

## A Taxonomic Study of Korean *Smilacina*

Kim, Jee Young and Nam Sook Lee\*

Department of Biology, Ewha Womans University, Seoul 120-750, Korea

Several taxonomic problems of Korean *Smilacina* were examined by statistical methods, based on morphological data. Consequently, *S. davurica* described in Korean flora differs greatly from original *S. davurica*, and closely related to *S. bicolor* morphologically. Therefore, the present authors treated this new taxon as a variety of *S. bicolor*, *S. bicolor* var. *flavovirens* N. S. Lee et J. Y. Kim var. nov ("Yondusomdae" in Korean). The distribution in South Korea of *S. bicolor* var. *bicolor* is known as only Mt. Chiri, but this species is collected in Mt. Dukyou, also. The bounds of morphological variations of *S. japonica* var. *japonica*, the short plant size and no hairs on the stem, were revealed. The morphological characteristics of *S. japonica* var. *japonica* and *S. japonica* var. *mandshurica* is obscure to distinguish. According to the present study, *S. japonica* var. *mandshurica* differs from *S. japonica* var. *japonica* in plant size, size of adaxial leaf epidermal cell, ratio of style/ovary length and shape of stigma. The unrecorded taxon in Korean flora, *S. robusta*, was given a new Korean name as "Kunsomdae." Although *S. japonica* var. *mandshurica* is the variety of *S. japonica* var. *japonica*, it is more closely related to *S. robusta* than to *S. japonica* var. *japonica*.

**Keywords:** statistical methods, *S. bicolor* var. *flavovirens*, Yondusomdae, *S. robusta*, Kunsomdae

### INTRODUCTION

*Smilacina*, with about twenty five species, is distributed in North America, Central America and Asia (Takahashi & Sohma, 1983; Ohwi, 1953). The genus is characterized by having perennial herbaceous habit, horizontally creeping rhizome, erect stem clothed in lower part with sheaths, petioled or sessile, leaves oblong or ovate, paniculate or racemous inflorescence, bisexual or unisexual flowers, 6 tepals, 6 stamens, spherical ovary, 3 locules, 1-2 ovules in each locule, shallowly or deeply trifid stigma and spherical berry (Wang & Tang, 1978).

The cytological studies of this genus were carried out by Therman (1956), Kawano & Iltis (1963), Kawano (1965), and Kawano & Iltis (1965). The pollen grains were investigated by Erdtman (1952), Ikuse (1956), and Takahashi & Sohma (1983). They studied the pollen grains of 21 species of this genus and reported that most pollen grains are monocolpate with reticulate exine. For Korean taxa, anatomical and cytological study of *S. bicolor*, *S. japonica* var. *japonica* and *S. japonica* var. *mandshurica*

was conducted (Kim & Oh, 1983). But the above studies included only a part of Korean species. Also the identity and relationships among Korean taxa are not certain.

In the Korean peninsula, *S. bicolor*, *S. davurica*, *S. japonica* var. *japonica*, *S. japonica* var. *mandshurica* and *S. trifolia* are distributed (Nakai, 1952; Lee, 1980; Lee, 1996).

The most problematic taxon of Korean *Smilacina* is *S. davurica*. Its description in Korean flora (Lee, 1980; Kim & Oh, 1983; Lee, 1996) differs from its original description (Fisher, 1835) and that of Chinese and Russian flora (Wang & Tang, 1978; Komarov, 1935), in the presence of petiole, color of perianth and presence of hairs on the plant. Based on the Korean flora, *S. davurica* with green perianth is distinguished from *S. bicolor* with purple perianth. But the perianth of *S. bicolor* is green at the early stage of the flowering period, and the shape and size of the marginal cells and no hairs on the plant are characteristics shared by both *S. bicolor* and *S. davurica*. The plant size of *S. japonica* var. *mandshurica* is larger than that of *S. japonica* var. *japonica* (Lee, 1980; Kim & Oh, 1983; Lee, 1996), but the criterion is so uncertain that it is difficult to distinguish between these taxa. *S. robusta*, endemic to

\*Corresponding author: Fax +82-2-360-2385  
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Japan (Makino & Honda, 1935), is distributed in Isl. Cheju, but this is not described in the Korean flora. The plant size of *S. japonica* var. *japonica* from Isl. Cheju is much shorter than that of *S. japonica* var. *japonica* from the rest populations. *S. japonica* var. *japonica* from Mt. Kaebang and Mt. Odae have no hairs on the stem. So the bounds of morphological variations of *S. japonica* var. *japonica* needs to be revealed.

*S. japonica* var. *japonica* and *S. japonica* var. *mandshurica* are widely distributed in the peninsula (Lee, 1996) and *S. trifolia* is in North Korea (Lee, 1980; Kim & Oh, 1983; Lee, 1996). Opinions vary about the distribution of *S. davurica*, such as Kangwondo (Lee, 1980), North Korea (Kim & Oh, 1983) and north of Mt. Chiri (Lee, 1996). *S. bicolor* was reported from Mt. Chiri and Mt. Paekdu (Lee, 1980; Kim & Oh, 1983; Lee, 1996), but also collected in Mt. Dukyou by the present authors.

The present study aimed to elucidate the taxonomic identities of Korean *Smilacina* by investigating the phenetic relationships among populations or taxa.

## MATERIALS AND METHODS

The specimens used in this study were authors col-

lections (EWH) from natural populations in South Korea, and other herbarium materials (GUH, PE, SKKU, SNUA, SWH) (Appendix 1).

**Morphological study** - Thirty five quantitative characteristics were measured and twenty five qualitative characteristics were observed from 326 specimens (Appendix 1~5). For the measurement of leaf and floral parts, the lowest were used. The terms used in description followed Radford (1986). Marginal cells of the leaf were observed and photographed using LM (Fig. 3). Also surface of leaf vein, pedicel and ovary was observed and photographed using SEM (Appendix 4,5). For SEM, the samples separated from herbarium materials were rinsed in the Glyciaeri H<sub>2</sub>O for 24 h at 60°C. They were fixed in FAA for 3 d at room temperature and stored in Glycerin-Acetic-Alcohol, following dehydrated in a graded alcohol series of 70% to absolute. After treated with isoamyl acetate, the samples were critical-point-dried in liquid carbon dioxide for 2 h. They were mounted on SEM stubs and coated with gold in JFC-1100 Ion Sputter, JEOL. Then they were observed and photographed with a JEOL 35-CF SEM at an acceleration voltage of 15 kv. **Anatomical study** - Both sides of the central part between main leaf vein and leaf margin were observed and photographed using LM. The size of epidermal

**Appendix 1.** Sample data used for the morphological study of some *Smilacina* taxa (The squared number before each locality represents the individual number used in this study)

- S. bicolor* var. *bicolor*: Korea-[20]Mt. Chiri (May 25, 1996, Kim s.n. EWH-No.S102), [20]Mt. Dukyou (May 24, 1996, Kim s.n. EWH-No.S101)
- S. bicolor* var. *flavovirens*: Kirea-[1]Mt. Gariwang (?), Lee s.n. No.SNUA-4414), [7]Mt. Hwangbyoung (Jul.13, 1964, Lee s.n. SNUA-No.3127), [11]Mt. Jumbong (?), 1996, Lee & Cho s.n. SNUA-No. 7796), [4]Mt. Odae (May 27, 1991, Lee s.n. EWH-No.S103), [5]Mt. Sorak (Jun.11, 1996, ? s.n. SNUA-?)
- S. davurica*: China-[1]An-tu-xian (Sep.21, 1959, Fu s.n. PE-0852232), [4]Chang-bai-shan (Aug. 18, 1959, tong s.n. PE-0989890; Aug. 29, 1963, Wang s.n. PE-1155162; Mar. 7, 1991, Yan s.n. PE-0989889), [1]E-er-gu-nei-qi (Aug. 2, 1951, Wang s.n. PE-296394), [2]Hei-long-jiang-sheng (Aug. 19, 1963, Liu s.n. PE-1200920; ?, 1959, Ye s.n. PE-1141590), [1]Xing-an-dong-sheng-bo-ke (Jun. 18, 1929, Sato s.n. PE-260682)
- S. japonica* var. *japonica*: Korea-[1]Choongyoungsa (Apr. 16, 1981, Oh & Yoon s.n. SWH-No.S2), [30]Guangnung (Apr. 27, 1996, Lee & Kim s.n. EWH-No.S104), [5]Isl. Anmyun (May 3, 1992, Lee s.n. SKKH-?), [40]Isl. Cheju (May 18, 1996, Kim s.n. EWH-No.S111), [1]Isl. Dukjuk (Jul. 7, 1981, Oh s.n. SWH-No.S5), [28]Mt. Chiri (May 25, 1996, Kim s.n. EWH-No.S109), [1]Mt. Chogae (Jun. 22, 1987, Oh s.n. SWH-No.S7), [1]Mt. Chunma (May 22, 1997, Oh & Kim s.n. SWH-No.S1), [29]Mt. Kaebang (Jun. 2, 1995, Kim s.n. EWH-No.S106), [20]Mt. Kaeryong (Jun.13, 1995, Kim s.n. EWH-No. S110), [1]Mt. Mani (May 15, 1985, Oh s.n. SWH-No.S4), [4]Mt. Myoungji (May 13, 1989, Kim s.n. SKKH-?), [30]Mt. Odae (May 11, 1996, Kim & Park s.n. EWH-No.S107), [20]Mt. Palgong (May 3, 1996, Kim & Kim s.n. EWH-No.S108), [2]Mt. Sorak (Jul. 31, 1962, Chung s.n. SKKH-No. 51987), [20]Mt. Yongmoon (Apr. 30, 1996, Kim & Park s.n. EWH-No.S105)
- S. japonica* var. *mandshurica*: Korea-[6]Isl. Cheju (Jun. 7, 1975, Lee s.n. SNUA-4419), [3]Sanggojari (Jun. 15, 1964, Lee & Park & Cho s.n. SNUA-3304)
- S. robusta*: Korea-[5]Mt. Halla (May 15, 1995, Kim s.n. EWH-No.S113), Japan-[3]Honshu (June 13, 1997, Takahashi s.n. 17186; June 19, 1997, Takahashi, Niwa & Sugiyama s.n. 17171, 17188)

Appendix 2. Quantitative characteristics of vegetative organs of some *Smilacina* taxa

Taxa	<i>S. bicolor</i> var. <i>bicolor</i>	<i>S. bicolor</i> var. <i>flavovirens</i>	<i>S. davurica</i>	<i>S. japonica</i> (typical)	<i>S. japonica</i> (Isl. Cheju)	<i>S. japonica</i> (Kaebang & Odae)	<i>S. japonica</i> var. <i>mandshurica</i>	<i>S. robusta</i>
Length of plant (cm)	24.0-35.8-51.0	21.5-36.4-56.0	26.0-56.1-75.5	16.3-34.1-56.0	8.0-17.0-33.0	24.7-32.5-45.0	70.0-89.1-107.0	33.5-40.7-46.0
Length of stem (cm)	12.1-19.5-33.0	11.0-20.3-27.5	6.5-21.3-33.5	8.4-19.2-30.0	3.8-9.5-16.0	12.7-18.1-28.0	34.0-41.4-44.8	15.5-19.0-20.7
Length of the first internode of rhizome (cm)	2.0-3.09-4.2	1.3-2.54-3.8	1.0-1.42-1.8	0.8-2.23-4.0	0.5-1.22-3.5	0.9-1.52-3.0	3.0-3.13-3.9	0.0-0.33-0.8
Length of petiole (cm)	0.3-0.89-1.8	0.5-1.03-2.0	0.0-0.00-0.0	0.2-1.09-3.0	0.2-0.32-0.6	0.5-0.97-2	2.0-2.33-3.0	0.5-0.62-0.8
Leaf								
Length (cm)	5.8-8.58-12.6	6.7-9.10-11.25	3.6-7.8-9.0	5.1-8.41-12.4	2.4-3.88-5.8	5.7-7.99-11.0	12.0-14.80-17.7	7.9-9.08-10.8
Width (cm)	3.5-5.20-6.9	3.2-4.48-6.6	1.2-1.98-3.1	2.5-4.56-7.2	1.8-2.56-4.8	2.7-3.42-5.2	5.5-6.94-8.0	5.5-7.3-6.3
W/L (ratio)	0.42-0.61-0.81	0.40-0.49-0.88	0.22-0.33-0.45	0.31-0.55-0.91	0.45-0.66-0.87	0.32-0.43-0.68	0.37-0.47-0.66	0.52-0.61-0.72
Number (#)	4-6.3-10	3-5.1-7	8-10-13	4-5.5-8	3-4.3-6	4-5.1-7	6-9.6-13	8-9.4-10
Number of vein (#)	7-8.0-9	7-7.2-9	3-4-5	5-6.9-9	3-4.8-5	5-7.1-9	9-12.3-15	7-8-9
Hairs on leaf (#/1 mm <sup>2</sup> )								
Adaxial	0	0	0-0.0-0	0-1.5-4	0-1.5-3	0-0.7-2	2-2.5-3	1-1.6-2
Abaxial	0	0	1-1.9-3	2-4.3-7	2-3.4-6	1-2.0-3	4-7.3-9	3-4.2-5
Epidermal cell (µm)								
Ad(length)	80.0-111-130.0	95.0-127.4-150.0	135.0-151.9-202.5	135.0-154.3-187.5	95.0-125-151.0	92.5-116.3-150.0	55.0-75.8-105.0	47.5-69.6-92.5
Ab(width)	75.0-88-100.0	55.0-69.6-90.0	55.0-68.8-72.5	65.0-80.8-95.0	55.0-68.8-90.0	62.5-80.0-125.0	47.5-63.8-80.0	45.0-54.3-70.0
Ab(length)	110.0-111-175.0	147.5-184.0-207.5	135.0-152.7-205.0	147.5-179.3-202.5	120.0-141.6-175.0	87.5-117.8-165.0	87.5-133.6-165.0	50.0-72.6-92.5
Ab(width)	55.0-68-85.0	72.5-85.0-72.5	55.0-61.9-72.5	80.0-91.3-97.5	55.0-70.8-87.5	55.0-73-95.0	55.0-72.5-92.5	47.5-58.1-77.5
Stomatal complex								
Length (µm)	42.5-55.4-52.5	42.5-43.1-52.5	35.0-39.5-42.5	45.0-53.0-62.5	42.5-45.5-52.5	42.5-46.6-55.0	42.5-46.6-55.0	40.0-42.5-55.0
Width (µm)	37.5-40.4-45.0	37.5-40.3-42.5	35.0-38.0-42.5	37.5-45.0-50.0	37.5-42.3-47.5	37.5-43.4-47.5	37.5-42.6-50.0	35.0-40.1-47.5
Frequency (#/1 mm <sup>2</sup> )	36-44-55	36-48-51-56	37-48.1-60	42-48.8-58	40-49.1-58	43-49.5-58	43-49.4-57	43-49-59

Appendix 3. Quantitative characteristics of reproductive organs of some *Smilacina* taxa

Taxa	<i>S. bicolor</i> var. <i>bicolor</i>	<i>S. bicolor</i> var. <i>flavovirens</i>	<i>S. davurica</i>	<i>S. japonica</i> (typical)	<i>S. japonica</i> (Isl. Cheju)	<i>S. japonica</i> (Kaebang & Odae)	<i>S. japonica</i> var. <i>mandshurica</i>	<i>S. robusta</i>
Length of inflorescence (cm)	2.4-3.83-6.8	1.5-3.53-7.0	1.5-2.58-4.0	1.4-3.79-11.5	0.5-2.03-7.0	1.0-4.25-8.4	7.0-10.78-15.5	3.7-5.18-7.4
Length of pedicel (mm)	1.7-3.90-6.0	2.5-3.37-4.0	5.0-6.12-7.0	0.6-1.33-3.0	0.5-1.10-1.5	0.7-1.21-1.8	2.5-2.97-4.0	1.2-1.28-1.5
Number of flowers (#)	4-12.3-41	2-17.5-32	5-9.7-19	2-25.1-76	2-11.8-22	4-20.5-41	47-68.5-96	20-24.0-30
Perianth								
Outer (length) (mm)	2.0-2.72-3.2	2.8-3.31-3.8	2.4-2.97-3.3	2.2-3.98-6.0	2.2-3.08-4.5	2.2-3.22-4.5	4.2-4.66-5.0	3.0-3.66-4.5
Outer (width) (mm)	0.7-1.05-1.4	1.1-1.32-1.6	0.7-0.99-1.2	0.6-1.10-1.7	0.7-1.01-1.4	0.7-0.91-1.1	1.3-1.46-1.6	0.7-1.36-2.0
Inner (length) (mm)	2.0-2.8-3.5	2.8-3.34-3.8	2.6-2.99-3.3	2.5-3.90-1.5	2.3-3.11-4.5	2.0-3.33-4.5	4.0-4.5-5.2	2.3-3.61-4.5
Inner (width) (mm)	0.7-1.10-1.5	1.1-1.34-1.5	0.7-0.96-1.1	0.6-1.1-1.5	0.7-0.98-1.2	0.7-0.94-1.1	1.4-1.6-1.6	0.7-1.18-1.5
W/L (outer) (ratio)	0.24-0.30-0.56	0.33-0.39-0.53	0.23-0.32-0.40	0.14-0.28-0.79	0.16-0.32-0.47	0.18-0.29-0.45	0.26-0.38	0.23-0.36-0.44
W/L (inner) (ratio)	0.23-0.30-0.58	0.33-0.40-0.53	0.26-0.31-0.35	0.11-0.28-0.47	0.18-0.32-0.43	0.19-0.29-0.50	0.31-0.38	0.29-0.32-0.40
Length of filament (mm)	0.7-1.39-2.0	1.2-1.35-1.6	1.1-1.31-1.5	1.2-1.97-3.5	0.5-1.29-2.0	1.5-1.97-2.3	2.0-2.28	2.0-2.42-3.0
F.L./P.L. (ratio)	0.46	0.40	0.44	0.51	0.41	0.59	0.59	0.67
Length of anther (mm)	0.1-0.26-0.5	0.4-0.56-0.8	0.4-0.68-0.8	0.4-0.90-1.4	0.5-0.89-1.1	0.7-0.92-1.2	0.6-0.73-0.8	0.8-0.92-1.0
Ovary								
Length (mm)	0.7-1.30-3.3	1.0-1.15-1.3	1.0-1.30-1.5	0.7-1.34-2.0	0.8-1.15-1.5	1.2-1.47-1.8	1.1-1.23-1.3	1.0-1.34-2.0
Width (mm)	0.8-1.51-3.3	1.0-1.24-1.5	1.0-1.17-1.1	0.6-1.28-1.9	0.6-1.1-1.7	1.0-1.29-1.5	1.0-1.23-1.3	1.2-1.52-2.3
W/L (ratio)	0.87-1.20-1.86	0.76-1.09-1.50	0.67-0.91-1.20	0.60-0.99-1.43	0.67-0.97-1.20	0.71-0.88-1.08	0.85-1.01-1.18	1.07-1.13-1.20
Length of style (mm)	0.2-0.48-0.9	0.2-0.25-0.3	0.5-0.63-0.8	0.3-0.59-1.2	0.3-0.56-1.0	0.5-0.73-0.9	1.1-1.25-1.3	1.0-1.18-1.9
S.L./O.L. (ratio)	0.15-0.34-0.80	0.15-0.23-0.30	0.43-0.48-0.53	0.20-0.44-0.58	0.33-0.49-0.60	0.42-0.50-0.65	0.85-1.01-1.18	0.71-0.88-1.00

F.L.: Length of filament, P.L.: Length of perianth, S.L.: Length of style, O.L.: Length of ovary

cell, and the size and frequency of guard cell were measured with a micrometer (Appendix 2). **Palynological study** – Pollen grains were obtained from herbarium specimens and acetolyzed according to the method of Erdtman (1960). Then they were stored in 70% alcohol and observed using a LM and SEM (Fig. 6). **Statistical study** – Clustering relationships of 8 OTUs, *S. bicolor* var. *bicolor*, *S. bicolor* var. *flavovirens*, *S. davurica*, *S. japonica* var. *japonica* from Isl. Cheju, *S. japonica* var. *japonica* from Mt. Kaebang & Odae, *S. japonica* var. *japonica* from the rest, *S. japonica* var. *mandshurica*, and *S. robusta* were investigated with twenty one qualitative characteristics (Table 1) using the NT-SYS numerical taxonomy program.

**Table 1.** Morphological characteristics used for phenogram of some *Smilacina* taxa

No.	Qualitative characters [character state]
1.	Hairs on stem: absent [0], present [1]
2.	Petiol: absent [0], present [1]
3.	Shape of leaf: elliptic or ovate [0], narrowly elliptic [1]
4.	Leaf apex type: narrowed [0], abruptly narrowed [1]
5.	Hairs on leaf surface: absent [0], present [1]
6.	Shape of leaf margin: ciliate [0], serrulate [1]
7.	Hairs on leaf margin, vein & pedicel: absent [0], present [1]
8.	Papillae on leaf margin, vein & pedicel: absent [0], present [1]
9.	Surface pattern of abaxial leaf vein: wrinkled [0], regular convex [1]
10.	Shape of epidermal cell of adaxial leaf: smooth [0], sinuous wave [1], deeply sinuous wave [2]
11.	Shape of epidermal cell of abaxial leaf: very slightly wave [0], deeply sinuous wave [1]
12.	Inflorescence type: Raceme with 1-3 flowers at each node [0] Raceme or compound raceme ramified once with one flower at each node [1] Compound raceme ramified more than once with 1-2 flowers at each node [2]
13.	Surface pattern of pedicel: parallel [0], wavy [1]
14.	Type of perianth apex: round [0], round or sharp [1], sharp [2]
15.	Color of perianth: white [0], green [1], green to purple [2]
16.	Lower part of filament: wide [0], not [1]
17.	Color of filament: white or pale yellow [0], white to purple [1]
18.	Color of pistil: white [0], green [1], yellow to orange or purple [2]
19.	Shape of ovary: round [0], heart-shaped [1]
20.	Surface pattern of ovary: little wavy [0], wavy [1], little wavy or wavy [2], uneven rippled [3]
21.	Stigma type: lobed [0], decurrent [1]

## RESULTS

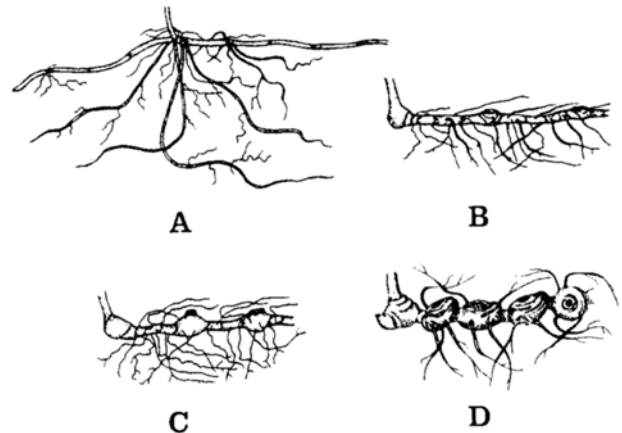
### Morphological Study

**Rhizome:** There are four types of rhizome based on the shape of node. The node of *S. davurica* not swollen at all (A), that of *S. bicolor* var. *bicolor* and *S. bicolor* var. *flavovirens* swollen little (B), and that of the rest beaded (C). Among the taxa beaded, a special note is given to *S. robusta*, where the node is closely beaded (D) (Fig. 1).

**Stem:** Stem glabrous in *S. bicolor* var. *bicolor*, *S. bicolor* var. *flavovirens*, and *S. japonica* var. *japonica* from Mt. Kaebang & Odae, or hairy in the rest (Appendix 4).

**Leaf:** Leaves sessile in *S. davurica* (B), or shortly petioled in all the rest (A). Leaves narrowly elliptic with an acuminate tip in *S. davurica* (B), or elliptic to ovate with an acute tip in the rest (A) (Fig. 2). Margins and leaf veins serrulate (owing to the short, flat, triangular papillae) in *S. bicolor* var. *bicolor*, *S. bicolor* var. *flavovirens*, and *S. davurica* (A), or ciliate (conical or flat hairs) in the rest (B, C) (Fig. 3). Hairs lacking in *S. bicolor* var. *bicolor* and *S. bicolor* var. *flavovirens*, present on the abaxial side only in *S. davurica*, but present on both sides (more in the abaxial surface) in the rest (Appendix 2).

**Inflorescence:** The types of inflorescence are various based on the number of ramification and flower. The type of *S. bicolor* var. *bicolor* and *S. bicolor* var. *flavovirens* raceme or compound raceme ramified once, with one flower at each node (A, B). That of *S. davurica* raceme with 1-3 flowers at each node, and that of the rest compound raceme ram-



**Fig. 1.** Rhizome types of some *Smilacina* taxa. A: Node not swollen, B: Node swollen little, C: Sparsely beaded, D: Closely beaded

Appendix 4. Qualitative characteristics of vegetative organs of some *Smilacina* taxa

Taxa	<i>S. bicolor</i> var. <i>bicolor</i>	<i>S. bicolor</i> var. <i>flavovirens</i>	<i>S. davurica</i>	<i>S. japonica</i> (typical)	<i>S. japonica</i> (Isl. Cheju)	<i>S. japonica</i> (Kaebang & Odae)	<i>S. japonica</i> var. <i>mandshurica</i>	<i>S. robusta</i>
Hair on stem	-	-	+	+	-	-	+	+
Leaf								
Shape	elliptic or ovate	elliptic or ovate	narrowly elliptic	elliptic or ovate	elliptic or ovate	elliptic or ovate	elliptic or ovate	elliptic or ovate
Apex	abruptly narrowed	abruptly narrowed	narrowed	abruptly narrowed	abruptly narrowed	abruptly narrowed	abruptly narrowed	abruptly narrowed
Leaf Margin								
Shape	serrulate	serrulate	serrulate	ciliate	ciliate	ciliate	ciliate	cilicat
Hair (conical)	-	-	-	+	+	+	+	+
Hair (flat)	-	-	-	+	+	+	+	+
Papillae	+	+	+	-	-	-	-	-
Leaf Vein								
Hair	-	-	-	+	+	+	+	+
Papillae	+	+	+	-	-	-	-	-
Surface	wrinkled	wrinkled	wrinkled	regular convex	regular convex	regular convex	wrinkled	wrinkled
Epidermal Cell								
Adaxial	sinuous wave	deeply sinuous wave	smooth	deeply sinuous wave	sinuous wave	sinuous wave	sinuous wave	smooth
Abaxial	deeply sinuous wave	deeply sinuous wave	very slightly wave	deeply sinuous wave	deeply sinuous wave	deeply sinuous wave	deeply sinuous wave	deeply sinuous wave

+: present, -: absent

ified more than once, with 1-2 flowers at each node (D) (Fig. 4).

Flower: For the color of perianth, *S. bicolor* var. *bicolor* clouded with dark purple, *S. bicolor* var. *flavovirens* green, and the rest white (Appendix 5). The color of filament dark purple in *S. bicolor* var. *bicolor*, or whitish in the rest (Appendix 5). The shape of ovary panduriform in *S. robusta* (F), or spherical in the rest (A-E). The color of ovary orange or dark purple in *S. bicolor* var. *bicolor* (C, D), green in *S. bicolor* var. *flavovirens* (B), and white in the rest (A, E, F). The ratio of style/ovary

length of *S. japonica* var. *mandshurica* (E) and *S. robusta* (F) is bigger than that of the rest (A~D), and *S. bicolor* var. *flavovirens* has no style (B) (Appendix 3). The shape of stigma deccurrent in *S. bicolor* var. *bicolor* (C, D), *S. japonica* var. *mandshurica* (E) and *S. robusta* (F), and lobed in the rest (A, B). The color of stigma dark purple in *S. bicolor* var. *bicolor* (C, D), green in *S. bicolor* var. *flavovirens* (B), and white in the rest (A, E, F) (Fig. 5).

## Anatomical Study

The boundary of abaxial leaf epidermal cell is

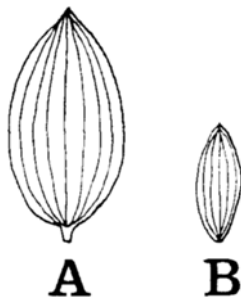


Fig. 2. Leaf types of some *Smilacina* taxa. A: Shortly petioled and elliptic to ovate with an acute tip, B: Sessile and narrowly elliptic with an acuminate tip.

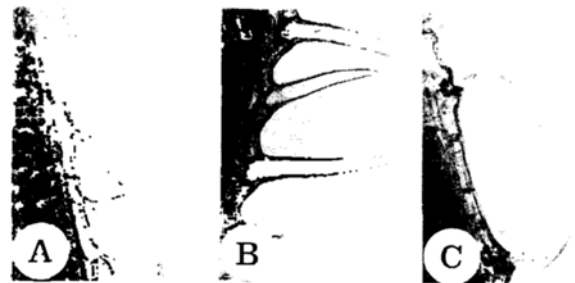


Fig. 3. Leaf marginal cell types of some *Smilacina* taxa. A: Serrulate, B: Ciliate (conical), C: Ciliate (flat)

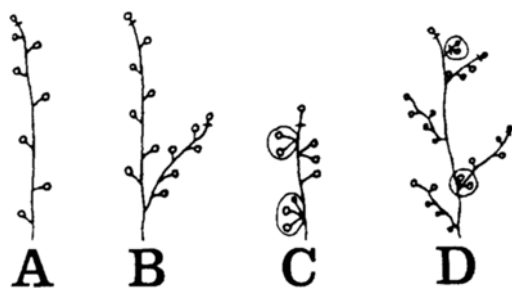


Fig. 4. Inflorescence types of some *Smilacina* taxa. A: Raceme with one flower at each node, B: Compound raceme ramified once with one flower at each node, C: Raceme with 1-3 flowers at each node, D: Compound raceme ramified more than once with 1-2 flowers at each node

more curved than that of adaxial, and *S. davurica* is less curved than the rest. The cell size of *S. japonica* var. *mandshurica* and *S. robusta* is smaller than that of the rest (Appendix 2,4).

**Palynological Study**

The shape of pollen grains of *Smilacina* is boat-shaped, monocolpate and monad (Fig. 6). The length is about 20~50 μm, medium by Erdtman's criterion (1969), and *S. japonica* var. *mandshurica* is the largest (Table 2). *S. bicolor* var. *bicolor* (B) and

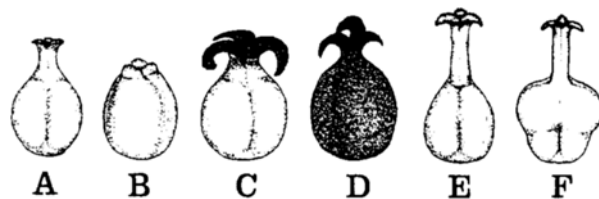


Fig. 5. Pistil types of some *Smilacina* taxa A: Lobed, B: Lobed without a style, C: Decurrent with a dark purple stigma, D: Decurrent and dark purple, E: Decurrent with a spherical ovary and long style, F: Decurrent with a panduriform ovary and long style.

*S. bicolor* var. *flavovirens* (C) have verrucae on the foveolate-reticulate surface, and the rest is foveolate-reticulate only (A) (Fig. 6). The number of verrucae per unit area of *S. bicolor* var. *bicolor* is fewer than that of *S. bicolor* var. *flavovirens* (Table 2).

**Statistical Study**

From the phenogram conducted with qualitative characteristics, five OTUs, *S. japonica* var. *japonica* from Isl. Cheju, *S. japonica* var. *japonica* from Mt. Kaebang & Odae, *S. japonica* var. *japonica* from the rest, *S. japonica* var. *mandshurica* and *S. robusta* clustered closely, and they clustered with *S. davurica*. *S. bicolor* var. *bicolor* and *S. bicolor* var.

**Appendix 5. Qualitative characteristics of reproductive organs of some *Smilacina* taxa.**

Taxa	<i>S. bicolor</i> var. <i>bicolor</i>	<i>S. bicolor</i> var. <i>flavovirens</i>	<i>S. davurica</i>	<i>S. japonica</i> (typical)	<i>S. japonica</i> (Isl. Cheju)	<i>S. japonica</i> (Kaebang & Odae)	<i>S. japonica</i> var. <i>mandshurica</i>	<i>S. robusta</i>
Shape of inflorescence	type a, b	a, b	c	d	d	d	d	d
Pedicel								
Hair	-	-	-	+	+	+	+	+
Papillae	+	+	+	-	-	-	-	-
Surface	parallel	wavy	parallel	parallel	parallel	parallel	parallel	parallel
Perianth								
Shape	sharped	round	round	round	round	round or sharp	round	round or sharp
Color	purple spotted	green	white	white	white	white	white	white
Filament								
Shape of bottom	wide	straight	straight	wide	wide	wide	wide	wide
Color	dark purple	white	white	white	white	white	white	white
Ovary								
Shape	round	round	round	round	round	round	round	panduriform
Color	orange or dark purple	white	white	white	white	white	white	white
Surface	type a	c	c	a	b	a, b	b	b
Stigma								
Shape	decurrent	lobed	lobed	lobed	lobed	lobed	decurrent	decurrent
Color	dark purple	white	white	white	white	white	white	white

+: present, -: absent

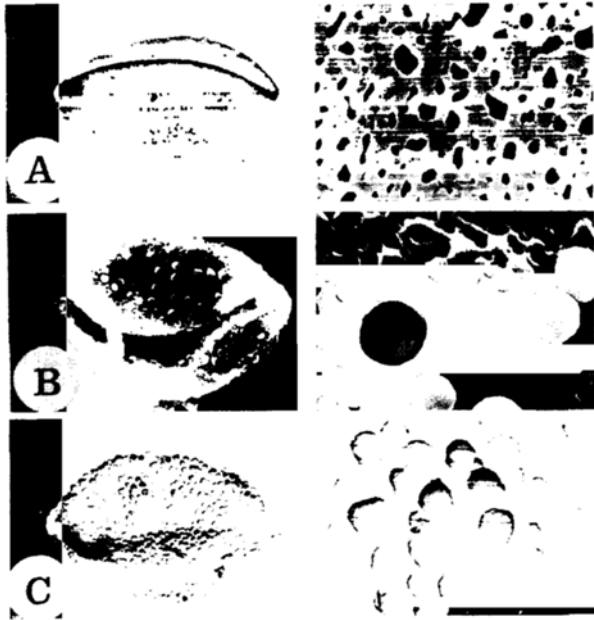


Fig. 6. Pollen types of some *Smilacina* taxa A: Foveolate-reticulate with psilate surface. B: Foveolate-reticulate with few verrucae, C: Foveolate-reticulate with many verrucae.

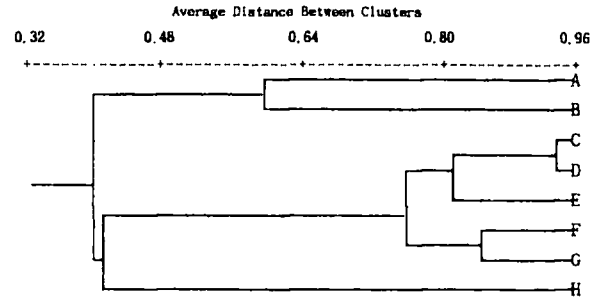


Fig. 7. The phenogram of some *Smilacina* taxa. A: *S. bicolor* var. *bicolor* B: *S. bicolor* var. *flavovirens* C: *S. japonica* (Isl. Cheju) D: *S. japonica* var. *japonica* E: *S. japonica* (Mt. Kaebang & Odae) F: *S. japonica* var. *mandshurica* G: *S. robusta* H: *S. davurica*

**Type:** Korea, Kangwon, Mt. Odae, 27 May, 1991, N. Lee, S103 [Holotype; EWH. Isotype; EWH]

**Korean name:** Yondusomdae (연두솨대)

Perennial herbs, glabrous. Rhizome horizontal, creeping. Stem erect. Leaves elliptic to ovate with an acute tip, shortly petioled. Inflorescence raceme. Perianth green. Filament white. Pistil green. Stigma trifid, lobed.

[Key to some *Smilacina* taxa]

- 1. Plant entirely glabrous.
  - 2. Perianth apex acute. Perianth, filament and stigma dark purple. Stigma decurrent  
.....*S. bicolor* var. *bicolor*
  - 2. Perianth apex round. Perianth green, filament whitish and stigma green. Stigma lobed  
.....*S. bicolor* var. *flavovirens*
- 1. Plant entirely or partially hairy
  - 2. Leaves sessile. ....*S. davurica*
  - 2. Leaves petioled.
    - 3. The ratio of style/ovary length 0.20~0.65. Stigma lobed.....*S. japonica* var. *japonica*
    - 3. The ratio of style/ovary length 0.70~1.20. Stigma decurrent.
      - 4. Rhizome sparsely beaded. Ovary spherical  
.....*S. japonica* var. *mandshurica*
      - 4. Rhizome closely beaded. Ovary panduriform  
.....*S. robusta*

**DISCUSSION**

The original description of *S. davurica* is as follows: "*S. dahurica* Turcz. (Mss.). *S. pilosa*; caule folioso; foliis alternis oblongis semiamplexicaulibus; pedunculis racemi simplicis ternis geminisve; flo-

*flavovirens* clustered with *S. davurica* at last (Fig. 7).

**Description of a New Variety and Key to the Taxa**

*S. davurica* described in Korean flora is newly designated as a variety of *S. bicolor* as follows.

*S. bicolor* var. *flavovirens* N. S. Lee et J. Y. Kim, var. nov.

Herba perennis, glaber. Rhizoma horizontale, cras-sum. Caulis erectus. Folia elliptica vel ovata, apice in acumen, breviter petiolata. Inflorescentia racemosa. Perianthium viridis. Filamentis albus. Pistillum viridis. Stigma trifidus, lobatus.

Table 2. Morphological characteristics of pollen of some *Smilacina* taxa

Taxa	Grain length (μm)	Grain width (μm)	Verrucate #/10 μm <sup>2</sup>
<i>S. bicolor</i> var. <i>bicolor</i>	38-43.5-48	23-33.3-38	2-2.6-3
<i>S. bicolor</i> var. <i>flavovirens</i>	38-42.8-48	20-32.2-38	5-7.3-8
<i>S. davurica</i>	40-46.5-53	20-31.1-35	-
<i>S. japonica</i> var. <i>japonica</i>	38-46.3-53	20-29.1-35	-
<i>S. japonica</i> var. <i>mandshurica</i>	46-52.4-58	28-33.6-38	-
<i>S. robusta</i>	40-47.7-53	23-30.6-35	-

ribus hexandris" (Fischer, 1835).

*S. davurica* described in Korean flora (Lee, 1980; Kim & Oh, 1983; Lee, 1996) is distinguished from its original description (Fischer 1835) and *S. davurica* in Chinese (Wang et Tang, 1978) and Russian flora (Komarov, 1935), morphologically in presence of petiole, shape of leaf and leaf apex, presence of hairs, shape of inflorescence, surface of pedicel, color of perianth and pistil, and surface of pollen grain (Fig. 2, 4, 6; Appendix 4, 5). *S. bicolor* and *S. davurica* described in Korean flora are similar in vegetative characteristics and pollen type, so they clustered in the phenogram (Fig. 7; Appendix 2, 4). Therefore, *S. davurica* described in Korean flora can be treated as *S. bicolor* var. *flavovirens*. But *S. bicolor* var. *flavovirens* differs from *S. bicolor* var. *bicolor* in color of perianth, shape of perianth apex, color of filament, shape of lower part of filament, color of pistil, surface of ovary and shape of stigma (Fig. 5; Appendix 5). There are reports on the perianth of these taxa; *S. bicolor* var. *bicolor* is yellow to purplish black (Lee, 1980), *S. bicolor* var. *bicolor* is white at the early stage of the flowering period and changes to brownish purple as it falls (Lee, 1996), and *S. bicolor* var. *flavovirens* is light green (Lee, 1980; Lee, 1996). In the present study, the color of perianth of *S. bicolor* var. *bicolor* is green at the early stage of the flowering period and changes to dark purple as it grows, and that of *S. bicolor* var. *flavovirens* is green during all the flowering period (Fig. 4).

*S. bicolor* var. *bicolor* known to be distributed in Mt. Chiri and Mt. Paekdu (Lee, 1980; Kim & Oh, 1983; Lee, 1996) is also distributed in Mt. Dukyou, so it can be inferred that the distribution site of *S. bicolor* var. *bicolor* in South Korea is not limited to Mt. Chiri.

The plant size of *S. japonica* var. *japonica* from Isl. Cheju is much shorter than that of *S. japonica* var. *japonica* from the rest, but the values between populations are continuous (Appendix 2). *S. japonica* var. *japonica* from Isl. Cheju, *S. japonica* var. *japonica* from Mt. Kaebang & Odae, and *S. japonica* var. *japonica* from the rest are related closely by the qualitative characteristics (Fig. 7). In addition, the surface of leaf vein regular convex in these three OTUs unlike wrinkled surface in the rest taxa (Appendix 4). For these reasons, the three OTUs of *S. japonica* var. *japonica* can be regarded as the same taxon. Therefore, the small plant size (Isl. Cheju) and no hairs on the stem (Mt. Kaebang & Odae) can be considered in the bounds of morphological

variations of *S. japonica* var. *japonica*.

The plant size of *S. japonica* var. *mandshurica* is larger than that of *S. japonica* var. *japonica* and each value between taxa is discontinuous (Appendix 2). This differs from the report of Lee (1996) where the plant size of *S. japonica* var. *mandshurica* is approximately 50 cm. According to the report of Kim & Oh (1983) on the anatomical and cytological characteristics of *S. bicolor* var. *bicolor*, *S. japonica* var. *japonica*, and *S. japonica* var. *mandshurica*, the size of adaxial leaf epidermal cell of *S. japonica* var. *mandshurica* is the largest, in addition, the size of adaxial leaf epidermal cell of *S. japonica* var. *japonica* is similar to that of *S. japonica* var. *mandshurica*. In the present study, the size of adaxial leaf epidermal cell of *S. japonica* var. *japonica* was visibly larger than that of *S. japonica* var. *mandshurica* (Appendix 2). Also *S. japonica* var. *japonica* and *S. japonica* var. *mandshurica* are distinguished by the following characteristics: surface of leaf vein, ratio of style/ovary length and shape of stigma (Fig. 5, Appendix 3). *S. japonica* var. *mandshurica* is distributed in Isl. Cheju and Sanggojari in Choongchungbuk-do only, differing from the report of Kim & Oh (1983) and Lee (1996).

As *Smilacina robusta*, endemic to Japan, is distributed in Isl. Cheju, Korea, this unrecorded taxon in Korean flora was given a new Korean name as "Kunsomdae." This taxon clustered with *S. japonica* var. *mandshurica* in the phenogram (Fig. 7). *S. japonica* var. *mandshurica* and *S. robusta* are distinct from *S. japonica* var. *japonica* by the following characteristics: size of leaf epidermal cell, surface of leaf vein, ratio of style/ovary length and shape of stigma (Fig. 5, Appendix 2~4). This statistical observation does not correlate with the fact that *S. japonica* var. *mandshurica* is the variety of *S. japonica* var. *japonica*. For the clear elucidation of relationships among *S. japonica* var. *japonica*, *S. japonica* var. *mandshurica* and *S. robusta*, molecular study is needed, too.

The difference between *S. japonica* var. *mandshurica* and *S. robusta* is shape of rhizome, shape of adaxial leaf epidermal cell and shape of ovary (Fig. 1,5; Appendix 4).

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