

## ***Sceptridium atrovirens* and *S. microphyllum* (Ophioglossaceae): First report in Korea and its phylogenetic position based on morphology**

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### **숲고사리삼과 애기고사리삼(고사리삼과): 한반도 미기록 식물의 형태로 본 계통적 위치**

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**ABSTRACT:** Two unrecorded species (*Sceptridium atrovirens* and *S. microphyllum*), previously known only in Japan, were found in a forest in Dosun-dong, Seogwipo-si, Jeju-do for the first time in Korea. *S. atrovirens* was distinguished from other related species of the genus *Sceptridium* in Korea by having the thickest rhizome and root, irregularly crenulate or roughly serrate, and a shorter sporophore blade. The local name was newly given as ‘Sup-go-sa-ri-sam’ for the species, denoting the habitat. *S. microphyllum* was distinguished by having the smallest plant height, compact sterile blades, and partly lateritious trophophyll in winter. The local name was newly given as ‘Aegi-go-sa-ri-sam’ for species, meaning of a small size. To reveal the interspecific relationships within the genus *Sceptridium* in Korea, cladistic analysis was performed for 27 morphological characteristics. The morphological characteristics and illustrations of the two taxa, as well as photographs at the habitat, are provided with a taxonomic key to the species of *Sceptridium* in Korea.

**Keywords:** *Sceptridium atrovirens* and *S. microphyllum*, first report, Ophioglossaceae

**적 요:** 제주도 서귀포시 도순동에서 우리나라 고사리삼과의 미기록 분류군, 숲고사리삼과 애기고사리삼이 새로이 발견되었다. 숲고사리삼(*Sceptridium atrovirens*)은 고사리삼속의 다른 분류군에 비해서 굵은 땅속줄기와 뿌리를 갖으며, 불규칙하고 거친 톱니가 있으며, 비교적 길이가 작은 포자낭이삭을 갖는 점에서 뚜렷이 구분된다. 국명은 서식지의 특징을 고려하여 ‘숲고사리삼’으로 신청하였다. 또한, 애기고사리삼(*Sceptridium microphyllum*)은 고사리삼속의 다른 분류군에 비해서 전체적으로 작고, 영양엽의 우편이 뾰뾰한 잎몸, 겨울에 부분적으로 벽돌색을 띠는 점에서 뚜렷이 구분된다. 국명은 전체적으로 작은 특징을 고려하여 ‘애기고사리삼’으로 신청하였다. 이들 미기록 식물들의 계통을 파악하기 위하여 이들 식물과 유연종들의 형태적 형질 27개를 분석하여 분류학적 위치를 파악하고자 하였다. 주요형질에 대한 분류군의 기재 및 종의 해부도와 서식지 식물사진을 제시하였고, 아울러 한국산 고사리삼속 식물에 대한 검색표를 제시하였다.

**주요어:** 숲고사리삼, 애기고사리삼, 미기록, 고사리삼과

The family Ophioglossaceae, known as adder’s tongue ferns, comprises four genera, about 80 taxa widely distributed worldwide from arctic to tropical regions, and three genera

(*Ohioglossum* L., *Botrychium* SW., and *Mankyua* B.-Y. Sun, M.H. Kim, and C.H. Kim), 11 taxa in Korea (Sun et al., 2001, 2009; Sun, 2007). The genus *Botrychium* (“moonwort”) sensu lato (s.l.) as an extended meaning was divided into three subgenera (*Sceptridium*, *Eubotrychium*, and *Osmundopteris*)

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by Clausen (1938). Subgenus *Sceptridium* of *Botrychium* (s.l.) have treated at the genus level, *Sceptridium* Lyon (Nishida, 1952; Kato, 1987; Wagner, 1990; Hauk et al., 2003). Four taxa, *S. japonicum* (Prantl) Lyon, *S. nipponicum* (Makino) Holub, *S. multifidum* (S. G. Gmel.) M. Nishida ex Tagawa var. *robustum* (Rupr. Ex Milde) Lyon, and *S. ternatum* (Thunb.) Lyon, belong to this genus among those taxa reported in Korea (Park, 1975; Lee, 1980; Iwatsuki, 1992; Lee, 2006; Park, 2007; Park et al., 2008). Korean *B. boreale* (Franch.) Milde and *B. lunaria* (L.) Sw. were found to belong to the subgenus *Eubotrychium* (Clausen, 1938) or genus *Botrychium* (s.s.), whereas Korean *B. strictus* (Underw.) Holub and *B. virginianus* (L.) Holub were found to belong to subgenus *Osmundopteris* (Milde) R. T. Clausen or genus *Osmundopteris* (Milde) Small or *Botrypus* Michx (Nishida, 1952; Kato, 1987; Wagner, 1990) in *Botrychium* (s.l.) by Clausen (1938). The classification used here will follow those of Sahashi (1979a), Kato (1987), Wagner (1990), and Hauk et al. (2003).

The genus *Sceptridium* Lyon is classified by a moderate size, short common stalk (phyllomorphore), tropophore (sterile) with a long petiole, longer than or equal to the common stalk, and producing a sporophore (fertile) blade from its basal part, dividing both fertile and sterile segments from user part of the stalk, and tropophore blades ternately decompounds (Lyon, 1905; Nishida, 1952, 1960; Kato, 1960, 1987).

In the limit of species within *Sceptridium*, there is a great diversity of opinion. *Sceptridium nipponicum* is distributed in Korea and Japan (Iwatsuki, 1992; Kato, 1995; Park, et al., 2008). This species has been very closely allied with *S. japonicum* (Makino, 1916), but has been treated as a variety of *S. ternatum*, *S. ternatum* (Thunb.) Lyon var. *nipponicum* (Makino) Nishida based on it having a similar spore surface (Nishida, 1959; Sahashi, 1976). *Sceptridium atrovirens* Sahashi has been misidentified confidingly as *S. daucifolium* (Wall.) Hook & Grev. or *S. japonicum* (Nishida, 1956), but was published as a new species based on different characteristics from the above two taxa, which have more dark greenish and some more glabrous blade, pinnule segment almost elongate and acuminate, shorter rachis of sporophore, and longer tropophore blade than the two taxa, and is widely distributed in Japan with *S. ternatum* (Sahashi, 1979a, b). Further, *S. daucifolium* from India, Southwestern China, Taiwan, and the Ryukyus, have been confused with *S. formosanum* (Tagawa) Holub from Japan, Taiwan, and S. China, and the latter was known newly by Tagawa (1940), or has been used as a synonym of the former (Nishida, 1960). However, Sahashi (1981c) insisted, based on study of the genus *Sceptridium* in Japan and adjacent regions, that *S. formosanum* differs from

*S. daucifolium* by having a blade with longer stalk, finer cutting of the blade, and thinner texture. In addition, *S. multifidum* var. *robustum* has been treated level up as a species, *S. robustum* Lyon. *S. microphyllum* Sahashi was reported as new species of Japan similar to *S. nipponicum* based on typically ternate blades and elongated pinna with acute apex, whereas it differs based on size, compact sterile blades, longer sterile stalk, and blades becoming partly lateritious-colored in winter (Sahashi, 1981a). So, taxa of the genus *Sceptridium* should be subjected to further taxonomic study.

In the present study, *Sceptridium atrovirens* and *S. microphyllum*, which were collected at a forest in Dosun-dong, Seogwipo-si, Jeju-do, are reported as new recorded taxa from Korea. These taxa were previously known as an endemic plant of Japan. *S. atrovirens* is distinguished from related taxa by having the thickest rhizome and root, long hair on rachis, and irregularly crenulate or roughly serrate and shorter sporophore blade (Sahashi, 1979a, b). The local name was given as ‘Sup-go-sa-ri-sam’ since it grows in the forest. *S. microphyllum* was distinguished by having the smallest plant height, compact sterile blades, and partly lateritious tropophyll in winter. The local name was given as ‘Aegi-go-sa-ri-sam’ based on its small size.

We performed cladistic analysis for 27 morphological characteristics to reveal the taxonomic position of *S. atrovirens* and *S. microphyllum* in Korea among related *Sceptridium* taxa.

## Materials and Methods

Two unrecorded species (*Sceptridium atrovirens* and *S. microphyllum*) were collected first in Korea (Figs. 1–4) and the voucher specimens are deposited in Ewha Womans University Herbarium (EWH). To reveal the taxonomic position of *S. atrovirens* and *S. microphyllum*, 27 morphological characters (Table 1) referred to the flora, illustrated books, and papers (Nishida, 1959, 1960; Sahashi, 1979a, b, 1981a, b, c, 1983; Iwatsuki, 1992; Kato, 1995; Tagawa, 1959; Shieh et al., 1994; Wagner, 1990; Lee, 2006; Sun, 2007). Twelve taxa of *Sceptridium* and two taxa of *Botrypus* as outgroup were coded for cladistic analysis (Table 2).

Morphological data matrix were analyzed using both maximum parsimony methods available in PAUP\* 4.01b (Swofford, 2002). For the maximum parsimony analysis, ACCTRAN character optimization, TBR branch swapping, with MULPARS and STEEPEST DESCENT, were employed. Bootstrap values (Felsenstein, 1985) were calculated from 100 replicate analysis using TBR branch swapping and the random stepwise addition of taxa. For the analysis of morphological

characters, weights were assigned to all characters such that minimum possible length of each character was as close to 1000 as possible. Thus binary characters were assigned a weight of 1000, three-state characters a weight of 500, four and five-state characters a weight of 333 (Lee et al., 2001). The data analyzed using MP and the heuristic search and apomorphic characters in each node described above, and bootstrap strategies described below.

## Description and Discussion

*Sceptridium atrovirens* Sahashi in J. Jap. Bot. 54: 241 (1979)  
Syn. *Botrychium atrovirens* (Sahashi) M. Kato in Fl. Jap. (Iwatsuki et al., eds.) 1: 26. 1995

**Korean name:** Sup-go-sa-ri-sam (숲고사리삼)

Winter green herb, height 20–50 cm. Rhizomes erect, cylindrical, 7–25 mm long, 5–8 mm thick, having many fleshy and thick roots. Common stalks 3–11 cm length, 5–7 mm width, reddish dark green. Trophophylls stalk 4–15 cm length, dark green; blade thick herbaceous, pentagonal, subternately divided, sparsely lanuginose on axes, 3 pinnate, 10–18 cm length, 9–23 cm width; pinnae alternate or subopposite, lanceolate to oblong or nearly elliptic, basal pinnae lanceolate or oblong, 5–10 cm length, 2–4 cm width, span 1.5 cm; pinnules lanceolate or ovate, with span; basal pinnule segments broadly elliptic or ovate, somewhat acute or obtuse at apex, blind vein, free, margin irregularly crenulate or roughly serrate. Sporophylls subdeltooid, 2–3 pinnate, stalk 10–20 cm, blade 4–5 cm length, rarely hairy, sporangia dark-brown or yellowish-brown when mature. Spore surface irregular papillae or spinules.

**Distribution:** Korea, Japan. In mountain areas.

**Specimens examined:** Dosun-dong, Seogwipo-si, Jeju-do, Korea, 11 Oct. 2011, C.S. Lee & Y.S. Kim 1110010-2; Pyodae-ri, Gujwa-eup, Bukjeju-gun, Jejudo, S.H. Park et al. 30019

The new local name ‘Sup-go-sa-ri-sam’ was given based on its growth in the forest. It was first found with *S. ternatum*, *S. nipponicum*, *S. japonicum*, *Camellia japonica*, and *Quercus myrsinaefolia* in a forest in Dosun-dong, Seogwipo-si, Jeju-do.

*Sceptridium microphyllum* Sahashi in J. Jap. Bot. 56: 129 (1981)

Syn. *Botrychium microphyllum* (Sahashi) M. Kato in Fl. Jap. (Iwatsuki et al., eds.) 1: 27. 1995

**Korean name:** Aegi-go-sa-ri-sam (애기고사리삼)

Winter green herb, height 12–20 cm. Rhizomes erect,

cylindrical, 15–20 mm long, 1.5 mm thick, having few fleshy and thin roots. Common stalks 3 cm length, 3 mm width, white. Trophophylls stalk 4–6 cm length, dark green; blade subternate, round subdeltooid, or subpentagonal, 2–3 pinnatifid, partly latericious in winter, 4 cm length, 4.5 cm width; basal pinnae unequal, 2.6 cm length, 2 cm width, span 0.8 cm; pinnules oblong or broad lanceolate, acute at apex, middle clear vein, free, margin minutely dentate or serrate. Sporophylls 2-pinnate, stalk 12 cm; blade oblong, 3.5 cm length. Spore surface subreticulate.

**Distribution:** Korea, Japan. In mountain areas.

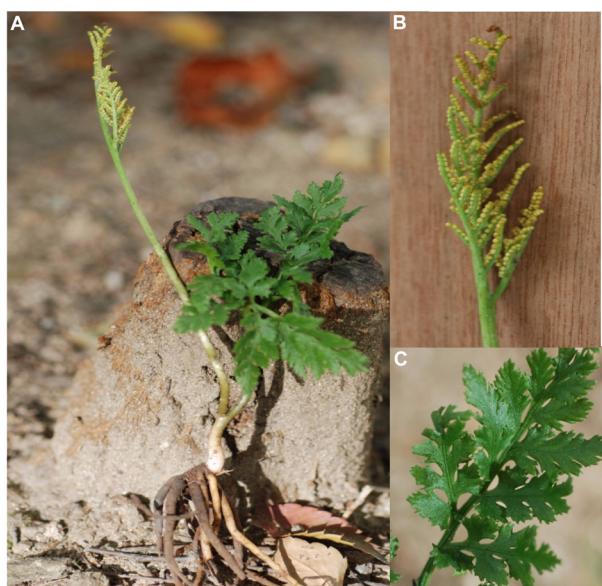
**Specimens examined:** Dosun-dong, Seogwipo-si, Jeju-do, Korea, 11 Oct. 2011, C.S. Lee & Y.S. Kim 1110015-20; 3 Dec. 2011, C.S. Lee 1112007-11

The new local name was given as ‘Aegi-go-sa-ri-sam’ based on its small size. It was first found with *S. nipponicum*, *S. japonicum*, *Camellia japonica*, and *Quercus myrsinaefolia* in a forest in Dosun-dong, Seogwipo-si, Jeju-do.

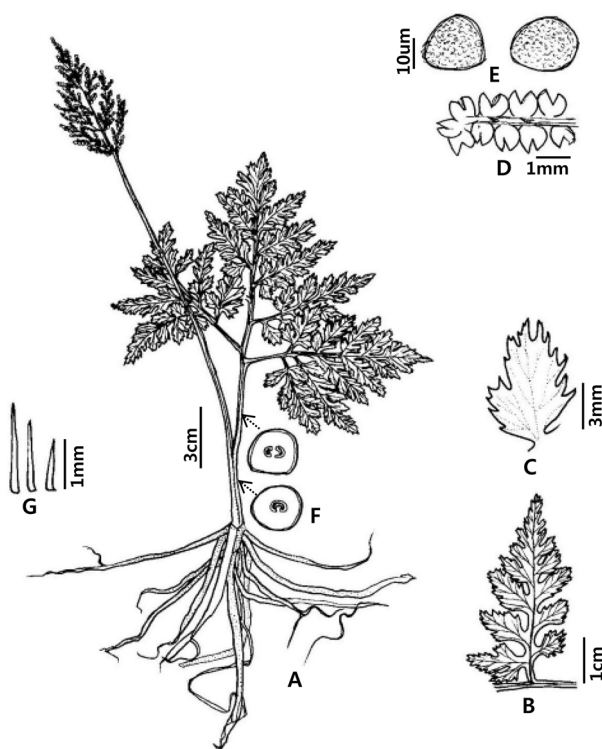
Maximum parsimony analysis of 27 morphological characteristics resulted in 82 trees. Bootstrap estimates were supported by values of 59–99%. The neighbor-joining trees showed similar patterns in how the taxa were grouped together. The phylogenetic tree with accompanying bootstrap values and apomorphic characteristics is presented in Fig. 5.

The cladistic tree of 12 taxa of *Sceptridium* and two taxa of *Botrypus* as an outgroup based on the 27 morphological characteristics showed that *Sceptridium* as an ingroup separated very strongly from the outgroup by a bootstrap value of 99%. This result suggests that it should be treated as a divided genus rather than the same genus in line with the classification system of Sahashi (1979), Kato (1987, 1988), Wagner (1990), and Hauk et al. (2003).

Twelve taxa of *Sceptridium* consisted of two monophyletic clades within the tree (Fig. 3). The first clade consisted of *S. japonicum*, *S. atrovirens*, *S. dissectum*, *S. daucifolium*, and *S. formosanum* by having homologous characteristics (more than 8 cm in average length of basal pinna as characteristic 14; serrate or lacerate margin of pinnule segment or pinnule as characteristic 20; hair presence in sporophore as characteristic 25; spore surface with spinules or papillate projections as characteristic 27). Second clade consisted of *S. nipponicum*, *S. ternatum*, *S. multifidum*, *S. robustum*, *S. triangularifolium*, *S. microphyllum*, and *S. biternatum* by having homologous characteristics (characteristic 11: trophophore length; characteristic 14: average length of basal pinna; characteristic 27: spore

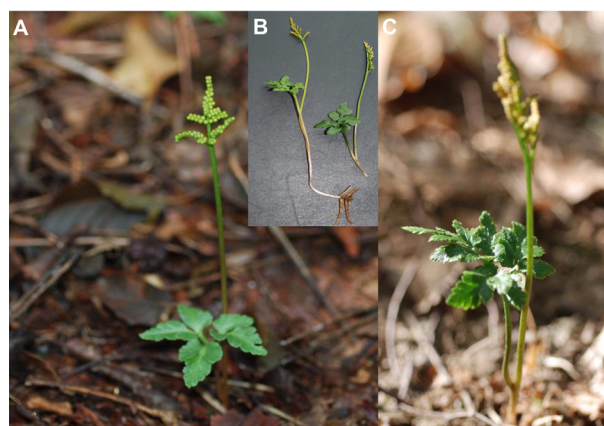


**Fig. 1.** Photographs of *Sceptridium atrovirens* Sahashi, taken in Dosun-dong, Seogwipo-si, Jeju-do on 11 Oct. 2011. A. Adult plants; B. Pinnule; C. Sporophore blade.

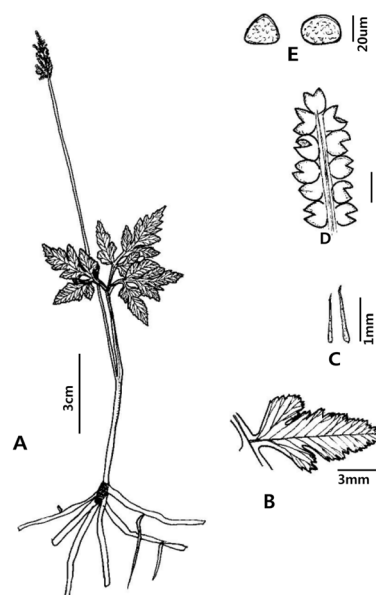


**Fig. 2.** *Sceptridium atrovirens* Sahashi, taken in Dosun-dong, Seogwipo-si, Jeju-do on 11 Oct. 2011. A. Habit; B. Pinnule; C. Pinnule segment; D. Sporangia; E. Spores; F. Steles in stalk; G. Hairs.

surface). This suggests that the genus *Sceptridium* can be split into two sections, sect. *Sceptridium* and sect. *Multifida* (Nishida, 1960; Kato, 1960; Sahashi, 1976, 1979a, b).



**Fig. 3.** Photographs of *Sceptridium microphyllum* Sahashi, taken in Dosun-dong, Seogwipo-si, Jeju-do on 11 Oct. 2011 (A, B), and 3 Dec. 2011 (C).



**Fig. 4.** *Sceptridium microphyllum* Sahashi, taken in Dosun-dong, Seogwipo-si, Jeju-do on 1 Oct. 2011. A. Habit; B. Pinnule; C. Hairs; D. Sporangia; E. Spores.

In the first clade of *Sceptridium*, *S. atrovirens* formed a monophyletic clade with these four taxa (*S. japonicum*, *S. dissectum*, *S. daucifolium*, and *S. formosanum*) based on homologous characteristics. This suggests that *S. dissectum* among these four taxa was most similar with *S. atrovirens* among the taxa of *Sceptridium*. This clade was separated into two clades again, with one clade containing *S. japonicum*-*S. atrovirens*-*S. dissectum* based on one homologous characteristic (less than 2/3 ratio of width/length of basal pinna as characteristic 15). Further, *S. atrovirens* with *S. dissectum* was separated from *S. japonicum* based on two characteristics (herbaceous tropophore as characteristic 10, and sporophore

**Table 1.** Morphological characters used in the cladistic analysis for 12 taxa of the genus *Sceptridium* as ingroup and 2 taxa of *Botrypus* as outgroup.

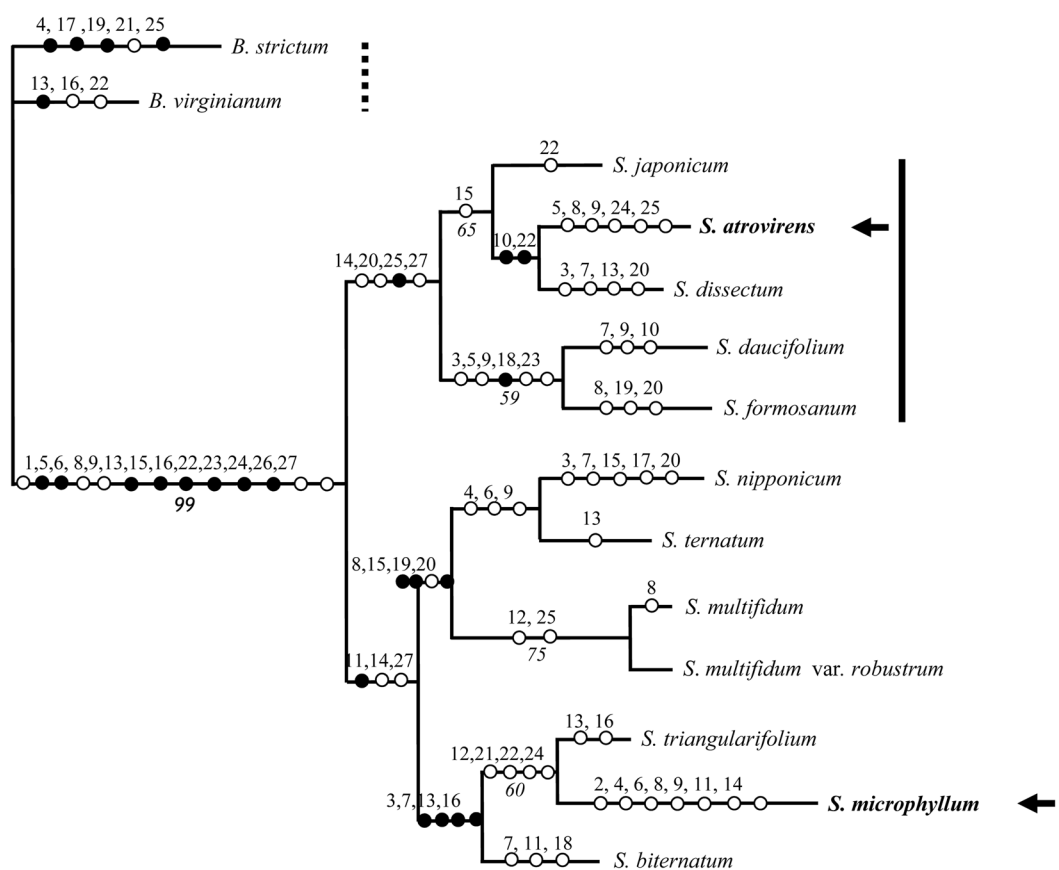
No.	Characters	Character state
1	Wintergreen	absent (0), present (1)
2	Average plant height	less than 20 cm (0), more than 20 cm (1)
3	Ratio of length of trophophore and sporophore	less than 2/3 (0), more than 2/3 (1), almostly 1 (2)
4	Hair presence in trophophore	absent (0), present (1)
5	Common stalk length	less than 5 cm (0), 5-10 cm (1), more than 10 cm (2)
6	Hair presence of common stalk	absent (0), present (1)
7	Trophophore color in winter	no change (0), partly lateritious (1), wholly lateritious (2)
8	Average length of trophophore stalk	no trophophore stalk (0), less than 10cm (1), more than 10 cm (2)
9	Ratio of common stalk and trophophore stalk	none (0), less than 1/3 (1), 1/3-1 (2), more than 1 (3)
10	Quality of trophophore	membranous to herbaceous (0) thick herbaceous (1)
11	Trophophore length	less than 5 cm (0), 5-12 cm (1), more than 12 cm (2)
12	Shape of trophophore blade	deltoid or subdeltoid (0), pentagonal or subpentagonal (1)
13	Degree of splitting in trophophore blade	less than 2-3 pinnatifid (0), 3 pinnated (1), 3-4 pinnatifid (2)
14	Average length of basal pinna	less than 3 cm (0), 3-8 cm (1), more than 8 cm (2)
15	Ratio of width/length of basal pinna	less than 2/3 (0), 2/3-1 (1), more than 1 (2)
16	Span length of basal pinna	less than 1 cm (0), 1-3 cm (1), more than 3 cm (2)
17	Presence of pinnule span	absent (0), present (1)
18	Basal pinnule segment shape	narrowly elliptic (0), broad lanceolate, elliptic, oblong, ovate (1), none (2)
19	Apex of pinnule segment or pinnule	almostly obtuse (0), acuminate or acute (1)
20	Margin of pinnule segment or pinnule	minutely dentate or crenulate (0), dentate or minutely serrate (1), sharply serrate (2), irregular roughly serrate (3), denticulate to lacerate (4)
21	Shape of sporophore blade	oblong (0), deltoid (1), linear (2)
22	Degree of splitting in sporophore blade	2 pinnate (0), 2-3 pinnate (1) more than 3 pinnated (2)
23	Length ratio of common stalk and sporophore stalk	less than 1/3 (0), more than 1/3 (1)
24	Length of sporophore blade	less than 5 cm (0), 5-12 cm (1), more than 12 cm (2)
25	Hair presence in sporophore	absent (0), present (1)
26	Sporangium dehiscence	transverse (0), longitudinal/subtransverse (1)
27	Spore surface	with spinules or papillate projections (0), vallate or faintly fossulate (1), irregular verrucae (2)

**Table 2.** Matrix of morphological data for 15 taxa of the genus *Sceptridium* and 2 taxa of *Botrypus* as outgroup. Character numbers are shown in Table 1.

Taxa/Characters	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
<i>S. japonicum</i>	1	1	1	1	0	1	1	2	1	0	2	1	1	2	0	1	1	0	1	2	1	0	0	1	1	0	0
<i>S. daucifolium</i>	1	1	2	1	2	1	1	2	3	1	2	1	1	2	1	1	1	0	1	2	1	1	1	1	1	0	0
<b><i>S. atrovirens</i></b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>2</b>	<b>1</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>	<b>0</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>3</b>	<b>1</b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>1</b>	<b>0</b>	<b>0</b>
<i>S. dissectum</i>	1	1	0	?	0	?	2	2	1	1	2	1	2	2	0	1	1	1	1	4	1	1	0	1	1	0	?
<i>S. formosanum</i>	1	1	2	1	2	1	0	1	2	0	2	1	1	2	1	1	1	0	0	3	1	1	1	1	1	0	0
<i>S. nipponicum</i>	1	1	0	0	0	0	2	1	2	0	1	1	1	1	1	1	0	1	0	1	1	1	0	1	0	0	1
<i>S. triangularifolium</i>	1	1	0	1	0	1	1	2	1	0	1	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	1
<b><i>S. microphyllum</i></b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1</b>	<b>1</b>	<b>2</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1</b>	<b>0</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1</b>
<i>S. biternatum</i>	1	1	0	?	0	?	2	2	1	0	2	1	0	1	1	0	1	2	1	1	1	1	0	1	?	0	?
<i>S. ternatum</i>	1	1	1	0	0	0	0	1	2	0	1	1	2	1	2	1	1	1	0	0	1	1	0	1	0	0	1
<i>S. multifidum</i>	1	1	1	1	0	1	0	2	1	0	1	0	1	1	2	1	1	1	0	0	1	1	0	1	1	0	1
<i>S. var. robustum</i>	1	1	1	1	0	1	0	1	1	0	1	0	1	1	2	1	1	1	0	0	1	1	0	1	1	0	1
<i>B. strictum</i>	0	1	1	0	2	0	0	0	0	0	2	1	0	2	2	0	0	1	0	1	2	0	1	2	1	1	2
<i>B. virginianum</i>	0	1	1	1	2	0	0	0	0	0	2	1	2	2	2	2	1	1	1	1	1	2	1	2	0	1	2

blade less than 5 cm long as characteristic 22). Based on these results, *S. atrovirens* in Japan and Korea is most similar with

*S. dissectum* in the USA, whereas *S. dissectum* does not have a common stalk length of 5–10 cm, trophophore stalk less than



**Fig. 5.** Phylogenetic tree for 12 taxa of the genus *Sceptridium* and 2 taxa of *Botryopus* as outgroup based on 27 morphological characters. Apomorphic characters and bootstrap percentages are provided above and below each branch, respectively. Closed circles represent nonhomoplastic synapomorphies and open circles represent homoplastic synapomorphies.

10 cm, ratio of width/length of basal pinna less than 2/3, length of sporophore blade less than 5 cm, or irregular sharply serrate pinnule segment margin. *S. atrovirens* Sahashi have been misidentified as *S. daucifolium* or *S. japonicum* (Christ, 1900; Nishida, 1956), but this supports Sahashi (1979)'s opinion that *S. atrovirens* is an obvious species.

In the other clade, *S. daucifolium* was most similar with *S. formosanum* based on five similar characteristics, but the former has distinctly different characteristic as tropophore color in winter, tropophore stalk length, ratio of common stalk and tropophore stalk, quality of tropophore, apex and margin of pinnule segment or pinnule, in characteristics 7, 8, 9, 10, 19, and 20. This supports that the two taxa could be distinct species.

The second clade consisted of *S. nipponicum*-*S. ternatum*-*S. multifidum*-*S. robustum*-*S. triangularifolium*-*S. microphyllum*-*S. biternatum* based on one homologous characteristic (characteristic 11: tropophore length; characteristic 14: average length of basal pinna; characteristic 27: spore surface). *S. nipponicum* has been very closely allied with *S. japonicum* (Makino, 1916), but has been treated as a variety of *S. ternatum*,

similar to *S. ternatum* (Thunb.) Lyon var. *nipponicum* (Makino) Nishida based on its similar spore surface (Nishida, 1959; Sahashi, 1976). In the results of the present study, *S. nipponicum* and *S. ternatum* have three homologous characteristics, (characteristic 4: hair presence in tropophore; characteristic 6: hair presence of common stalk; characteristic 9: ratio of common stalk and tropophore stalk), but have six different characteristics (characteristic 3: ratio of length of tropophore and sporophore; characteristic 7: tropophore color in winter; characteristic 13: degree of splitting in tropophore blade, characteristic 15: ratio of width/length of basal pinna; characteristic 17: presence of pinnule span; characteristic 20: margin of pinnule segment or pinnule). These phylogenetic trees support *S. nipponicum* Makino instead of *S. ternatum* (Swartz) Lyon var. *nipponicum* (Makino) Nishida. On the other hand, *S. robustum* is of the same variety as *S. multifidum*, based on its robust plant and more lanuginose and subcoriaceous leaves (Kato, 1995). This morphological analysis supports *S. multifidum* var. *robustum* instead of *S. robustum* as only one characteristic is not enough to affiliate its species.

*Sceptridium microphyllum* is known as an endemic in Japan (Sahashi, 1981c; Iwatsuki, 1992; Kato, 1995), but was found firstly in Jeju Island in Korea. It is the most similar with *S. triangularifolium* among the 12 taxa of *Sceptridium* based on this cladistic analysis, but it has as many different as nine characteristics (Fig. 3). Further analysis should elucidate anatomy, molecular approach etc.

*Sceptridium atrovirens* Sahashi and *S. microphyllum* Sahashi can be distinguished from the other taxa of genus *Sceptridium* in Korea as follows:

1. Plants sparingly hairy, more than 8 cm in average length of basal pinna, serrate or denticulate to lacerate in margin of pinnule segment or pinnule, spinules or papillate projections in spore surface ..... Sect. *Sceptridium*
2. Ratio of common stalk and trophophore stalk less than 1/3, sharply serrate, 2-pinnate and more than 5 cm long in sporophore blade ..... *S. japonicum* 산꽃고사리삼
2. Ratio of common stalk and trophophore stalk more than 1/3, irregular roughly serrate, 2-3-pinnate and less than 5 cm long in sporophore blade ..... *S. atrovirens* 숲고사리삼
1. Plants almost glabrous, 3–8 cm in average length of basal pinna, serrate or denticulate to lacerate in margin of pinnule segment or pinnule, vallate or faintly fossulate in spore surface ..... Sect. *Multifida*
3. Plant height more than 20 cm, more than 3 pinnated in trophophore blade, basal pinna more than 3 cm, a mostly obtuse apex of pinnule segment or pinnule.
4. Hair absent in trophophore, 1/3-1 in ratio of common stalk and trophophore stalk, pentagonal or subpentagonal trophophore blade, hair absent in sporophore.
5. Less than 2/3 in ratio of trophophore and sporophore length, latericious in winter season, 3 pinnated, pinnule span present, dentate or minutely serrate margin of pinnule or pinnule segment ..... *S. nipponicum* 단풍고사리삼
5. More than 2/3 in ratio of trophophore and sporophore length, no latericious in winter season, 3–4 pinnatifid, pinnule span absent, minutely dentate or crenate margin of pinnule or pinnule segment ..... *S. ternatum* 고사리삼
4. Hair present in trophophore, less than 1/3 in ratio of common stalk and trophophore stalk, trophophore blade deltoid or subdeltoid, hair presence in sporophore ..... *S. multifidum* var. *robustum* 산고사리삼
3. Plant height less than 20 cm, less than 2 3 pinnatifid in

trophophore blade, basal pinna less than 3 cm, acuminate or acute apex of pinnule segment or pinnule ..... *S. microphyllum* 애기고사리삼

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