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A morphometric analyses of genus *Acer* L., section *Palmata* Pax, series *Palmata*

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단풍나무屬, 단풍나무節에 對한 多變量分析 硏究

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Abstract

Acer, section *Palmata,* series *Palmata* is a morphologically variable group occurring geographically from central China to western North America. Phenetic multivariate analyses (principal components analysis and cluster analysis) have been applied to morphological data obtained from 18 taxa to identify and characterize patterns of variation within and between taxa. Among morphological characters found to be taxonomically significant, qualitative (absence/presence of pubescence on ovaries, twigs, leaf petioles and veins) and quantitative characters (nutlet size, wing size, petiole length, number of leaf lobe and leaf width) were useful to delimit the taxa. This study, along with comparative flavonoid analysis, resulted in a full evaluation of vegetative and fruit characters and tested the validity of several previous taxonomic treatments based on morphological data alone. Several taxonomic changes, including new combinations for *A. takesimense, A. amoenum* var. *matsumurae, A. amoenum* var. *nambuanum* and several varieties of *A. pseudosieboldianum,* were proposed. Also, phenetic analyses of morphological characters indicated that the taxonomic status of several varieties of Chinese maples, which were based on highly variable leaf shapes and forms, should be reevaluated and based on more reliable diagnostic characters.

Introduction

Acer L, section *Palmata* Pax, ranges throughout the forest region of China, Taiwan, Korea and Japan and Western North America (Ogata, 1967; de Jong, 1976). Pax (1885, 1986) first proposed that sect. *Palmata* consisted of only five species. Pojarkova (1932) later listed 8 species. Momotani (1962b) then transferred series *Sinensia* of sect. *Microcarpa* into sect. *Palmata*. Ogata (1967) subsequently included series *Laevigata* of sect. *Intergrifolia* under sect. *Palmata* and then characterized sect. *Palmata,* now consisting of three series (*Laevigata, Sinensia* and *Palmata*), by the presence of four bud scales, elliptic or convex nutlets and cotyledons morphology. De Jong (1976) generally accepted Ogata's treatment of sect. *Palmata,* but renamed Ogata's series *Laevigata* as *Penninervia,* determining that the former name was a *nomen superfluum*.

The taxa included in this section appear to be a natural group as supported by seed protein (Momotani, 1962a) and leaf venation type (Tannai, 1978) studies, but the delimitation of each series was very variable based on other systematic information (de Jong, 1976; Delendick, 1981).

Most species of series *Palmata* seem to be easily distinguished on the basis of leaf shape, size, the number of lobes, fruit size, fruit shape and flower color. However, as Ogata (1965) pointed out some continuous variation in the major diagnostic characters causes some ambiguity in identification. Further, many of the infraspecific taxa and poorly studied species in China and Korea have received no wide acceptance by many authors (Komarov, 1949; Murray, 1970; de Jong, 1976; Fang, 1981) due to the variation in morphological characters and overt similarities of many taxa.

The purpose of this present study was 1) to describe precisely the patterns of morphological variation of the widespread species of series *Palmata* in Japan and Korea, 2) to qualify and quantify this variation phenetically and 3) finally provide a basis for the delimitation of taxa in ser. *Palmata*. These numerical analyses, accompanying flavonoid data, and correlative phytogeographical information, provided the basis for taxonomic changes presented here.

Materials and Methods

Specimens for this study were obtained from herbaria (A, WS, WTU, OSC, SNUA, GH, PE, TUS, TI, NF, KYO, TAI, B) and personal collections (vouchers deposited at GA). Specimens used in the phenetic studies are listed in Appendix I. Ten specimens from each taxon [less than five specimens were available for the following Chinese taxa: *A. duplicatoserratum* Hayata var. *duplicatoserratum, A. duplicatoserratum* var. *chinense* C. S. Chang, *A. ceriferum* Rehder, *A. pubipalmatum* Fang, *A. pauciflorum* Fang and *A. changhuaense* (Fang et Fang f.) Fang et P. L. Chiu] were selected to represent a wide range of geographical and morphological variation. Since both fruit and flower specimens were not available at the same time for all taxa, flower characters (flower color, pubescence of ovary) for some species were assigned based on published descriptions (Fang, 1932a,b, 1939, 1966, 1979, 1981; Li, 1952;

Lee, 1979; Kitamura and Murata, 1984; Ohwi, 1984) and observation of separate floral specimens.

For leaf measurements a 'typical' and usually the largest measurable leaf was selected. The same approach was used for floral characters. Fifty four characters were utilized in the analyses (Table 1). The derivation of these measurements and various ratios are shown in Fig.1.

To identify interspecific characters, a principal components analysis (PCA) was performed on standardized data (Sneath and Sokal, 1973). A correlation matrix was generated using selected significant characters along with the univariate and analysis of variance (ANOVA).

Phenograms for the taxa were then generated using UPGMA (average linkage clustering) clustering of an Euclidian distance matrix. The cluster analyses were performed using SPSS/PC (Norusis, 1986), while all other analyses were conducted with PC-SAS, version 6 edition (1988).

Table 1. A list of characters for the numerical analyses.

1. the number of leaf lobe (N)
2. angle (three lobe) (A)
3. width (W)
4. petiole length (PL)
5. depth of lobe (DL)
6. length (L)
7. leaf area (LA)
8. form factor (FO)
9. leaf perimeter (PE)
10. length of wing (WL)
11. length of nutlet (NL)
12. width of nutlet (WN)
13. width of wing (tip) (W1)
14. width of wing (1/2 position) (W2)
15. angle of fruits (FA)
16. distance between two wings (DW)
17. the pubescence of pedicel (+ +, + or −) (PD)
18. the pubescence of seed (+ +, + or −) (PS)
19. the pubescence of leaf vein (+ +, + or −) (PP)
20. the pubescence of petiole (+ +, + or −) (PK)
21. the pubescence of ovary (+ +, + or −) (PO)
22-35. each lobe angle (A1-A14)
36-50. each lobe length (L1-L14)
51. ratio (length/width) (R1)
52. lobe ratio (R2)
53. leaf length/petiole length (R3)
54. ratio (length of seed/length of wing) (R4)

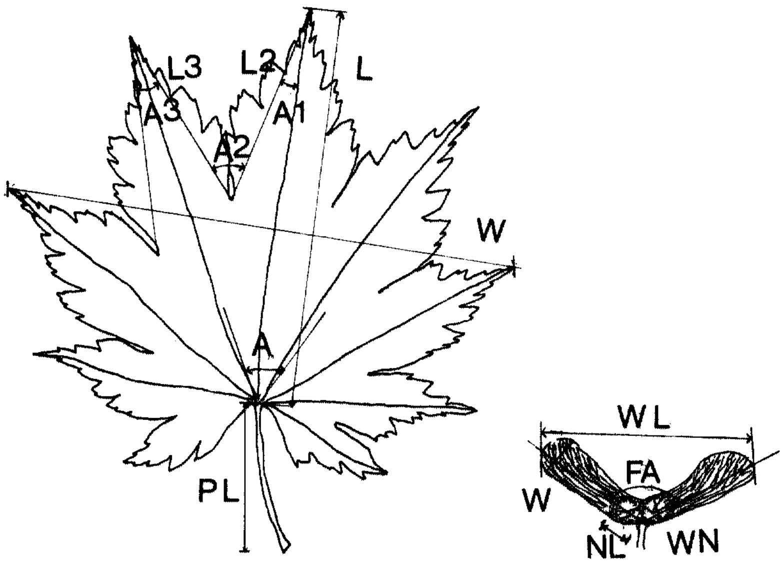

Figure 1. The representative measured characters for the numerical analyses (See Table 1 for character designations).

Results and Discussion

Among the examined characters, the 19 most highly significant characters (N, FO, PE, WL, NL, WN, PD, PP, PK, PO, A1, A2, A4, A6, A10, A12, L9, L12, R3: see Table 1) were chosen from ANOVA and correlation analysis for the principal components analysis.

Principal components analysis (PCA) of these 19 characters of the taxa (17 OTUs) investigated resulted in the extraction of three major components having eigenvalues of 0.25, 0.23, 0.18 (67 % of total variation) respectively.

In general, characters highly correlated with the first and second principal components were related to the leaf size, leaf angle, leaf form factor, leaf perimeter, the number of leaf lobes, length of wing and length of nutlet. Those correlated with the third component were mostly qualitative characters, absence/presence of pubescence on leaves and fruits (wings and nutlets).

The two dimensional ordinate plot of the first two principal components (Fig.2) revealed two distinct groups. The *Acer palmatum* complex [closed triangles: *A. palmatum* Thunb. var. *palmatum, A. amoenum* Carr. var. *amoenum, A. amoenum* var. *matsumurae* (Koidz.) Ogata] and the '*A. japonicum* group' (open diamond).

***Acer palmatum* complex:** Three dimensional PCA (Fig.3) fail to separate any species from the others. A variation of the Korean individuals of *A. palmatum* var. *palmatum* (closed

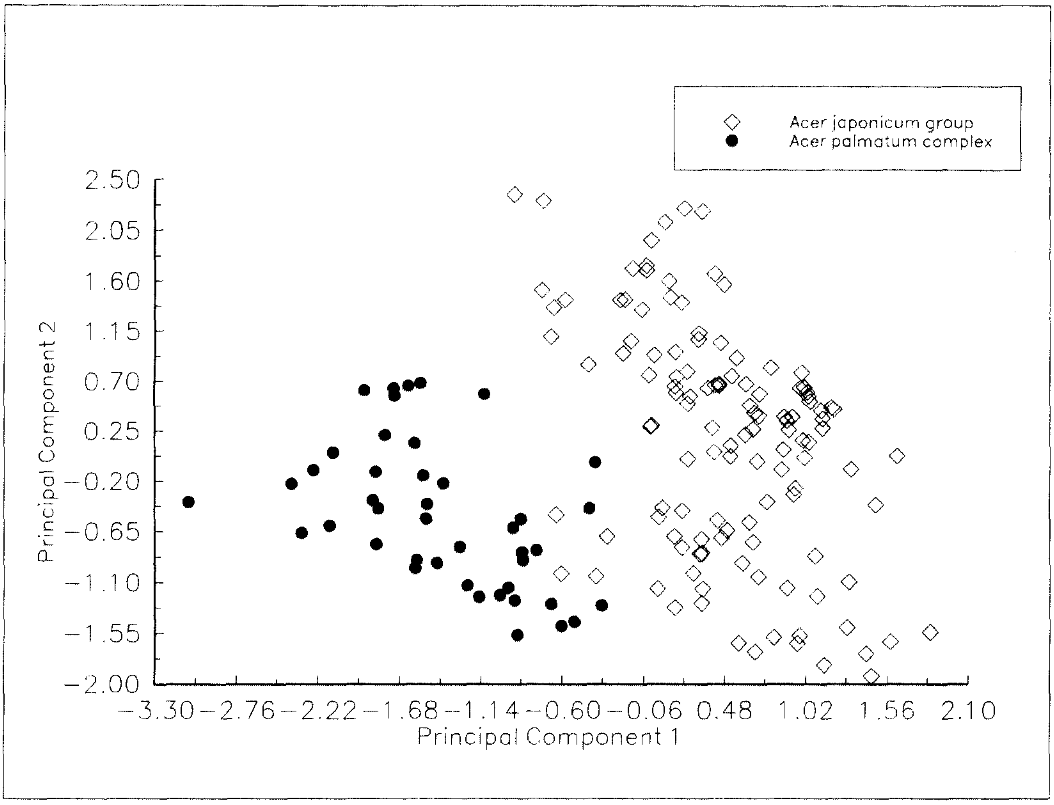

Figure 2. Principal components analysis of *Acer*, section *Palmata*, series *Palmata*.

triangles), however, appeared continuous between that of two extreme *A. amoenum* var. *amoenum* (closed circle). Individual characters (e.g. length of wing and nutlet, width of nutlet and width of leaf; Fig.4) gave some insight into the relationships within the complex. *Acer amoenum* var. *amoenum*, which was treated as a distinct species by Ogata (1965), was distinguished from Japanese individuals of *A. palmatum* on the basis of fruit characters (length of wing and nutlet, width of nutlet; Fig.4). However, the multivariate portion (Fig.3) and univariate analysis (Fig.4) of this study did not clearly separate Korean individuals of *A. palmatum* (closed triangles) from *A. amoenum* var. *amoenum* (closed circles). Korean individuals of *A. palmatum* distributed continuously between Japanese *A. palmatum* (open circles) and *A. amoenum* var. *amoenum* (closed diamonds) due to large leaves and nutlets as well as nine lobed leaves (Fig.3). All three OTUs were partly intermixed in the PCA (Fig.3) and cluster analysis (Fig.5). Cluster analysis (Fig.5) of Korean individuals of *A. palmatum*, Japanese individuals of *A. palmatum*, *A. amoenum* var. *amoenum* and *A. amoenum* var. *matsumurae* showed no distinct groupings. All diagnostic characters, which were used for the separation of this complex, were continuously variable from Japanese individuals of *A. palmatum* to *A. amoenum* var. *amoenum* through Korean individuals of *A. palmatum.*

Acer amoenum var. *matsumurae* in this study partly separated from the related *A. amoenum* var. *amoenum* due to the number of leaf lobes (nine lobes in var. *matsumurae* vs. seven lobes in var. *amoenum:* Figs. 3, 4 and 6). Specimens collected from western populations of Honshu in Japan possessed this character, but showed intermediate variation with *A. amoenum* var. *amoenum* in eastern populations. Other authors (Ogata, 1965; Kitamura and Murata, 1984) have also used types of leaf lobe serration (singly vs. doubly serrate) to distinguish these two taxa. However, this character is extremely difficult to determine in the great majority of individuals from these two taxa. It is more difficult to separate extreme types of Korean individuals of *A. palmatum* var. *palmatum* from *A. amoenum* var. *matsumurae,* since these two taxa have the same number of leaf lobes (9) and similar leaf size. However, the unique habitats for *A. palmatum* var. *palmatum* both in Japan and Korea can be utilized for taxon delimitation. The semi-aquatic habitats (valleys or creeks in mountains) of *A. palmatum* contrast to the xeric sites of *A. amoenum* var. *amoenum* and *A. amoenum* var. *matsumurae*

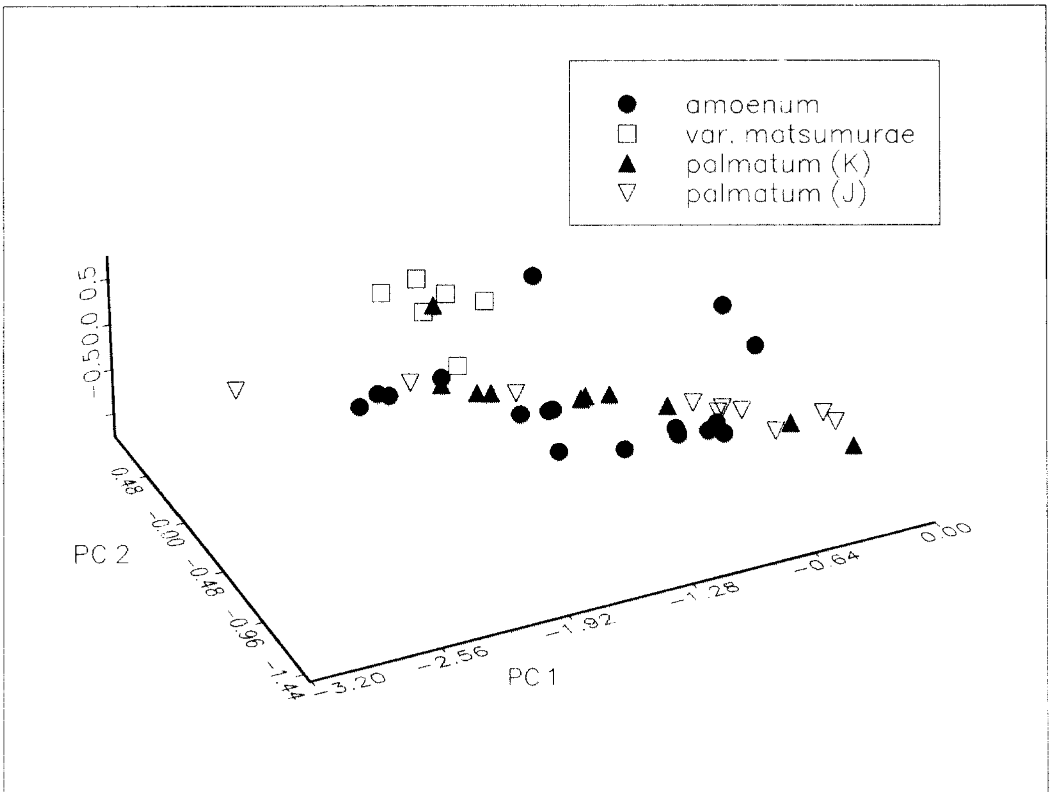

Figure 3. Principal components analysis of *Acer palmatum* complex.

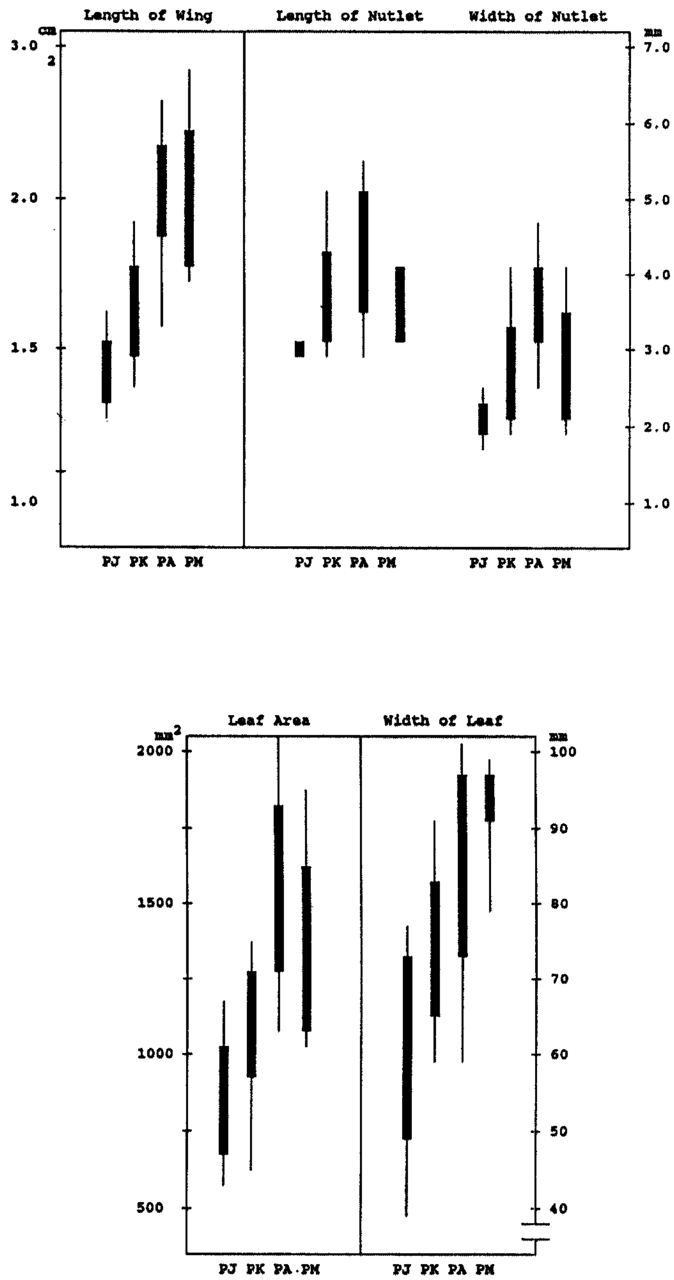

Figure 4. Morphological variation of *A. palmatum* complex (PJ: Japanese individuals of *A. palmatum*, PK: Korean individuals of *A. palmatum*, PA: *A. amoenum*, PM: *A. amoenum* var. *mastumurae*)

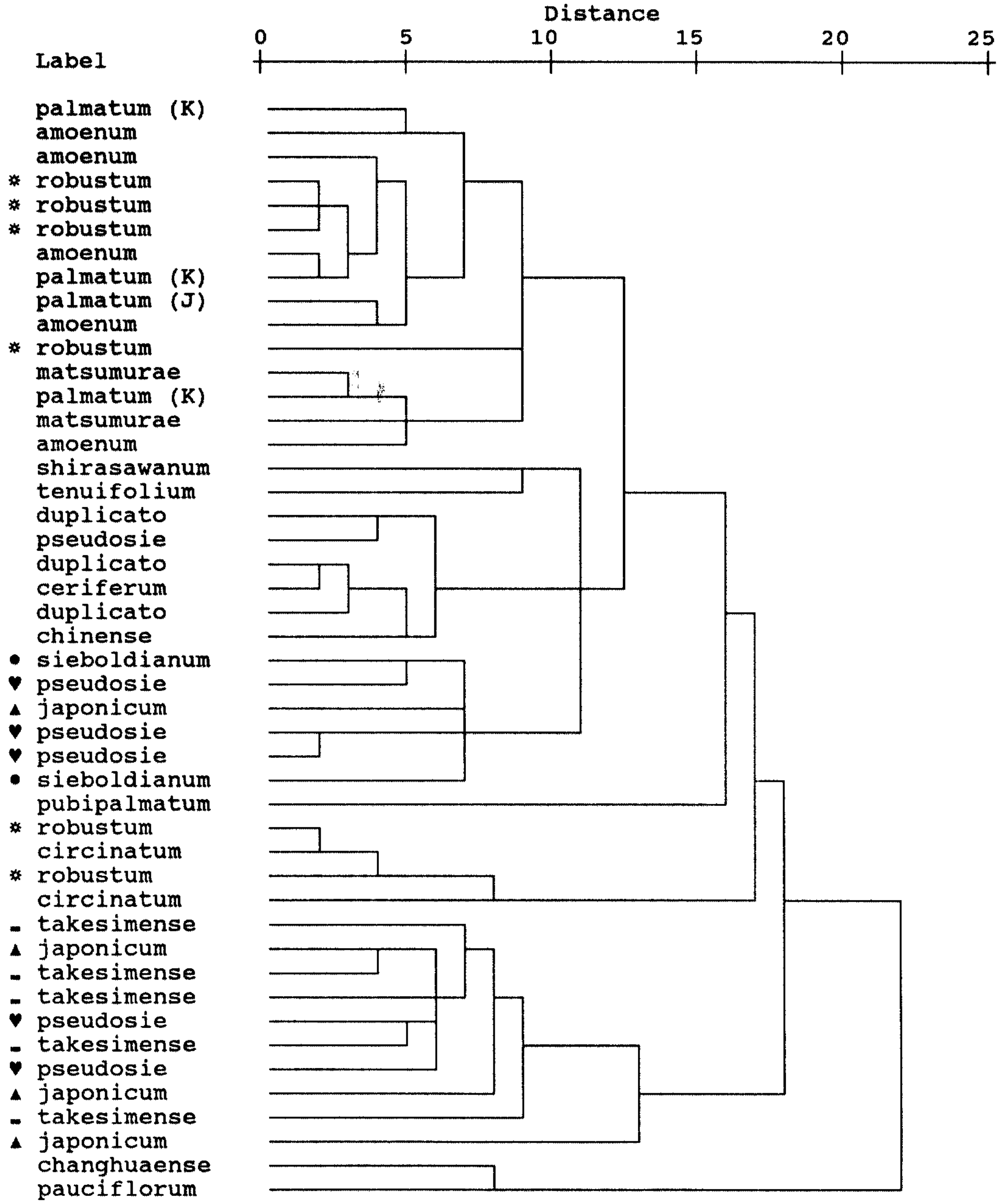

Figure 5. Phenogram of hierarchial cluster produced using UPGMA for series *Palmata* (reduced phenogram from 161 individuals, Chang 1989).

as understory trees. Vertrees (1978) reported that a moist, chilling treatment was required for a good yield of germination of *A. palmatum* seeds. Although he did not recognize two distinctive taxa (*A. palmatum* var. *palmatum* and *A. amoenum* var. *amoenum*), it is likely that this physiological adaptation, in association with habitat preference, could justify the recognition of two distinctive taxa.

Based on these morphological data, it appears that the variation among these taxa is considerable and does not support the recognition of two separate species, *Acer palmatum* and *A. amoenum*. However, it does seem reasonable to categorize the variation, both morphological and habitat preference, by recognizing two varieties of a single species; *A. palmatum* var. *palmatum* in Korea and Japan and *A. palmatum* var. *amoenum* in Japan, only with *Acer amoenum* var. *matsumurae* being synonomized with the latter variety. Flavonoid evidence (Chang and Giannasi, 1991) supports this conclusion, where *A. amoenum* var. *amoneum* is intermediate between Japanese and Korean *A. palmatum*, and *A. amoenum* var. *matsumurae* having a flavonoid profile identical to *A. amoenum* var. *amoenum*. Flavonoid evidence also

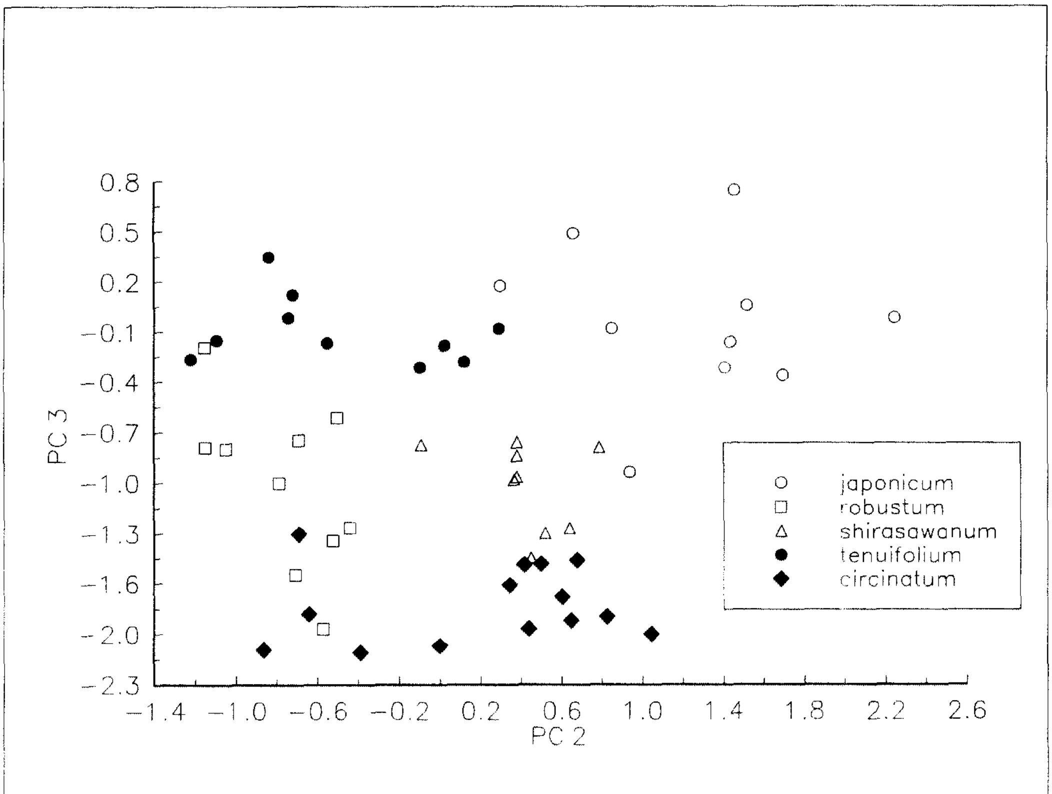

Figure 6. Principal components analysis of *Acer japonicum, A. robustum, A. shirasawanum, A. tenuifolium* and *A. circinatum* (principal component 2 vs principal component 3).

does not support the recognition of other subspecific taxa recognized by other previous author [i.e. *A. amoenum* var. *nambuanum* by Ogata (1965)].

***Acer japonicum* group:** Six Chinese taxa, (*A. duplicatoserratum* var. *duplicatoserratum, A. duplicatoserratum* var. *chinense, A. ceriferum, A. pubipalmatum, A. pauciflorum* and *A. changhuaense*) showed conspicuous separation from other related Korean and Japanese taxa due to leaf characters (number of leaf lobes, angle of three middle lobes and width of leaf) in the first and second principal components (not shown; Chang, 1989). Most OTUs were readily apparent in the PCA, except several taxa (among *A. pseudosieboldianum, A. sieboldianum, A. japonicum* and *A. takesimense*; *between A. robustum* and *A. circinatum*: Fig.6). In Fig.5, *A. pseudosieboldianum, A. japonicum* and *A. takesimense* formed a group, although most individuals of *A. pseudosieboldianum* were shown to be closely related to *A. sieboldianum* within cluster.

The lack of clear separation of these taxa within the '*A. japonicum* group' by the PCA and cluster analysis suggested that several characters should be reevaluated for delimiting the taxa in this group.

Acer japonicum, which is usually separated from other related taxa (*A. pseudosieboldianum, A. circinatum* and *A. sieboldianum*), has several diagnostic characters, such as persistent pubescence on nutlets of fruit, absence of pubescent petioles, leaf area and leaf width (figures 6 and 7). *Acer takesimense* (closed box in Fig.7), which closely clustered with the *A. japonicum* in the PCA (closed triangle) and cluster analysis (Figs. 5 and 7), could be separated by the absence of pubescence on nutlets as well as the geographical isolation (Island of Ul-lung-do, off the coast of Korea for *A. takesimense* vs. Honshu and Hokkaido in Japan for *A. japonicum*).

Likewise, a major key character that distinguishes *A. sieboldianum* (open circle) from *A. pseudosieboldianum* (open diamond), but not scored for this analysis, is flower color (purple in *A. pseudosieboldianum* vs. yellow in *A. sieboldianum*). Additionally, these two species are geographically isolated (Korea and Northeastern China for *A. pseusosieboldianum* vs. Japan for *A. sieboldianum*).

Recent studies (de Jong, 1976; Murray, 1970) considered *A. takesimense* as conspecific with *A. pseudosieboldianum*. Originally, *A. takesimense* was separated from *A. pseudosieboldianum* by the number of leaf lobes (13 for *A. takesimense* vs. 9 or 11 for *A. pseudosieboldianum*). In this analysis, *A. takesimense* is distinguished from *A. pseudosieboldianum* based on petiole length, leaf area, length of nutlet, width of nutlet, absence of pubescence on petioles as well as leaf lobe number (11 lobes, rather than 13 lobes). This separation is evident in the PCA (pc 2 vs pc 3, Figure 7). However, all of these characters overlapped considerably in the univariate analysis (Fig.8). It is probable that the separation of these two species present in the PCA (Fig.6) is due to the fact that only individuals with more or less extreme leaf forms and several scored qualitative characters (presence/absence of pubescence in pedicel, seed, leaf vein and petiole) of *A. takesimense* were chosen for numerical analysis. If more intermediate individuals were included (i.e. individuals in high elevations on Ul-lung-do Island in Korea; personal observation in 1986 and 1989), it is likely that these two species would not separate. Additionally *A. takesimense* and *A. pseudosiebodianum* had nearly identical flavonoid profiles (Chang and Giannasi, 1991). Thus, flavonoid data as well as univariate analysis of morphological data (Fig.8) supports the conspecific treatment of *A. takesimense* and *A. pseudosieboldianum.*

Acer circinatum, a western North American species, is generally considered most closely related to *A. japonicum.* However, it is quite distinct due to differences in leaf perimeter, the absence of pubescence on leaf veins, leaf width and leaf vein angle A (see Fig.1). The distinctness of this species is evident in figure 6. The flavonoid complement of *Acer circinatum* also serves to distinguish it from *A. japonicum* (Chang and Giannasi, 1991).

Two confusing taxa, *Acer shirasawanum* and *A. tenuifolium,* were easily separated by the petiole length, leaf width and nutlet width (Fig. 6). Flavonoid data (Chang and Giannasi, 1991) also clearly distinguished between these two species.

The results from this study have also supported that a new taxonomic treatment be provided from *Acer palmatum* var. *pubescens* Li. Figures 5 and 9 show that the *A. duplicatoserratum* complex are clearly separated from the *A. palmatum* complex. Thus, it appears that *A. palmatum* var. *pubescens* should be recognized as a distinct species, *A. duplicatoserratum* as was suggested in a previous study (Chang, 1990). The characters that distinguish between two varieties of this species are width of nutlet, pubescence on leaf veins and petioles.

The Chinese taxa in the '*Acer japonicum* group' all appear to represent distinct species (not shown; Chang, 1989). However, the major problematic species are *Acer robustum* and *A. ceriferum.* Morphologically, the Chinese *A. ceriferum* Rehder (Rehder, 1911), which has thus far been found only in western Hupeh of China (*Wilson 1934:* type collection), appears to be closely related to the Taiwanese *A. duplicatoserratum* var. *duplicatoserratum.* The morphological differences between these two taxa are mainly in the degree of pubescence (villous to pubescent) on leaves and twigs (Fig.9). However, flavonoid chemistry indicates that *A. ceriferum* is most closely related to *A. duplicatoserratum* var. *chinense,* rather than var. *duplicatoserratum.* Since flower color (possibly a significant distinguishing character for these species, as was the case between *A. pseudosieboldianum* and *A. sieboldianum*: see Key) of *A. ceriferum* and members of the *A. duplicatoserratum* complex is unknown, any nomenclatural changes involving *A. ceriferum* await further study (Chang, 1990).

Fang (1979) divided *Acer robustum* into three subspecific taxa, var. *robustum,* var. *honanense* and var. *minus* based on leaf size, fruit size and fruit shape. In this study *A. robustum* exhibits highly variable leaf size (6-12.5 cm), nutlet length (3.5-7 cm) and nutlet width (3.0-6.0 mm). Due to this extreme variation, small leaves (6-8 cm) plants with few lobes (7) of *A. robustum* clustered with the '*A. palmatum*' complex, while large leaved plants (8-12.5

cm) with many lobes (9) clustered with the '*A. circinatum*' in the PCA (Fig.7) and cluster dendrogram (Fig.6). Since very few specimens (15) were available for this study, no taxonomic decisions are appropriate until a larger number of specimens can be examined.

These morphological analyses showed that the *Acer palmatum* complex is characterized by glabrous ovaries, while the *A. japonicum* group possessed villous hairs on ovaries. The former morphological group was also found to possess C-glycosylflavones, while the latter morphological group lacked these compounds (Chang and Giannasi, 1991). The only exceptions to this general correlation are *A. shirasawanum* and *A. robustum*. *A. shirasawanum,* which belongs to the *A. japonicum* group based on morphology, posses a flavonoid profile characteristic of the '*A. palmatum*' type. Similarly *A. robustum,* also a member of the *A. japonicum* group based on morphology, has a characteristic flavonoid profile, not of the '*palmatum*' or '*japonicum*' types (Chang and Giannasi, 1991).

This study also pointed out that several characters used to distinguished between certain taxa were highly variable and not reliable diagnostic characters. For example, previous authors (e.g. Nakai, 1915, 1931) divided *A. pseudosieboldianum* into several subspecific taxa. These variable characters including fruit wing size, wing angle, wing shape, leaf base shape, leaf lobe shape and leaf size were employed to delimit six different varieties of *A. pseudosieboldianum*. The results from this study indicated that none of these varieties warrant taxonomic distinction and that their diagnostic characters are too variable (80 to 90 % within species) for use in delimiting any taxa (Chang, 1989). A similar situation was true for several Chinese species that have been divided into varieties as well. These include *A. pubipalmatum* and *A. anhweiense*.

Besides these infraspecific Chinese taxa, the morphologic differences between *A. robustum* and *A. anhweiense* (wing and nutlet greater than 3.5-4 cm in length, wings horizontal vs. wing and nutlet less than 3 cm in length, wing angle oblong to obtuse) intergrade considerably. Similar situation occurs between *A. pauciflorum* and *A. changhuaense* [whitish hairs on petioles, small wing (1.5 cm-1.8 cm) vs. yellowish or gray hairs on leaves, large wing (1.8 cm-2 cm): see Fig.6].

Summarizing the morphological data, most taxa can be assigned to distinct species based on both the qualitative and quantitative characters used in this study. In conjunction with flavonoid data, several Korean and Japanese taxa have been redelimited, while other taxa (six variesties of *A. pseudosieboldianum, A. amoenum* var. *mastumurae, A. amoenum* var. *nambuanum* and *A. takesimense*) were determined to be unworthy of formal taxonomic recognition (See below). Finally, any new comprehensive taxonomic treatment for Chinese taxa must await avilability of adequate field and herbarium specimens.

Key to *Acer*, section *Palmata*, series *Palmata*

The following key was developed from the results of analyses using both qualitative and

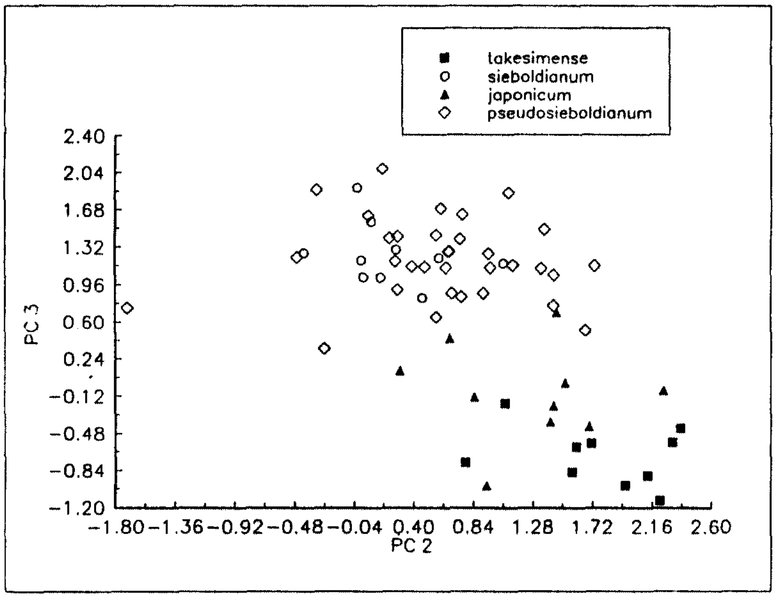

Figure 7. Principal components analysis of *Acer japonicum, A. sieboldianum, A. pseusodieboldianum* and *A. takesimense* (principal component 2 vs principal component 3).

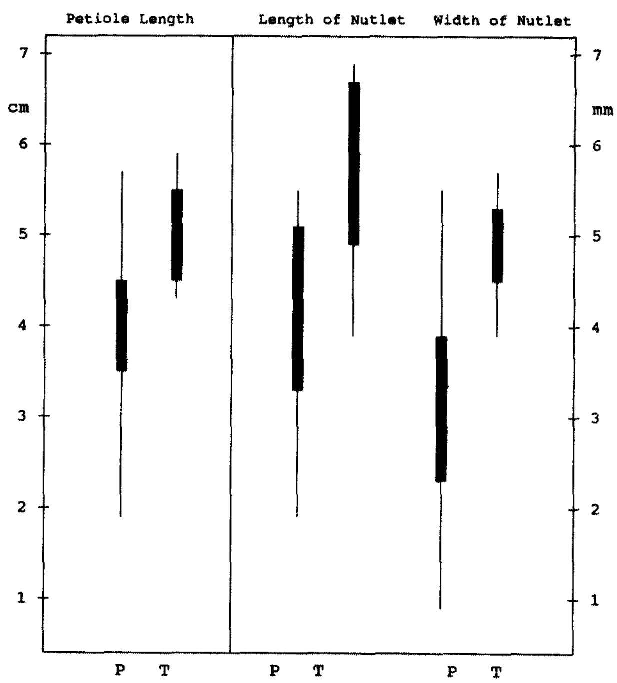

Figure 8. Morphological variation of *Acer pseudosieboldianum* (P) and *A. takesimense* (T).

quantitative characters. Without both vegetative characters and reproductive characters (flowers and fruits) for all species, it is difficult to identify with confidence some taxa of series *Palmata*. Thus, different geographical distributions (many of which seem to be absolute) in addition to these morphological characters are useful for identification.

1. Leaves with 5-7 lobes, blade (4-6) 7-8 cm wide.
  2. Petioles and peduncles pubescent at least when young.
    3. Leaves usually (5) 7 lobed, blades 5-8 cm wide; fruits with wings (1.3) 2 (2.3) cm long and nutlet (3.5) 5 mm long.
      4. Petioles of mature leaves persistently pubescent; nutlet (2.5) 3.5 (5)mm long, 2-3 mm wide; from Taiwan .... *A. duplicatoserratum* var. *duplicatoserratum* (including *A. ceriferum* see discussion in text)
      4. Petioles of mature leaves becoming glabrous with age; nutlet 4-5 mm long, 3.5-4.5 mm wide; from eastern China .... *A. duplicatoserratum* var. *chinense*
    3. Leaves usually 5 (7) lobed, blades 4-5 cm wide; fruits with wings 1.7-1.8cm long, nutlet 3 mm long.
      5. Leaves with blades 5.5 -6.5 cm wide, petioles 3.5 cm long .... *A. pubipalmatum*
      5. Leaves with blades (3.0) 3.5 cm wide, petiole 1.5 cm long .... *A. pauciflorum* (including *A. changhuaense,* see discussion in text)
  2. Petioles and peduncles glabrous or nearly so.
    6. Wing (1.3) 1.5 (2.0) cm long.
      7. Nutlets (2) 2.5 mm wide and 3 mm long; leaves 4-7 cm wide; wings 6 mm wide and (13) 14 (16) mm long; growing in valleys or creeks; from southern Korea and Japan. .... *A. palmatum* var. *palmatum*
      7. Nutlets (3) 4.3 (5.5) mm wide and (2.5) 3.4 (4.5) mm long; leaves 6-10 cm wide; wings 8 mm wide and (16) 18 (23) mm long; growing in mountain as understory trees; from Japan .... *A. palmatum* var. *amoenum*
    6. Wing 2.5-3.5 cm long.
      8. Short whitish hairs present between mid vein and branch veins, each leaf lobe ratio (lobe width/lobe length) 0.7-0.8, ovary glabrous or nearly so; from central China .... *A. robustum* (including *A. anhweiense,* see discussion in text)
      8. No hairs between mid vein and branch veins, each leaf lobe ratio (lobe width/lobe length) 0.5-0.6, ovary villous; from western North America ..... *A. circinatum*
1. Leaves with 9-13 lobes, blades (5-6) 8.5-10.5 (11.5) cm wide.
  9. Twigs and petioles of mature leaves pubescent.
    10. Flowers yellow; leaf under-surface pubescent, petioles pubescent; from Japan ... . *A. sieboldianum*
    10. Flowers purple; leaf pubescent only on veins, petioles very pubescent; from Korea,

northeast China, and southern Siberia .... *A. pseuodosieboldianum*

9. Twigs and petioles of mature leaves glabrous.
    11. Nutlets pubescent, leaves (9) 11 (14) cm wide (Japan) .... *A. japonicum*
    11. Nutlets glabrous, leaves less than 10 (11) cm wide.
        12. Leaf lobes (7) 9.
            13. Ovary pubescent .... *A. circinatum*
            13. Ovary glabrous or nearly so.
                14. Short whitish hairs pubescent between mid and branch veins; from central China .... *A. robustum*
                14. No hairs between mid and branch veins.
                    15. Wing (1.3) 1.7 cm long, growing in valleys or creeks; leaves not deeply serrate; from southern Korea .... *A. palmatum* var. *palmatum*
                    15. Wing (1.6) 2.0 (2.3) cm long; growing in mountains as understory trees; leaves very deeply serrate; from Japan .... *A. palmatum* var. *amoenum*
        12. Leaf lobes (9) 11 to 13.
            16. Leaves (6) 7.5-8.5 (9) cm wide, nutlet ca. 4.5 mm long, wing (1.7) 2.2 (2.7) cm long, petioles 5-6 cm long, leaf serration less than 2 mm long (not doubly serrate).. *A. shirasawanum*
            16. Leaves (4) 5-6 (6.5) cm wide, nutlet (3) 3.8 mm long, wing (1.5) 1.7 (2.1) cm long, petiole 3-4 cm long, leaf serration 3-4mm long (motsly doubly serrate) .... *A. tenuifolium*

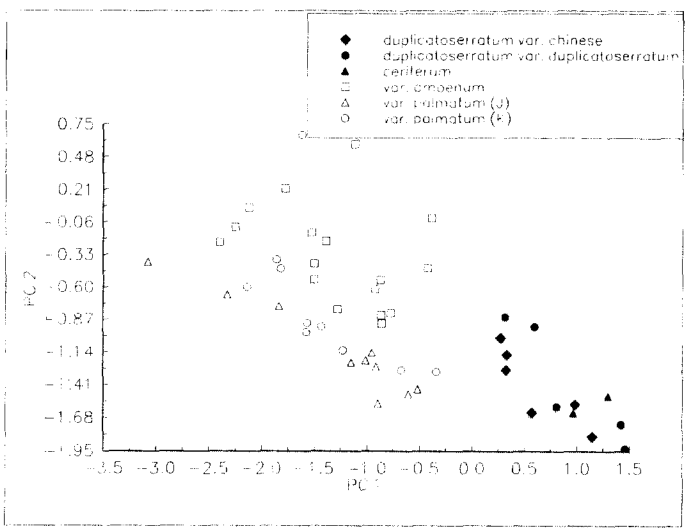

Figure 9. Principal components ordination of *Acer palmatum* complex and *A. duplicatoserratum* complex (principal component 1 vs principal component 2).

Taxonomic treatment

1) ***Acer pseudosieboldianum*** (Pax) Komarov in Trudy Glavn. Bot. Sada 22: 725 (1904). Type: China. Northeast (Manchuria) Port Bruce, *Maximowicz s.n.* 1860, NY! (lectotype, here chosen).

A. circumlobatum Max. var. *pseudosieboldianum* Pax in Bot. Jahrb. Syst. 7:199 (1886).

A. sieboldianum Miquel var. *mandshuricum* Max. in Melanges Biol. Bull. Phys.-Mat. Acad. Imp. Sci. Sait-Pétersbourg 12: 433 (1886) (Type: Not seen).

A. japonicum Thunb. ex Murray var. *nudicarpum* Nakai J. Coll. Sci. Imp. Univ. Tokyo 26: 135 (1909) (Type: *Uchiyama s.n.,* July 20, 1902 in TI!, lectotype, here chosen).

A. pseudosieboldianum var. *koreanum* Nakai in J. Coll. Sci. Imp. Univ. Tokyo 26: (1909) (Type: *T. Uchiyama s.n.* Oct. 14, 1900 in TI!, lectotype, here chosen; *T. Uchiyama s.n.* Oct. 2, 1902 in TI!, syntype).

A. okamotoi Nakai in Bot. Mag. (Tokyo) 27: 130 (1913) *nomen nudum*; Bot. Mag. (Tokyo) 29: 28 (1915) (Type: *K. Okamoto 063* in TI!, holotype).

A. pseudosieboldianum (Pax) Komarov var. *ambiguum* Nakai in Bot. Mag. (Tokyo) 27: 130 (1913) *nomen nudum*; Fl. Kor. I (1915) p 12. (Type: *Taquet 4169* in TI, holotype).

A. pseudosieboldianum var. *macrocarpum* Nakai in Bot. Mag. (Tokyo) 22: 130 (1913) *nomen nudum*; Bot. Mag. (Tokyo) 29: 27 (1915) (Type: *Ishidoya s.n.* Sep. 28, 1912 in TI!, holotype).

A. ishidoyanum Nakai in Bot. Mag. (Tokyo) 27: 130 (1913) *nomen nudum*; Bot. Mag. (Tokyo) 29: 28 (1915) (Type: *Ishidoya s.n.* June 10, 1912 in TI!, holotype).

A. nudicarpum Nakai in Bot. Mag. (Tokyo) 29: 28 (1915).

A. takesimense Nakai in Bot. Mag. (Tokyo) 32: 107 (1918) (Type: *Nakai 4418* in TI!, holotype).

A. palmatum var. *pilosum* Nakai in Bot. Mag. (Tokyo) 33: 59 (1919) (Type: *Wilson 8649* in A!, lectotype).

A. pseudosieboldianum var. *lanuginosum* Nakai in Bot. Mag. (Tokyo) 45: 127 (1931) Type: *Nakai 11769* in TI!, holotype).

A. microsieboldianum Nakai in Bot. Mag. (Tokyo) 45: 24 (1931) (Type: *Nakai 13974* in TI!, holotype).

A. pseudosieboldianum var. *nudicarpum* (Nakai) Nakai in Handb. Kor. Mandsh. For. p 164 (1939).

A. pseudosieboldianum var. *pilosum* Nakai in Handb. Kor. Mandsh. For. p 164 (1939) (Type: Not seen).

A. pseudosieboldianum var. *ishidoyanum* (Nakai) Uyeki in Woody Pl. p 70 (1940).

A. pseudosieboldianum f. *macrocarpum* (Nakai) S. L. Tung in Bull. Bot. Res. North-East. Forest Inst. 5: 103 (1985).

A. pseudosieboldianum var. *microsieboldianum* (Nakai) S. L. Tung in Bull. Bot. Res. North-East. Forest Inst. 5: 103 (1985).

Shrub. Leaves deciduous, ca. 5-11.5 cm broad, mostly cordate base, usually 9-11 lobed (rarely 7 or 13 lobes). Lower surface pubescent, especially very pubescent on the nerves of both surfaces while young. Petioles 3-5 cm long, densely pubescent while young, then slightly pubescent; Flowers andro-monoecious, purple sepals 5 and yellowish white petals 5. Ovary villous; Nutlets of fruit convex, glabrous 3-5 mm broad; wings of fruit narrow to broad (variable), widely spreading to incurved, 1.6-2.4 cm long.
Distribution: Northeast China, Southern U.S.S.R and Korea.
Representative Specimens: China: **Jilin:** *Liou 4288* (LE), *Wang 621* (PE) *Wu and Chou 1895* (LE) U.S.S.R.: **Ussuri:** *Desoulavy 956* (LE) Korea: **Kyong-sang-buk-do:** *Chang 587* (GA), *Chang 183* (GA), **Kang-won-do:** *Lee s.n.* (SNUA), *Lee and Cho 8523* (SNUA) **Chel-la-buk-do:** *Lee and Cho 6118* (SNUA) **Ryang-kang-do:** *Yim s.n.* (LE)

2) ***Acer palmatum*** Thunb. var. ***palmatum*** in Nov. Act. Soc. Sci. Upsal. 4: 36 & 40 (1783) *excl. specim. ramis florif., promajor. part.*
Type: *Thunberg s.n.* in UPS as microfiche!
Acer palmatum var. ***amoenum*** (Carr.) Ohwi Fl. Jap. 745 (1953) *Comb. nud.*; in Bull.Sci. Mus. Tokyo 33: 79 (1953). (Type: Not seen)

A. polymorphum Seibold et Zucc. in Abh. Akad. Muench. 4-2: 158 (1845). *pro parte*; non Spach 1834 (Type: collector-unknown in K! as photo, holotype).
A. polymorphum δ. septemlobum K. Koch in Hort Dendr. 80 (1853) (Type: not seen).
A. palmatum τ. septemlobum K. Koch in Ann. Mus. Bot. Lugd-Bat. 1: 251 (1864).
A. amoenum Carr. in Rev. Hort. 39: 280 (1867) (Type: not seen).
A. palmatum var. *septemlobum* Nicholson in Gard. Chron. ser.2, 16: 137 (1881).
A. palmatum var. *thunbergii* subvar. *septemlobum* f. *euseptemlobum* Schwerin in Gartenfl. 42: 678, (1893)
A. palmatum var. *thunbergii* subvar. *septemlobum* Schwerin in Gartenfl.52:678 (1893). *pro parte.*
A. palmatum subsp. *septenlobum* Koidzumi in J. Coll. Sci. Imp. Univ. Tokyo 32: 46 (1911), *excl. basonym* et *syn. nunnull*; non *A. septemlobum* Thunb. 1784. (Type: not seen).
A. palmtum subsp. *matsumurae* subvar. *elegans* Koidzumi in J. Coll. Sci. Imp. Univ. Tokyo 32: 50 (1911) (Type: not seen).
A. palmatum subsp. *septemlobum* var. *latiobatum* Koidz. in J. Coll. Sci. Imp. Univ. Tokyo 32: 47 (1911) (Type: not seen).
A. palmatum subsp. *septenlobum* var. *palmatupartinum* Koidzumi in J. Coll. Sci. Imp. Univ. Tokyo 32: 47 (1911) (Type: not seen).
A. palmatum subsp. *matsumurae* Koidz. in J. Coll. Sci. Imp. Univ. Tokyo 32:49 (1911).
A. euseptemlobum (Schwerin) Koidzumi in Bot. Mag. (Tokyo) 39: 306 (1925).
A. horonaisense Nakai in Bot. Mag. (Tokyo) 40: 584 (1926) (Type: not seen).

A. ornatum var. *matsumurae* (Koidz.) Koidz. in Bot. Mag. (Tokyo) 43: 383 (1928).
A. sanguineum var. *euseptenlobum* (Schwerin) Koidzumi in Bot. Mag. (Tokyo) 43: 382 (1929).
A. palmatum var. *latialatum* Nakai in Bot. Mag. (Tokyo) 46: 613 (1932) (Type: not seen).
A. amoenum var. *latiobatum* (Koidz.) Nakai in Bot. Mag. (Tokyo) 46: 611 (1932).
A. ornatum var. *miyajimense* Nakai in Bot. Mag. (Tokyo) 46: 613 (1932)(Type: July 8, 1913 collector-unknown, collected in Miyajima in TI!, holotype).
A. sanguineum var. *amoenum* (Carr.) Koidzumi in Act. Phytotax. Geobot. 3:148 (1934).
A. palmatum var. *matsumurae β. spontaneum* (Koidz.) Nemoto in Fl. Jap. Suppl. p 454 (1936).
A. nambuana Koidzumi in Act. Phytotax. Geobot. 6:210 (1937) (Type: not seen).
A. palmatum var. *heptalobum* Rehder in J. Arnold Arb. 19: 86 (1938).(Type:not seen).
A. palmtum var. *matsumurae* (Koidz.) Makino in III. Fl. Nippon p. 351 (1940) *comb. nud.*
A. euseptemlobum var. *palmatipartitum* (Koidz.) Koidzumi in Ishii, Engei-Jitten 1: 386 (1944). *comb. nud.*
A. matsumurae var. *elegans* Koidzumi in Ishii, Engei-Jitten 1: 386 (1944). *nom. nud.*
A. euseptemlobum var. *latiobatum* Koidzumi in Ishii, Engei-Jeten 1: 386 (1949). *comb. nud.*
A. palmatum subsp. *amoenum* (Carr.) Hara in Enum. Sperm. Jap. 3: 109 (1954).
A. palmatum subsp. *amoenum* var. *nambuanum* (Koidz.) Hara in Enum. Sperm. Jap. 3: 110 (1954).
A. amoenum var. *nambuanum* (Koidz.) Ogata in Bull. of the Tokyo University Forests. 60:25 (1965).
A. amoenum var. *matsumurae* (Koidz.) Ogata in Bull. of the Tokyo University Forests. 60:26 (1965).

Shrub. Leaves deciduous, ca. 6-10 cm broad, usually 7-9 lobed (rarely 5 or 11 lobes). Leaf margin is deeply double serrate to simply serrate, lower leaf surface glabrous. Petioles 3.0-5.5 cm long, glabrous; Flowers andro-monoecious, purple sepals 5 and petals 5. Ovary glabrous; Nutlets of fruit convex, glabrous 2.5-4.5 mm broad and 3-5 mm long; wings of fruit narrow, widely spreading (sometimes horizontally spreading) to incurved, 1.6 to 2.3 cm long.

Note: Most type specimens, are unknown (in TI or the following European herbaria: L, LE, BM, K, G, F, GOET). Most names were probably based simply on cultivated plants in gardens (not properly preserved as specimens).

Distribution: Japan (throughout from Hokkaido to Kyushu).
Representative specimens: Japan: **Hokkaido:** *Chang 788* (GA) **Akita Prefecture:** *Fujita 827* (KYO), **Aomori Prefecture:** *Chang 917* (GA), **Kyoto Prefecture:** *Murata 9480* (KYO), *Chang 1039* (GA), **Miyaki Prefecture:** *Tohoku University staff of the Botanical Garden s.n.* (KYO), **Nara Prefecture:** *Chang 1344* (GA), **Shiga prefecture:** *Chang 1013* (GA), **Yamagata Prefecture:** *Nemoto 1747* (TUS), *Kitamura and Momma s.n.* (TUS).

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摘　　要

中國 中部에서 北美西部地域까지 널리 分布하는 단풍나무屬 단풍나무節에 對한 多變量分析을 通하여 種間, 種內의 形態的 變異를 調査하였다. 각 種間의 形質變異를 알기 위해서 우선 ANOVA와 相關關係分析을 통하여 19개의 有效形質을 設定한 후 多變量分析을 實施하였다. 調査된 形質變異중 子房, 小枝, 葉柄의 털의 유무, 種子, 열매날개의 길이, 그리고 잎의 葉脈數가 種間 變異를 說明하는데 有效하였다. 또한 多變量分析을 根據로 두개의 形質分類群(단풍分類群과 당단풍分類群)으로 나눈 후 種間變異를 調査했다. 단풍분류群중 日本産 단풍과 韓國産 단풍(*Acer palmatum* var. *palmatum*)은 거의 모든 形質에 있어 日本産 왕단풍(*A. palmatum* var. *amoenum*)을 中間變異로 해서 連續分布를 보인바, Ogata의 왕단풍과 단풍의 獨立的 處理는 認定하기가 힘들었다. 한편 당단풍分類群(*A. pseudosieboldianum* complex)중 Nakai에 의해 記載된 6亞變種(서울단풍, var. *nudicarpum*; 좁은단풍, var. *koreanum*; 넓은고로실나무, var. *ambiguum*; 왕단풍, var. *macrocarpum*; 털참단풍, var. *lanuginosum*; 산단풍, var. *ishidoyanum*)과 섬단풍(*A. takesimense*)은 가장 變異가 심한 열매와 잎의 形質變異에 基準(80-90%가 種內變異)을 두었기에, 당단풍(*A. pseudosieboldianum* var. *pseudosieboldianum*)에 包含시켰다. 또한 내장단풍(*A. palmatum* var. *nakaii*)은 단풍(*A. palmatum* var. *palmatum*)에, 털단풍(*A. palmatum* var. *pilosum*)은 당단풍(*A. pseudosieboldianum* var. *pseudosieboldianum*)으로 각각 處理하였다.

Fang의 最新 新記載種 대부분은 變異가 심한 外部形質에 根據를 두어서, 中國産 단풍나무의 分類學的 種處理는 보다 正確한 形質分析을 土臺로 再檢討가 要求된다.

Literature Cited

Chang, C. S. 1989. A systematic study of genus *Acer* L., section *Palmata* Pax, series *Palmata*. Ph.D. dissertation, The University of Georgia, Athens.

________. 1990. A reconsideration of the *Acer palmatum* complex in China, Taiwan and Korea. J. Arnold Arbor. 71: 553-565.

________ and D. E. Giannasi. 1991. Foliar flavonoids of *Acer*, sect. *Palmata*, series *Palmata*. Syst. Bot. 16: 225-241.

de Jong, P. C. 1976. Flowering and sex expression in *Acer* L.: A biosystematic study. Meded. Landbouwhogeschool 76: 1-201.

Delendick, T. J. 1981. A systematic review of the Aceraceae. Ph.D. Dissertation. The City University of New York.

Fang, W. P. 1932a. Preliminary notes on Chinese Aceraceae. Contr. Biol. Lab. Chin. Assoc. Advancem. Sci., Sect. Bot. 7: 143-188.

________. 1932b. Further notes on Chinese Aceraceae. Contr. Biol. Lab. Chin. Assoc. Advancem. Sci., Sect. Bot. 8: 162-182.

________. 1939. A monograph of Chinese Aceraceae. Contr. Biol. Lab. Chin. Assoc. Advancem. Sci., Sect. Bot. 11: 1-346.

________. 1966. Revisio Taxorum Aceracearum Sinicarum. Acta. Phytotax. Sin. 2: 139-184 (in Chinese).

________. 1979. Praecursores Florae Aceraceratum Sinensium. Acta. Phytotax. Sin. 17: 60-86 (in Chinese).

________. 1981. Aceraceae. in Flora Republicae Popularis Sinicae. Vol 46. Beijing: Science Pub. Co. (in Chinese).

Kitamura, S. and G. Murata 1984. Colored Illustrations of Woody Plants of Japan. vol. 1. Osaka: Horikusha Pub. Co. (in Japanese).

Komarov, V. L. 1949. Flora of the USSR. Vol XIV. B.K. Shishkin (ed.) Izdatel'stvo Akademii Nauk SSR Moskva-Lennigrad Israel Program for Scientific Translations, Jerusalem.

Lee, T. B. 1979. Illustrated Flora of Korea. Seoul: Hyang-mun Pub. Co. (in Korean).

Li, H. L. 1952. The genus *Acer* (maples) in Formosa and the Liukiu [Ryukyu] Islands. Pacific Sci. 6: 288-294.

Momotani, Y. 1962a. Taxonomic study of the genus *Acer* with special reference to the seed proteins. II. Analysis of protein, Mem. Coll. Sci. Kyoto Imp. Univ., ser B 29: 81-102.

________. 1962b. Taxonomic study of the genus *Acer* with special reference to the seed proteins. III. System of Aceraceae. Mem. Coll. Sci. Kyoto Imp. Univ., ser B 29: 177-189.

Murray, E. A. 1970. A monograph of the Aceraceae. Ph.D. Dissertation. The Pennsylvania State University, PA.

Nakai, T. 1915. Praecursores ad floram sylvaticam Koreanam I. Bot. Mag. Tokyo 29: 25-30.

________. 1931. Notulae ad plantas Japoniae et Koreae XL. Bot. Mag. Tokyo 45: 91-137.

Norusis, M. J. 1986. SPSS/PC+ for the IBM PC/XT/AT. Chicago: SPSS INC.

Ogata, K. 1965. A dendrological study on the Japanese Aceraceae, with special reference to the geographical distribution. Bull. Tokyo Univ. Forest 60: 1-99.

________. 1967. A systematic study of the genus *Acer*. Bull. Tokyo Univ. Forest 63: 89-206.

Ohwi, J. 1984. Flora of Japan. Washington, D.C.: Smithsonian Institute.

Pax, F. 1885. Monographie der Gattung *Acer*. Bot. Jahrb. Syst. 6: 287-374.

________. 1886. Monographie der Gattung *Acer*. Bot. Jahrb. Syst. 7: 177-263.

Pojarkova, A.I. 1933. Botanico-geographical survey of the maples in connection with the history of the whole genus *Acer* L. Acta. Inst. Bot. Acad. U.S.S.R., ser 1, 1: 225-374 (in Russian with Englush summary).

Rehder, A. 1911. Aceraceae. pp. 83-98 in C.S. Sargent (ed.) Plantae Wilsonianae. vol. 1. Cambridge: Harvard University Press.

SAS Institute Inc. 1988. SAS/STAT guide for personal computers, ver. 6. SAS institute Inc., Cary, North Carolina.

Sneath, P.H.A. and R.P. Sokal. 1973. Numerical Taxonomy. San Francisco: W.H. Freeman.

Tanai, T. 1978. Taxonomical reinvestigation of the genus *Acer* L., based on vein architecture of leaves. J. Jap. Bot. 53: 65-83 (in Japanese).

Vertrees, J. D. 1978. Japanese maples. Forest Grove, Oregon: Timber Press.

Appendix I. Vouchers for numerical analyses of morphology (Vouchers are at GA or as otherwise indicated).

Acer sieboldianum Miquel

Japan **Miyagi prefecture:** *Chang 968* **Shiga prefecture:** *Chang 1019*, **Kyoto Prefecture** *Chang 1020, Chang 1055* **Fukuoka Prefecture:** *Chang 1185* **Tochigi Prefecture:** *Chang 1414, Chang 1416* **Iwate Prefecture:** *Chang 1464* **Niigata Prefeture:** *Togashi and Yamazaki 10005* (TUS) **Miyazaki Prefecture:** *Ohashi et al. 21805* (TUS).

Acer japonicum Thunb. ex Murray.

Japan **Hokkaido:** *Chang 786, Chang 793* **Aomori Prefecture:** *Chang 919, Chang 930, Chang 892, Chang 916* **Tochigi Prefecture:** *Chang 659*, **Shiga Prefecture:** *Chang 1061*, **Miyagi Prefecture:** *Chang 969* **Kyoto Prefecture:** *Chang 1024.*

Acer tenuifolium (Koidz.) Koidz.

Japan **Kyoto Prefecture:** *Chang 1026* **Yamanashi Prefecture:** *Chang 1390, Chang 1391* **Ehime Prefecture:** *Takahashi and Fujita 261* (KYO), *Murata et al. 162* (KYO) **Gifu Prefecture:** *Murata 10652* (KYO) **Shiga Prefecture:** *Koyama 0451* (KYO) **Hyogo Prefecture:** *Iwastuki 6100* (KYO) **Gunma Prefecture:** *Koidzumi s.n.* (KYO) **Gifu Prefecture:** *Takahashi 1939* (KYO).

Acer shirasawanum Koidz.

Japan **Nara Prefecture:** *Makino 238598* (MAK) **Yamanashi Prefecture:** *Makino 235691* (MAK), *Makino 172954* (MAK), *Noshiro 2763* (TUS) **Wakayama Prefecture:** *Makino 235692* (MAK) **Shiga Prefecture:** *Chang 1012* **Tochigi Prefecture:** *Makino 133062* (MAK), *Kubo 205* (TUI) **Nagano Prefecture:** *Makino 24632* (MAK) **Tottori Prefecture:** *Makino 172962* (MAK).

Acer palmatum Thunb.

Korea **Cheol-la-nam-do Province:** *Chang 1161, Chang 1162, Chang 1171* **Cheol-la-buk-do Province:** *Chang 1153, Chang 1143, Chang 1145, Chang 397, Chang 405* **Che-chu-do Province:** *Chang 622, Chang 651*

Japan **Gunma prefecture:** *Chang 713* **Fukuoka Prefecture:** *Chang 1182, Chang 1184* **Shiga Prefecture:** *Chang 1016, Chang 1018* **Oita Prefecture:** *Chang 1258, Chang 1264* **Tokushima Prefecture:** *Chang 1293, Chang 1323* **Hiroshima Prefecture:** *Chang 1292.*

(as *A. amoenum* var. *matsumurae)*

Ishikawa Prefecture: *Chang 1090, Chang 1077, Chang 1068, Chang 1059, Chang 1100, Chang 1099.*

Acer palmatum var. *amoenum* (Carr.) Ohwi

Japan **Hokkaido:** *Chang 783, Chang 788, Chang 790*, **Gunma Prefecture:** *Chang 749* **Aomori Prefecture:** *Chang 917, Chang 918* **Miyagi Prefecture:** *Chang 1001* **Shiga prefecture:** *Chang 1013* **Kyoto Prefecture:** *Chang 1039*, **Nara Prefecture:**

Chang 1344.

Acer pseudosieboldianum (Pax) Komarov

Korea **Seoul City** *Chang 069, Chang 078,* **Kyong-sang-buk-do Province:** *Chang 293, Chang 297* **Kyong-sang-nam-do Province:** *Chang 309, Chang 333, Chang 349* **Chel-la-buk-do Province** *Chang 409, Chang 526, Chang 559.*

(as *A. takesimense* Nakai)

Korea **Kyong-sang-buk-do Province:** *Chang 183, Chang 182, Chang 097, Chang 094, Chang 129, Chang 105,Chang 119, Chang 159, Chang 077, Lee s.n.* (SNU).

Acer duplicatoserratum Hayata var. *duplicatoserratum*

Taiwan **Nantow Hsien:** *Chang 1376, Chang 1374* **Hualien Hsien:** *Huang 166* (TUS), *Tashiro s.n.* (KYO) **Taichung Hsien:** *Ohwi s.n.* (KYO).

Acer duplicatoserratum var. *chinense* C. S. Chang

China **Jiangxi Province** *Wilson 1504* (A), *Hu 2414* (NAS), *Ip 1784* (A) **Zhejiang Province:** *Chiao 14317* (US), **Anhui Province:** *Ching 3243* (A), *Liou and Tsuong 2931* (PE).

Acer robustum Pax

China: **Hupeh Province:** *Wilson 1920* (US), *Wilson 339* (US), *Sino American Exped. 1359* (NA), *Chun 4158* (A), *Fang 679* (PE), *Liu 1103* (A), *Hu 334* (A), *Wilson 2050* (US), **Yunnan Province:** *Rock 9406* (A) **Honan Province:** *Ga 122* (NAS)

Acer circinatum Pursh

U.S.A.: **California:** Siskiyou Co.: *W.B.C. 15309* (OSC), Del Norte Co.: *Mastriquiseppe 145* (WS), Humbolt Co.: Tr*acy 18424* (WTU), **Washington** Skamania Co.: *Chang 1129* **Oregon** Polk Co. / Lincoln Co.: *Chang 1102, Chang 1104,* Linn Co.: *Chang 1135, Chang 1123, Chang 1117, Chang 1114*

Acer ceriferum Rehder

China **Hupeh Province:** *Wilson 1934* (A)

Acer pubipalmatum Fang

China **Zejiang Province:** *Chen 493* (PE), *GA 24286* (PE), *Song 674* (NAS)

Acer pauciflorum Fang

China **Zejiang Province:** *Ching 1790* (A)

Acer changhuaense (Fang et Fang f.) Fang et P.L. Chiu

China **Zejiang Province:** *Ga 22988* (PE), *Fang 22986* (PE)