and free. – Type: China, Hunan, Zhangjiajie, Yongding District, 762 m, 29°2′7.60′′N, 110°29′12.19′′E, 25 x 2011, *Y.K. Wei & Y.B. Huang* S0297 (holo, here designated, CSH [CSH0126047]; iso CSH, E). **Figs. 1,2**.

Etymology. The epithet commemorates Daigui Zhang, the species' first collector.

Vernacular name. 张家界鼠尾草 ('Zhangjiajie sage').

Description. Perennial herb, 13–21 cm, roots fibrous. *Stem* with up to 5 branches below ground, unbranched above. *Indumentum* of lower stem, petioles and veins puberlous and glandular; inflorescence axis tomentose and densely glandular hairy. *Leaves* all basal, simple or trifoliolate, with the lateral leaflets sometimes much reduced and very oblique. *Petiole* usually purplish, 2–14.5 cm. *Leaf blade* subleathery, obovate to broadly elliptic or ovate, 2–5.9 × 1.2–2.9 cm, apex obtuse, base cuneate to rounded, margin crenate, glabrous above, sparsely puberlous below, denser on the veins. *Inflorescence* 8–15.5 mm, thyrsoid, a raceme of dense, 6- to 8-flowered verticillasters. *Bracts* elliptic 5–35 mm, bracteoles ovate to lanceolate, acuminate, 3–4 mm, entire. *Pedicels* 0.8–2.7 mm, covered with glandular hairs. *Calyx* tubular-campanulate 4.5–5.9 mm, bilabiate to one-third its length, upper lip rounded, 1.5–2 mm, mucronate, lower lip 2–3 mm, teeth 1.5 mm, acuminate, tube exannulate, glandular outside, sparsely strigillose within. *Corolla* white, pubescent outside, with glandular and simple hairs, 8–11.5 mm, tube 6–8 mm, 2–4 mm across, annulus 4 mm from base, throat pronounced, with the upper and lower lips spreading at nearly 180°, upper lip 3–5 mm, lower lip c.5 mm, middle lobe obcordate, apex bilobed, c.4 × 6 mm. *Stamens* exserted 5 mm from the corolla, filaments 2.6–3.2 mm, connective 4.2–5.7 mm, upper arm 2.7–4.1 mm, lower arm

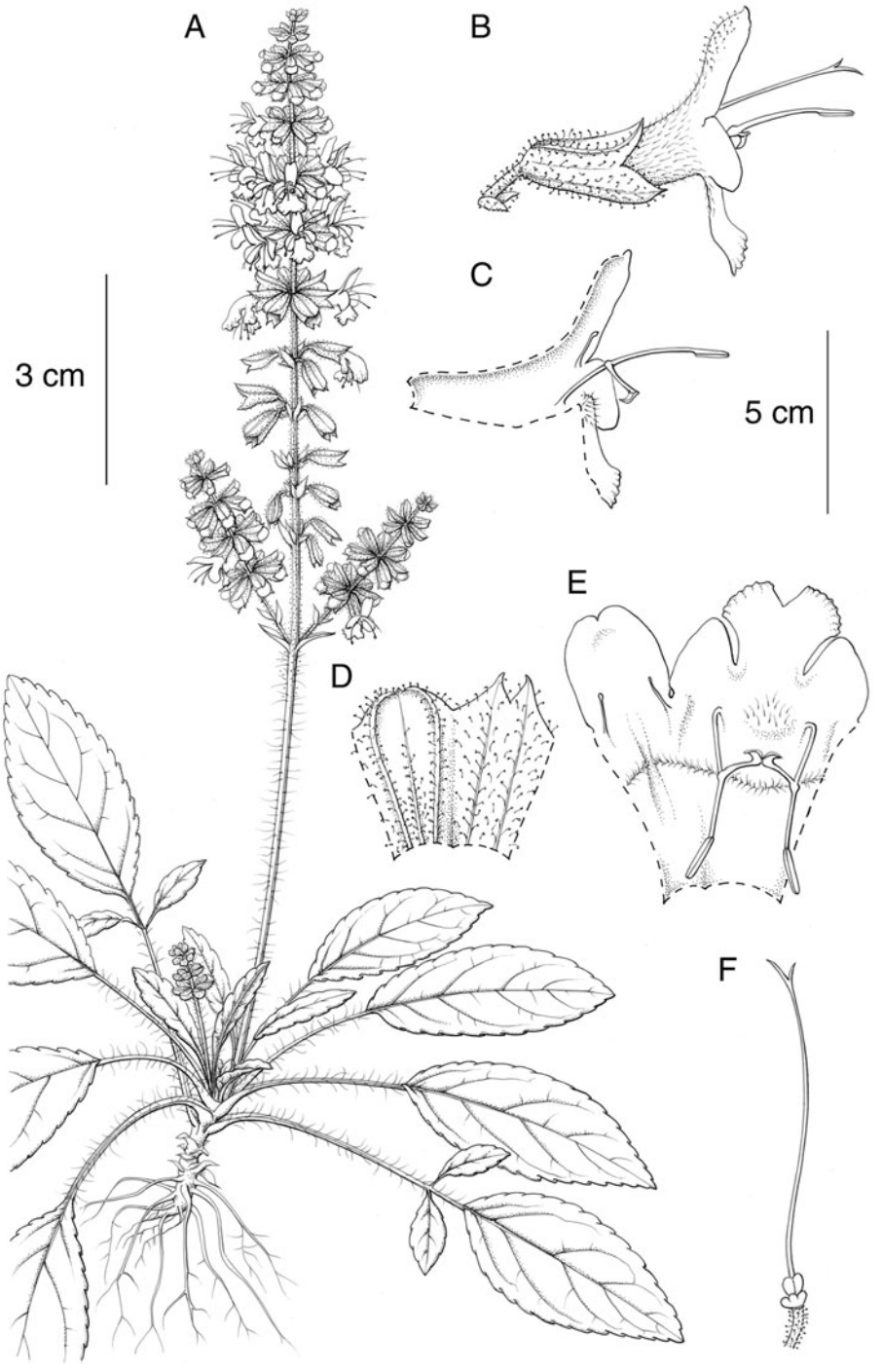

FIG. 1. *Salvia daiguii* sp. nov. A, Habit; B, side view of flower; C, longitudinal section of flower; D, outer view of dissected calyx; E, corolla with stamens reflexed; F, ovary and style. Scale bars: A, 3 cm; B–F, 5 mm. Drawn by Claire Banks, based on *D.G. Zhang* S0297 (E).

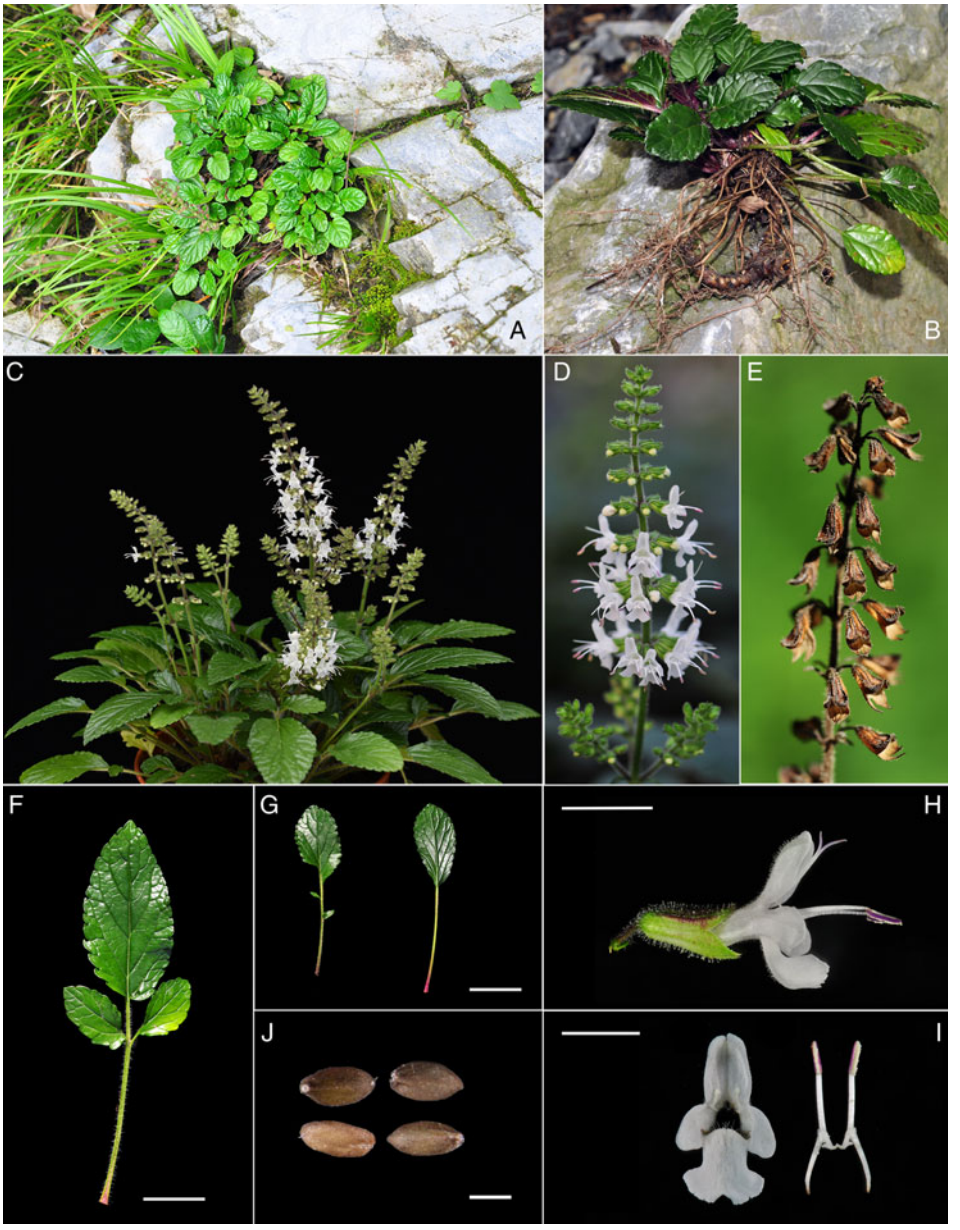

FIG. 2. *Salvia daiguii* sp. nov. A, Plant growing in a crevice in limestone; B, excavated plant showing roots; C, habit; D, inflorescence; E, infructescence; F, leaf; G, leaves showing reduced or absent lateral leaflets; H, flower; I corolla and stamens; J, nutlets. Scale bars: F and G, 4 cm; H and I, 5 mm; J, 1 mm.

0.8–1.7 mm, upper theca fertile, 1.5 mm, lower theca sterile and fused, boot-shaped. At anthesis upper connective arms close to upper lip of the corolla, later bending downwards until the upper thecae reach the middle lobe of the lower lip of the corolla. *Staminodes* 1–2 mm.

Pistil 10.6–14.1 mm, included or up to 4–6 mm exserted. *Nutlets* ellipsoid, yellow-brown, c. 2 × 1 mm, apex slightly acute, base rounded, mucilaginous on wetting.

Additional specimens examined. China. **Hunan**: Zhangjiajie, 600 m, 3 x 2015, *Jianjun Zhou* 15100303 (CSFI, four duplicates); Tianmenshan, 8 vii 2007, *Daigui Zhang* 70708009 (Herbarium of Hupingshan National Nature Reserve).

Flowering. June to July.

Fruiting. July to August.

Elevational range. 300–800 m.

Ecology. Rocky streamsides and cliffs, on limestone. Growing in cracks in the rocks and apparently well adapted to intermittent floods.

Distribution. Salvia daiguii is currently known only from Wulingyuan Zhangjiajie, Hunan Province, China, where two populations have been recorded.

Conservation status. Despite extensive searches made in 2011, 2012 and 2015, *Salvia daiguii* has been observed at only two sites, which are only about 1 km apart and therefore considered to constitute a single locality. There are no more than 200 individuals present at each of the two sites, and the total area of occupancy is 8 km^2, so our assessment is CR B2ab(iii) (IUCN Standards and Petitions Subcommittee, 2017).

Discussion

The current taxonomic system classifies the Chinese species of *Salvia* into three subgenera, *Salvia*, *Allagospadonopsis* and *Sclarea*, based on stamen structure and whether their lower arms are fertile and united (Wu & Li, 1977). Recent molecular work has shown that almost all the *Salvia* species native to East Asia belong to a single clade that has been recognised as a new subgenus, *Glutinaria* (Raf.) G.X.Hu, C.L.Xiang & B.T.Drew (Hu *et al*., 2018). Within subgenus *Glutinaria* there are eight major subclades, which Hu *et al*. (2018) treated as sections. Although there is some congruence with Wu & and Li's (1977) classification, the clades do not correspond well with the existing subgenera, particularly for species from subgenera *Allagospadonopsis* and *Sclarea* which are spread across six of the eight new sections.

The newly described *Salvia daiguii* is most similar to *S. cavaleriei* and *S. prionitis* so clearly belongs to section *Sobiso* (Raf.) G.X.Hu, A.Takano & B.T.Drew. Wu & Li's (1977) classification relied heavily on the fusion or otherwise of the lower stamen arms and placed these two species in subgenus *Sclarea* because of their united lower stamen arms. However, this character is unreliable, because in some individuals the lower arms are free, and there are clear morphological differences from the other species in subgenus *Sclarea*.

Section *Sobiso* includes two clades: the *Salvia lutescens* (Koidz.) Koidz. group and the *S. chinensis* Benth. group. The *Salvia lutescens* group is made up exclusively of taxa from Taiwan and Japan, and the *S. chinensis* group (including *S. cavaleriei* and *S. prionitis*) has 14 exclusively Chinese species, one species occurring in both China and Japan, and one species that is endemic to Japan. It is in the latter group that *Salvia daiguii* is placed. Within the *Salvia chinensis* group, Hu *et al*. (2018) observed a distinct staminal character in

all the sampled taxa: at anthesis the upper connective arms initially cling closely to the upper lip of the corolla, and then bend downwards gradually until the upper, fertile thecae reach the middle lobe of the lower lip of the corolla. This character is considered to be diagnostic for the *Salvia chinensis* group.

Key to the Species of the *Salvia chinensis* Group

1a. Leaves hairy. Upper and lower lips of corolla subrounded, upper lip spreading. Stamens clearly exserted from the corolla _____ **S. prionitis** Hance
1b. Leaves glabrous. Upper and lower lips of corolla oblong, upper lip folded. Stamens included in the corolla or scarcely exserted _____ 2

2a. Cauline leaves simple, sessile or very shortly petiolate. Inflorescence secund. Calyx 6–7 mm. Corolla 12–18 mm long _____ 3
2b. Cauline leaves usually compound, sometimes simple, petiolate. Inflorescence not secund. Calyx 4–6(–7) mm. Corolla 7–12 mm long _____ 6

3a. Corolla 15–18 mm long _____ 4
3b. Corolla 12–13 mm long _____ 5

4a. Leaf lanceolate, apex attenuate. Corolla tube widening to the throat **S. liguliloha** Y.Z.Sun
4b. Leaf broadly lanceolate to ovate, apex acute. Corolla narrow with constricted throat_____ **S. chienii** E.Peter

5a. Corolla tube and lower lip pink, upper lip cream. Anhui and Hubei **S. baimaensis** S.W.Su & Z.A.Shen
5b. Corolla purple or cream. Jiangxi, Hunan and Fujian _____ **S. kiangsiensis** C.Y.Wu

6a. Lower arms of stamens modified into a secondary structure, fused or rarely free ____ 7
6b. Lower arms of stamens reduced, free _____ 9

7a. Plants up to 21 cm. Leaves all basal, simple or trifoliolate, subleathery **S. daiguii** Y.K.Wei &Y.B.Huang
7b. Plants up to 30–60 cm. Cauline leaves 2 or 3, simple to 2- or 3-pinnate, papery _____ 8

8a. Cauline leaves 2- to 3-pinnate or deeply bipinnatisect. Corolla white **S. filicifolia** Merr.
8b. Cauline leaves simple to 1-pinnate. Corolla white to purple or deep purple-red **S. cavaleriei** H.Lév.

9a. Calyx tube strigillose-annulate within. Corolla white or blue-purple to pale blue-purple, densely villous or glandular hairy _____ 10
9b. Calyx tube exannulate. Corolla pale purple or purplish red, sparsely puberulous or glandular _____ 11

10a. Leaves 1- or 2-pinnate, bipinnatisect or trifoliolate, apex acute to attenuate, closely spaced with short internodes _____ **S. japonica** Thunb.
10b. Leaves simple or trifoliolate, apex obtuse to rounded, distantly spaced with long internodes _____ **S. chinensis** Benth.

11a. Leaves 1- or 2-pinnate, or deeply bipinnatisect _____ **S. adiantifolia** E.Peter
11b. Leaves simple _____ **S. scapiformis** Hance

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