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Reexamination of vascular plants in Ullung Island, Korea II: Taxonomic identity of *Acer takesimense* Nakai (Aceraceae)

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울릉도산 관속식물의 재검토 II: 섬단풍나무(단풍나무과)의 분류학적 실체

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Abstract

Acer takesimense, an endemic species of Ullung Island, is morphologically very similar to *A. pseudosieboldianum,* and often treated as synonymy with the latter species. As a part of comprehensive systematic study on the vascular plants in Ullung Island, morphological characteristics, including microstructures of pollen and leaf epidermis, of *A. takesimense* and *A. pseudosieboldianum* were examined to evaluate the degree of distinctness of *A. takesimense*. The results of morphological analyses indicated that *A. takesimense* can be distinguished from *A. pseudosieboldianum* on the basis of leaf characters such as the number of leaf lobes, degree of leaf division, and petiole length. In addition, the two species show significant differences in leaf epidermal characteristics, including shape of epidermal cells, cuticular ornamentation, and stomatal density. These observations strongly suggest that *A. takesimense* is distinct from *A. pseudosieboldianum* and should be recognized as taxonomically distinct.

Introduction

Acer is a taxonomically difficult, highly diversified genus of about 150 species (Delendick, 1981). The species of *Acer* are widely distributed in temperate regions of the Northern Hemisphere and some tropical regions including southeast Asia (Murray, 1970). In Korea, 18 species are found (Lee, 1979), and among them five species including two endemics are reported from Ullung Island (Lee and Yang, 1981).

Acer takesimense is an endemic species of Ullung Island, and belongs to sect. *Palmata* Pax. The species was first described by Nakai (1918), mainly on the basis of leaf shape including the number of leaf lobes. According to Nakai (1918), *A. takesimense* is morphologically similar to *A. pseudosieboldianum* (Pax) Komarov and *A. nudicarpum* Nakai (=*A. pseudosieboldianum*), but it differs from the latter two species in having 13- or rarely 14-lobed and more incisely sinuated leaves. Since Nakai described *A. takesimense*, it has been recognized as a distinct species by most Korean botanists (Chung, 1957; Lee, 1979; Lee and Yang, 1981). Recently, however, Chang, C. (1991) and Chang, C. and Giannasi (1991) suggested mainly on the basis of flavonoid chemistry that *A. takesimense* is conspecific with *A. pseudosieboldianum*, and placed *A. takesimense* in synonymy under *A. pseudosieboldianum*. As Chang, C. (1991) himself pointed out, however, his morphological analysis regarding *A. takesimense* was inconclusive because extensive collections were not available for the analysis; the degree of morphological distinctness of *A. takesimense* and its close relative, *A. pseudosieboldianum*, remained rather unclear.

As a part of comprehensive systematic study on the vascular plants in Ullung Island, morphological characteristics, including microstructures of pollen and leaf epidermis, of *A. takesimense* and *A. pseudosieboldianum* were examined to evaluate the degree of distinctness of *A. takesimense*.

Materials and Methods

Morphological analysis: Data used in this study were obtained from the individuals collected by the authors in Ullung Island from 1991 to 1993 and the specimens deposited in SNU and the Herbarium of Jeonbuk National University (JNU). A total of ca. 100 specimens were examined to determine the morphological variation of *A. takesimense* and *A. pseudosieboldianum*. Specimens were identified primarily by the characters mentioned in the original descriptions and those used by previous authors (Chung, 1957; Komarov, 1904; Lee, 1979; Nakai, 1918).

After removal of duplicates and poor specimens, 47 fully matured individuals, including 22 of *A. pseudosieboldianum* and 25 of *A. takesimense*, were selected for morphological analyses (Appendix 1). Individuals were selected to represent morphological variability of each species. From these individuals, 14 leaf characters, five of which were derived ratios, were scored for morphological analyses (Table 1, Fig. 1), since the leaf shape has been regarded as most important for distinguishing these two species (Chung, 1957; Nakai, 1918; Lee, 1979). For measurements of these characters, the largest, fully mature leaf in each individual was used. To better evaluate the distinctness of these two species, data derived from the above measurements were subjected to

Table 1. Characters used in morphological analyses of *A. takesimense* and *A. pseudosieboldianum*. See Fig. 1 for further clarification.

1. Leaf length (cm)
2. Leaf width (cm)
3. Leaf width/leaf length (character 2/character 1)
4. Number of leaf lobes (no.)
5. Petiole length (cm)
6. Middle lobe length (cm)
7. Middle lobe width at base (cm)
8. Middle lobe width at the widest point (cm)
9. Leaf length/petiole length (character 1/character 5)
10. Middle lobe length/leaf length (character 6/character 1)
11. Middle lobe width at the widest point/middle lobe width at base (character 8/character 7)
12. Length from the middle lobe base to the widest point of middle lobe/middle lobe length
13. Divergent angle between the two lateral lobes (degree)
14. Leaf angle/2 (degree)

principal components analysis and cluster analysis. The principal components analysis and the cluster analysis (UPGMA) were carried out using Statistical Analysis System (SAS Institute, 1990; Release 6.04) and NTSYS (Rohlf, 1988; version 1.50), respectively, on an IBM PC. Data matrix used for the analyses is provided in Appendix 2.

Microstructures of pollen and leaf epidermis: Pollen grains taken from herbarium specimens were acetolyzed by the procedure of Erdtman (1966), and prepared for light microscopy, including size measurements, by mounting them on slides in glycerine jelly. For SEM, acetolyzed grains were coated with gold-palladium and examined and photographed with an Akashi SX-40 scanning electron microscope.

Leaf epidermal characteristics were examined using leaf segments taken from herbarium specimens. The segments were taken from near the base of middle lobe of the largest, fully mature leaf in each individual. For SEM, each segment was coated with gold-palladium and examined and photographed with the same scanning electron microscope. Size and density of stomatal complex were measured from the leaf segments bleached with sodium hypochlorite solution (Clorox), using an ocular micrometer and a mesh-micrometer, respectively, under a light microscope. Fourteen individuals of *A. takesimense* and 13 of *A. pseudosieboldianum* were examined for leaf epidermal characteristics. Collection data of specimens used for SEM and LM studies of pollen and leaf epidermis are provided in Appendix 1.

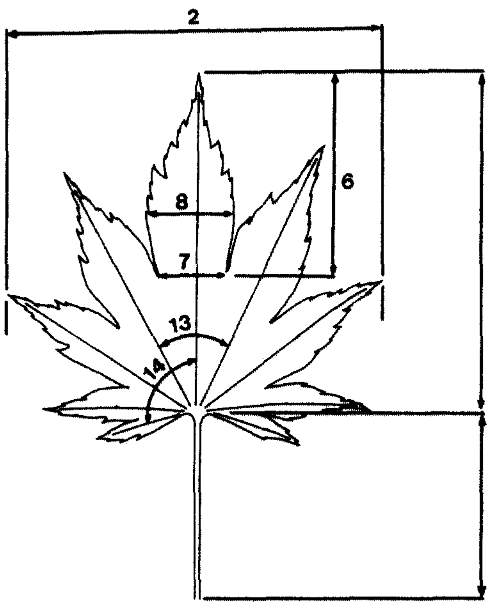

Fig. 1. Diagram of leaf characters measured for numerical analyses of *A. takesimense* and *A. pseudosieboldianum*. Numbers correspond to character numbers in Table 1.

Results and Discussion

Morphological analysis: The ranges and means of the 14 leaf characters measured for *A. takesimense* and *A. pseudosieboldianum* are summarized in Table 2. In general, the two species show some degree of overlap in all characters measured (Table 2), but scatter plots of some character pairs, including leaf length vs. middle lobe length and the number of leaf lobes vs. middle lobe length/leaf length ratio, show that they could be separated from each other by the combinations of these characters (Fig. 2). For individuals of the same leaf length, *A. takesimense* tends to have shorter middle lobe than *A. pseudosieboldianum*, indicating that leaves of *A. takesimense* tend to be shallowly lobed as compared to those of *A. pseudosieboldianum*. Also, for individuals of the same middle lobe length/leaf length ratio, *A. takesimense* has more lobes than *A. pseudosieboldianum* except one individual (Fig. 2); this result agrees with the contention (Chung, 1957; Lee, 1979; Nakai, 1918) that *A. takesimense* is distinct from *A. pseudosieboldianum* in having leaves with more lobes.

To better evaluate the patterns of morphological variation and the degree of distinctness of *A. takesimense* and *A. pseudosieboldianum*, measurements of 14 characters (Table 1) from 47 individuals were analyzed using principal components analysis. The first three principal

Table 2. Ranges and means of 14 morphological characters of *A. takesimense* and *A. pseudosieboldianum.* Character numbers and units correspond to those in Table 1. Parenthetical numbers represent mean.

Character No.	*takesimense*	*pseudosieboldianum*
1	5.7-(6.8)-8.6	5.8-(6.9)-8.2
2	7.6-(9.6)-19.5	7.4-(9.1)-11.0
3	1.18-(1.41)-3.10	1.18-(1.32)-1.56
4	9-(11.6)-13	9-(9.3)-11
5	2.7-(4.5)-6.6	2.2-(3.6)-5.0
6	2.9-(3.6)-4.9	3.3-(4.3)-5.4
7	1.1-(1.5)-2.6	0.9-(1.4)-1.8
8	1.4-(2.0)-2.4	1.7-(2.1)-2.9
9	1.20-(1.59)-2.33	1.43-(1.98)-2.75
10	0.47-(0.53)-0.62	0.56-(0.62)-0.74
11	0.92-(1.37)-1.75	1.20-(1.52)-2.24
12	0.26-(0.40)-0.61	0.27-(0.39)-0.57
13	43.0-(50.5)-61.0	48.0-(59.9)-71.5
14	124-(140.4)-170	116-(129.1)-145

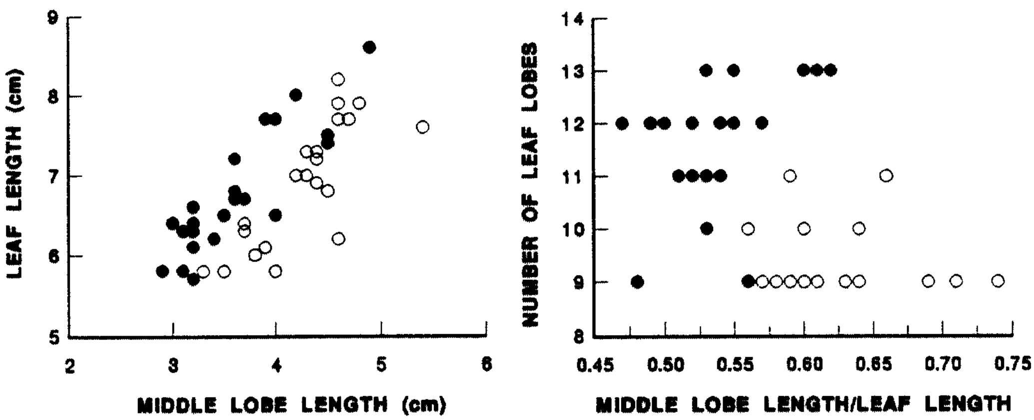

Fig. 2. Scatter plots of leaf length vs. middle lobe length and the number of leaf lobes vs. middle lobe length/leaf length ratio. Some individuals are hidden due to the same values. Symbols: Closed circles = *A. takesimense.* Open circles = *A. pseudosieboldianum.*

Table 3. Loadings of the first three principal components for 14 morphological characters from the analysis of 47 individuals of *A. takesimense* and *A. pseudosieboldianum*. Character numbers correspond to those in Table 1

Character No.	Component		
	1	2	3
1	0.2271	0.4196	-0.2548
2	0.2176	0.3445	0.4061
3	0.0998	0.1274	0.5949
4	0.3535	-0.1783	0.0828
5	0.3723	0.1027	-0.3751
6	-0.0886	0.4987	-0.2795
7	0.3477	0.2454	0.0794
8	0.1251	0.4191	0.1152
9	-0.2801	0.1392	0.3287
10	-0.3688	0.2888	-0.1538
11	-0.3011	0.0620	-0.0618
12	-0.0721	-0.0679	0.0349
13	-0.3457	0.2058	0.1501
14	0.2309	-0.0922	0.1079
Eigenvalue	3.6184	2.8351	2.0556
Cumulative % of eigenvalues	25.8	46.1	60.8

components accounted for 25.8, 20.3, and 14.7 percent of the total variance, respectively (Table 3). The first principal component reflected high positive loadings for the number of leaf lobes (4; parenthetical numbers here and subsequently refer to character numbers in Table 1), petiole length (5), and middle lobe width at base (7), and high negative loadings for ratio of middle lobe length/leaf length (10) and divergent angle between the two lateral lobes (13). The second component was weighted heavily for leaf length (1), leaf width (2), middle lobe length (6), and maximum width of middle lobe (8). The character related to the third component was ratio of leaf width/leaf length (3) (Table 3).

The plot of individuals projected on the first two principal components (Fig. 3) indicated that most individuals of *A. takesimense* and *A. pseudosieboldianum* are separable on the basis of the morphological characters included in the analysis. In the plot (Fig. 3), individuals of *A. takesimense* are separated from those of *A. pseudosieboldianum* with little overlap by the first

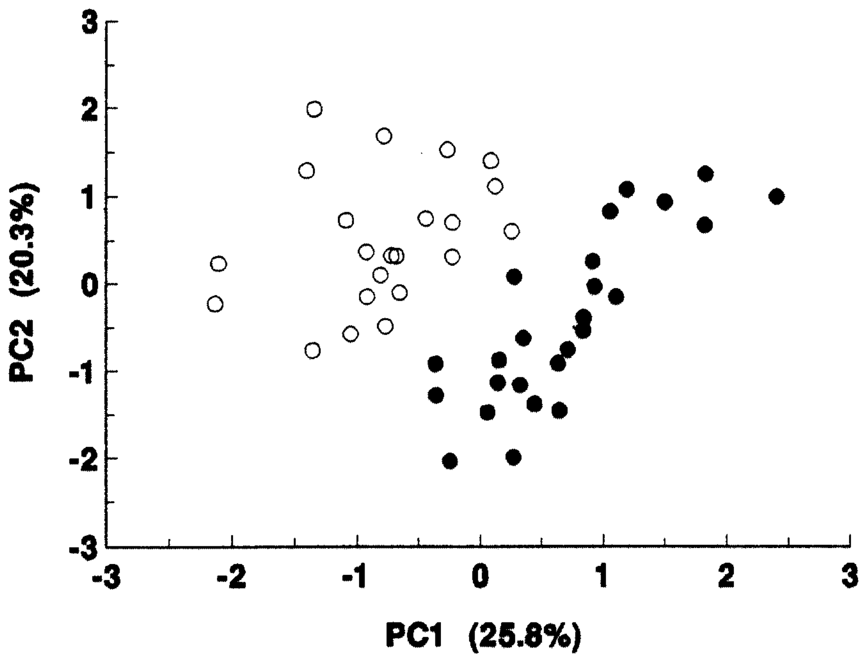

Fig. 3. Principal components analysis of *A. takesimense* and *A. pseudosieboldianum* using 14 characters (cf. Table 1). Some individuals are hidden due to the same values. Symbols: Closed circles= *A. takesimense*. Open circles = *A. pseudosieboldianum.*

principal component, which is primarily a function of characters related to the leaf lobing and petiole length (Table 3). The relative positions of individuals of these two species on the first component (Fig. 3) suggest that the plants of *A. takesimense* tend to have leaves divided less deeply but with more lobes and longer petioles as compared to those of *A. pseudosieboldianum* (Table 3). This tendency was also apparent in the multivariate analyses of Chang, C. (1991), but he ascribed the separation of *A. takesimense* from *A. pseudosieboldianum* to the insufficient sample size of *A. takesimense.*

UPGMA-derived phenogram of 47 individuals of these two species, based on correlation coefficient computed from the same standardized data set, also shows a good separation of individuals of *A. takesimense* from those of *A. pseudosieboldianum* (Fig. 4).

Pollen: Pollen morphology of *Acer* has been studied by many authors (cf. Delendick, 1981), and the size and microstructure of pollen of *A. pseudosieboldianum* were reported by Chang, N (1986)

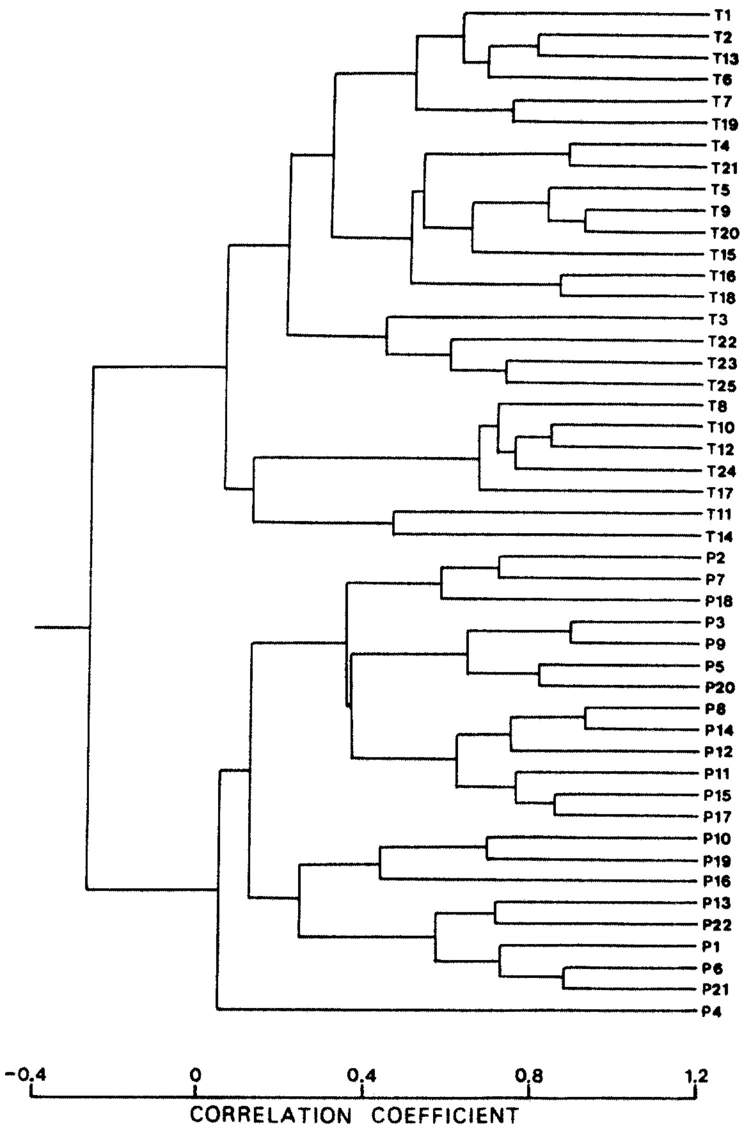

Fig. 4. UPGMA phenogram for 47 OTU's of *A. takesimense* and *A. pseudosieboldianum* based on correlation coefficient computed from 14 standardized characters (cf. Table 1). OTU numbers correspond to those in Appendices 1 and 2. P = *A. pseudosieboldianum*, T = *A. takesimense*.

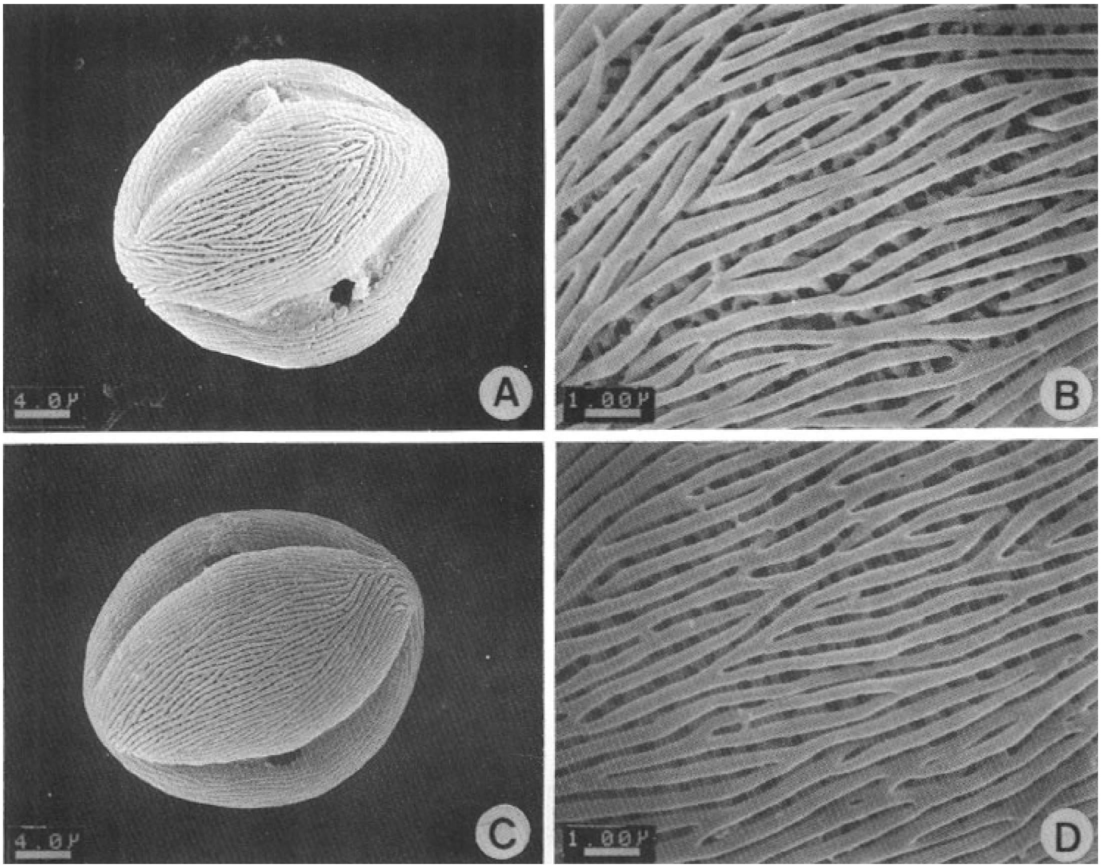

Fig. 5. Scanning electron micrographs of pollen of *A. takesimense* (A, B) and *A. pseudosieboldianum* (C, D).

and Delendick (1981). However, pollen morphology of *A. takesimense* has not been studied previously.

Scanning electron micrographs of representative pollen grains of *A. takesimense* and *A. pseudosieboldianum* are provided in Fig. 5, and the size and shape measurements are summarized in Table 4. As in other species of sect. *Palmata*, *A. takesimense* and *A. pseudosieboldianum* have tricolporate pollen with striate exine. The pollen grains of the two species are nearly identical in size and shape (Table 4, Fig. 5), supporting the view (Nakai, 1918) that the two species are very closely related. Pollen grains of both species are suboblate to spherical, the polar axis 23.6-31.8 μm, and the equatorial axis 20.3-30.5 μm. Exine sculpturing of the two species are also very similar, and the exine is striate with closely packed or fused striae in both species.

Table 4. Size and shape of acetolyzed pollen of *A. takesimense* and *A. pseudosieboldianum*. Parenthetical numbers represent mean.

Character	*takesimense*	*pseudosieboldianum*
Equatorial length (μm)	22.9-(24.9)-26.7	20.3-(25.1)-30.5
Polar length (μm)	26.7-(28.5)-31.8	23.6-(28.4)-31.8
P/E ratio	1.10-(1.15)-1.28	1.00-(1.13)-1.50

Table 5. Size and density of stomatal complex of *A. takesimense* and *A. pseudosieboldianum*. Parenthetical numbers represent mean.

Character	*takesimense*	*pseudosieboldianum*
Length (μm)	15.2-(18.9)-25.4	12.7-(17.9)-22.9
Width (μm)	10.2-(13.3)-17.8	7.6-(12.9)-15.2
Length/width ratio	1.2-(1.4)-2.0	1.2-(1.4)-2.0
Density (no./0.03 mm^2)	15-(24)-37	11-(16)-21

Leaf epidermis: Characteristics of leaf epidermis, including cuticular ornamentation of adaxial surface, have been regarded as taxonomically useful in *Acer* (Delendick, 1981). Scanning electron micrographs of leaf surfaces of *A. takesimense* and *A. pseudosieboldianum* are provided in Fig. 6, and the size and shape measurements are summarized in Table 5.

In these species, epidermal cells of adaxial surface are, in general, five- to six-sided and have short striae over the cuticular surface (Fig. 6 A, C). Epidermal cells of abaxial surface are somewhat irregular in shape, and the cuticle surfaces are relatively smooth. Stomata are restricted to the abaxial surface and anomocytic in both species (Fig. 6 B, D). There are, however, some significant differences in the shape of epidermal cells between the two species. In *A. takesimense*, the anticlinal walls are straight on adaxial surface and almost straight or slightly sinuous on abaxial surface (Fig. 6 A, B), whereas in *A. pseudosieboldianum* they are moderately to strongly sinuous on both surfaces (Fig. 6 C, D). Also, in *A. pseudosieboldianum*, epidermal cells of adaxial surface are more or less irregular in shape, usually two to three times longer than wide, and the cuticular ornamentation is thinner and sparser than that of *A. takesimense* (Fig. 6 C, D). The size and shape of stomatal complexes of these two species are very similar, but the two species show significant differences in stomatal density; *A. takesimense* has much more stomata as compared to *A. pseudosieboldianum* (Table 5).

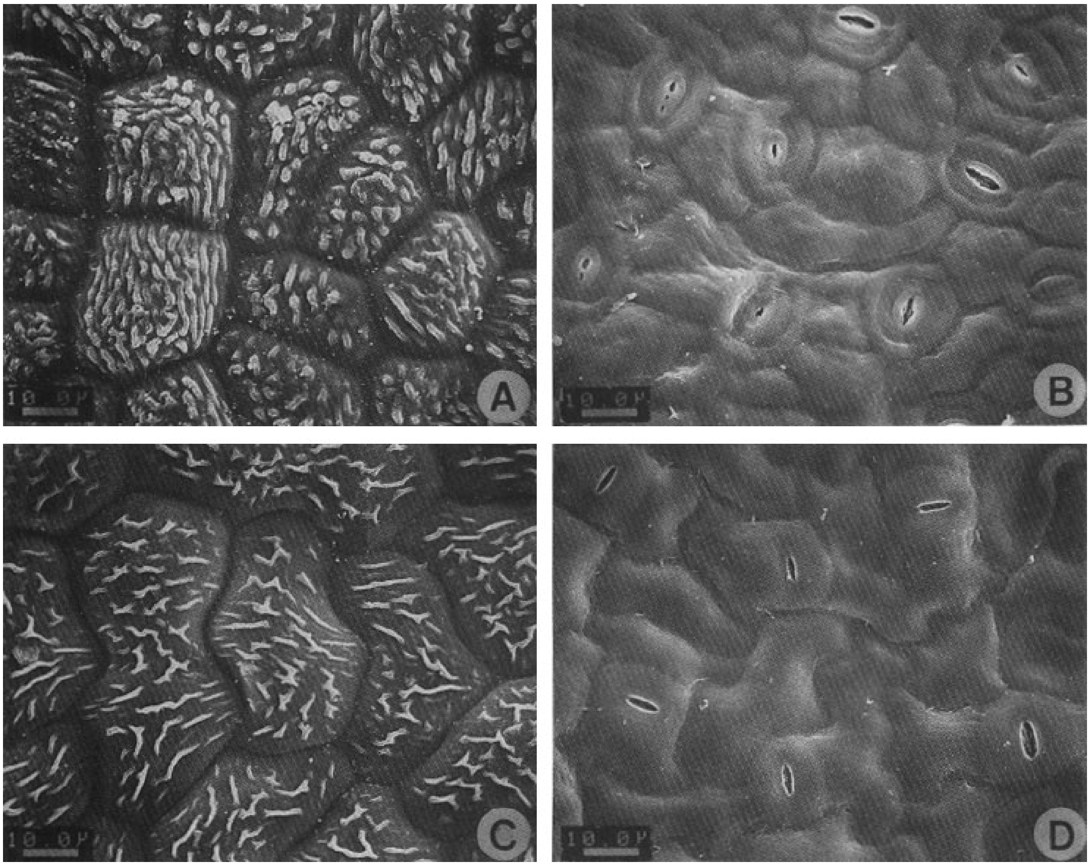

Fig. 6. Scanning electron micrographs of leaf epidermis of *A. takesimense* (A, B) and *A. pseudosieboldianum* (C, D). A, C: adaxial surface. B, D: abaxial surface.

Conclusion

Although *A. takesimense* shows some degree of overlap with *A. pseudosieboldianum* in major morphological characters, the results of morphological analyses including principal components analysis and cluster analysis indicated that the two species can be distinguished by the combinations of leaf characters such as the number of leaf lobes, degree of leaf division, and petiole length. Diagnostically, *A. takesimense* tends to have leaves divided less deeply but with more lobes (usually 10-13) and longer petioles as compared to those of *A. pseudosieboldianum*. In addition, *A. takesimense* can be distinguished from *A. pseudosieboldianum* by leaf epidermal characteristics, including shape of epidermal cells, cuticular ornamentation, and stomatal density.

These observations strongly suggest that *A. takesimense* is distinct from *A. pseudosieboldianum* and should be recognized as taxonomically distinct.

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적 요

울릉도 고유종으로 알려진 섬단풍나무는 당단풍나무와 형태적으로 매우 유사하여 그 분류학적 타당성 및 한계 해석에 있어 혼란이 나타나고 있다. 따라서 본 연구에서는 울릉도산 관속식물에 대한 분류학적 연구의 일환으로 섬단풍나무및 당단풍나무의 주요 형태적 식별형질과 화분 및 잎 표피의 미세구조를 분석하여 섬단풍나무의 분류학적 타당성을 검토하고자 하였다. 그 결과, 섬단풍나무는 잎 열편의 수 및 결각 정도, 엽병의 길이, 잎 표피세포의 형태, 기공수, cuticular ornamentation pattern 등에 의해 당단풍나무와 구분될 수 있는 것으로 밝혀졌다.

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Appendix 1

A list of specimens used for this study. OTU numbers used in the numerical analyses are given in brackets following the collection data. E: specimens used for LM and SEM studies of leaf epidermis; PO: specimens used for LM and SEM studies of pollen.

A. takesimense Nakai:

KOREA. Kyungbuk. Ullung Island: Without specific locality, 26 Jun 1988, *Hyun s.n.* (SNU 72379) [T1]; without specific locality, 26 Jun 1988, *Hyun s.n.* (SNU 72380) [T2, E]; Sadong-Seonginbong, 17 May 1992, *Shin & Lee 14* (SNU) [E]; Sadong-Seonginbong, 17 May 1992, *Shin & Lee 16* (SNU) [T3, E]; Sadong-Seonginbong, 17 May 1992, *Shin & Lee* 53 (SNU) [T4]; Sadong-Seonginbong, 17 May 1992, *Shin & Lee* 56 (SNU) [T5, E]; Sadong-Seonginbong, 17 May 1992, *Shin & Lee 92* (SNU) [E, PO]; Sadong-Seonginbong, 17 May 1992, *Shin & Lee 141* (SNU) [T6]; Sadong-Seonginbong, 17 May 1992, *Shin & Lee 142* (SNU) [T7]; Sadong-Seonginbong, 17 May 1992, *Shin & Lee 161* (SNU) [T8, E, PO]; Dodong-Seonginbong, 3 Jun 1991, *Sun 1214* (JNU) [T9, E]; Dodong-Seonginbong, 3 Jun 1991, *Sun 1223* (JNU) [T10]; Dodong, 5 Jun 1991, *Sun 1290* (JNU) [T11, E]; Dodong, 3 Jun 1991, *Sun 1344* (JNU) [T12, E]; Seonginbong, 16 Jul 1937, *Toh & Shim 8391* (SNU 7629) [T20, E]; Seonginbong, 16 Jul 1937, *Toh & Shim 8393* (SNU 7639) [T21]; Namyang-Taeha, 18 Jul 1937, *Toh & Shim 8394* (SNU 7640) [T22, E]; Namyang-Taeha, 18 Jul 1937, *Toh & Shim 8395* (SNU 7630) [T23]; Seonginbong, 16 Jul 1939, *Toh & Shim 11190* (SNU 7617) [T25]; without specific locality, 18 Jul 1939, *Toh & Shim 11188* (SNU 7614) [T24, E]; Nari, 22 Aug 1947, *Toh & Shim s.n.* (SNU 7632) [T13]; Nari, 22 Aug 1947, *Toh & Shim s.n.* (SNU 7636) [T14]; Nari, 22 Aug 1947, *Toh & Shim s.n.* (SNU 7637) [T15, E]; Namyang-Seonginbong, 24 Aug 1947, *Toh & Shim s.n.* (SNU 7633) [T16]; Namyang-Seonginbong, 24 Aug 1947, *Toh & Shim s.n.* (SNU 7634) [T17]; Namyang-Seonginbong, 24 Aug 1947, *Toh & Shim s.n.* (SNU 7635) [T18, E]; Namyang-Seonginbong, 24 Aug 1947, *Toh & Shim s.n.* (SNU 7638) [T19].

A. pseudosieboldianum (Pax) Komarov:

KOREA. Without specific locality, in 1935, *Col.?* (SNU 7620) [P1]. **Chunbuk:** Mt. Deokyoo, 27 Jun 1923, *Fukugara & Kanagai s.n.* (SNU 7618) [P2]. **Chunnam:** Mt. Chiri, 8 May 1987, *Kim s.n.* (SNU 63419) [PO]; Mt. Chiri, 24 Sep 1990, *Lee s.n.* (SNU 73221) [P3]; Mt. Chiri, 3 Aug 1939, *Toh & Shim 11162* (SNU 7578) [P4]. **Hamnam:** Without specific locality, 23 Sep 1920, *Ishidoya s.n.* (SNU 7623) [E]. **Kangwon:** Without specific locality, 20 Sep 1920, *Col.?* (SNU 7619) [P5]; Mt. Kariwang, 13 Jul 1989, *Lee s.n.* (SNU 70735) [P6]; Mt. Myun, 4 Aug 1990, *Oh*

Appendix 1 (continued)

s.n. (SNU 74082) [P7, E]. **Kyungbuk:** Mt. Sobaek, 2 Jun 1975, *Choi & An s.n.* (SNU 49057) [P8]; Mt. Sobaek, 2 Jun 1975, *Choi & An s.n.* (SNU 49060) [PO]; Mt. Sobaek, 2 Jun 1975, *Choi & An s.n.* (SNU 49067) [E]; Mt. Sobaek, 30 Aug 1975, *Choi & An s.n.* (SNU 49072) [P9]; Mt. Chuheul, 28 Aug 1987, *Kim s.n.* (SNU 65166) [P10, E]; Mt. Chuheul, 2 Jun 1979, *Lee s.n.* (SNU 49738) [P11, E]; Mt. Chuheul, 10 May 1991, *Nam s.n.* (SNU 75178) [PO]; Mt. Chuheul, 3 Jun 1979, *Shin s.n.* (SNU 49830) [P12, E]. **Kyunggi:** Mt. Yongmun, 18 Jun 1983, *Kim s.n.* (SNU 58104) [E]; Mt. Kwanak, 25 Apr 1992, *Kim s.n.* (SNU 76387) [P13]; Mt. Unak, 30 May 1992, *Kim s.n.* (SNU 75982) [P14, E]; Mt. Unak, 30 May 1992, *Kim s.n.* (SNU 75917) [P15, E]; Mt. Unak, 9 May 1992, *Mun 188* (SNU 76668) [PO]; Mt. Unak, 29 Jun 1992, *Mun 189* (SNU 76669) [P16, E]; Mt. Kwanak, 2 Jun 1982, *Nam s.n.* (SNU 53011) [P17, E]; Mt. Taehwa, 23 Jun 1983, *Shin s.n.* (SNU 57365) [P18]; Mt. Taehwa, 17 Jul 1983, *Shin s.n.* (SNU 57366) [P19]; Kwangreung, 15 Aug 1932, *Shinito s.n.* (SNU 7613) [P20]; Kwangreung, 26 Sep 1933, *Tenoiwa s.n.* (SNU 7616) [P21, E]. **Pyungbuk:** Without specific locality, 18 Jul 1938, *Toh & Shim 8378* (SNU 7621) [P22, E].

Appendix 2

Data matrix used for the principal components analysis and the cluster analysis of morphological characters. Character numbers and units correspond to those in Table 1, and OTU numbers correspond to those in Appendix 1.

OTU	Characters													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
T1	6.5	7.80	1.20	11	3.6	3.5	1.30	1.80	1.81	0.54	1.38	0.27	49.0	149
T2	6.7	8.80	1.31	12	4.9	3.6	1.50	2.20	1.37	0.54	1.47	0.33	54.0	152
T3	6.3	9.20	1.46	11	2.8	3.2	1.30	2.00	2.25	0.51	1.54	0.50	54.0	138
T4	8.0	9.40	1.18	13	4.3	4.2	1.40	2.10	1.86	0.53	1.50	0.41	43.0	146
T5	6.2	8.50	1.37	13	3.6	3.4	1.20	1.70	1.72	0.55	1.42	0.47	50.0	138
T6	6.5	9.50	1.46	13	4.0	4.0	1.40	2.30	1.63	0.62	1.64	0.40	61.0	170
T7	7.4	11.50	1.55	13	5.8	4.5	1.50	2.20	1.28	0.61	1.47	0.40	58.0	152
T8	7.7	9.30	1.21	12	5.5	4.0	1.50	2.00	1.40	0.52	1.33	0.40	45.0	127
T9	6.8	9.30	1.37	13	3.7	3.6	1.50	2.00	1.84	0.53	1.33	0.47	45.0	139
T10	8.6	12.20	1.42	12	6.5	4.9	1.70	2.00	1.32	0.57	1.18	0.27	45.0	134
T11	6.3	19.50	3.10	12	2.7	3.1	1.70	2.30	2.33	0.49	1.35	0.38	56.0	136
T12	7.7	11.50	1.49	11	6.0	3.9	1.90	2.20	1.28	0.51	1.16	0.26	50.0	135
T13	6.1	7.70	1.26	11	4.6	3.2	1.40	1.80	1.33	0.52	1.29	0.34	55.0	145
T14	6.6	8.60	1.30	9	3.6	3.2	1.50	1.90	1.83	0.48	1.27	0.31	49.0	126
T15	6.4	9.20	1.44	12	4.0	3.2	1.50	2.10	1.60	0.50	1.40	0.44	45.0	124
T16	5.8	7.80	1.34	12	4.4	2.9	1.10	1.80	1.32	0.50	1.64	0.38	44.0	133
T17	7.7	10.00	1.30	11	6.4	4.0	2.60	2.40	1.20	0.52	0.92	0.43	50.0	137
T18	6.4	7.70	1.20	12	4.9	3.0	1.20	2.10	1.31	0.47	1.75	0.33	45.0	138
T19	7.5	10.10	1.35	13	4.7	4.5	1.50	2.00	1.60	0.60	1.33	0.40	50.0	153
T20	6.7	9.60	1.43	12	3.9	3.7	1.40	1.90	1.72	0.55	1.36	0.46	50.0	137
T21	7.2	9.00	1.25	12	4.1	3.6	1.50	2.10	1.76	0.50	1.40	0.39	46.0	142
T22	5.7	7.60	1.33	9	4.3	3.2	1.30	1.80	1.33	0.56	1.38	0.44	58.0	140
T23	6.3	8.00	1.27	11	4.0	3.2	1.50	1.90	1.58	0.51	1.27	0.44	55.0	140
T24	8.0	11.30	1.41	10	6.6	4.2	1.70	2.30	1.21	0.53	1.35	0.43	50.0	140
T25	5.8	7.90	1.36	11	3.3	3.1	1.30	1.40	1.76	0.53	1.08	0.61	56.0	140
P1	6.8	9.80	1.44	11	3.7	4.5	1.20	1.95	1.84	0.66	1.63	0.44	57.5	142

Appendix 2 (continued)

OTU	Characters													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
P2	7.2	9.40	1.31	9	3.5	4.4	1.50	2.10	2.06	0.61	1.40	0.30	61.0	145
P3	6.1	8.90	1.46	9	3.0	3.9	1.60	2.10	2.03	0.64	1.31	0.37	71.5	145
P4	7.0	10.95	1.56	10	4.2	4.2	1.50	2.90	1.67	0.60	1.93	0.54	62.5	138
P5	6.0	7.90	1.32	9	4.2	3.8	1.50	2.10	1.43	0.63	1.40	0.34	71.0	130
P6	6.2	8.60	1.39	9	4.2	4.6	0.85	1.90	1.48	0.74	2.24	0.57	56.0	118
P7	7.3	10.10	1.38	9	4.3	4.3	1.75	2.25	1.70	0.59	1.29	0.28	63.5	136
P8	7.7	9.50	1.23	9	2.8	4.7	1.35	2.20	2.75	0.61	1.63	0.43	62.0	118
P9	6.3	7.90	1.25	9	2.8	3.7	1.50	2.05	2.25	0.59	1.37	0.38	64.0	141
P10	7.7	9.60	1.25	9	5.0	4.6	1.30	2.00	1.54	0.60	1.54	0.39	52.0	120
P11	5.8	8.00	1.38	9	2.2	3.3	1.30	1.80	2.64	0.57	1.38	0.27	62.0	130
P12	7.3	8.60	1.18	9	3.3	4.4	1.50	1.80	2.21	0.60	1.20	0.39	57.0	120
P13	7.6	10.75	1.41	9	4.0	5.4	1.20	2.20	1.90	0.71	1.83	0.33	65.5	126
P14	7.9	10.05	1.27	9	3.0	4.8	1.60	2.40	2.63	0.61	1.50	0.44	58.5	125
P15	6.9	9.65	1.40	10	2.6	4.4	1.40	2.05	2.65	0.64	1.46	0.32	59.0	128
P16	8.2	10.00	1.22	10	4.0	4.6	1.50	1.90	2.05	0.56	1.27	0.39	48.0	130
P17	6.4	8.10	1.27	9	3.2	3.7	1.35	1.85	2.00	0.58	1.37	0.32	52.5	119
P18	7.9	9.65	1.22	9	3.9	4.6	1.80	2.40	2.03	0.58	1.33	0.42	58.0	136
P19	7.3	10.00	1.37	11	4.3	4.3	1.30	2.00	1.70	0.59	1.54	0.47	52.5	116
P20	5.8	7.40	1.28	9	3.4	3.5	1.30	2.00	1.71	0.60	1.54	0.31	61.0	126
P21	5.8	7.60	1.31	9	3.2	4.0	1.00	1.90	1.81	0.69	1.90	0.45	65.0	122
P22	7.0	8.60	1.23	9	4.6	4.3	1.15	1.70	1.52	0.61	1.48	0.35	58.0	129