

A Systematic Study of the Genus *Acer**

Ken OGATA**

CONTENTS

Introduction	89	8. Wood	104
Historical survey	89	a) Ray	
Purpose of the investigation and the taxonomic system proposed here	92	b) Crystal	
Acknowledgements	93	c) Starch-storing fiber (add.) Latex	
Part 1. General remarks	94	Part 2. The taxonomic system of the Genus <i>Acer</i>	109
1. Bud	94	Part 3. The phylogenetic relation among the sections of the Genus <i>Acer</i>	157
2. Inflorescence.....	95	Literatures	161
3. Sexuality	97	摘 要.....	163
4. Flower	99	Appendices	167
5. Fruit	101	Plates	179
6. Embryo	102		
7. Leaf.....	103		

Introduction

Historical survey

The systematic study of Gen. *Acer* was founded by Pax who published "Monographie der Gattung *Acer*" in 1885 to 1886. His work of 1885 ("Allgemeiner Teil") covered a wide area from the general morphology to the taxonomical system, the geographical distribution, the matters of fossils, and the phylogenetic consideration. He remarked many taxonomical characters, most of which are still considered as important, and divided the genus into 4 large groups¹⁾ and 14 sections cited below.

The system of Pax (1885)

I Extrastaminalia

- Sect. 1) Rubra Pax
- 2) Spicata Pax
- 3) Palmata Pax
- 4) Trifoliata Pax
- 5) Integrifolia Pax

II Adiscantha

- Sect. 6) Negundo (Boehm.) Maxim.

III Intrastaminalia

- Sect. 7) Indivisa Pax

IV Perigyna

- Sect. 8) Glabra Pax

* The doctoral thesis submitted to the University of Tokyo Graduate School.

** Present address: Laboratory of Wood Anatomy, Division of Wood Technology, Government Forest Experiment Station.

- 9) *Campestris* Pax
- 10) *Platanoidea* Pax
- 11) *Saccharina* Pax
- 12) *Macrantha* Pax
- 13) *Lithocarpa* Pax
- 14) *Coelocarpa* Pax

In the work of 1886 ("Spezieller Teil"), he arranged 81 species with descriptions into the 14 sections, and furthermore, in 1902, 114 species in all into the 13 sections, in which Sect. *Coelocarpa* was joined into Sect. *Trifoliata*.

The species of Gen. *Acer* show very variable characters externally. Therefore, before Pax, dividing Gen. *Acer* into some groups had been also carried out. Especially, *A. negundo* was often considered to form a genus, Gen. *Negundo*, independent of Gen. *Acer* (Boehmer, 1760; De Candolle, 1824; Endlicher, 1836-1840; Bentham & Hooker, 1862). Rafinesque (1809) separated also *A. negundo* from Gen. *Acer*, as Gen. *Negundium*, while he (1869) classified the remaining part of Gen. *Acer* based on the species native to North America into 6 subgenera. Koch (1869) put 23 species of Gen. *Acer* including *A. negundo* under 4 groups. Maximowicz (1880) placed 2 sections in Gen. *Acer*, Sect. *Acer* and *Negundo*, in the study of 29 Asiatic species of the genus, into the latter section of which the species having 3-foliate leaves, such as *A. nikoense*, were distributed.

Though the merit of Pax who made for the first time a thorough study on Gen. *Acer* and laid a foundation for the later studies on the genus should be highly estimated, his system itself, in other words, the arrangement of the species into the sections, was very imperfect and required inevitably much modification, which was done mainly by Rehder (1950; 1911; 1927; 1949), Koidzumi (1911a), Pojarkova (1933) and Momotani (1962b).

Rehder, in 1905, added a new section, Sect. *Arguta*, to the 13 sections in the Pax's system, and from 1905 to 1927, revised a part of Pax's system, especially Sect. *Macrantha*, *Lithocarpa* and *Indivisa*. In 1949, he reduced all the sections but for Sect. *Negundo* to the rank of series and placed them under Sect. *Acer* (cf. App. 1).

In the study of Japanese species of Gen. *Acer*, Koidzumi (1911a) established 5 new sections, Sect. *Parviflora*, *Carpinifolia*, *Palmatoidea*, *Cissifolia*, and *Diabolica*, and divided the whole genus into 2 large groups and 19 sections (cf. App. 1). In the same year, he (1911b) made general remarks on the genus and referred to the phylogenetic relations among sections (cf. App. 2). Both Rehder's and Koidzumi's systems can be regarded essentially as following Pax's one.

Pojarkova (1933) criticized severely Pax's system and conception. According to her, Gen. *Acer* is divided into 32 series arranged in 17 sections, of which 4 are new sections (cf. App. 1). There is no doubt that Pax's or Rehder's system was much revised, especially in their Sect. *Campestris* and *Spicata*, by Pojarkova. She took also an excellent view on the problem of the phylogenetic history of Gen. *Acer*. She regarded each series as a unit in the phylogenetic history of the genus and considered that the history of the development of the whole genus can be comprehended by tracing back

the history of the development and migration of the series, and that "the first question to be solved (for it) is the question as to the primary centre of development of the genus, the location of this primary centre where the present diversity of maples has originated, and which has been the starting point of their migration". And, she came to a conclusion, "the centre of the primary development of the genus *Acer* must be sought in Eastern Asia", contrary to Pax (1885; 1893) who thought the boreal origin of the genus.

In the investigation of the seed proteins of Gen. *Acer* by means of the turbidometric titration, Momotani (1962a) found that the affinity of protein components shows the taxonomic affinity among the species, and indicated diagrammatically the degree of the affinity (cf. App. 2). On the basis of the protein affinity, he criticized Rehder's system, particularly Rehder's Sect. *Campestris* and *Spicata*, and then (1962b) proposed a system in which Gen. *Acer* was divided into 3 subgenera, Subgen. *Acer*, *Negundo* and *Carpini-folia*, and subdivided them into some sections and series (cf. App. 1). Momotani's system may be regarded as a modified one of Pojarkova's system. I agree with him in that he transferred Ser. *Sinensia* and Ser. *Trifida*²⁾ respectively from Sect. *Spicata* and *Trilobata* in Pojarkova's system to Sect. *Palmata* and Sect. *Integrifolia*, but I can not agree in some points later explained in the description of each section. Momotani's method is certainly very interesting as showing a new approach to taxonomy. But I regret, in this case, that some species whose correct positions are considered not enough to be solved morphologically were not examined by him³⁾, and therefore his study, in a sense, resulted only in indicating the presence of relation between the affinity of seed proteins and that of morphological characters among the species of Gen. *Acer*.

There are some other important investigations concerning the taxonomy of Gen. *Acer*. Warsow (1903) made a detailed comparative anatomical study on the leaves of 110 species included in Pax's 13 sections. In Schneider's Handbuch (1907), the leaves, flowers and fruits of many species were illustrated. His arrangement of species into sections almost followed Pax (1902) and Rehder (1905). Almstedt (1933) suggested a phylogenetic series on the inflorescences of 9 American species (cf. Inflorescence). Watari (1936) published a very detailed account of the petiole structure in 42 species of Gen. *Acer* from Japan and Formosa. Fang (1939) described, in his "A monograph of Chinese *Aceraceae*", the characters and distribution of 88 species of Gen. *Acer*. But, not only his observation is very superficial, but also his identification itself is often unreliable⁴⁾. And besides, he showed no originality in the arrangement of species into the sections, only following Rehder (1927) even in the order of the sections. It is useful, however, that this monograph includes the republications of the original descriptions of many species over 90 pages in the appendix. Hall (1951; 1954; 1961) made a comparative study of the floral anatomy on 11 species of Gen. *Acer* and 1 species of Gen. *Dipteronia*, and questioned the necessity of maintaining Gen. *Dipteronia* as a distinct genus. Yamuchi (1962) investigated the wood anatomical characters of 21 Japanese species of Gen. *Acer*. It may be permitted to add here my study (1965) mainly on the distribution of the Japanese species and varieties of the genus.

The separation of Gen. *Negundo* from Gen. *Acer* was insisted upon especially by Nieuwland (1911) and Plowman (1915), and it was also supported by Hall (1954) on the viewpoints of the floral anatomy. Small (1933) proposed the division of Gen. *Acer* into 5 genera⁵⁾ on the basis of the American species. But these conceptions have not generally been accepted.

Note: 1) These groups were not employed by Pax himself after that time.

2) But, I do not distinguish Ser. *Trifida* in Sect. *Integrifolia*.

3) For instance, *A. cissifolium*, *A. saccharinum*, *A. pubescens*, *A. sinense*, *A. laevigatum*, *A. monspessulanum*, *A. saccharum*, *A. syriacum*, *A. macrophyllum*, *A. laurinum*, *A. decandrum* and so on.

4) For instance, Fang mentioned some localities in China on *A. japonicum*, *A. nikoense* and *A. rufinerve*, but these species are all considered to be endemic to Japan.

5) *Acer*, *Saccharodendron*, *Argentacer*, *Rufacer* and *Negundo*.

Purpose of the investigation and the taxonomic system proposed here

As above mentioned, the taxonomic system of Gen. *Acer* has been studied by many authors, but, after Pax, the comprehensive study of the exomorphic characters of the genus was not made. Momotani (1961) attempted it but his observation was rather fragmental as a whole. Under the reexamination of the exomorphic characters and furthermore the investigation of wood anatomical characters, I intended to revise the taxonomic system of Gen. *Acer*. Thus, the present work consists of three parts: the first treats the general remarks of the characters which I consider as important phylogenetically, the second deals with the problem of the taxonomic system and the third is devoted to the discussion of the phylogenetic relation among sections.

I propose here the following system:

Gen. *Acer*

Sect. *Macrantha* Pax

Ser. *Macrantha*

Ser. *Rufinervia* (Momotani) Ogata

Ser. *Micrantha* Pojark.

Sect. *Distyla* Ogata

Sect. *Parviflora* Koidz.

Sect. *Spicata* Pax

Sect. *Palmata* Pax

Ser. *Sinensia* (Pojark.) Ogata

Ser. *Palmata*

Ser. *Laevigata* Ogata

Sect. *Glabra* Pax

Sect. *Arguta* Rehd.

Sect. *Negundo* (Boehm.) Maxim.

Sect. *Cissifolia* Koidz.

Sect. *Trilobata* Pojark.

Sect. *Rubra* Pax

Ser. *Rubra*

Ser. *Eriocarpa* (Raf.) Ogata

Sect. *Platanoidea* Pax

Sect. *Campestris* Pax

Sect. Pubescentia (Pojark.) Ogata
 Sect. Acer
 Ser. Acer
 Ser. Velutina (Pojark.) Ogata
 Sect. Goniocarpa Pojark.
 Ser. Opulifolia Pojark.
 Ser. Monspessulana Pojark.
 Sect. Saccharina Pax
 Sect. Integrifolia Pax
 Sect. Syriaca Ogata
 Sect. Trifoliata Pax
 Sect. Lithocarpa Pax
 Sect. Macrophylla (Pojark.) Ogata
 Sect. Laurina Ogata
 Sect. Decandra Ogata
 Sect. Indivisa Pax
 ?Sect. Pentaphylla Hu et Cheng

On the assignment of species to each section, refer to Appendix.

Acknowledgements

I wish to express my heartfelt thanks to Emeritus Professor Taizô Inokuma for his helpful guidance and encouragement throughout the course of this study. I deeply indebted to Professor Satoru Kurata who gave me continuously valuable advices and looked carefully over the manuscript. My sincere thanks are also due to Associate Professor Ken Shimaji who instructed me kindly in the wood anatomy.

I am much obliged to the following persons for their kindness in presenting very useful materials: Dr. Kenton L. Chambers, Oregon State University, Corvallis Ore., U.S.A.; Dr. Vladimir Necesný, Forest Products Research Institute, Lamacská, Bratislava, Czechoslovakia; Dr. Zvonimir Spoljaric, Department of Forestry, University of Zagreb, Maksimir, Yugoslavia; Dr. Abraham Fahn, Department of Botany, Hebrew University, Jerusalem, Israel; Mr. Roy M. Nordine, The Morton Arboretum, Lisle, Ill., U.S.A.; Dr. William L. Stern, Department of Botany, Smithsonian Institution, U.S. National Museum, Washington, D.C., U.S.A.; Dr. Toshio Hamaya, University Forest in Hokkaido, University of Tokyo, Japan; Dr. Hiroshi Hara, Dr. Shunji Watari and Dr. Takashi Yamazaki, Botanical Institute, Faculty of Science, University of Tokyo.

I am grateful to the curators of the following herbaria who gave me facilities for examining specimens:

Botanical Institute, Faculty of Science, Kyoto University, Kyoto, Japan.

Botanical Institute, Faculty of Science, University of Tokyo, Tokyo, Japan.

Institute of Forest Botany, Faculty of Agriculture, University of Tokyo, Tokyo Japan.

Finally, I should not miss to express my cordial thankfulness to Mr. Osamu Sato, the Director of University Forest in Chichibu, University of Tokyo, Saitama, Japan who provided every convenience for my material collections.

Part 1. General remarks

1. Bud

In Gen. *Acer*, buds are regularly developed in the axils of each pair of leaves¹⁾. In the apex of twigs, a terminal bud, besides two lateral buds, is usually formed (Plate 1 & 2). Flower buds can not be distinguished externally from leaf buds.

To each section of the genus, buds take characteristic features. In the buds with 2 pairs of scales, the inner pair is covered completely by the outer one (Plate 1, A~C). In the buds with many pairs of scales, the scales are generally imbricate (Plate 2, D). In Sect. *Macrantha* and *Glabra*, the buds are often stalked. The buds of Sect. *Cissifolia* are usually enclosed by the base of the petiole. In Sect. *Palmata* and *Indivisa*, the terminal buds are often wanting (Plate 2, A).

The number of bud-scales is very important for the classification of sections. Momotani (1961: 456) divided it into the following three types: 1) generally 2-paired but rarely 3-paired; 2) mainly 4-paired; and 3) many-paired. But this division is too rough. The five types on the number of bud-scales may be considered, for convenience, on the basis of well-developed terminal buds. The species of the sections included in the Type A (Table 1) have constantly 2 pairs of bud-scales. In the sections of the other types, the number of bud-scales is somewhat fluctuant within a species according to the degree of the development of the buds, as the number shown in the parenthesis (Table 1).

Table 1. The types on the number of bud-scales.

Type	Bud-scales	Sections
Type A	Always 2-paired	Macrantha, Distyla, Parviflora, Arguta, Cissifolia
Type B	ca. 3-paired	Spicata (2-3), Negundo (3)
Type C	ca. 4-paired	Palmata (4), Glabra (2-4)
Type D	ca. 5-8-paired	Rubra (5-7), Platanoidea (5-8), Campestria (5-8), Pubescentia (5-8), Acer (5-8), Goniocarpa (5-8), Saccharina (5-8)
Type E	ca. 10-paired	Trilobata (7-10), Integrifolia (9-13), Syriaca (9-13), Trifoliata (11-15), Lithocarpa (8-12), Macrophylla (8-10), Laurina (7-11), Decandra (ca. 9), Indivisa (9-13)

Under consideration of other characteristics, the following principles may be considered on the phylogenetic relation among sections: 1) the sections in a near relationship are similar in the number of bud-scales; but 2) the sections being similar in it, in other words, those included in the same type, are not always related closely to one another; 3) the sections being largely different in the number of bud-scales are generally in remote relationships to one another.

Note: 1) In *A. (Sect. Trifoliata) nikoense*, accessory buds are sometimes developed. They are arranged collaterally at the base of the terminal and lateral buds. In a male tree of the species planted in the Botanical Garden of the University of Tokyo, I found a twig which had 10 buds at the apex (Fig. 1). The terminal bud A and one of the lateral buds C were flower buds and the other buds were all leaf buds. The accessory buds except D,

that is, E and F, G and H, and I and J, were placed inside a pair of the outermost scales respectively of A, B and C. The number of the bud-scales of each bud was as shown in the following table.

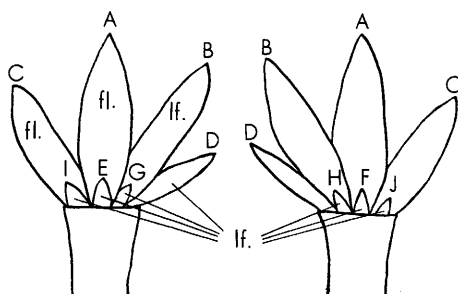


Fig. 1-a

Fig. 1-b

Fig. 1-a. fl.: flower bud, lf.: leaf bud.

Fig. 1-b. The opposite side of Fig. 1-a.

Table 2. The buds found in the apex of a twig of *A. nikoense*.

Bud	The number of bud-scales (pairs)
A	15
B	14
C	12
D	8
E	10
F	10
G	7
H	7
I	5
J	5

These accessory buds are often functional, and there are sometimes found in the trees of this species several twigs being out together from a place.

2. Inflorescence

For the discussion of the inflorescence type of Gen. *Acer*, the position, the number of leaves accompanied and the manner of ramification should be considered. On the basis of these respects, the inflorescences are divided into the following types:

A) by the position

- a) inflorescence appearing from terminal and lateral buds of the previous year (T)
- b) inflorescence appearing only from lateral buds of the previous year (L)

B) by the number of leaves accompanied

- a) inflorescence accompanied with 2-3 pairs of leaves (2-3)
- b) inflorescence accompanied with 1 pair of leaves (1)
- c) inflorescence not accompanied with leaves (0)

C) by the manner of ramification

- a) inflorescence compound (C)
- b) inflorescence simple
 - 1) stalked (raceme) (SR)
 - 2) not stalked (umbellate) (SU).

The inflorescence types of Gen. *Acer* can be expressed by the combination of each type in A), B) and C) mentioned above, and they are considerably characteristic according to the sections as shown in Table 3. Here T(2-3)C type, for instance, means one in which the inflorescence is compound and appears from terminal and lateral buds accompanied with 2-3 pairs of leaves.

The inflorescence of Sect. *Palmata* is T(2-3)C type or T(1)C type according to series. The inflorescence of Sect. *Trifoliata* is usually simple but sometimes compound, and accompanied usually with 1 pair of leaves but sometimes with 2-3 pairs of leaves. The female inflorescence of Sect. *Arguta* is always accompanied with a pair of leaves,

Table 3. The arrangement of sections according to the inflorescence type.

	Terminal and lateral with 2-3 pairs of leaves T(2-3)	Terminal and lateral with 1 pair of leaves T(1)	Terminal and lateral without leaves T(0)	Lateral with 2-3 pairs of leaves L(2-3)	Lateral with 1 pair of leaves L(1)	Lateral without leaves L(0)
Compound (C)	Parviflora Spicata Palmata (Ser. Sinensia & Ser. Laevigata) Trilobata Platanoidea Campestris Pubescentia Acer Goniocarpa Saccharina Integrifolia Syriaca Macrophylla	Distyla Palmata (Ser. Palmata) Glabra ?Pentaphylla			Negundo (♂)	Laurina
Simple (SR) (raceme)	Trifoliata	Macrantha Indivisa			Arguta (♀) Negundo (♀) Cissifolia	Lithocarpa Arguta (♂) Decandra
Simple (SU) (umbellate)						Rubra

but male one usually with no leaves. The inflorescence, especially the female one, of Sect. *Negundo* and *Cissifolia* is sometimes accompanied with a pair of (usually poor) leaves. The inflorescence of Sect. *Lithocarpa* is usually simple but sometimes compound at the basal parts.

The shape of inflorescence is very variable, but in most cases it is very characteristic of each section. For instance, Sect. *Platanoidea* is characterized by the loose-flowered broad panicle and Sect. *Macrantha* by the elongated raceme. On the other hand, in Sect. *Palmata* there are found various shapes from spike-like panicles to loose- or dense-flowered elongated panicles and corymboso-panicles. In the androdioecious and dioecious species, the male and female inflorescences are often different from each other in the shape and it is especially remarkable in Sect. *Negundo* and *Arguta*.

It must be noticed that Table 3 does not directly show any phylogenetic relation among sections. In other words, the sections having the same inflorescence type in this table are not always in a near relationship. The case is often rather reverse. For instance, Sect. *Macrophylla*, *Laurina*, *Lithocarpa* and *Decandra* which are supposed to be closely related to one another have respectively more or less different inflorescence types. In this respect, Pax (1902), Rehder (1949) and some other authors are considered

to be possessed with the superficial appearance of inflorescences. For instance, Rehder's Sect. *Spicata* includes the species which are here arranged in Sect. *Parviflora*, *Spicata*, *Trilobata*, *Palmata* Ser. *Sinensia*, *Acer* and *Macrophylla*, and his Sect. *Campestris* includes the species composing here Sect. *Campestris*, *Pubescentia*, *Goniocarpa* and *Syriaca*. Though his Sect. *Spicata* and *Campestris* are roughly characterized respectively by elongated or dense-flowered panicles and loose-flowered panicles, of T(2-3)C type, they should be divided into the sections mentioned above which are independent of one another phylogenetically, judging from other important characters.

On the study of the inflorescence type, Almstedt (1933) thought of the following phylogenetic series from the primitive to the advanced: 1) loose-flowered elongated panicles of *A. pseudoplatanus*—most primitive; 2) spike-like dense-flowered elongated panicles of *A. spicatum*—derived from the foregoing panicles by the reduction of the axis and flowers of the lateral branches; 3) racemes of *A. pennsylvanicum*—resulting from the further reduction in number of flowers and a shifting down of the pedicels of the preceding type; 4) not stalked umbels of *A. rubrum* and *A. saccharinum*—formed by the reduction of the main axis of the raceme. Hall (1951) supported her view on the basis of the floral anatomy. In my conception, however, these species characterized by the four inflorescence types are related very remotely to one another, each having the individual phylogenetic history, and it is impossible to explain the inflorescence types of these species in a single phylogenetic series.

It may be said, in some cases, that the following evolutionary trend of the inflorescence type has proceeded: 1) from leafy inflorescences to leafless ones; 2) from terminal inflorescences to lateral ones; 3) compound inflorescences to simple ones. This trend is considered to be usually accompanied with the reduction of the number of some flower-elements. The existing sections of lateral inflorescence type, that is, Sect. *Arguta*, *Negundo*, *Cissifolia*, *Rubra*, *Lithocarpa*, *Laurina* and *Decandra* may be thought to result from some different ancestors with leafy, terminal and compound inflorescence types. But it is wrong to consider these ancestors in connection with the existing sections of T(2-3) or T(1) type and also to apply such a trend to the whole genus *Acer*.

Bract and bracteole: The bracts and bracteoles of Gen. *Acer* are caducous, minute and inconspicuous, scales or sometimes tufts of hairs found at the base of pedicels, usually about 1-3 mm long and 1-2 mm wide, attaining at most 10 mm long and 3 mm wide, and often wanting in the upper part of inflorescences. The degree of their development seems to be somewhat different according to species, but it differs considerably also according to individuals, so that it is not regarded as a constant and reliable character taxonomically. Of all Gen. *Acer*, bracts and bracteoles are worst developed in the species of Sect. *Macrantha*, often almost completely lacking.

3. Sexuality

It can be said that no detailed explanation has been made on the sexuality of Gen. *Acer*, except for that I referred to it in a few places of the previous paper (1965). Most

authors described it only to be andropolygamous, andromonoecious, androdioecious or dioecious according to species (Pax; Koidzumi; Rehder; Pojarkova; Momotani).

The sexuality of Gen. *Acer* is represented by the three types of andromonoecism (or andropolygamy), androdioecism and dioecism.

A) Andromonoecism: The condition in which male and hermaphrodite flowers are produced on the same tree (on the same inflorescence in the case of Gen. *Acer*). In the case of Gen. *Acer* hermaphrodite flowers are considered to be functionally female, because the filaments are always very short in comparison with those of male flowers and the anthers seem usually not to be dehiscent. On the other hand, the male flowers have always very small but distinct vestiges of pistils. Throughout the species of this sexuality, there are often found trees or herbarium specimens whose inflorescences bear only male flowers (but never found ones whose inflorescences are of only hermaphrodite flowers). Therefore, in the species of the present sexuality type, there are apparently two kinds of trees on the sexuality, that is, male one and bisexual one, and such a sexuality type might be called andropolygamy instead of andromonoecism. But, this condition seems to arise not from that male trees exist quite separately from bisexual trees but from that a tree being bisexual and producing fruits in a year is completely sterile, bearing only male flowers, in another year, though there may be some tendency of sterility or fertility according to individuals. I observed such a case in a tree of *A. mono*. Thus, I consider the type of this sexuality as essentially andromonoecism. The bisexual trees can be generally reproduced by self-fertilization¹⁾.

B) Androdioecism: The condition in which male and hermaphrodite flowers are produced on different trees. As in the case of andromonoecism, hermaphrodite flowers are also female functionally and male flowers have small but fairly distinct vestiges of pistils. In Sect. *Macrantha*, which is characterized by this sexuality, andromonoecious condition is occasionally found.

C) Dioecism: This condition means here that male and female flowers which are produced on different trees have respectively no vestiges of pistils and no stamens.

These three types of the sexuality are closely connected with the inflorescence types. The sections of the T(2-3)C inflorescence type in Table 3 are exclusively characterized by andromonoecism, while those of the T(1)RS type and the lateral inflorescence types, by androdioecism or dioecism. The dioecious condition is not sharply isolated from the androdioecious condition. The degree of reduction of the abortive pistils in male flowers and the stamens in female flowers is different according to sections. It is shown in Table 4. In Sect. *Lithocarpa*, stamens are wanting in female flowers and abortive pistils in male flowers are very much reduced usually to a small tuft of hairs, so that the section may be said to be dioecious. On the other hand, Hall (1954) observed occasional occurrences of some stamens in the female flowers of *A. (Sect. Negundo) negundo*.

As previously mentioned, however, these sections can never be arranged on the line of a single phylogenetic series of reduction on the structure of flowers. Each section has an individual phylogenetic history.

Table 4. The sexuality of Gen. *Acer*.

Sexuality	Sections (Inflorescence type)	Abortive pistils in male flowers	Stamens in female flowers
Andromonoecious	All of T(2-3)C and T(1)C types	Small but distinct	As many as stamens of male flowers, but filaments very short
Androdioecious	Trifoliata (T(1)C-SR)	Very small	
	Macrantha (T(1)SR)	Small but fairly distinct	
	Indivisa (T(1)SR)	Wanting	
	Rubra (L(0)SU)	Very small	
	Arguta { ♂ (L(0)SR) ♀ (L(1)SR)		Much reduced in size and number
	Laurina (L(0)C)		Not much reduced
	Decandra (L(0)SR)		?
		Lithocarpa (L(0)SR)	Nearly wanting
Dioecious	Negundo { ♂ (L(0-1)C) ♀ (L(0-1)SR)	Wanting	
Cissifolia (L(0-1)SR)			

Note: 1) A tree of European species *A. campestre* is planted in the Botanical Garden of the University of Tokyo, Tokyo, Japan. From the seeds produced by self-fertilization of the tree, some young trees are growing.

4. Flower

Pax (1885: 304) suggested that the existing species of Gen. *Acer* derived, usually by the reduction or sometimes by the unusual increase of the number of some flower-elements, from the ancestors having pentamerous flowers in all whorls represented by the formula $K_5C_5A_{5+5}G_5$. This conception seems to have been almost uncritically accepted by many authors (e.g. Koidzumi, 1911b: 49). The sepals and petals are certainly pentamerous in most of the existing species, but there is no clear evidence that the stamens were diplostemonous and the pistils were 5-carpellate. Hall (1951) agreed to this theory on the ground of the floral anatomy, but the ground seems very uncertain to me¹⁾. He himself said, "In 8 of the *Acer* species studied here, the stamen traces all arise from the stele at the same level and in what appears to be a single whorl", and concluded, "Any difference in level of the 2 whorls that may have existed in ancestral forms have been lost in phylogeny concurrent with compression of the floral axis". As one of the evidences to support this theory, he referred to the frequent occurrences of 3-, 4- or "even" 5-carpellate pistils. But, such pistils, especially the last one, are found only very rarely and may be regarded as accidental, when taking it into consideration that even a 8-carpellate pistil was reported in *A. pseudoplatanus* (Bouché, 1879, quoted from Pax, 1885: 310).

In Sect. *Cissifolia* and *Arguta*, the flowers are usually tetramerous in the sepals, petals and stamens, and the stamens are regularly antisepalous (Plate 6, A & D). In the

latter section, there are sometimes found flowers having 5 or 6 stamens, and in this case, the fifth and sixth stamens do not always take antipetalous position (Plate 6, B). As compared with these two sections which have tetramerous flowers usually arranged in good order, in some other sections, for instance, Sect. *Rubra* and *Indivisa*, some whorls show remarkable fluctuation in the number. Especially the petals in male flowers are often much reduced also in the size. Therefore, it can be said that the manner of reduction, if the species of Gen. *Acer* derived from the ancestors which had pentamerous flowers, is quite different at least between the flowers of the former two sections and those of the latter two sections. Such difference is found also among other sections.

What I should like to say here is that the existing species, or rather existing sections, of Gen. *Acer* were established perhaps after considerably complicated evolutionary process of flowers and each section has an individual phylogenetic history. Accordingly the number of each flower-element is more or less characteristic of each section, even if the difference is apparently very slight. Taking the sections usually having 5 sepals and 5 petals, 8 stamens are fairly constant in Sect. *Platanoidea* and *Macrantha*, while in Sect. *Distyla*, *Parviflora*, *Spicata* and some others, the number of stamens is mostly 8 but somewhat fluctuant, changing from 7 to 9 according to specimens, and in Sect. *Acer* and *Macrophylla*, it is inclined to be somewhat more than 8. Most authors seem not to have been much concerned about this problem. Rehder (1940: 584) described the number of the stamens of Sect. *Trifoliata* to be 8 and made no mention of that of the sepals and petals²⁾. The section is, however, actually characterized by the numerousness of each flower-element, having 6 sepals, 6 petals and 10-14 (commonly 12) stamens. Even Pojarkova, a specialist of Gen. *Acer*, was often very insensible to this matter (cf. Sect. *Pubescentia*).

Not only the number but also the shape of each flower-element or the appearance of whole flowers is characteristic of each section. For instance, in Sect. *Palmata*, the sepals are usually brown or purple, the petals are whitish yellow, always somewhat folded and more or less rolled inside, the stamens are long exserted and dropping off easily, the style is long and erect, and the disc is thick with stamens in the middle, while in Sect. *Macrantha* except Ser. *Micrantha*, the petals are somewhat similar to sepals, whitish yellow and not rolled, the stamens are included, the style is relatively short, and the disc is thin with stamens inserted outside and deeply hollowed to the center of the flower. In most sections, the sepals are broad at the base in comparison with the spatulate petals being attenuate towards the base, but in Sect. *Trifoliata*, the sepals are also spatulate as the petals. The characteristics of flowers must be examined more carefully throughout Gen. *Acer*.

Since Pax (1885: 326), a great importance has been attached to the relative position of stamens to discs. Pax (1885: 326) divided Gen. *Acer* into four large groups, *Extrastaminalia*, *Adiscantha*, *Intrastaminalia* and *Perigyna*, on the basis of that the disc is developed or reduced, and the stamens are hypogynous or perigynous and inserted inside the inner margin of the disc (extrastaminal disc), outside the outer margin of the disc

(intrastaminal disc) or at the middle of the disc. Pax's four groups were reorganized into two, *Intrastaminalia* and *Extrastaminalia*, by Koidzumi (1911a; 1911b), which were mainly characterized respectively by intrastaminal discs and extrastaminal discs³⁾. These groups were considered as fundamentally different from one another phylogenetically by both the authors (cf. App. 2).

Rehder (1940) and Momotani (1961; 1962b) likewise regarded it as important whether the disc is intrastaminal or extrastaminal. In the species of Gen. *Acer*, however, the two conditions, intrastaminal and extrastaminal, of the disc are never clearly isolated, the relative position of stamens to discs being quite various according to sections. Therefore, in some species, the disc is interpreted to be either intrastaminal or extrastaminal. In fact, Momotani (1961: 460) thought the disc of *A.* (Sect. *Rubra*) *pycnanthum* and the species of Sect. *Spicata* intrastaminal, against Koidzumi (1911a) who included these species all in his group *Extrastaminalia*. In the species of Sect. *Platanoidea* the disc surrounds completely the base of the stamens, showing the extrastaminal condition in Koidzumi's sense, but in some species or specimens of the section, the disc is lobed at the insertion of the stamens and may be not enough distinguished from the intrastaminal condition. Even in *A.* (Sect. *Indivisa*) *carpinifolium* which was undoubtedly said to have intrastaminal discs by any author, there are sometimes found flowers in which some of the stamens are inserted, not outside, but upon the discs. Thus, I can not help questioning of the significance of dividing the disc of Gen. *Acer* into two categories, intrastaminal and extrastaminal. The appearance of the disc including the relative position to stamens is very variable in the species of Gen. *Acer* as shown in Plate 3-11, but it is characteristic of each section.

In conclusion, I think that only one or a few characteristics of flowers can not be used, in the case of Gen. *Acer*, for the discussion of any phylogenetic relation, if not merely for the identification.

Note: 1) Hall observed, only in a specimen of *A. pennsylvanicum*, that of 8 stamens 3 were antipetalous and 5 antisepalous anatomically as well as externally. But I think this condition happened accidentally in the specimen, because I could not find such any constant condition, at least externally, in some of the allied species, that is, those belonging to Sect. *Macrantha* Ser. *Macranatha*. Generally, in the species which have more stamens than sepals in the number, the position of stamens is never regularly antisepalous nor antipetalous.

2) In 1907 (p. 25), Rehder mentioned that the flowers of *A.* (Sect. *Trifoliata*) *sutchuense* are 5-merous, having 10 stamens, but illustrated a figure of the flower having 5 sepals, 5 petals and 12 stamens.

3) Koidzumi distinguished the two conditions of discs, intrastaminal and extrastaminal, respectively by that stamens are inserted outside or inside of the outer margin of the disc. This conception was followed by Rehder and Momotani.

5. Fruit

The appearance of fruits, especially that of the nutlets, is considerably characteristic of each section of Gen. *Acer*, though to express precisely the difference of it among sections by words is somewhat difficult. A rough standard that nutlets are convex or

flat and smooth or veined is practically useful for the classification of sections. Such characteristics of fruits were apparently almost disregarded by Pax (1902) and Rehder (1940), at least in some sections of their systems. Rehder usually referred to the shape of nutlets in the description of each section, but the observation was very superficial or incorrect. For instance, his Sect. *Spicata*, which followed nearly Pax's one, was said to be characterized by the fruits with convex and strongly veined nutlets, but the fruits of the species included actually in the section by him are very various in the shape, the nutlets being not necessarily convex nor veined. In my conception, the section should be divided into 7 sections, each of which has a characteristic feature in the shape of nutlets. I can not also agree with Momotani who united Sect. *Goniocarpa*, which was separated by Pojarkova from Pax's Sect. *Campestris*, with Sect. *Platanioidea*, because these two sections differ clearly from each other by the convex and flat nutlets respectively (cf. Sect. *Goniocarpa*).

I consider that the shape of nutlets is important equally as the number of bud-scales for the classification of sections. Many sections, the validness of which is verified by other correlated characters, can be distinguished by the combination of these two characters.

Momotani (1961: 461; 464, Fig. 6; 466, Fig. 7) studied the structure of pericarps of 31 species and illustrated diagrammatic figures. According to him, the pericarp of each species is composed of 3 to 5 kinds of cell layers¹⁾ and differs in the thickness of each cell layer and its arrangement.

Note: 1) The layers of epidermal cells, parenchymatous cells, two kinds of sclerenchymatous cells and fibrous cells.

6. Embryo

The seed of Gen. *Acer* is destitute of albumen and the whole cavity within the testa is occupied by the embryo. The cotyledons are usually epigeal but hypogeal only in *A. saccharinum*. The radicle is usually about as long as the loculus, but very short in the species of Sect. *Trilobata* and *A. saccharinum*. The folding manner of cotyledons has been treated as important taxonomically (Pax, 1885; Rehder, 1905; Schneider, 1907; Momotani, 1961). Pax (1885: 289) discerned two types of cotyledons: 1) the median plane of cotyledons lies in the plane of fruit-wings—*A. diabolicum*, *A. heldreichii*, *A. insigne*, *A. laevigatum*, *A. monspessulanum*, *A. palmatum*, *A. coriaceum*, *A. pseudo-platanus*; and 2) the median plane of cotyledons lies perpendicularly to the plane of fruit-wings—divided into 5 modifications. These two conditions almost accord respectively with incumbent and accumbent ones¹⁾, the words of which were used by Rehder and Momotani.

Each section of Gen. *Acer* is clearly characterized by incumbent or accumbent cotyledons (the cotyledons of Sect. *Pubescentia*, *Laurina*, *Decandra* and *Pentaphylla* are unknown to me).

The sections having incumbent cotyledons: *Distyla*, *Parviflora*, *Palmata*, *Acer*, *Goniocarpa*, *Saccharina*, *Integrifolia*, *Syriaca*, *Trifoliata* and *Lithocarpa*.

The sections having accumbent cotyledons: *Macrantha*, *Spicata*, *Glabra*, *Arguta*, *Negundo*, *Cissifolia*, *Trilobata*, *Rubra*, *Platanoidea*, *Campestris*, *Indivisa* and *Macrophylla*.

The cotyledons of the former group are always circinate in such a manner as shown in Fig. 2-a, while those of the latter are not circinate (Fig. 2-b), but generally plane or somewhat folded or plicate irregularly showing the more or less different features of each section.

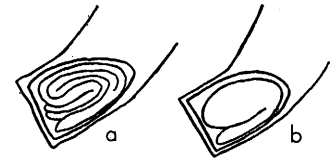


Fig. 2 Folding manner of cotyledons.
a: incumbent.
b: accumbent.

The folding manner of cotyledons is closely connected with the appearance of nutlets. In the species having incumbent cotyledons, the nutlets are exclusively strongly convex. On the other hand, in most species having accumbent cotyledons, the nutlets are compressed-flat. The species of Sect. *Macrantha* Ser. *Rufinervia* and Sect. *Macrophylla* are exceptional in having accumbent cotyledons and convex nutlets. In these species, the convex condition of the nutlets is caused by the presence of some brown materials filling a part of the cavity within the testa.

Note: 1) The cotyledons of Sect. *Palmata* are incumbent and circinate horizontally, as indicated by Momotani (1961: 465). Accordingly, the median plane of cotyledons lies perpendicularly to the plane of fruit-wings, so that the two species of Sect. *Palmata*, *A. laevigatum* and *A. palmatum*, should be referred to the second type, according to Pax's division.

7. Leaf

In the species of Sect. *Negundo*, *Cissifolia* and *Trifoliata*, the leaves are compound. But they are always simple in the early few pairs, at least in the first pair, of seedlings (Fig. 3). This fact may suggest that the compound leaves of these species evolved out of simple leaves.

The transition from bud-scales to leaves is abrupt and these two are usually quite isolated in the shape. Though the inner scales of buds make sometimes leafy development in the apex, they do not take continuous transitional forms to leaves.

Scaly leaves are often present in some species. They are very similar to the innermost one or two pairs of elongated bud-scales in the shape and color, being usually destitute of chlorophylls (but sometimes greenish) and reddish or purplish, though somewhat larger than the latter, so that they may be confused with the latter (Momotani, 1961: 457, Fig. 1). But they are considered as belonging to a somewhat different category from the bud-scale, because they are separated from crowded bud-scales by long internodes, as normal leaves, and moreover take sometimes the opposite position to normal leaves. Scaly leaves are caducous, falling off almost at the

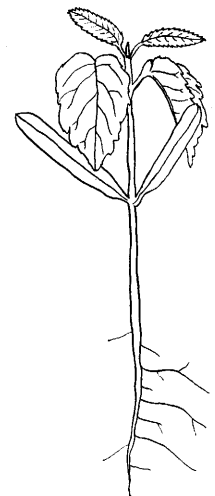


Fig. 3. The seedling of *A. negundo*.
(Y. Yanagita, 1929).

same time with bud-scales, therefore only the scars of them are left midway between normal leaves and the scars of bud-scales. Such scars are often found in herbarium specimens. Scaly leaves seem most common in the species of Sect. *Palmata* Ser. *Sinensia* and Ser. *Laevigata*. Otherwise, they are frequent in *A.* (Sect. *Indivisa*) *carpinifolium*. Pax (1885: 298) reported, "Bei *A. rubrum* und andern Arten erscheint bisweilen das eine Laubblatt wohl ausgebildet, das andere Blatt desselben Paares aber schon als Knospenschuppe". The scaly leaves may interpret what was observed by Rehder (1907: 25): "A peculiarity of *Acer Sutchuense* rarely seen in other species is the occasional suppression of one of the leaves of the pair below the inflorescence, which is borne on branchlets furnished with two or with one pair of leaves, but sometimes on leafless branchlets". It is true that scaly leaves appear even immediately below inflorescences instead of usual pairs of leaves.

Pax (1885; 1902) thought much of the shape of leaves in the classification of sections. The fact is reflected in the names of sections, that is, *Indivisa*, *Palmata*, *Integrifolia* and *Trifoliata*, all of which were established by him. But the shape of leaves is generally a very unreliable character. For instance, when *A.* (Sect. *Cissifolia*) *cissifolium* and *A.* (Sect. *Trifoliata*) *nikoense*, the both of which were included in Sect. *Trifoliata* by Pax, are compared, it is clear that many important characters of these two species are quite different from each other except the 3-foliolate leaves. Such Pax's misconception was gradually amended by later authors. I found that even Pax's Sect. *Integrifolia*, which has been considered, by any author, as a good section remarkably characterized by the usually undivided, entire and evergreen leaves, should be truly divided into 4 sections (cf. Sect. *Integrifolia*).

8. Wood

The secondary xylem of Gen. *Acer* is composed of vessel elements, fiber-tracheids, parenchyma strands and ray parenchyma cells, and characterized by the following remarkably constant features:

1) Vessels small to moderately small and quite evenly distributed throughout the annual ring; solitary and in multiples of 2-several cells. Spiral thickening present. Perforation plate oblique or transverse with exclusively simple perforation. Intervascular pitting alternate or sometimes opposite; pits angular (usually hexagonal) or circular. Tylosis wanting.

2) Fibers unstoried, with narrow bordered pits (fiber tracheid). Starch-storing fibers present as terminal bands and vascicentric sheath.

3) Parenchyma strands usually sparse, terminal and sometimes paratracheal, and composed of 2-4 cells.

4) Rays unstoried, generally homogeneous (Kribs' Homogeneous Type I) and composed of small cells containing much of starch grain. Crystals wanting in ray cells.

On account of the high consistency of the anatomical features throughout Gen. *Acer*, it is often difficult to find any difference among species. Here I investigated the type

of rays, and the distribution of crystals and starch-storing fibers, which are considered as showing most conspicuous and significant variation in the wood of this genus. Transverse, radial and tangential sections of woods were prepared with a sliding microtome. The sections, generally 10–15 μ thick, were stained with safranin 0 and fast-green FCF. The materials used in this study are listed in App. 3.

a) Ray

Rays show relatively large variation in their size among the species of Gen. *Acer*. For instance, *A. carpinifolium* has very big rays (Plate 12, A), but they are always narrow and small in *A. crataegifolium* (Plate 12, B). Therefore the size of rays in tangential section is generally the most important key to identify the wood of this genus. One must be careful, however, that the size of rays is not constant throughout the secondary xylem, but alters with the age of woods.

In all the species of Gen. *Acer*, rays are completely or predominantly uniseriate in the inner part of the 1st annual ring, where rays originate. During the secondary growth, the uniseriate rays increase in width to become multiseriate. The pattern of the ontogenetic developmental process of rays is almost the same in all the species, but the speed of increasing the width and the maximum width attained are more or less different. In this respect, I examined the wood, which contains from the center to the mature part, respectively of *A. tschonoskii* and *A. diabolicum* and obtained the following result:

A. tschonoskii: rays are completely uniseriate throughout the 1st annual ring (Plate 12, C & D); in the 2nd ring 2-seriates appear and thereafter the percentage of 2-seriates gradually increase as age advances (Plate 13, A); but 3-seriates do not appear until about 40 th ring (Plate 13, B); in about 70 th ring 3-seriates are still the maximum width (Plate 13, C & D).

A. diabolicum: in the part adjacent to the pith and primary xylem, rays are predominantly uniseriate but some of them are 2-seriate from their origin (Plate 14, A & D); 3-seriates appear in the end of the 1st annual ring and 4-seriates in the 2nd ring (Plate 15, A), and so on; and in about 20 years the wood becomes mature and rays attain the maximum width of 8–9 cells (Plate 15, D).

Thus, in the mature wood, the percentage of multiseriate rays increases, revealing a continuous variation of the width from uniseriates to multiseriates in a given section.

In regard to the height of rays, considerably high ones are found in the 1st annual ring. They also increase the height with the expansion of the width, but in a certain period they are often dissected into some lower ones by the intrusion of fibers (Plate 16, A & B). The time of dissection is not constant. Owing to this, the height of rays is fairly variable within a species and therefore not regarded as a diagnostically reliable character, though it may be said that wide rays are generally high.

On the contrary, the width of rays are little affected by the dissection. As above mentioned, rays in the mature wood are 1- to a few-, several- or more multi-seriate according to species. I found that not only the width of rays but also the shape are more or less characteristic of each section of Gen. *Acer* which is classified on the basis

of the exomorphic characters. For instance, the species of Sect. *Macrantha* have rays which are narrow, usually attaining 3 cells wide (rarely up to 5 cells wide), and fairly irregular in the outline, while Sect. *Palmata* is characterized by rather broader rays than the former sections, attaining usually 5-6 cells wide (rarely up to 7 cells wide), with a relatively smooth outline. The size (width attained) and the shape of rays in all the sections examined are shown in Table 5 and in the description of each section, and they are also picturized in Plates 16-23.

It may be said to some extent that the sections in a near phylogenetic relationship have similar rays to one another as to the width or the shape. Indeed, the rays of Sect. *Acer*, *Goniocarpa* and *Saccharina*, for instance, are very similar, usually attaining 6-8 cells wide, with very smooth margin; and these sections are guessed to be closely

Table 5. The type of rays and the amount of crystals and starch-storing fibers in each section of Gen. *Acer*.

Section	Ray			Crystal	Starch storing-fiber
	Shape	A*	B**		
Macrantha	I	3	5	not found	+~++
Distyla	(I)	3-4		do.	do.
Parviflora	I	6	7-8	do.	++
Spicata	I	4-6	7	do.	do.
Palmata	(S)-(I)	5-6	7	(T)-T	++++
Glabra	I	5	6	not found	
Arguta	I	7-10		do.	++++
Negundo	(I)	3		((T))	+++
Cissifolia	(I)	5	6	((T))	+
Trilobata	(I)	3	4	not found	
Rubra	(I)	4-4		do.	++
Platanoidea	(S)	5	6	((T))-(T)	++++
Campestris	(I)	4		(T)-T	do.
Acer	S	6-8	9-10	not found	
Goniocarpa	S	6	8	(T)-T	
Saccharina	S	6-8	8-10	(T)	
Integrifolia	S	4	5	TT	++
Syriaca	(S)	5	6	DDDD	
Trifoliata	(I)	4-5	6	TTT	+++
Lithocarpa	I	8	9	not found	do.
Macrophylla	(I)	4	5	T	
Indivisa	(S)	10-25	25	TT	++++

A*: the width of rays usually attained (cells wide)

B**: the width of rays rarely attained (cells wide)

I: irregular-fusiform

(I): somewhat irregular-fusiform

S: smooth-fusiform

(S): rather smooth-fusiform

DDDD: very rich and diffused throughout annual ring

TTT: rich, restricted to terminal zone

TT: rather rich, do.

T: rather few, do.

(T): few, do.

((T)): very few, do.

++++: rich

+++ : rather rich

++ : rather few

+ : few

related, judging also from the exomorphic characters. If the ontogenetic developmental pattern accords with the phylogenetic one, the sections with narrow ray may be considered as primitive in comparison with the related sections with broader rays. But, at present, I can not discuss on the problem of the phylogenetic development of rays, because no correlated wood anatomical character is found.

b) Crystal

In the plants of Gen. *Acer*, crystals are found in the parenchymatous tissue of the leaf¹⁾, stem and root wood²⁾, and bark³⁾. Here, I investigated the distribution of crystals in the stem wood.

The presence or absence and the amount of crystals in the stem wood are different in each species or specimen of Gen. *Acer*. Crystals, if present, are usually restricted to the terminal zone but rarely diffused almost evenly throughout the annual ring. They are rhombohedral, squarefaced or diamond-shaped and 10–20 μ (at minimum less than 3 μ and at maximum 35 μ) in the length of the axis. Crystalliferous cells are very low, containing 1 or sometimes more crystals per cell, and 10 (5) to 30 (40) of these cells compose the whole strand.

In the transverse section, crystals are often overlooked because they are very small and usually stained not enough with safranin O and fast-green FCF. It is most certain to seek them in the radial section along the terminal borders of annual rings, where the strands of tortuously continuous crystalliferous cells are conspicuous (Plate 23, C). In the tangential section, it is observed that crystalliferous strands are frequently in contact partly or wholly with rays (Plate 23, D). They are also found among the tissues of fibers, isolated from rays, and generally independent of vessels.

As crystals are found even from the 1st annual ring, small twigs of more than 1 year (e.g., those from herbarium sheets) may be often available to examine them roughly. It must be noted, however, that the amount and distribution of crystals are somewhat variable depending on the years of growth.

I examined the woods from 22 sections and obtained a rough result shown in Table 5. As known from this table, crystals were relatively abundant in the wood of Sect. *Syriaca*, *Trifoliata*, *Integrifolia* and *Indivisa*. Especially in the first named section, of which I could examine only one specimen of *A. syriacum*, crystals were extremely abundant and diffused almost evenly throughout annual rings (Plate 22, A). In the wood of the latter 3 sections, crystals were generally found restricted to the terminal zone of the annual ring forming often a continuous band in the outermost 1–3 layers and also with occasional occurrences in a little more inner part (usually within 10–15 cell layers from the outermost layer) (Plate 23, B).

On the other hand, I did not find crystals in the woods from 10 sections of 22. For instance, I examined 19 specimens of 8 species belonging to Sect. *Macrantha* and could not find crystals in any of them. In the case of Sect. *Negundo* and *Cissifolia*, crystals were found very rarely. Likewise, crystals were lacking completely in the 3 specimens of Sect. *Saccharina* examined (cf. App. 4) but for a specimen of *A. grandis*.

dentatum (TOFOW 11921) in which crystals were rather rich. In the species of Sect. *Palmata*, crystals were considerably abundant in *A. palmatum*, *A. tenuifolium* and *A. laevigatum*, with the occurrences of a few to several strands in a square centimeter of the radial section, while they were rather scanty in other 6 species of this section examined.

Though I can not give a clear solution about the problem, it may be said that the amount and distribution of crystals are fairly characteristic of each section.

In a specimen respectively of *A.* (Sect. *Integrifolia*) *oblongum* and *A.* (Sect. *Indivisa*) *carpinifolium*, crystals were observed along false rings as well as in the terminal of annual rings.

- Nete: 1) Crystals contained in the leaf were examined by Warsow (1903). According to Momotani (1961: 458), the distribution of crystals in the leaf is constant to each section, but he did not give any more account on the matter.
- 2) The amount and distribution of crystals in the root wood are almost the same with those in the stem wood.
- 3) In general, crystals are considerably abundant in the bark, regardless of the amount of crystals in the stem wood.

c) Starch-storing fiber

The presence of starch-storing fibers in the wood of some species belonging to Gen. *Acer* was noticed by Janssonius (1908: 411, 412, 414), Inokuma (1928: 187, 191) and Pearson and Brown (1932: 298, 300), and Heimsch (1941-1942, according to Metcalfe and Chalk, 1950: 434) stated that bands or areas of starch-storing fibers are characteristic of Gen. *Acer*. These authors discerned that the fibers have somewhat thicker walls and are distributed in the outer part of annual rings and in the neighborhood of vessels.

Starch-storing fibers are considerably abundant in any species of Gen. *Acer*, forming continuous bands of a few to 10 or more cell layers in the terminal zone of annual rings and often thick vasicentric, aliform or confluent sheaths (Plate 24, A & B). Nevertheless, the presence of the fibers is not well known, the reason of which lies perhaps in that starch grains are almost completely dissolved in the wood specimens which were boiled for softening, as done in common section-cutting techniques. I made sections from unboiled materials and treated with iodine potassium iodide which gives a blue reaction on starch grains.

In the wood of Gen. *Acer*, starch grains are abundant also in ray parenchyma cells and parenchyma strands, and small amounts of them are often found in the cells of the pith (Plate 24, D). I examined the stem and root wood of 24 species and recognized the following facts:

- 1) Starch grains are generally very abundant in the root wood and starch-storing fibers give a conspicuous patchwork appearance in the transverse section (Plate 25, A).
- 2) The cells of medullary sheath containing starch grains give a stellate pattern around the pith (Plate 25, B).
- 3) Starch grains are lacking almost completely in the fibers of the tension wood (Plate 25, C).
- 4) The distribution and amount of starch grains are uneven in a tree: starch

grains are often very few on one side of a branch, while they are relatively abundant on the other side.

5) In the specimens obtained in the growing season (spring to summer), starch grains are not yet deposited in the ray cells and fibers of this year (Plate 25, D), and moreover they are often lacking in the wood of the last few years, while in the specimens obtained in the dormant season (winter) starch grains are stored abundantly in the ray cells and fibers. From this fact, it is evident that starch-storing fibers have parenchymatous function.

6) Judging from the distribution of starch grains, excessive sugar is considered to be deposited as starch grains at first in ray cells, second in the fibers distributed in the terminal zone of rings and third in the fibers around vessels; generally starch grains are common in this order.

Starch-storing fibers are not clearly distinguished morphologically from other fiber tracheids. Starch-storing fibers have somewhat thicker walls and distributed in the terminal zone and around vessels, giving a pattern in the transverse section which may be more or less conspicuous even in the sections from boiled specimens in which starch grains have been dissolved away. However, the transition from starch-storing fibers to other fiber tracheids with thinner walls is not always sharp. In the radial or tangential section, both types of fibers can not be discriminated in the shape, and also in the macerated specimens, fibers are all similar in the whole appearance and in the number and distribution of pits on them. Therefore starch-storing fibers are regarded also as a kind of fiber tracheids morphologically.

According to my observation, the fibers containing starch grains were relatively abundant in the wood of the species belonging to Sect. *Palmata*, *Platanoidea*, *Arguta* and *Indivisa*. The relative amount of starch-storing fibers in each section is shown in Table 5. As known well, maple sugar is obtained by concentrating the sap of some species of Gen. *Acer*, especially *A. saccharum* in North America (in Japan, the sap of *A. mono* is used for the purpose). It may be an interesting problem to know the relation between the amount of starch-storing fibers and the concentration of sugar in the sap.

(Add.) Latex

The presence of latex in the leaf and young twig is easily ascertained by that these tissues exude milky sap when broken. Latex is characteristic only of the species of Sect. *Platanoidea*, *Campestris*, *Lithocarpa* and *Macrophylla*. Warsow (1903) made a detailed study on latex and indicated, from the result, some contradictions in Pax's system.

Part 2. The taxonomic system of the Genus *Acer*

Abbreviations

anths.: anthers	fld.: flowered	lflet.: leaflet	smt.: sometimes
cotyls.: cotyledons	fr.: fruit	oft.: often	smw.: somewhat
fls.: filaments	infl.: inflorescence	pets.: petals	sts.: stamens
fl.: flower	lf., lvs.: leaf, leaves	seps.: sepals	usu.: usually

Acer Linnaeus (1753: 1054; 1754: 474)—Maximowicz (1880: 437)—Pax (1885: 287; 1886: 177; 1893: 269; 1902: 6)—Rehder (1905: 175; 1911: 83; 1927: 558; 1940: 566; 1949: 412)—Schneider (1907: 192)—Koidzumi (1911: 2)—Pojarkova (1933: 225; 1949: 580)—Fang (1939: 18)—Momotani (1962b: 180).

Negundo Boehmer (1760: 308)—De Candolle (1824: 596), ut *Negundo* Moench—Endlicher (1836–1840: 1056), ut *Negundo* Moench—Bentham et Hooker (1862: 409), ut *Negundo* Moench—Small (1933: 825).

Rulac Adanson (1763: 383).

Negundium Rafinesque (1808: 352, nom. nud.; 1836: 47, cum descr.).

Euacer Opiz (1852: 42), nom. subnud.

Crula Nieuwland (1911: 140).

Sachrospendamnus Nieuwland (1914: 183).

Argentacer Small (1933: 825).

Rufacer Small (1933: 825).

1) Deciduous, smt. evergreen or half-evergreen trees; andromonoecious, androdioecious or dioecious (cf. p. 97, Sexuality); chromosomes usu. diploid ($n=13$), smt. tri- or tetra-ploid (Takizawa, 1952).

2) Winter-buds developing regularly in the axils of each pair of leaves, with 2–15-paired decussate scales; scales and lvs. usu. distinct (cf. p. 94, Bud & p. 103, Leaf).

3) Infl. panicle, raceme or not stalked umbel from terminal and lateral buds or only from lateral buds, of the previous year, accompanied usu. with 1–3 pairs of lvs. or without lvs., appearing usu. in the spring to early summer, almost at the same time, smw. before or after lvs.; bract and bracteole usu. present, smt. little developed (cf. p. 95, Inflorescence).

4) Fl. small, usu. inconspicuous. a) Perianth usu. free, smt. connate: seps. 4–6, mostly 5, smt. much reduced or wanting. b) Sts. free, usu. 4–12 in ♂, 0–12 in ♀ (♀) exserted or included, upon disc or outside of disc; anths. smooth or scabrous; pollen 3-colporate (Ikuse, 1956: 101); fils. usu. glabrous, smt. hairy. c) Disc usu. developed and fleshy, rarely wanting, roundish or lobed, usu. glabrous, rarely hairy. d) Pistil: ovary 2-carpellate, compressed contrary to the septum, hairy or glabrous; ovules 2 in each carpel, the only one of which developed, attached to the central axis, collateral or superposed; stigmas 2, usu. diverged outside, sessile or on short or long style; rudimentary pistil in ♂ usu. present, smt. wanting (cf. p. 97, Sexuality; p. 99, Flower).

5) Fr. 2-winged schizocarp (samara), hairy or glabrous, usu. ripe in the autumn, rarely in the spring to early summer; nutlets convex or flat; seeds exalbuminous (cf. p. 101, Fruit).

6) Embryo: cotyledons 2, accumbent or incumbent, plane, plicate or circinate, usu. epigeal, rarely hypogeal; radicle usu. elongated about as long as loculus, rarely very short (cf. p. 102, Embryo).

7) Lf. opposite, petiolate, exstipulate; blade simple, undivided or 3–13-lobed, or pinnately 3–9-foliolate, entire or serrate (cf. p. 103, Leaf).

8) Wood. a) Ray composed of small procumbent cells, homogeneous (Kribs' Homogeneous Type I), narrow- or broad-fusiform with smooth or irregular margin, attaining a few, several or more cells wide according to sections, abundant in starch (cf. p. 105, Ray). b) Crystals present or absent, usu. restricted to the terminal portion of annual rings, rarely distributed almost evenly throughout annual rings (cf. p. 107, Crystal). c) Starch-storing fiber present as terminal band and vascicentric sheath (cf. p. 108, Starch-storing fiber). d) Latex present in the young tissue of some sections (cf. p. 109, Latex).

9) Composed of 26 sections and 7 series, distributed mainly in the temperate zone of the northern hemisphere.

Sect. *Macrantha* Pax (1885: 328, sub *Perigynis*; 1886: 244; 1893: 272; 1902: 67), pro major. part.—Rehder (1905: 181; 1940: 580)—Schneider (1907: 236), pro major. part.—Pojarkova (1933: 238 et 344, excl. Ser. *Parvifloris* (Koidz.) Pojark. et *A. distylo* Sieb. et Zucc. in Ser. *Crataegifoliis* Pojark.; 1949: 609)—Fang (1934: 142; 1939: 163).

Acer Group *Macrantha* (Pax)—Rehder (1927: 573).

Acer Sect. *Acer* Ser. *Macrantha* (Pax) Rehder (1949: 424).

Acer Subgen. *Acer* Sect. *Macrantha* (Pax) Momotani (1962b: 180).

1) Androdioecious.

2) Bud oft. stalked; scales 2-paired, the outer pair covering completely the inner.

3) Infl. 10–15-fl. elongated raceme from terminal and lateral buds with 1 pair of lvs., almost at the same time with lvs.; bract and bracteole not much developed.

4) Fl. a) Perianth usu. pale greenish yellow; seps. 5, pets. 5. b) Sts. 8, usu. included, inserted at the outside of disc; anths. scabrous. c) Disc slightly eight-lobed. d) Pistil: ovary usu. glabrous; style short with divergent and recurved stigmas; abortive pistil in ♂ small but fairly distinct.

5) Fr. not very big; nutlets flat, smw. convex or rarely strongly convex.

6) Cotyls. accumbent and plane or folded.

7) Lf. undivided or 3–5-lobed, serrate.

8) Wood. a) Ray narrow, irregular-fusiform, usu. attaining 3 cells wide, 400–750 μ

Table 6. The Sect. *Macrantha* of each author's view.

Pax (1902)	Koidzumi (1911)	Rehder (1927)	Pojarkova (1933)	Momotani (1962b)	Ogata
INDIVISA	INDIVISA	INTEGRIFOLIA	Crataegifolia	SPICATA	DISTYLA
MACRANTHA	MACRANTHA	MACRANTHA	Tegmentosa	Macrantha	Macrantha
	PALMATOIDEA		Micrantha	Rufinervia	Rufinervia
	PARVIFLORA		Parviflora	Micrantha	Micrantha
		SPICATA		SPICATA	PARVIFLORA

The area within a thick line means Sect. *Macrantha*. Sections are shown by the full capital letter and series by the small letter.

high and at max. 5 cells wide, 800–1150 μ high according to specimens. b) Crystals not found. c) Starch-storing fibers not very rich.

9) Composed of Ser. *Macrantha*, Ser. *Rufinervia* (Momotani) Ogata and Ser. *Micrantha* Pojark.

The each author's view of Sect. *Macrantha* is shown in Table 6. Pojarkova takes the widest view of this section, regarding *A. (Sect. Distyla) distylum* and *A. (Sect. Parviflora) nipponicum* as belonging to it. The Sect. *Macrantha* without these two species, namely that following Rehder's view, is characterized by the stalked bud and the terminal raceme with one pair of leaves.

Pojarkova (1933: 345) distinguished Ser. *Crataegifolia* and Ser. *Tegumentosa* on the basis of that the leaves of the former are undivided or shallowly 3-lobed, while those of the latter 3-lobed or 5-lobed. But the classification of series only by lobulation of leaves is considered to be improper for the species included within these Pojarkova's two series. These species were rearranged by Momotani (1962b: 180) into Ser. *Macrantha* and Ser. *Rufinervia*, mainly based on the characters of fruits. I enlarge the area of Momotani's Ser. *Rufinervia*. Ser. *Micrantha* Pojark. is a distinct group and accords just with Sect. *Palmatoidea* Koidz.

Since Koidzumi (1911), whether anthers are scabrous or smooth and ovaries are hairy or glabrous have been used for the classification of the section or the series¹⁾. In my examination, however, anthers are scabrous and ovaries glabrous or nearly so in the species of all the series of this section.

On the sexuality of this section, all the authors described only to be "andro-monoecious" or "androdioecious", without any more examination. In my observation, this section is principally androdioecious. In the previous paper (1965: 37), I reported the occasional occurrences of androdioecism in *A. (Ser. Micrantha) tschonoskii*²⁾. Thereafter I observed andromonoecism also in *A. (Ser. Rufinervia) morifolium*³⁾ and *A. (Ser. Macrantha) crataegifolium*⁴⁾. But generally the trees of this section are unisexual, each bearing exclusively either male or female (hermaphrodite) flowers and bearing flowers of the same sex every year⁶⁾.

As the species of this section are considerably variable in the characters, there are left problems on the classification of the series.

Ser. *Macrantha*

Acer Subgen. *Evotrium* Rafinesque (1836: 47).

Acer Sect. *Indivisa* Pax—Pax (1886: 213; 1902: 67), pro parte—Rehder (1905: 180)—Schneider (1907: 215), pro parte—Koidzumi (1911a: 13), excl. *A. distylo* Sieb. et Zucc.

Acer Sect. *Macrantha* Ser. *Tegmentosa* Pojarkova (1933: 238, 345), pro parte.

Acer Sect. *Macrantha* Ser. *Crataegifolia* Pojarkova (1933: 238, 345), pro parte.

Acer Subgen. *Acer* Sect. *Macrantha* (Pax) Momotani Ser. *Macrantha*—Momotani (1962b: 180), pro major. part.

Bud ovoid, not very big, perianth more or less upright, stamens included, disc caved

in deeply towards the center of the flower, nutlets compressed-flat and somewhat concave on one side, cotyledons plane or folded partly.

Species belonging to this series: *A. davidii* Franch. widely in China; *A. laxiflorum* Pax in C. China; *A. grosseri* Pax in C. China; *A. wardii* W. W. Smith in S. China to Tibet; *A. metcalfei* Rehd. in S. China; *A. chienii* Hu et Cheng in S. China; *A. kawakamii* Koidz. in Formosa; *A. insulare* Makino in Japan (Amami-Ōshima); *A. crataegifolium* Sieb. et Zucc. in Japan; *A. hookeri* Miq. in E. Himalaya; *A. pectinatum* Wall. in C. Himalaya; *A. tegmentosum* Maxim. in Korea and Manchuria; *A. pennsylvanicum* L. in the Atlantic N. America.

Ser. *Rufinervia* (Momotani) Ogata, comb. nov.

Acer Subgen. *Acer* Sect. *Macrantha* Ser. *Rufinervia* Momotani (1962b: 180).

Acer Sect. *Indivisa* Pax—Pax (1886: 213; 1902: 33), ad *A. sikkimense* Miq. tantum.

Acer Sect. *Macrantha* Pax, emend. Koidzumi (1911: 18).

Acer Sect. *Macrantha* Ser. *Tegmentosa* Pojarkova (1933: 238, 345), pro parte.

Acer Sect. *Macrantha* Ser. *Crataegifolia* Pojarkova (1933: 238, 345), ad *A. sikkimense* Miq. tantum.

Acer Subgen. *Acer* Sect. *Macrantha* (Pax) Momotani Ser. *Macrantha*—Momotani (1962b: 180), pro parte.

Bud ovoid and big, perianth more or less upright, stamens included or almost as long as perianth, disc caved in deeply towards the center of the flower, nutlets somewhat or strongly convex, cotyledons somewhat irregularly folded.

Species belonging to this series: *A. sikkimense* Miq. in E. Himalaya; *A. rubescens* Hayata in Formosa; *A. morifolium* Koidz. in Japan (Yakushima); *A. capillipes* Maxim. in Japan; *A. rufinerve* Sieb. et Zucc. in Japan.

The nutlets of *A. rufinerve* are spherically convex, the cause of which lies in that there are some brown materials filling in the center of the accumbent some-

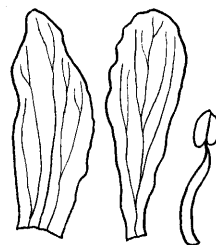


Fig. 4. The sepal, petal and stamen of *A. crataegifolium* (♂) (×7).

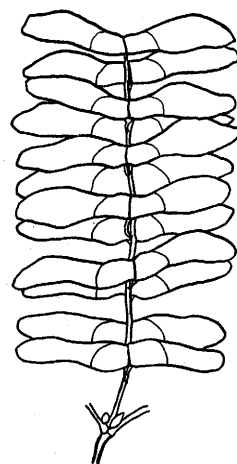


Fig. 5. The infructescence of *A. pectinatum* (× $\frac{2}{3}$).

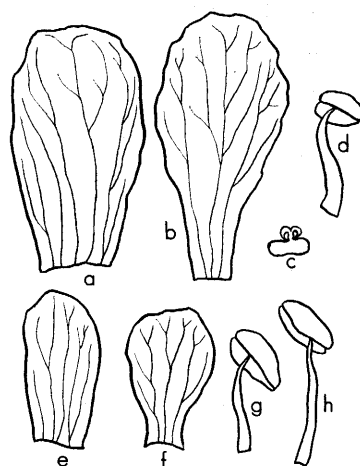


Fig. 6. a~d: *A. rufinerve* (♂) (×7). a: sepal, b: petal, c: abortive pistil, d: stamen, e~h: *A. morifolium* (♂) (×7). e: sepal, f: petal, g~h: stamen.

what irregularly and horizontally folded cotyledons. Such a condition is also found in the fruits of *A. (Sect. Macrophylla) macrophyllum*, and different from that of the convex nutlets in some other species, for example, *A. distylum* and *A. nipponicum*, which is caused by the incumbent and perpendicularly circinate cotyledons. Momotani (1961: 465) said that the cotyledons of *A. rufinerve*, *A. rubescens* and *A. morifolium* are incumbent and circinate perpendicularly, but in my observation they are not so.

The nutlets of the other species in this series are not so strongly convex but ovoid. They are usually concave on one side while young, like those of the other two series of Sect. *Macrantha*, and become ovoid as they mature. The cotyledons are less irregularly folded without much of fillings within the testa.

According to Momotani (1961, 1962a), *A. rufinerve* is more closely related to *A. (Sect. Parviflora) nipponicum* rather than to the other species of Sect. *Macrantha* including *A. capillipes*, *A. tschonokii*, *A. crataegifolium* and others, in the structure of the pericarp and the components of seed proteins, and he established Ser. *Rufinervia* typified by *A. rufinerve*, including in it *A. rubescens* and *A. morifolium* under consideration of the folding manner of cotyledons. But, he made no mention on the structure of the pericarp and the components of seed proteins of the latter two species. I add two more species to this series, *A. capillipes* and *A. sikkimense*, which were arranged in Ser. *Macrantha* by Momotani. These species have also ovoid untlets, and I consider that *A. capillipes* is very closely related to *A. morifolium* and *A. rubescens*.

Ser. Micrantha Pojarkova (1933: 238, 345).

Acer Sect. *Palmatoidea* Koidzumi (1911: 22).

Acer Subgen. *Acer* Sect. *Macrantha* (Pax) Momotani Ser. *Micrantha* (Pojark.) Momotani (1962b: 181).

Bud linear-lanceolate, stamens included or exserted, anthers apiculate, disc not deeply hollowed, nutlets compressed-flat and somewhat concave on one side, cotyledons plane or nearly so, leaves usually 5-lobed, 3 middle lobes long acuminate.

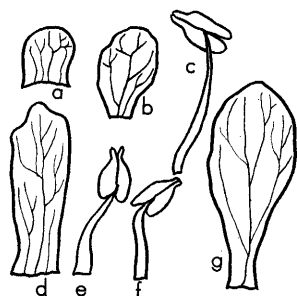


Fig. 7. a~c: *A. micranthum* (♂) (×7). a: sepal, b: petal, c: stamen. d~g: *A. tschonokii* (♂) (×7). d: sepal, e~f: stamen, g: sepal.

Species belonging to this series: *A. maximowiczii* Pax in C. China, *A. tschonokii* Maxim.⁶⁾ in Corea, Manchuria and Japan, and *A. micranthum* Sieb. et Zucc. in Japan.

The species of this series resemble one another especially in the shape of leaves. The patent perianth, apiculate anther and not deeply hollowed disc show that this series is in a relatively remote relation to the other two series.

The flowers of *A. micranthum* is somewhat different from those of the other two species, they are smaller, the stamens exserted and the disc more deeply hollowed.

Note: 1) According to Koidzumi, Pojarkova and Momotani, the anthers are scabrous and the ovary glabrous only in *A. tschonokii* group (Ser. *Micrantha*).

- 2) A tree of *A. tschonoshii* I observed had male flowers on the whole but female ones only in the lowest poor branch. Another case in which male and female flowers shared the same branch or even the same inflorescence was found.
- 3) There was also found in *A. morifolium* a similar condition to the first case of *A. tschonoshii* above mentioned, but in this case the tree had predominantly female flowers, and male flowers only in a small branch.
- 4) In a tree of *A. crataegifolium*, the flowers were exclusively male in the spring of 1965, but many axes of infructescence without fruits were left in the branches of the previous year.
- 5) There are often found trees of this section which bear female flowers in the branches of this year and the remains of infructescences in the branches of the previous year. But a long-term observation in some marked individuals must be made on this problem.
- 6) The two varieties of *A. tschonoshii*, var. *rubripes* Komarov in Corea and Manchuria and var. *australe* Momotani in S. Japan are sometimes regarded as independent species, respectively *A. komorovii* Pojark. and *A. australe* (Momotani) Ohwi et Momotani. The typical variety var. *tschonoshii* is endemic to N. Japan.

Sect. Distyla Ogata, Sect. nov.

Acer Sect. *Indivisa* Pax—Pax (1886: 213; 1902: 33), ad *A. distylum* Sieb. et Zucc. tantum—Schneider (1907: 215), ad *A. distylum* Sieb. et Zucc. tantum—Koidzumi (1911a: 12), sub *Intrastaminalibus*, ad *A. distylum* Sieb. et Zucc. tantum.

Acer Group *Integrifolia* (Pax)—Rehder (1927: 571), ad *A. distylum* Sieb. et Zucc. tantum.

Acer Sect. *Macrantha* Pax Ser. *Crataegifolia* Pojarkova (1933: 238, 345), ad *A. distylum* Sieb. et Zucc. tantum.

Acer Sect. *Integrifolia* auct. non Pax, Rehder (1940: 579), ad *A. distylum* Sieb. et Zucc. tantum.

Acer Sect. *Acer* Ser. *Integrifolia* (Pax) Rehder (1949: 424), ad *A. distylum* Sieb. et Zucc. tantum.

Acer Subgen. *Acer* Sect. *Spicata* (Pax) Momotani Ser. *Parviflora* (Koidz.) Momotani (1962b: 181), ad *A. distylum* Sieb. et Zucc. tantum.

Planta andromonoecia. Gemmae perulae 2-jugae, exterioribus perfecte tegentibus interiores. Inflorescentia elongato-paniculata in ramulis 2-foliatis terminalis. Sepala 5, petala 5, stamina vulgo 8. Discus bene evolutus, lobatus in insertionibus staminum. Stigmata sessilia, divergentia, recurvata. Samarae loculi elliptico-convexi. Cotyledones incumbentes, circinatae. Folia ovata, basi profunde cordata, apice subito breve acuminata, crenato-serrulata.

Typus: *A. distylum* Sieb. et Zucc.

- 1) Andromonoecious.
- 2) Bud with 2-paired valvate scales, the outer pair covering completely the inner.
- 3) Infl. 30–100-fl. elongated panicle from terminal and lateral buds with usu. 1 pair of lvs., smw. after lvs.; bract and bracteole small or wanting.
- 4) Fl. a) Perianth whitish yellow, smw. fleshy; seps. 5, smw. excavate with recurved tips, scabrous with glandular hairs; pets. 5. b) Sts. usu. 8, smt. 7, exserted; anths. small, scabrous. c) Disc strongly lobed with sts. inserted between lobes, smw. scabrous. d) Pistil: ovary rufously thick hairy; stigmas sessile, divergent from the base

and recurved outside; abortive pistil in ♂ rather small but distinct, showing vestigial ovary and stigmas.

5) Fr. covered with rufous hairs when young, usu. becoming glabrous later; nutlets elliptic-convex.

6) Cotyls. green, incumbent and circinate perpendicularly.

7) Lf. undivided, ovate, deeply cordate at the base, short acuminate at the apex, shallowly serrate; petiole $1/3-1/2$ as long as blade.

8) Wood. a) Ray smw. irregular-fusiform, usu. attaining 3-4 cells wide, $500-800\mu$ high according to specimens and at max. 1200μ high. b) Crystals not found. c) Starch-storing fibers not very rich.

9) Only one species, *A. distylum* Sieb. et Zucc. endemic to Japan.

As known from the synonyms of this section mentioned above, *A. distylum* has been placed in four different sections by each author. It means that the clear position of this species is considerably difficult to be decided. In other words, this species has

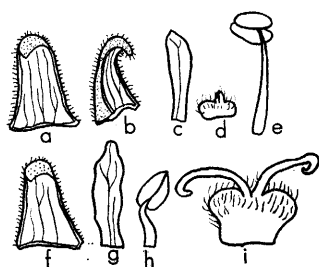


Fig. 8. *A. distylum*. a-e: ♂, f-i: ♀. a-b-f: sepal; c-g: petal; d: abortive pistil, e-h: stamen; i: pistil. ($\times 7$).

no close relative. The affinity with the species of Sect. *Integrifolia* to which Rehder referred is quite out of the question. From the viewpoint of the bud with 2-paired scales, the terminal inflorescence with 1 pair of leaves, the ray type and others¹⁾, the nearest relation of this species with the species of Sect. *Macrantha* is conjectured. The components of seed proteins examined by Momotani (1962a: 96, Fig. 11) also support it. But this species differs from the latter essentially in having bisexual panicle inflorescences instead of unisexual racemes. Momotani

(1962b: 181) included this species in Sect. *Spicata* Ser. *Parviflora* with another species *A. nipponicum*, also taking the protein affinity of the seeds into consideration (cf. App. 2), but this mating is considered as unacceptable (cf. Sect. *Parviflora*), though both the species have common points in the buds with 2-paired scales, the fruits with elliptic-convex nutlets and the incumbent and circinate cotyledons. I think *A. distylum* is in a more remote relation with the species of Sect. *Spicata* than with those of Sect. *Macrantha*.

The name Sect. *Indivisa* was applied to *A. carpinifolium* after Rehder (cf. Sect. *Indivisa*). I propose a new section, Sect. *Distyla* Ogata, for this species.

Note: 1) The leaves of *A. distylum* are similar to those of *A.* (Sect. *Macrantha*) *sikkimense*.

Sect. *Parviflora* Koidzumi (1911: 11), sub *Intrastaminalibus*.

Acer Sect. *Macrantha* Pax—Pax (1886: 244; 1902: 67), ad *A. parviflorum* Fr. et Sav. (= *A. nipponicum* Hara) tantum—Schneider (1907: 236), ad *A. parviflorum* Fr. et Sav. tantum.

Acer Group *Spicata* auct. non Pax, Rehder (1927: 566), ad *A. parviflorum* Fr. et Sav. tantum.

Acer Sect. *Macrantha* Ser. *Parviflora* (Koidz.) Pojarkova (1933: 238, 345).

Acer Sect. *Spicata* auct. non Pax, Rehder (1940: 574), ad *A. nipponicum* Hara tantum.

Acer Sect. *Acer* Ser. *Spicata* (Pax) Rehder (1949: 418), ad *A. nipponicum* Hara tantum.

Acer Subgen. *Acer* Sect. *Spicata* (Pax) Momotani Ser. *Parviflora* (Koidz.) Momotani (1962b: 181), ad *A. nipponicum* Hara tantum.

- 1) Andromonoecious.
- 2) Bud big; scales 2-paired, the outer pair converging completely the inner.
- 3) Infl. many-fld. (ca. 400 or more) cylindric-elongated panicle from terminal and lateral buds with 1-3 pairs of lvs., long after lvs., hairy; bracteole fairly common.
- 4) Fl. small. a) Perianth yellow; seps. and pets. 5 respectively, glabrous. b) Sts. 8, smt. 7, 9 or 10, long exserted in ♂, inserted outside disc; anths. small, scabrous. c) Disc well developed, slightly lobed at the insertion of sts. d) Pistil: ovary hairy; stigmas nearly sessile, short; abortive pistil fairly well developed in ♂.
- 5) Fr. big, rufously tomentose at least when young; nutlets spherically convex.
- 6) Cotyls. incumbent and circinate perpendicularly.
- 7) Lf. 3-5-lobed, big, doubly serrate; petiole $2/3-1$ as long as blade.
- 8) Wood. a) Rays irregular-fusiform, usu. attaining 6 and at max. 7-8 cells wide, 700-900 μ high. b) Crystals not found. c) Starch-storing fiber not very rich.
- 9) Only one species, *A. nipponicum* Hara endemic to Japan.

Momotani (1962a: 100; 1962b: 181) referred *A. nipponicum* to Sect. *Spicata* Ser. *Parviflora* with *A. distylum*. But *A. nipponicum* is different from the species belonging to Sect. *Spicata* Ser. *Spicata* sensu Momotani, in 1) the number of bud-scales, 2) the relative position of stamens to the disc, 3) the size and shape of fruits, 4) the folding manner of cotyledons, 5) the ray type and so on. Momotani mentioned that the bud-scales of Ser. *Spicata* are 2-paired, but according to my observation on considerably many specimens the bud-scales of *A.* (Sect. *Spicata*) *ukurunduense* were 2- or 3-paired. Momotani conceived the disc of Ser. *Spicata* intrastaminal because of that it is lobed at the insertion of stamens. But the difference of the disc between *A. nipponicum* and *A. ukurunduense* is distinct as shown in Plate 4, B and 4, D.

A. nipponicum differs from *A. distylum* mainly in 1) the number of flowers in an inflorescence, 2) the shape of the disc and especially 3) the ray type. The multiseriate rays of *A. nipponicum* are wider and more irregular than those of *A. distylum* which are rather similar to those of Sect. *Macrantha*.

Sect. *Spicata* Pax (1885: 326, sub *Extrastaminalibus*; 1886: 182; 1893: 270; 1902: 8), pro minor. part.—Rehder (1905: 179; 1940: 574), pro minor. part.—Schneider (1907: 196), pro minor. part.—Koidzumi (1911a: 28), sub *Extrastaminalibus*, ad *A. spicatum* Lam. var. *ukurunduense* (Trautv. et Mey.) Maxim. tantum—Fang (1934: 140; 1939: 73), pro minor. part.

Acer Subgen. *Evotrium* Rafinesque (1836: 47).



Fig. 9. The sepal, petal and stamen of *A. nipponicum* ($\times 7$).

Acer Group *Spicata* (Pax)—Rehder (1927: 566), pro minor. part.

Acer Sect. *Microcarpa* Pojarkova Ser. *Spicata* (Pax) Pojarkova (1933: 236, 339).

Acer Sect. *Acer* Ser. *Spicata* (Pax) Rehder (1949: 574), pro minor. part.

Acer Subgen. *Acer* Sect. *Spicata* (Pax) Momotani Ser. *Spicata*—Momotani (1962b: 182).

1) Andromonoecious.

2) Bud big: scales 2- or 3-paired, the innermost pairs covered completely by the outer, but when 3-paired, the outermost pair smw. opening.

3) Infl. many-fl. (ca. 100–200-fl.) cylindric-elongated panicle from terminal and lateral buds usu. with 2 or 3 pairs of lvs., long after lvs., hairy; bract and bracteole fairly common.

4) Fl. small. a) Perianth whitish yellow; seps. 5, very short in comparison with petals, hairy outside; petals 5, glabrous. b) Sts. 7–10, usu. 8, long exserted in ♂; anthers small, scabrous. c) Disc well developed, with stamens at the inside, lobed at the insertion of stamens. d) Pistil: ovary hairy; stigmas splitted nearly to the base, but usu. not divergent to the middle or upper part and erect; abortive pistil fairly well developed in ♂ with distinct stigmas.

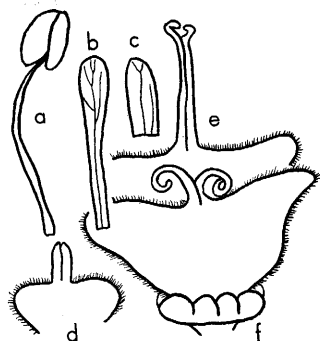


Fig. 10. *A. ukurunduense*. a~d: ♂; e~f: ♀. a: stamen, b: petal, c: sepal, d: abortive pistil, e~f: pistil. (×7).

5) Fr. small, glabrous or smw. hairy; nutlets flat and veined.

6) Cotyls. accumbent, plane or nearly so, the tips smt. recurved, whitish yellow.

7) Lf. usu. 3- or 5-lobed, smw. coarsely serrate; petiole 2/3–1 as long as the blade.

8) Wood. a) Ray irregular-fusiform, usu. attaining 4–6 cells wide according to specimens, 600 μ high and at max. 7 cells wide, 1000 μ high. b) Crystals not found. c) Starch-storing fibers not very rich.

9) *A. caudatum* Wall. in Himalaya and China; *A. ukurunduense* Trautv. et Meyer in Manchuria, Korea and Japan; *A. spicatum* Lam. in the Atlantic N. America.

Pax (1902) included many species in this section. But his delimitation was very rough so that most of them have been redistributed into other sections or some new sections by later authors (Rehder, 1905; Pojarkova, 1933; Momotani, 1962b). According to Momotani with whom I almost agree, Sect. *Spicata* sensu Pax consists of 8 sections, that is Sect. *Spicata*, *Trilobata*, *Integrifolia*, *Lithocarpa*, *Acer*, *Macrophylla*, *Glabra* and *Palmata*.

The 3 species included now in this section are closely related to one another and form a very natural group. Momotani placed in this section Ser. *Parviflora* (Koidz.) Momotani composed of *A. nipponicum* and *A. distylum*, but I separate these species from Sect. *Spicata* and consider them to represent Sect. *Parviflora* Koidzumi and Sect. *Distyla* Ogata, respectively (cf. Sect. *Parviflora* and *Distyla*).

Sect. *Palmata* Pax, emend. Ogata.

- 1) Andromonoecious.
- 2) Bud with 4-paired valvate or imbricate scales; terminal buds oft. wanting.
- 3) Infl. elongated panicle or corymboso-panicle from terminal and lateral buds with a few pairs of lvs.
- 4) Fl. a) Perianth: seps. 5, usu. brownish or purplish; pets. 5, usu. whitish yellow, wrinkled and smw. rolled inside in the middle to the upper part. b) Sts. usu. 8, smt. 7 or 9, exserted or almost as long as perianth, dropping off easily; anths. more or less scabrous. c) Disc well developed, roundish (usu. not lobed), with sts. inserted at the inside. d) Pistil: style long and erect with short divergent and recurved stigmas: abortive pistil distinct.
- 5) Fr.: nutlets elliptic-convex, veined or relatively smooth according to species.
- 6) Cotyls. incumbent and circinate horizontally.
- 7) Lf. undivided or 3-13-lobed, the margin entire or serrate.
- 8) Wood. a) Ray almost smooth or smw. irregular-fusiform, usu. attaining 5-6 cells wide, 400-900 μ high according to specimens and at max. 7 cells wide, 1000-1300 μ high. b) Crystals few to rather rich. c) Starch-storing fibers rather rich.
- 9) Composed of 3 series, Ser. *Sinensia* (Pojark.) Ogata, Ser. *Palmata* and Ser. *Laevigata* Ogata.

Pax's Sect. *Palmata* of 1902 was composed only of 5 species. Pojarkova (1933) added more 8 species with typical palmate leaves and corymbose inflorescences to this section. Momotani (1962b) transferred some species of Sect. *Microcarpa* Pojark. Ser. *Sinensia* Pojark. into Sect. *Palmata* Ser. *Palmata* and at the same time Ser. *Sinensia* itself from Sect. *Microcarpa* into Sect. *Palmata* as one of the series. In Momotani's system, Ser. *Palmata* includes 21 species and Ser. *Sinensia* 5 species. I separate some species from Sect. *Integrifolia* and establish a new series of Sect. *Palmata*, Ser. *Laevigata*, for them (cf. Sect. *Integrifolia*).

Thus, Sect. *Palmata* is not characterized now by the typically palmate leaves and corymbose inflorescences. The essential characteristics of this section are that 1) bud-scales are 4-paired, 2) sepals and petals are distinct in the color and petals with irregular and shallow furrows somewhat rolled inside, 3) stamens drop off easily, 4) nutlets are elliptic-convex, and 5) cotyledons are incumbent and circinate horizontally.

In the previous paper (1965, App., Table 1), I described that the bud-scales are 5-paired in the Japanese species of this section. In these cases, the bud with 4-paired normal scales is usually accompanied by one more, not paired scaly appendage at the base (Plate 1, D & 2, A). This appendage is often well developed and covers completely the base of the bud, but sometimes much reduced only to some hairs. It is found not only in Japanese species but also in all the species of Sect. *Palmata*. If one regards it as a kind of bud-scale and as reduced from a pair of scales, the bud-scales of Sect. *Palmata* can be considered to be essentially 5-paired.

In the species of Ser. *Sinensia* and Ser. *Laevigata*, scaly leaves are very often present.

They take sometimes the opposite positions to normal leaves (Fig. 11, B), as found also in Sect. *Indivisa*.

Ser. *Sinensia* (Pojark.) Ogata, comb. nov.

Acer Sect. *Microcarpa* Pojarkova Ser. *Sinensia* Pojarkova (1933: 236, 339), pro parte.

Acer Sect. *Spicata* Pax—Pax (1886: 182; 1902: 8), pro parte—Rehder (1905: 179; 1940: 574), pro parte—Schneider (1907: 196), pro parte—Fang (1934: 140; 1939: 574), pro parte.

Acer Group *Spicata* (Pax)—Rehder (1927: 566), pro parte.

Acer Subgen. *Acer* Sect. *Palmata* (Pax) Momotani Ser. *Sinensia* (Pojark.) Momotani (1962b: 183).



Fig. 11.

Acer Subgen. *Acer* Sect. *Palmata* (Pax) Momotani Ser. *Palmata*—Momotani (1962b: 182), ad *A. flabellatum* Rehd. tantum.

Inflorescence elongated broad or narrow panicle or spike-like panicle with 1–3 pairs of leaves, leaves 3–7-lobed and serrate, scaly leaves very often present.

Species belonging to this series: *A. sinense* Pax in C. China; *A. campbellii* Hook. f. et Thoms. ex Brandis in C. and S. China, Tibet and Himalaya; *A. erianthum* Schw. in C. China; *A. flabellatum* Rehd. in C. China; *A. tutcheri* Duthie in S. China and *A. wilsonii* Rehd. in C. and S. China.

The species of this series are distributed from Central to Southern China, to Tibet and Himalaya.

Ser. *Palmata*—Pojarkova (1933: 238)¹⁾.

Acer Subgen. *Antadenium* Rafinesque (1836: 49).

Acer Sect. *Palmata* Pax—Pax (1886: 198; 1902: 24)—Rehder (1905: 178; 1940: 577)—Schneider (1907: 207)—Koidzumi (1911a: 35), sub *Extrastaminalibus*—Fang (1934: 141; 1939: 55).

Acer *Spicata* Pax—Pax (1902: 8), ad *A. oliverianum* Pax tantum—Rehder (1905: 179; 1940: 574), ad *A. oliverianum* Pax tantum—Schneider (1907: 196), ad *A. oliverianum* Pax et *A. robustum* Pax—Koidzumi (1911: 28), sub *Extrastaminalibus*, ad *A. oliverianum* Pax tantum—Fang (1934: 140; 1939: 73), pro parte.

Acer Group *Palmata* (Pax)—Rehder (1927: 569).

Acer Group *Spicata* (Pax)—Rehder (1927: 566), ad *A. oliverianum* Pax tantum.

Acer Sect. *Microcarpa* Pojarkova Ser. *Sinensia* Pojarkova (1933: 236, 339), pro parte.

Acer Sect. *Acer* Ser. *Spicata* (Pax) Rehder (1949: 418), ad *A. oliverianum* Pax tantum.

Acer Subgen. *Acer* Sect. *Palmata* (Pax) Momotani Ser. *Palmata*—Momotani (1962b: 182), excl. *A. flabellatum* Rehd.

Terminal buds wanting very often, inflorescence long-stalked corymboso-panicle usually with 1 pair of leaves, leaves 3–13-lobed, serrate, scaly leaves rare.

Species belonging to this series: *A. robustum* Pax in C. China; *A. pseudosieboldianum* Komarov in Corea and Manchuria; *A. takeshimense* Nakai in Corea (Ullungdo Isl.); *A. ishidoyanum* Nakai in Corea; *A. nudicarpum* Nakai in Corea; *A. sieboldianum* Miq. in Japan; *A. japonicum* Thunb. in Japan; *A. tenuifolium* (Koidz.) Koidz. in Japan; *A. shirasawanum* Koidz. in Japan; *A. palmatum* Thunb. in E. China, Formosa, S. Corea and Japan; *A. amoenum* Carr. in Japan; *A. circinatum* Pursh in the Pacific N. America; *A. serrulatum* Hayata in Formosa; *A. oliverianum* Pax in China; *A. schneiderianum* Pax et K. Hoffm. in C. China; *A. heptalobum* Diels in S. China; *A. pubipalmatum* Fang in E. China; *A. pauciflorum* Fang in E. China; *A. ceriferum* Rehd. in C. China; *A. chingii* Hu in S. China; *A. confertifolium* Merr. et Metcalf in S. China; *A. johnewardianum* Metcalf in S. China.

The species of this series are distributed mainly in China, Formosa, Manchuria, Corea and Japan, and one species in the Pacific N. America. The species with many-lobed leaves are found in Manchuria, Corea, Japan and N. America (in the above

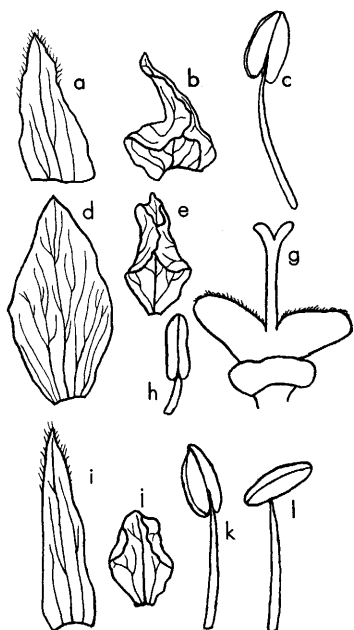


Fig. 12. a~c: *A. sieboldianum* (♂, ×7); d~h: *A. japonicum* (♀, ×3.5); i~l: *A. amoenum* (♂, ×7). a·d·i: sepal; b·e·j: petal; c·h·k·l: stamen; g: pistil.

enumeration, from *A. pseudosieboldianum* to *A. circinatum*). The species with 3-lobed leaves are found in S. China (e. g., *A. chingii*, *A. confertifolium*). From Central to Southern China, there are some intermediate species between Ser. *Palmata* and Ser. *Sinensia* in the shape of leaves and inflorescences (e. g., *A. oliverianum*).

The tendency of lacking in terminal buds appears often strongly in the species of this series. For instance, they are lacking almost always in *A. palmatum* and *A. amoenum*, but in *A. japonicum* present or absent nearly half and half according to the twigs in an individual.

The distinction of sepals and petals is most remarkable in *A. japonicum* and *A. circinatum*, the sepals being thick purplish-colored in contrast with the whitish yellow petals.

Ser. *Laevigata* Ogata.

Acer Sect. *Integrifolia* Pax—Pax (1886: 207; 1902: 31), pro parte—Rehder (1905: 179; 1940: 579), pro parte—Schneider (1907: 213), pro parte—Fang

(1934: 141; 1939: 132), pro parte.

Acer Group *Integrifolia* (Pax)—Rehder (1927: 571), pro parte.

Acer Sect. *Integrifolia* Pax Ser. *Trinervium* Metcalf (1932: 194), pro parte.

Acer Sect. *Integrifolia* Pax Ser. *Penninervium* Metcalf (1932: 202), pro parte.

Acer Sect. *Integrifolia* Pax Ser. *Oblonga* Pojarkova²¹ (1933: 238), nom. nud., pro parte.

Acer Sect. *Integrifolia* Subsect. *Oblonga* (Pojark.) Hu et Cheng (1948: 200), ut Subsect. *Oblongae*, pro parte.

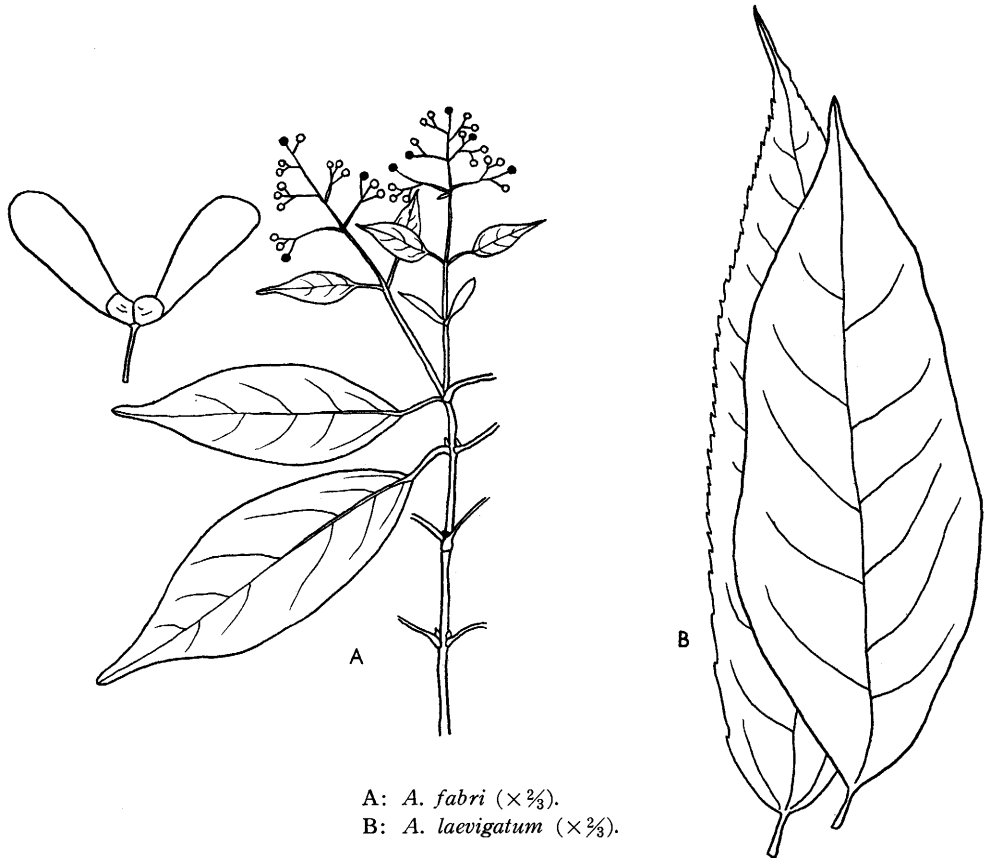
Acer Sect. *Acer* Ser. *Integrifolia* (Pax) Rehder (1949: 418), pro parte.

Acer Subgen. *Acer* Sect. *Integrifolia* (Pax) Momotani Ser. *Integrifolia*—Momotani (1962b: 185), pro parte.

Arbor andromonoecia. Gemmae perulae 4-jugae. Inflorescentia paniculata in ramulis 1-3-jugo-foliatis terminalis. Sepala 5, purpurea, petala 5, albo-lutea, irregulare tenuiterque plicata, convoluta intra, apice saepe dentata. Stamina vulgo 8 exserta, caduca, antheris scabriusculis. Discus bene evolutus, rotundus, extrastaminalis. Stylus longe erectus, stigmatibus breve revolutis. Samarae loculi elliptico-convexi. Cotyledones incumbentes, horizontaliter circinatae. Folia coriacea vel chartacea, oblonga vel obovata, integerrima vel minute serrulata.

Typus: *A. laevigatum* Wall.

Inflorescence loose-flowered, elongated panicle or corymboso-panicle from terminal and lateral buds with 1-3 pairs of leaves, leaves deciduous or half-evergreen, oblong or



A: *A. fabri* ($\times \frac{2}{3}$).
 B: *A. laevigatum* ($\times \frac{2}{3}$).

Fig. 13.

obovate, entire or slightly serrate, scaly leaves very often present.

Species belonging to this series: *A. laevigatum* Wall. from C. and S. China to E. Himalaya; *A. fabri* Hance in C. and S. China; *A. reticulatum* Champ. in S. China; *A. dimorphifolium* Metcalf in S. China; *A. cordatum* Pax in C. and S. China.

The species of this series are distributed in the warmer region from C. and S. China to Himalaya.

The leaves are usually entire and much resemble those of *A. oblongum* and its allies in the shape, but those of vigorously elongated shoots and of the young plants are more or less serrate. The leaves of *A. cordatum* are often remotely serrate in the normal condition.

There may be actually present some more species of this series. Although many species with oblong and entire leaves were described, to which one of the four sections³⁾ characterized by such leaves they belong can not be often judged owing to the incomplete descriptions (cf. Sect. *Integrifolia*).

Note: 1) & 2) Pojarkova's Sect *Palmata* and Sect. *Integrifolia* are composed respectively of only one series, Ser. *Palmata* and Ser. *Oblonga*.

3) Sect. *Palmata* Ser. *Laevigata*, Sect. *Integrifolia*, Sect. *Laurina* and Sect. *Decandra*.

Sect. *Glabra* Pax (1885: 327, sub *Perigynis*; 1886; 217; 1893; 272; 1902: 45)—Schneider (1907: 222)—Pojarkova (1933: 240)—Rehder (1940: 579).

Acer Subgen. *Saccharodendron* Rafinesque (1836: 47), ad *A. glabrum* Torr. tantum.

Acer Group *Glabra* (Pax)—Rehder (1927: 571).

Acer Sect. *Acer* Ser. *Glabra* (Pax) Rehder (1949: 423).

Acer Subgen. *Acer* Sect. *Glabra* (Pax) Momotani Ser. *Glabra*—Momotani (1962b: 180).

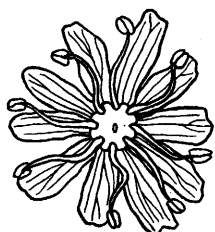


Fig. 14. The male flower of *A. glabrum*. ($\times 3.5$).

- 1) Andromonoecious or androdioecious¹⁾.
- 2) Bud oft. stalked; scales 2-4-paired²⁾.
- 3) Infl. loose-flid. small panicle with 3-11 fls. from terminal and lateral buds usu. with 1 pair of lvs.; bract and bracteole fairly common.

- 4) Fl. a) Perianth greenish yellow; seps. 5, glabrous, similar to pets.; pets. 5. b) Sts. usu. 8, nearly as long as perianth; anths. small, smooth; fils. smw. crooked. c) Disc lobed, with sts. inserted between the lobes, caved in to the center of the

flower. d) Pistil: ovary glabrous; stigmas nearly sessile, recurved outside; abortive pistil in ♂ very small.

- 5) Fr. glabrous; nutlets flat, strongly veined.

- 6) Cotyls. accumbent, folded irregularly.

- 7) Lf. 3-5-lobed or smt. 3-parted to the base of the blade, smw. doubly serrate, glabrous.

- 8) Wood. a) Ray irregular-fusiform, usu. attaining 5 cells wide, 700μ high and at max. 6 cells wide, 1000μ high. b) Crystals not found.

- 9) Only one species, *A. glabrum* Torr., found in the Pacific N. America.

Pojarkova (1933: 236; 271, Fig. 7) placed Sect. *Glabra* and Sect. *Arguta* in the neighbouring position and showed in the scheme of the phylogenetic relation that these two sections were derived immediately from the same stock (cf. App. 2). Momotani (1962a: 102; 1962b: 180) united both the sections into Sect. *Glabra*, distinguishing them into Ser. *Glabra* and Ser. *Arguta*. According to him, they are closely related to each other in the components of seed proteins.

Morphologically, Sect. *Glabra* and Sect. *Arguta* are more or less different in the sexuality, the number of bud-scales, the inflorescence type and the number of each flower element. But the strongly veined nutlets and the whole impression of the leaves remind us really of the close affinity of both the sections. The ray of this section is narrow in comparison with that of Sect. *Arguta*, but they resemble each other in the shape, especially the irregularity. They are now regarded as forming different sections, because considered as fairly differentiating from each other, even if derived from a common ancestor.

Note: 1) Sargent (1905: 631) described, "the staminate and pistillate produced on different plants", and Rehder (1940: 579), "Fls. andro-polygamous or andro-dioecious". In my observation of herbarium specimens, the staminate and hermaphrodite flowers are either on different

individuals (andro-dioecious) or on the same inflorescences (andromonoecious). From the fact, I guess that the species is tending from andromonoecism to androdioecism, or possibly vice versa.

- 2) Momotani (1962a: 102) mentioned that the bud-scales of Sect. *Glabra* are 2-paired, but, in my observation, they are 2- to 4-paired according to specimens.

Sect. *Arguta* Rehder (1905: 181; 1940: 582)—Schneider (1907: 244)—Koidzumi (1911a: 25), sub *Intrastaminalibus*—Pojarkova (1933: 240, 366)—Fang (1934: 142; 1939: 211).

Acer Sect. *Spicata* Pax—Pax (1886: 182; 1902: 8), pro parte.

Acer Sect. *Indivisa* Pax—Pax (1886: 213; 1902: 33), ad *A. stachyophyllum* Hiern tantum.

Acer Sect. *Lithocarpa* Pax (1886: 249; 1902: 170), pro parte.

Acer Group *Arguta* (Rehder)—Rehder (1927: 574).

Acer Sect. *Acer* Ser. *Arguta* (Rehder) Rehder (1949: 425).

Acer Subgen. *Acer* Sect. *Glabra* (Pax) Momotani Ser. *Arguta* (Rehder) Momotani (1962b: 180).

- 1) Androdioecious.

- 2) Bud with 2-paired valvate scales, the outer pair covering completely the inner.

3) Infl. from lateral buds: ♂ 5-15-fld. fascicled-raceme without lvs.¹⁾; ♀ 7-11-fld. elongated raceme with long pedicels, with 1 pair of normal lvs.; bract and bracteole fairly developed.

4) Fl. usu. 4-merous. a) Perianth upright in ♂; seps. 4; pets. 4. b) Sts. usu. 4 in ♂, smt. more or less antisepalous when 4, exserted, and in ♀ much reduced in the number and size, often absent; anths. small, smw. scabrous. c) Disc deeply 4-lobed, with sts. inserted between the lobes. d) Pistil: ovary glabrous; style short; stigmas recurved outside; abortive pistil in ♂ very small only as a minute 2-lobed process.

- 5) Fr.: nutlets flat, strongly veined.

- 6) Cotyls. accumbent, folded in half obliquely.

7) Lf. undivided or 3-5-, smt. 7-lobed, coarsely or sharply, doubly serrate; petiole 1/3-2 as long as blade.

8) Wood. a) Ray elongated irregular-fusiform, usu. attaining 7-10 cells wide, 1800 μ or more high²⁾. b) Crystals not found. c) Starch-storing fibers rich.

9) *A. tetramerum* Pax in C. China; *A. stachyophyllum* Hiern in C. China and Himalaya; *A. acuminatum* Wall. ex D. Don in Himalaya; *A. barbinerve* Maxim. in Corea and Manchuria; *A. argutum* Maxim. in Japan.

Though the species mentioned above had been arranged in 3 different sections by Pax, before Sect. *Arguta* Rehder was established, they really form a very natural group characterized especially by the 2-paired bud-scales, the inflorescence type, the 4-merous flowers and the shape of fruits. They are distinguished clearly from one another mainly

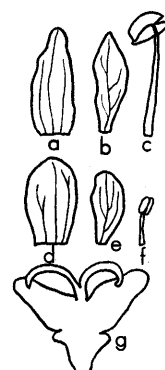


Fig. 15. *A. argutum* ($\times 3.5$).

a~c: ♂, d~g: ♀. a~d: sepal; b~e: petal; c~f: stamen; g: pistil.

in the lobulation and serration of the leaves, the length of the pedicels, and the size and wing-angle of the fruits.

The inflorescences of this section, both male and female, emanate only from lateral buds on the branches of the previous year. The descriptions of almost all authors are erroneous or incomplete on the female inflorescences. For instance, Rehder (1940: 582) described, "the pistillate fls. in racemes terminal on 2-leafed brts., the staminate from leafless lateral buds³⁾", and Momotani (1962b: 177), "Inflorescentia fructifera in ramulis foliatis terminalis". As the female inflorescences of this section bear always 1 pair of normal leaves and moreover are usually supported with a short (ca. 1-2 cm) hornotinous twig, the condition looks just like the same with that observed in the species of the terminal inflorescence type. But, actually, the inflorescences are out always from lateral buds of the annotinous twigs, and the terminal buds are always vegetative.

Note: 1) As a very rare case, I have seen a male inflorescence of *A. argutum* which has a pair of normal leaves (loc.: the Chichibu Mts., Japan; date: May 21, 1962; coll.: Sakata).
 2) In a specimen of *A. argutum* I examined, the ray became high and irregular with the age of the tree and the highest one attained, at an age of about 55 growth rings, more than 3000 μ high with the frequent indented margin (Plate 18, C).
 3) But, Rehder expressed correctly the condition, in Sargent's Trees and Shrubs (1905: 131, 171), saying that the pistillate flowers of the species of Sect. *Arguta* (*A. argutum* and *A. tetramerum*) are terminal on short lateral two-leaved branchlets.

Sect. Negundo (Boehmer) Maximowicz (1880: 450), ut Sect. *Negundo* (Moench) Maxim.—Pax (1885: 327, sub *Adiscanthis*; 1886: 210; 1893: 271, ut Sect. *Negundo* (Moench) Pax; 1902: 42, ut Sect. *Negundo* (Ludw.) K. Koch)—Schneider (1907: 220), ut Sect. *Negundo* K. Koch—Pojarkova (1933: 240)—Rehder (1940: 585, ut Sect. *Negundo* (Boehm.) K. Koch; 1949: 428, ut Sect. *Negundo* (Boehm.) Pax), pro parte.

Negundo Boehmer (1760: 308)—Moench (1794: 334).

Rulac Adanson (1763: 383).

Negundium Rafinesque (1808: 352).

Acer Gruppe *Negundo* (Boehm.)—K. Koch (1869: 543), ut *Acer* Gruppe *Negundo* Moench.

Acer Group *Negundo* (Boehm.)—Rehder (1927: 577), ut *Acer* Group *Negundo* K. Koch, pro parte.

Acer Subgen. *Negundo* (Boehm.) Momotani Ser. *Negundo*—Momotani (1962b: 188).

1) Dioecious, usu. lacking sts. in ♀ fl.

2) Bud with a tendency of opening indeterminately¹⁾; scales usu. 3-paired.

3) Infl.: ♂ fascicled panicle with very slender pedicels, from lateral buds without or smt. with 1 pair of usu. stinging lvs.; ♀ elongated raceme with long pedicels, rarely with 2-fld. ramifications in the lower part, from lateral buds without or smt. with 1 pair of usu. stinging lvs.; both ♂ and ♀ smw. before lvs.

4) Fl. apetalous, yellowish green. a) Seps. small, usu. 4-5, smt. 3, hairy. b) Sts. 4-6 in ♂, usu. lacking but rarely present²⁾ in ♀; anths. big, linear-oblong; fls. slender and very long, hairy. c) Disc completely reduced. d) Pistil: ovary hairy; stigmas

nearly sessile and long spreading; abortive pistil usu. absent in ♂³⁾.

5) Fr. glabrous; nutlets flat, veined.

6) Cotyls. accumbent.

7) Lf. 3-7-, smt. 9-pinnate; lflets. oblong, coarsely serrate.

8) Wood. a) Ray narrow, smw. irregular-fusiform, usu. attaining 3 cells wide, 350-700 μ high according to specimens, and at max. 800-1200 μ high. b) Crystals usu. not found⁴⁾. c) Starch-storing fibers rather rich.

9) *A. Negundo* L. and its allies widely distributed in N. America.

Many authors regarded *A. negundo* and its allies as composing a distinct genus, Gen. *Negundo*, independent of Gen. *Acer*. The ground was that first they have foliolate leaves and secondly they are dioecious, lacking stamens in female flowers and abortive pistils in male flowers.

Plowman (1915) studied very many characters of *A. negundo* under the title of "Is the box elder a maple?", covering the growth habit, the general external-morphology, the anatomy of stem and root woods, bark, young twigs, leaves and fruits, and geographical records, and concluded, "*Negundo* possesses characteristics of generic rank, and while the box elder is undoubtedly a descendant from the ancestral *Acer* stock, it has now reached a stage of differential development that may fairly exclude it from the group of true maples". But in the characters adopted by him are included ones considered not always important taxonomically, and moreover some (at least) of his observations on anatomical characters seem not only unessential but sometimes incorrect⁶⁾. Therefore, one may get such an impression from his report as if he observed *A. negundo* only with the aim of separating it from Gen. *Acer*.

Hall (1951) made detailed study on the floral anatomy of *A. negundo* with some other species of Gen. *Acer*, and also supported the separation of the genus *Negundo* on the ground of the complete dioecism and the absence of the disc with its vascular supply, while considered it as one closely related to and derived from the true *Acer*. But, later, as the result of the more thorough study of the species, he (1954) found stamens in some of the female flowers. Here, he raised the question of how basic the difference is between *A. negundo* and other species of Gen. *Acer*, taking it also into consideration that Buchenau (1861) mentioned the presence of the vestigial pistils in the male flowers of this species.

The complete dioecism, that is, the absence of abortive pistils in male flowers and of stamens in female flowers, is also the normal condition of Sect. *Cissifolia*, though the disc is well developed in this case. Foliolate leaves are also found in Sect. *Cissifolia* and *Trifoliata*, though the leaflets are always 3, and moreover the leaves in the early stage of growth are simple not only in these two sections but also in Sect. *Negundo*.

Momotani (1962b: 102) considered *Negundo* as one of the three subgenera of Gen. *Acer* and included in it Sect. *Cissifolia* as Ser. *Cissifolia*. But the reason was not explained on these changes.

Thus, I think that there is not any remarkable evidence which forces the separation

of *A. negundo* and its allies from Gen. *Acer*, at least morphologically. The wood of *A. negundo* is also provided with all the essential characteristics of Gen. *Acer*.

The habit of being easily propagated by cuttings of *A. negundo*, which was noticed also by Plowman, is a certainly distinguished one restricted to this species.

Note: 1) Plowman (1915: 171) said, "An interesting peculiarity of the box elder (= *A. negundo*) is its very common habit of developing new buds and leaves as long as the growing season lasts", and therefore, "the terminal buds are usually killed (by the first frost) and the lateral buds carry on the development in the following season."

2) Hall (1954: 531) found the presence of 1, 2 or 3 stamens in some female flowers.

3) Buchenau (1961) mentioned the presence of vestigial pistils in the staminate flowers.

4) Plowman (1915: 183) reported the very rare occurrences of crystals.

5) Plowman mentioned, for instance, that the marginal ray cells of *A. negundo* show marked irregularity in form along the free border, while those of *A. saccharinum* are quite straight on the outer margin. But I could not find any essential difference in this respect between both the species.

Sect. Cissifolia Koidzumi (1911a: 26), sub Extrastaminalibus—Pojarkova (1933: 240).

Negundo auct. non Boehmer, Siebold et Zuccarini (1845: 159).

Negundo auct. non Boehmer, Miquél (1866: 90).

Acer Sect. *Negundo* (Boehm.) Maximowicz (1880: 450), ut Sect. *Negundo* (Moench) Maxim., ad *A. cissifolium* (Sieb. et Zucc.) K. Koch tantum—Fang (1934: 143, excl. *A. pentaphyllo* Diels; 1939: 242, ut Sect. *Negundo* (Ludw.) K. Koch)—Rehder (1940: 585, ut Sect. *Negundo* (Boehm.) K. Koch; 1949: 428, ut Sect. *Negundo* (Boehm.) Pax), pro parte.

Acer Sect. *Trifoliata* Pax—Pax (1886: 203; 1902: 29), pro parte—Rehder (1905: 181), ad *A. henryi* Pax tantum—Schneider (1907: 209), pro parte.

Crula Nieuwland (1911: 140).

Acer Group *Negundo* (Boehm.)—Rehder (1927: 577), ut Sect. *Negundo* K. Koch, pro parte.

Acer Sect. Subgen. *Negundo* (Boehm.) Momotani Ser. *Cissifolia* (Koidz.) Momotani (1962b: 188).

1) Dioecious, lacking sts. in ♀ fls.

2) Bud small, almost completely enclosed by the petiole (intrapetiolar bud, Plate 2, B); scales 2-paired, the outer pair covering completely the inner.

3) Infl., both ♂ and ♀, 20–40-fl. raceme from lateral buds without lvs. or smt. with 1 pair of usu. stingy lvs., almost at the same time with lvs., hairy; bract and bracteole fairly common.

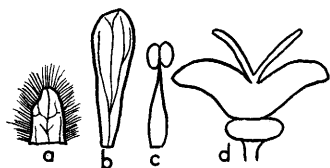


Fig. 16. *A. cissifolium* (×7). a~c: ♂, d: ♀. a: sepal, b: petal, c: stamen, d: pistil.

4) Fl. 4-merous. a) Perianth yellow; seps. 4, short in comparison with pets., hairy outside; pets. 4, glabrous. b) Sts. 4 in ♂, antisepalous, or rarely 5, included, inserted upon disc, 0 in ♀; anths. small, smooth; fils. swollen from the middle to the lower part. c) Disc developed, smw. mounded wholly. d) Pistil: ovary glabrous; stigmas nearly sessile, spread-

ing straight outside; abortive pistil absent in ♂.

5) Fr. glabrous; nutlets flat, veined.

6) Cotyls. accumbent, nearly plane, whitish yellow.

7) Lf. 3-foliate; llet. oblong, coarsely serrate; petiole $2/3-3/2$ as long as llet.

8) Wood. a) Ray smw. irregular-fusiform, usu. attaining 5 cells wide, $450-550\mu$ high, and at max. 6 cells wide, $600-700\mu$ high. b) Crystals very few. c) Starch-storing fibers not very rich.

9) *A. henryi* Pax in C. China and *A. cissifolium* (Sieb. et Zucc.) K. Koch in Japan.

The species now included in this section are often considered as the members of Sect. *Negundo*. Indeed, these two sections are all the same or much alike in the sexuality, the type of inflorescences, the shape of fruits and the foliolate leaves, but differ in the number of bud-scales, the features of flowers and the ray type¹⁾. I think these two sections have considerably differentiated from each other, if originated from the same stock.

The filament swollen from the middle to the lower part is a remarkable characteristic only found in this section (Plate 6, D).

Note: 1) The rays of Sect. *Negundo* is very narrow in comparison with that of Sect. *Cissifolia*, but the ray type of the latter section in the immature stage resembles that of Sect. *Negundo* in the mature stage (Plate 18, D & 19, A). Whether there is any phylogenetic meaning in this fact is not clear at present.

Sect. *Trilobata* Pojarkova (1933: 238, 324), ad Ser. *Tatarica* Pojark. tantum.

Acer Sect. *Spicata* Pax—Pax (1886: 182; 1902: 8), pro parte—Rehder (1905: 179; 1940: 574), pro parte—Schneider (1907: 179), pro parte—Koidzumi (1911a: 28), sub *Extrastaminalibus*, ad. *A. ginnala* Maxim. tantum—Fang (1934: 141, ad *A. tataricum* L. tantum; 1939: 73, ad *A. ginnala* Maxim. tantum).

Acer Group *Spicata* (Pax)—Rehder (1927: 566), pro parte.

Acer Sect. *Acer* Ser. *Spicata* (Pax) Rehder (1949: 418), pro parte.

Acer Subgen. *Acer* Sect. *Trilobata* (Pojark.) Momotani (1962b: 182).

1) Andromonoecious.

2) Bud with 7-10-paired imbricate scales.

3) Infl. usu. dense-fld. (50-100-fld.), but smt. loose-fld., broad panicle from terminal and lateral buds with a few pairs of lvs., almost at the same time with lvs.; bract and bracteole much developed.

4) Fl. a) Perianth pale yellow; seps. 5; pets. 5. b) Sts. usu. 8, smt. 9, exserted; anths. small, smw. scabrous. c) Disc thick, roundish with sts. inserted at the inside. d) Pistil: ovary hairy; stigmas splitted to the base but oft. not divergent to the middle; abortive pistil in ♂ fairly developed, showing vestiges of style and stigma.

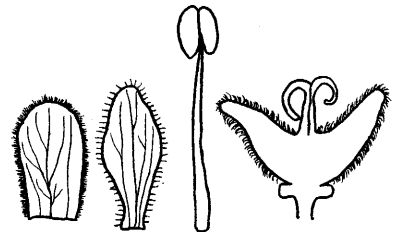


Fig. 17. The sepal, petal and stamen of ♂ ($\times 7$), and the pistil of ♀ ($\times 3.5$) in *A. aidzuense*.

5) Fr. smw. hairy when young, usu. becoming glabrous later; nutlets flat, strongly veined.

6) Cotyls. accumbent, almost plane; the radicle very short in comparison with that of other sections except for Sect. *Rubra* Ser. *Eriocarpa* in which the radicle is likewise short.

7) Lf. undivided or 3-lobed, irregularly serrate; petiole $1/3-2/3$ as long as blade.

8) Wood. a) Ray narrow, smw. irregular-fusiform, usu. attaining 3 cells wide, 500–600 μ high, and at max. 4 cells wide, 700–1000 μ high according to specimens. b) Crystals not found.

9) *A. tataricum* L. in E. Europe (Jugoslavia to the Urals); *A. semenovii* Regel et Herder in C. Asia (Tienshan Mts.; Pamir Pl.; N.E. Afganistan); *A. ginnala* Maxim. in Manchuria and Corea; *A. aidzuense* (Franch.) Nakai in Japan; one species, not yet described, in C. to E. China¹⁾.

This section is a quite natural group and the species included in it are distinguished from one another by the shape of leaves. They are usually small trees or shrubs and grow in marshy places.

Pojarkova (1933: 324) established Sect. *Trilobata* Ser. *Tatarica* for this group which was included in Sect. *Spicata* by Pax (1902) and Rehder (1927), while she arranged *A. buergerianum* group which was also placed in Sect. *Spicata* by the latter two authors into the another series of Sect. *Trilobata*, Ser. *Trifida*. Momotani (1962: 182) transferred Ser. *Trifida* into Sect. *Integrifolia* and remained the name of Sect. *Trilobata* for Ser. *Tatarica* probably after due consideration of the original description. I agree with Momotani. Sect. *Trilobata* sensu Momotani differs from Sect. *Integrifolia* essentially in the shape of fruits, the folding manner of cotyledons and the ray type and I consider these two sections to be in a remote relationship.

Note: 1) There is a species of this section in Central to Eastern China, to which the name *A. tataricum* has been generally applied (Franchet, 1884: 76; Forbes et Hemsley, 1886: 142; Rehder, 1911: 91; Fang 1934: 141). Pojarkova (1933: 328) suggested that this species is closely related to *A. aidzuense* in Japan. Fang (1939: 112) united the three species of this section in Eastern Asia, that is, the problem one in China, *A. ginnala* in Corea and Manchuria, and *A. aidzuense* in Japan, into one species, *A. ginnala*, considering the variation of the leaves of these species seen in herbarium specimens as representing the different stage of growth. But his conception is clearly incorrect. As the leaves of these three species are compared, the leaves of the Chinese species are usually undivided, while those of *A. ginnala* deeply 3-lobed, and *A. aidzuense* takes an intermediate form between them in the incision of the leaves. These three species should be treated in the relation of independent species of one another, or at least of varieties. The undivided leaves of the Chinese species resemble somewhat those of *A. tataricum*, but the relation between these species is considered rather distant, judging from the separated distribution areas of the both. *A. semenovii* has small and deeply 3-lobed leaves.

Sect. *Rubra* Pax (1885: 326, sub *Extrastaminalibus*; 1886: 178; 1893: 270; 1902: 37)—Schneider (1907: 218)—Rehder (1940: 583).

Acer Group *Rubra* (Pax)—Rehder (1927: 575).

Acer Sect. *Acer* Ser. *Rubra* (Pax) Rehder (1949: 426).

Acer Subgen. *Acer* Sect. *Rubra* (Pax) Momotani (1962b: 182).

- 1) Androdioecious.
- 2) Bud with 5-7-paired imbricate scales.
- 3) Infl. 4-10-fl'd. not stalked umbel from lateral buds without lvs., about 10 days before lvs.; bract and bracteole present.
- 4) Fl. opening in late-March to early-April. a) Perianth reddish brown to greenish yellow; seps. free and 4-5, or united and 5-lobed; pets. 0-5, oft. much reduced also in the size. b) Sts. 5-8, mostly 5-6, long exserted; anths. scabrous. c) Disc developed, with sts. at the outside, smw. lobed at the insertion of sts. d) Pistil: stigmas sessile, long divergent outside; abortive pistil in ♂ very small.
- 5) Fr. ripening in the spring or early summer; nutlets compressed-flat or smw. convex.
- 6) Cotyls. accumbent, plane or smw. folded.
- 7) Lf. usu. 3-5-lobed, smt. undivided, serrate, glaucous beneath; petiole 1/2-1 as long as blade.
- 8) Wood. a) Ray narrow, smw. irregular-fusiform, usu. attaining 3-4 cells wide, 500-1000 μ high according to specimens, and at max. 1300 μ high. b) Crystals not found. c) Starch-storing fibers not very rich.
- 9) Composed of Ser. *Rubra* and Ser. *Eriocarpa* (Raf.) Ogata.

The two remarkable characteristics of this section distinguishing it from any other sections of Gen. *Acer* are that the inflorescences are completely sessile umbel and fruits are ripe very early. The inflorescences of the other sections are more or less stalked, having the peduncle and the fruits of the other sections at least in the temperate zone are ripe in the autumn, from September to October, the germination being in the next spring. The fruits of this section are ripe usually in late-April to early-May, within about a month from the anthesis, and germinate as soon as they fall to the ground.

Ser. *Rubra*—Pojarkova (1933: 240; 1949: 619).

Acer Subgen. *Clinotrox* Rafinesque (1836: 47).

Rufacer Small (1933: 825, 1505).

Sepals free, 4-5, petals 4-5 in female flowers, and 0-5, usually much reduced in male flowers; fruits with compressed-flat, smooth nutlets; cotyledons epigeal, radicle long; leaves usually 5-lobed, sometimes undivided; ray cells large.

Species belonging to this series: *A. rubrum* L. in the Atlantic N. America and *A. pycnanthum* K. Koch in C. Japan.

A. rubrum is widely and commonly found in the Atlantic North America and distinguished into several

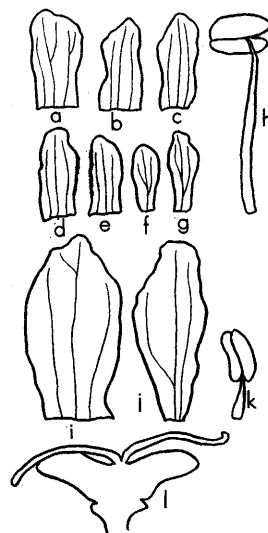


Fig. 18. *A. pycnanthum* (×7).
a~h: ♂; i~l: ♀. a~e: i:
sepal; f~g~j: petal; h~k:
stamen; l: pistil.

varieties and forms, differing mainly in the shape and hairiness of leaves, the color of flowers and fruits, the tree habit and others. Some of them are often regarded as independent species. On the other hand, the distributions of *A. pycnanthum* is restricted to a very small area of C. Japan (Ogata, 1965a). *A. pycnanthum* resembles so closely *A. rubrum* in most of the characters that it is sometimes regarded also as a variety of the latter species. Some fossils belonging to Sect. *Rubra* were reported from Europe, Saghalien, Kamchatka, Greenland, Alaska and the Pacific N. America.

Ray cells are somewhat large in the species of this series in comparison with any other species of Gen. *Acer*.

Ser. Eriocarpa (Raf.) Ogata.

Acer Subgen. *Eriocarpum* Rafinesque (1836: 47).

?*Acer* Subgen. *Saccharodendron* Rafinesque (1836: 47).

Saccharodendron (Raf.) Nieuwland (1914: 182), ad *S. saccharinum* (L.) Nieuwl. tantum.

Sachrosphendamnus Nieuwland (1914: 183).

Argentacer Small (1933: 825, 1505).

Acer Sect. *Rubra* Ser. *Saccharina* Pojarkova (1933: 240, nom. nud.; 1949: 620, nom. subnud.).

Calyx united and 5-lobed, corolla usually wanting, ovary thick hairy; fruits big with considerably convex nutlets; cotyledons very thick, whitish yellow and hypogeal; radicle very short. Leaves 5-lobed.

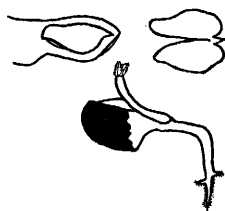


Fig. 19. The seed of *A. saccharinum* ($\times \frac{2}{3}$).

To this series belongs only one species, *A. saccharinum* L., native to the Atlantic North America.

I propose a new series, Ser. *Eriocarpa* (Raf.) Ogata, for this species, instead of Sect. *Rubra* Ser. *Saccharina* Pojarkova which was not validly published¹⁾ and thereafter invalidated by the homonym Ser. *Saccharina* (Pax) Rehd.

Ser. *Rubra* and Ser. *Eriocarpa* are very similar in some characteristics, especially in the inflorescence type, but differentiate considerably from each other in the characters of flowers and seeds.

The hypogeal cotyledons are found only in this series.

The radicle is very short also in Sect. *Trilobata*.

Note: 1) Pojarkova (1933: 240, Table 1) divided Sect. *Rubra* into Ser. *Rubra* and Ser. *Saccharina*, including the species respectively of *A. rubrum* group and *A. saccharinum*, but made no description. Her description of 1949 was made only in Russian, but in the same year Rehder published a combination, Sect. *Acer* Ser. *Saccharina* (Pax) Rehd., which is here considered as a synonym of Sect. *Saccharina*.

Sect. Platanoidea Pax (1885: 327, sub *Perigynis*; 1886: 233; 1893: 272; 1902: 46, excl. *A. miyabei* Maxim.).—Rehder (1905: 177; 1940: 568, excl. *A. miyabei* Maxim.).—Schneider (1907: 233), excl. *A. miyabei* Maxim.—Koidzumi (1911a: 57), sub *Extrastaminibus*, excl. *A. miyabei* Maxim.—Fang (1934: 139; 1939: 19), excl. *A. stenolobo* Rehd.

Acer Group *Platanoidea* (Pax)—Rehder (1927: 561), excl. *A. miyabei* Maxim.

Acer Sect. *Platanoidea* Grex *Platanoidea*—Pojarkova (1933: 226, 278), incl. Ser. *Platanoideis*, Ser. *Pictis* Pojark. et Ser. *Quinquelobis* Pojark.

Acer Sect. *Acer* Ser. *Platanoidea* (Pax) Rehder (1949: 412), excl. *A. miyabei* Maxim.

Acer Subgen. *Acer* Sect. *Platanoidea* (Pax) Momotani Ser. *Platanoidea*—Momotani (1962b: 184).

1) Andromonoecious.

2) Bud big; scales 5–8-paired.

3) Infl. dense- to loose-fl. broad panicle from terminal and lateral buds with a few pairs of lvs., almost at the same time with lvs.; bract and bracteole fairly common; vegetative axillary buds at the base of infl. sprouting very often with the development of infl.

4) Fl. a) Perianth yellow; seps. 5; pets. 5. b) Sts. usu. 8, included or smw. exserted, inserted upon disc; anths. small, smw. scabrous; c) Disc well developed oft. slightly lobed at the insertion of sts. d) Pistil: style short but distinct; stigmas divergent and recurved outside or rolled; abortive pistil in ♂ distinct.

5) Fr. glabrous or slightly hairy; nutlets compressed-flat, smooth.

6) Cotyls. accumbent, folded irregularly.

7) Lf. 3–9-lobed or rarely undivided, entire or remotely dentate with pointed teeth; petiole $2/3$ – $5/3$ as long as blade.

8) Wood. a) Ray fusiform or elongated-fusiform, usu. attaining 5 cells wide, 400 – 800μ high according to specimens, and at max. 6 cells wide, 1000 – 1200μ high¹⁾. b) Crystals few to very few²⁾. c) Starch-storing fibers rich. d) Latex present in young tissue.

9) *A. longipes* Franch. ex Rehd. in C. China; *A. amplum* Rehd. in C. China; *A. tenellum* Pax in C. China; *A. catalpifolium* Rehd. in C. China; *A. fulvescens* Rehd. in C. to S. China; *A. acutum* Fang in C. China; *A. chunii* Fang in S. China; *A. tibetense* Fang in Tibet; *A. cappadocicum* Gleditsch in C. China, Himalaya, Caucasus, Iran and Asia Minor; *A. turkestanicum* Pax in C. Asia; *A. mono* Maxim. in Amur, Manchuria, Corea and Japan; *A. okamotoanum* Nakai in Corea; *A. truncatum* Bunge in Manchuria and Corea; *A. lobelii* Tenore in Mediterranean reg.; *A. divergens* Pax in Mediterranean reg.; *A. platanoides* L. in Europe.

Though relatively many species are included in this section, they form a natural group apparently characterized by the leaves with entire or sometimes remotely dentate, but not serrate, and pointed lobes, and by the fruits with flat and smooth nutlets. They are extremely differentiated especially in Eastern Asia, that is, China, Manchuria, Corea and Japan. If the species in these regions are further studied, some of them will possibly be divided into more numerous species. For instance, the species which is generally regarded as *A. mono* today occupies a very wide range from Amur, Manchuria,

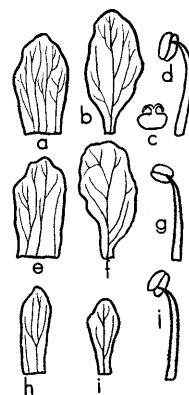


Fig. 20. *A. truncatum* (a~d); *A. mono* var. *mayrii* (e~g); *A. mono* var. *connivens* (h~j) (♂) ($\times 3.5$).

Table 7. The Sect. *Platanoidea* of each author's view.

Pax (1902)		Pojarkova (1933)		Momotani (1962)		Ogata	
PLATANOIDEA	PLATANOIDEA	Picta	PLATANOIDEA	Platanoidea	PLATANOIDEA		
		Platanoidea					
		Quinqueloba					
CAMPESTRIA		Campestris		CAMPESTRIA			
		Pubescentia		PUBESCENTIA			
	GONIO-CARPA	Opulifolia		GONIO-CARPA	Opulifolia		
		Monspessulana			Monspessulana		
					SYRIACA		

Full capital letter: Section; Small letter: Series.

Corea to Japan and has many variation in it. I (1964) recognized distinct 8 varieties of *A. mono* only in Japan, each of which is considered, in a viewpoint, to have enough characteristics for an independent species. On the other hand, if one may understand the species in a wide sense, *A. okamotoanum* and some other species in China may be regarded as the varieties of *A. mono*. Thus, a well-balanced demarcation among species seems not yet to be made.

Pojarkova (1933: 226; 278; 297; 307) placed, under Sect. *Platanoidea*, the five series, Ser. *Picta* Pojark., Ser. *Platanoidea*, Ser. *Quinqueloba* Pojark., Ser. *Campestris* (Pax) Pojark. and Ser. *Pubescentia* Pojark., and Momotani (1962b: 184) also the four series, Ser. *Platanoidea*, Ser. *Campestris*, Ser. *Pubescentia* and Ser. *Monspessulana* Pojark. sensu Momotani. The former three series in the Pojarkova's system and Ser. *Platanoidea* in the Momotani's system accord almost with Sect. *Platanoidea* Pax originally meant by Pax and also with Sect. *Platanoidea* adopted in this paper. In my conception, the other series included in Sect. *Platanoidea* by Pojarkova and Momotani, Ser. *Campestris*, *Pubescentia* and *Monspessulana*, compose Sect. *Campestris*, Sect. *Pubescentia*, Sect. *Goniocarpa* and Sect. *Syriaca*, as shown in Table 7. These sections resemble one another in having the androdioecious sexuality, many imbricate bud-scales, paniculate inflorescences usually accompanied with a few pairs of leaves, and leaves with the entire margin, but they are considered to have more or less different phylogenetic histories respectively.

Sect. *Platanoidea* has a strong tendency of sprouting new shoots from axillary buds at the base of inflorescences. The habit is sometimes found also in some other sections of Gen. *Acer* but not very frequent.

Note: 1) But a specimen of *A. mono*, among twelve specimens of this section examined, had wider and far higher rays attaining 7-8 cells wide and 1500-2000 μ high, rarely 2500 μ high.

2) According to Yamabayashi (1938: 191) and Yamauchi (1962: 9, 10), the wood of *A. mono* is often or very often crystalliferous, contrary to my observation.

Sect. *Campestris* Pax (1885: 327, sub *Perigynis*; 1886: 219; 1893: 272; 1902: 54), ad *A. campestre* L. tantum—Schneider (1907: 229), ad *A. campestre* L. tantum—Rehder (1940: 571), ad *A. campestre* L. tantum.

Acer Sect. *Platanoidea* Pax—Pax (1886: 233; 1902: 46), ad *A. miyabei* Maxim. tantum—Schneider (1907: 223), ad *A. miyabei* Maxim. tantum—Koidzumi (1911a: 57), sub *Extrastaminalibus*, ad *A. miyabei* Maxim. tantum—Rehder (1940: 568), ad *A. miyabei* Maxim. tantum—Tsoong (1954: 83).

Acer Group *Campestris* (Pax)—Rehder (1927: 563), ad *A. campestre* L. tantum.

Acer Group *Platanoidea* (Pax)—Rehder (1927: 561), ad *A. miyabei* Maxim. tantum.

Acer Sect. *Platanoidea* Ser. *Campestris* (Pax) Pojarkova (1933: 236, 297).

Acer Sect. *Acer* Ser. *Campestris* (Pax) Rehder (1949: 415), ad *A. campestre* L. tantum.

Acer Sect. *Acer* Ser. *Platanoidea* (Pax) Rehder (1949: 412), ad *A. miyabei* Maxim. tantum.

Acer Subgen. *Acer* Sect. *Platanoidea* (Pax) Momotani Ser. *Campestris* (Pax) Momotani (1962b: 185).

- 1) Andromonoecious.
- 2) Bud with 5–8 pairs of imbricate scales.
- 3) Infl. loose-fl. panicle with ca. 15 flowers, from terminal and lateral buds with a few pairs of lvs., almost at the same time with lvs.; bract and bracteole fairly common.
- 4) Fl. a) Perianth yellow or greenish yellow; seps. 5; pets. 5. b) Sts. usu. 8, almost as long as perianth or smw. exerted, inserted upon disc; anths. small, smw. scabrous. c) Disc well developed, smt. eight-lobed at the insertion of sts. d) Pistil: ovary usu. hairy; style fairly long; stigmas divergent and recurved; abortive pistil distinct.
- 5) Fr.: wings spreading horizontally; nutlets compressed-flat, densely pubescent or nearly glabrous.
- 6) Cotyls. accumbent and folded irregularly, green.
- 7) Lf. 3–5-lobed with blunt apices; lobes usu. remotely and obtusely dentate with entire margin; petiole $2/3$ – $3/2$ as long as blade.

8) Wood. a) Ray smw. irregular-fusiform, usu. attaining 4 cells wide, 800–1200 μ high according to specimens. b) Crystals few to rather few. c) Starch-storing fibers rich. d) Latex present in young tissue.

9) *A. miaotense* Tsoong in China (Shensi); *A. miyabei* Maxim. in Japan; *A. campestre* L. in C. to S. Europe to Caucasus.

Pax (1902) arranged 10 species in his Sect. *Campestris*. His system was almost followed by Rehder (1927: 1949). Pojarkova (1933) made a combination of Sect. *Platanoidea* Ser. *Campestris* (Pax) Pojark. and included in the series only two species, *A. campestre* and *A. miyabei*, the latter of which the former two authors referred to Sect. *Platanoidea*.

It admits of no doubt that *A. campestre* and *A. miyabei* are closely related, forming

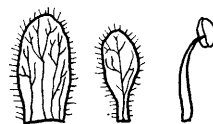


Fig. 21. The sepal, petal and stamen of *A. miyabei* ($\times 3.5$).

a natural group. They are remarkably characterized by the fruits with the horizontally spreading wings and the leaves with the entire margin and unpointed lobes.

A. miaotense Tsoong which was recently found in N.E. China is considered to belong to this section. I have seen no specimen of this species, but according to the original description, it shows the affinity with *A. miyabei* and has the characteristics mentioned above in the fruits and leaves. The locality of this species has an important meaning of the stepping stone connecting the far remote distribution of the former two species.

Sect. *Campestris* accords with Sect. *Platanoidea* in many important characters. Therefore it may be preferable to distinguish them in the relation of series under the same section. But they are fairly different in the ray type. The ray of the former section is narrower than that of the latter. Considering also the marked characteristic of the fruits and leaves of the former, these sections may be regarded as somewhat isolated from each other phylogenetically.

Sect. Pubescentia (Pojark.) Ogata, stat. nov.

Acer Sect. *Platanoidea* Ser. *Pubescentia* Pojarkova (1933: 236, 307; 1949: 594, excl. *A. piloso* Maxim.).

Acer Sect. *Campestris* Pax—Pax (1886: 219; 1902: 54), pro parte—Schneider (1907: 229, in adnota), pro parte.

Acer Sect. *Platanoidea* auct. non Pax, Rehder (1922: 216)—Fang (193: 139; 1939: 21), ad *A. stenolobum* Rehd. tantum.

Acer Subgen. *Acer* Sect. *Platanoidea* (Pax) Momotani Ser. *Pubescentia* (Pojark.) Momotani (1962b: 185).

- 1) Andromonoecious.
- 2) Bud with 5–8 pairs of imbricate scales.
- 3) Infl. loose-fl. (ca. 9–15-fl.) panicle from terminal and lateral buds with a few pairs of lvs.
- 4) Fl. a) Perianth: seps. 5; pets. 5. b) Sts. 5, more or less exserted, inserted upon disc¹⁾.
- 5) Fr.: nutlets flat, thin hairy or glabrous.
- 6) Cotyls. unknown.
- 7) Lf. 3-lobed, the margin entire or obtusely and shallowly serrate, or smt. dentate.
- 8) Wood unknown.
- 9) *A. pubescens* Franch. in C. Asia (Pamir Pl.); *A. regelii* Pax in C. Asia (Pamir Pl.; Afganistan); *A. stenolobum* Rehd. in N.E. China (Shansi).

The species of this section are remarkably characterized by having five stamens. Pojarkova (1933: 307) established a new series, Ser. *Pubescentia*, in Sect. *Platanoidea* and included in it *A. pubescens*, *A. regelii* and *A. fedtschenkoanum* Krysh., the former two of which Pax referred to Sect. *Campestris*. Subsequently, she (1949: 594) added three more species, *A. pilosum* Maxim., *A. isolobum* Kurz and *A. pentapomicum* Stew.²⁾ to this series, while she regarded *A. fedtschenkoanum* as a synonym of *A. pubescens*.

Rehder (1922: 216) published *A. stenolobum* and placed it in Sect. *Platanoidea*, but



Fig. 22. *A. stenolobum* ($\times \frac{2}{3}$).

stated that it differs from the other species of the section not only in the shape of leaves but also in the five exserted stamens, the puberulous ovary and the longer style.

I propose the raise of Pojarkova's series to an independent section, Sect. *Pubescentia*, and arrange *A. pubescens*, *A. regelii* and *A. stenolobum* in it. It obviously differs at least from Sect. *Platanoidea* sensu Pax (=sensu Ogata) in the leaves without pointed teeth, and in this sense it may be rather near to Sect. *Campestris*. But the eight stamens of Sect. *Campestris* as well as Sect. *Platanoidea* are considered fairly constant, and moreover, throughout Gen. *Acer*, the stamen number of andromonoecious species is usually not less than eight. From these respects, that the species of the present section have usually five stamens is a very remarkable fact. It can be enough said that this section has considerably differentiated now from Sect. *Platanoidea* or Sect. *Campestris*, even if it was derived from either of the two.

Of the other three species which Pojarkova mentioned, *A. pilosum* is questioned in the real existence (cf. Sect. *Lithocarpa*), *A. pentapomicum* referred to Sect. *Syriaca* and *A. isolobum* unknown to me.

Note: 1) I have seen no flower specimen of this section. The two flowers illustrated by Pojarkova separately in 1933 (p. 310, Fig. 17) and 1949 (p. 581, Table 31, 3) respectively under the name of *A. fedtschenkoanum* and *A. pubescens* show the different number of tepals; the former is distinctly five-merous in the sepals and petals, while the latter four-merous.

She made no mention of the tepal number in the description. On the flower of *A. stenolobum*, Rehder (1922: 216) described that sepals are five, and Fang (1939: 21) also that sepals and petals are five respectively.

- 2) Pojarkova, in her system of 1933, referred *A. pilosum* and *A. isolobum* to Sect. *Trilobata* Pojark. and *A. pentapomicum* to Sect. *Microcarpa* Pojark. Ser. *Sinensia* Pojark.

Sect. *Acer*.

Acer Sect. *Spicata* Pax—Pax (1886: 182; 1902: 8), pro parte—Schneider (1902: 196), pro parte—Rehder (1905: 179; 1940: 574), pro parte.

Acer Group *Spicata* (Pax)—Rehder (1927: 566), pro parte.

Acer Sect. *Gemmata* Pojarkova (1933: 236, 312; 1949: 597).

Acer Sect. *Acer* Ser. *Spicata* (Pax) Rehder (1949: 418), pro parte.

Acer Subgen. *Acer* Sect. *Acer*—Momotani (1962b: 184).

- 1) Andromonoecious.
- 2) Bud with 5–8 pairs of imbricate scales.
- 3) Infl. elongated or broad panicle from terminal and lateral buds with a few pairs of lvs.
- 4) Fl. a) Perianth greenish yellow; seps. 5, pets. 5. b) Sts. usu. 8–10, exserted; fls. hairy or glabrous. c) Disc thick, roundish with sts. inserted at the inside. d) Pistil: style fairly long and erect with divergent and recurved stigmas; abortive pistil in ♂ distinct.
- 5) Fr. big; nutlets strongly convex.
- 6) Cotyls. incumbent and circinate perpendicularly.
- 7) Lf. 5-lobed, coarsely and smw. obtusely serrate or dentate; petiole usu. 1/2–3/2 as long as blade.
- 8) Wood (Ser. *Acer*). a) Ray smooth-fusiform, usu. attaining 6–8 cells wide, 900–1000 μ high according to specimens, and at max. 9–10 cells wide, 1200–1400 μ high. b) Crystals not found.

- 9) Composed of Ser. *Acer* and Ser. *Velutina* (Pojark.) Ogata.

Pojarkova (1933) separated 5 species including *A. pseudoplatanus* from Pax's Sect. *Spicata* and established a new section, Sect. *Gemmata*, for them. She divided it into 3 series, Ser. *Velutina*, Ser. *Pseudoplatani* and Ser. *Trautvetteriana* mainly based on the character of the inflorescences. It is obvious that this section is isolated from Sect. *Spicata*, judging from the number of bud-scales, the big fruits with convex nutlets, the folding manner of cotyledons and the ray type (but I have not seen the woods of Ser. *Velutina* and *Trautvetteriana* sensu Pojarkova).

Momotani (1962b) changed Pojarkova's section name *Gemmata* to *Acer* on the ground of that the type species of Gen. *Acer*, *A. pseudoplatanus*, belongs to it and at the same time united Pojarkova's Ser. *Velutina* and Ser. *Trautvetteriana* into Ser. *Velutina* sensu Momotani. Thus, Sect. *Acer* in Momotani's system consists of 2 series, Ser. *Acer* which accords with Pojarkova's Ser. *Pseudoplatani* and is represented by only one species, *A. pseudoplatanus*, and Ser. *Velutina* which includes the other 4 species. I have not enough knowledge about the species of Ser. *Velutina* sensu Momotani. Here, I follow Momotani,

but I think that it may be necessary to transfer the series into other sections, when the species of the series are more fully examined.

Ser. Acer.

Acer Sect. *Gemmata* Pojarkova Ser. *Pseudoplatani* Pojarkova (1933: 236, 312; 1949: 598).

Acer Subgen. *Acer* Sect. *Acer* Ser. *Acer*—Momotani (1962b: 184).

The inflorescence of this series is an elongated panicle with about 50 flowers. The filaments of stamens are hairy. The only one species, *A. pseudoplatanus* L., is widely distributed in the European Continent.

Ser. Velutina (Pojark.) Ogata.

Acer Sect. *Gemmata* Pojarkova Ser. *Velutina* Pojarkova (1933: 236, 312; 1949: 597).

Acer Sect. *Gemmata* Ser. *Trautvetteriana* Pojarkova (1933: 236, 312, ut Ser. *Trautvetteriana*; 1949: 598).

Acer Subgen. *Acer* Sect. *Acer* Ser. *Velutina* (Pojark.) Momotani (1962b: 184).

The inflorescence of this series is a broad panicle¹⁾. The filaments are glabrous. *A. velutinum* Boiss. is found in Caucasus to Elburz, *A. caesium* Wall. ex Brandis in Himalaya (Kashimir to Nepal), *A. trautvetteri* Medw. in Caucasus, and *A. herdreichii* Orph. ex Boiss. in S.E. Europe to Caucasus.

Note: 1) The inflorescence of Ser. *Velutina* sensu Pojarkova (composed of *A. velutinum* and *A. caesium*) is big, producing many fruits up to 60, and hairy, while that of Ser. *Trautvetteriana* (including the remaining 2 species) is rather small and glabrous.

Sect. Goniocarpa Pojarkova (1933: 347), pro major. part.

Acer Sect. *Campestris* Pax—Pax (1886: 219; 1902: 54), pro parte—Schneider (1907: 229), pro parte—Rehder (1940: 571), pro parte.

Acer Group *Campestris* (Pax)—Rehder (1927: 563), pro parte.

Acer Sect. *Acer* Ser. *Campestris* (Pax) Rehder (1949: 415), pro parte.

Acer Subgen. *Acer* Sect. *Platanoidea* (Pax) Momotani Ser. *Monspessulana* (Pojark.) Momotani (1962b: 185), pro major. part.

1) Andromonoecious.

2) Bud with 5–8 pairs of imbricate scales.

3) Infl. loose-fl. (ca. 5–30-fl.) short-stalked or subsessile fascicled-panicle from terminal and lateral buds with a few pairs of lvs.

4) Fl. a) Perianth pale greenish yellow; seps. 5, longer than seps. b) Sts. 8–10, smt. more, exserted; anths. smw. scabrous. c) Disc well developed with sts. inserted at the inside. d) Pistil: style short; stigmas divergent outside; abortive pistil distinct.

5) Fr. small; nutlets keeled-convex.

6) Cotyls. incumbent, circinate perpendicularly.

7) Lf. 3–5-lobed, the margin entire, or obtusely and coarsely serrate or dentate; petiole 1/2–3/2 as long as blade.

8) Wood. a) Ray smooth-fusiform, usu. attaining 6 cells wide, 400–900 μ high according to specimens, and at max. 8 cells wide, 1100 μ high. b) Crystals few to rather few.

9) Composed of 2 series, Ser. *Opulifolia* Pojark. and Ser. *Monspessulana* Pojark.

Pojarkova (1933: 347) separated Sect. *Goniocarpa* Pojark. from Pax's Sect. *Campestris* and placed in it 2 series, Ser. *Opulifolia* Pojark. and Ser. *Monspessulana* Pojark., while she made a combination Sect. *Platanoidea* Ser. *Campestris* (Pax) Pojark. But Momotani (1962b: 185) reduced just Pojarkova's Sect. *Goniocarpa* to series, Ser. *Monspessulana* (Pojark.) Momotani, referring it also to Sect. *Platanoidea*, with Ser. *Campestris* (cf. p. 134, Table 7).

I do not agree with Momotani, because Sect. *Goniocarpa* is clearly isolated from Sect. *Platanoidea* as well as from Sect. *Campestris* in the keeled-convex nutlets, the folding manner of cotyledons, the lacking in latex in the young tissue (Warsow, 1903), and the smooth and broader ray. This section is probably in a near relationship to Sect. *Saccharina* and Sect. *Acer*. These 3 sections are common in many essential characters and especially much resemble one another in the shape of multiseriate rays which are fairly big and elongated-fusiform with very smooth margin. Pojarkova (1933: 271) considered, in her scheme showing the phylogenetic relation among the series of Gen. *Acer* (cf. App. 2), that Sect. *Goniocarpa* and Sect. *Saccharina* were derived from the same stock.

The species of this section are distributed from the Mediterranean region, through Asia Minor and Caucasus, to Turkmen and Iran. Ser. *Opulifolia* and Ser. *Monspessulana* are distinguished mainly by the leaves and inflorescences.

Ser. *Opulifolia* Pojarkova (1933: 347; 1949: 613).

In the species of this series, the leaves are generally large, 5-lobed, and remotely and obtusely dentate and serrate. The inflorescences are short-stalked and relatively many-flowered, with about 10–30 flowers.

The following species are discerned: *A. opalus* Mill. in S. Europe, *A. hispanicum* Pourr. in the Iberian Pen.; *A. obtusatum* Waldst. et Kit. ex Willd. in Italy, the Balkan Pen. and Algeria; *A. tauricolum* Boiss. et Bal. in Asia Minor; *A. hyrcanum* Fish. et Mey. in Asia Minor, Caucasus and Armenia; *A. stevenii* Pojark. in the Crimean Pen.

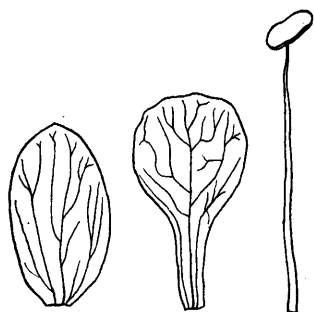


Fig. 23. The sepal, petal and stamen of *A. opalus* (♂, $\times 3.5$).

Ser. *Monspessulana* Pojark. (1933: 355, pro parte; 1949: 615).

The leaves are generally small, 3-lobed and entire or sometimes remotely and obtusely serrate in the upper part, and the inflorescences are subsessile and fewer in the number of flowers (ca. 5–15).

The following species are included in this series: *A. monspessulanum* L. widely in

the Mediterranean region; *A. cinerascens* Boiss. in Iran; *A. assyriacum* Pojark. in Syria and Iraq; *A. turkomanicum* Pojark. in Turkmen.

I would propose a new section, Sect. *Syriaca*, for *A. syriacum* Boiss. et Gaill., *A. orientale* L. and probably *A. persicum* Pojark., which Pojarkova included in the present series.

Sect. *Saccharina* Pax (1885: 328, sub *Perigynis*; 1886: 241; 1893: 272; 1902: 73)—Schneider (1907: 241)—Pojarkova (1933: 240)—Rehder (1940: 572).

Acer Subgen. *Saccharodendron* Rafinesque (1836: 47).

Saccharodendron (Raf.) Nieuwland Sect. *Saccharina* (Pax) Nieuwland (1914: 182).

Acer Sect. *Campestris* Pax—Pax (1886: 219), ad *A. grandidentatum* Nuttall ex Torr. et Gray tantum.

Acer Group *Saccharina* (Pax)—Rehder (1927: 565).

Acer Sect. *Acer* Ser. *Saccharina* (Pax) Rehder (1949: 417), ut Ser. *Saccharina*.

Acer Subgen. *Acer* Sect. *Saccharina* (Pax) Momotani (1962b: 187).

- 1) Andromonoecious.
- 2) Bud with 5–8 pairs of imbricate scales.
- 3) Infl. loose-flid. (7–15-flid.) fascicled panicle with very slender pedicels, from terminal and lateral buds with a few pairs of lvs., almost at the same time with lvs.
- 4) Fl. a) Perianth connate and campanulate, usu. several-lobed at the upper part. b) Sts. usu. 8, smt. 7 or 9, exserted; anths. nearly smooth. c) Disc thick and roundish, with sts. inserted at the inside. d) Pistil: stigmas nearly sessile, recurved outside; abortive pistil small but distinct.

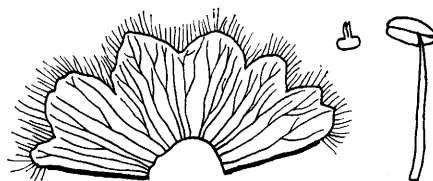


Fig. 24. The perianth, abortive pistil and stamen of *A. saccharum* (♂, $\times 3.5$).

- 5) Fr. glabrous; nutlets strongly convex, spreading horizontally; wings more or less upright.
- 6) Cotyls. incumbent, circinate perpendicularly.
- 7) Lf. 3–5-lobed, the lobes acuminate with smw. blunt apices and sinuate or coarsely dentate with the entire margin; petiole usu. $1/2$ –1 as long as blade.
- 8) Wood. a) Ray smooth, fairly big fusiform, usu. attaining 6–8 cells wide, 900–1000 μ high, and at max. 8–10 cells wide, 1100–1400 μ high according to specimens. b) Crystals smt. found according to specimens.
- 9) The following species endemic to the Atlantic N. America: *A. saccharum* Marsh.; *A. grandidentatum* Nuttall ex Torr. et Gray; *A. barbatum* Michx.; *A. nigrum* Michx. f.; *A. leucoderme* Small.

Since Pax, Sect. *Saccharina* Pax has been accepted without any essential alteration. The species included in this section are closely related to and distinguished from one another mainly in the lobulation or dentation and hairiness of the leaves, the size and wing-angle of the fruits, the length of the peduncle (whether short or sessile), and the appearance of the bark. But the distinction among species is not always sharp with

the gradation from one to other species, and some authors regarded them in the relation of varieties.

In the description of the flowers, all the authors exclusively mentioned that sepals are connate and petals wanting. Hall (1951: 796) said also, on the basis of the floral anatomy of *A. saccharum*, "there are no petals nor vestiges of petal traces". Gathering from the context, he seems to consider it as the result of the reduction of petals.

On this problem, I have a different opinion. Petals are not wanting but united with sepals, forming together a campanulate perianth. Taking a survey of the whole Gen. *Acer*, petals are usually much reduced in the male flowers of Sect. *Rubra* and Sect. *Indivisa*, and completely wanting in the flowers of Sect. *Negundo*. In these flowers, the reduction occurs not only in petals but also in other elements of flowers, and moreover the traces of reduction are often left. The sexuality of these flowers differentiates into androdioecism or dioecism. On the contrary, the flowers of Sect. *Saccharina* show no tendency of such reduction as a whole, and the sexuality is andromonoecious. I think it is difficult to consider that only petals are completely reduced leaving no traces at all.

Sect. *Integrifolia* Pax (1885: 327, sub *Extrastaminalibus*; 1886: 207; 1893: 271; 1902: 31), pro parte—Rehder (1905: 179), pro parte—Schneider (1907: 213), pro parte—Koidzumi (1911a: 55), sub *Extrastaminalibus*—Fang (1934: 141; 1939: 132), pro parte.

Acer Sect. *Spicata* Pax—Pax (1886: 182; 1902: 8), pro parte—Rehder (1905: 179; 1940: 574), pro parte—Schneider (1907: 196), pro parte—Koidzumi (1911a: 28), sub *Extrastaminalibus*, ad *A. trifidum* Hook. et Arn. (= *A. buergerianum* Miq.) tantum—Fang (1934: 140; 1939: 73), pro parte.

Acer Group *Integrifolia* (Pax)—Rehder (1927: 571), pro parte.

Acer Group *Spicata* (Pax)—Rehder (1927: 566), pro parte.

Acer Sect. *Integrifolia* Ser. *Trinervium* Metcalf (1932: 194), pro parte.

Acer Sect. *Integrifolia* Ser. *Penninervium* Metcalf (1932: 202), ad *A. sinooblongum* Metcalf tantum.

Acer Sect. *Integrifolia* Ser. *Oblonga* Pojarkova (1933: 238) nom. nud., pro parte.

Acer Sect. *Trilobata* Pojarkova Ser. *Trifida* Pojarkova (1933: 238, 324), pro parte.

Acer Sect. *Integrifolia* Subsect. *Oblongae* Hu et Cheng (1948: 200), pro parte.

Acer Sect. *Acer* Ser. *Integrifolia* (Pax) Rehder (1949: 418), pro parte.

Acer Sect. *Acer* Ser. *Spicata* (Pax) Rehder (1949: 418), pro parte.

Acer Subgen. *Acer* Sect. *Integrifolia* (Pax) Momotani Ser. *Integrifolia*—Momotani (1962b: 185), pro parte.

Acer Subgen. *Acer* Sect. *Integrifolia* Ser. *Trifida* (Pojarkova) Momotani (1962b: 186).

1) Andromonoecious.

2) Bud with 9–13 pairs of imbricate scales.

3) Infl. dense-fl. (usu. 50–100-fl.) broad panicle from terminal and lateral buds with 2, 3 or more pairs of lvs., hairy; bract and bracteole fairly common.

4) Fl. small. a) Perianth whitish yellow; seps. 5, short in comparison with pets.;

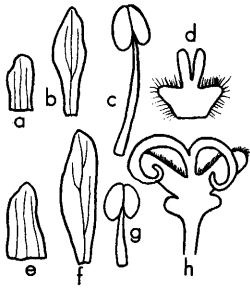


Fig. 25. *A. buergerianum*. a~d: ♂ ($\times 7$); e~h: ♀ (e~f: $\times 7$; h: $\times 3.5$). a~e: sepal; b~f: petal; c~g: stamen; d~h: pistil.

8) Wood. a) Ray short and smooth-fusiform, usu. attaining 4 cells wide, 300–350 μ high, and at max. 5 cells wide, 400–450 μ high. b) Crystals rather rich. c) Starch-storing fibers not very much.

9) *A. oblongum* Wall. ex De Candolle and its near allies found in Himalaya, S. China, Indo-China, Formosa and Loochoo, *A. buergerianum* Miq. in E. China and Formosa, and *A. paxii* Franch. in S. China.

Since Pax (1885), those species which have oblong and entire leaves have been all considered as belonging to this section. Rehder, Pojarkova and Momotani also did so. But only Bloembergen (1948: 3–4) regarded *A. laurinum* Hassk. as not belonging to Sect. *Integrifolia* but possibly related to Sect. *Lithocarpa*, because of its axillary leafless inflorescences (cf. Sect. *Laurina*).

Merrill (1932: 47–48) described *A. decandrum* Merrill under Sect. *Integrifolia*, but mentioned, “rather unusual in the number of its stamens.”

Hu et Cheng (1948) proposed Sect. *Integrifolia* Subsect. *Decandrae* which included

pets. 5. b) Sts. usu. 8, smt. 7, 9 or 10, exserted; anths. smw. scabrous. c) Disc thick and roundish with sts. inserted at the inside. d) Pistil: ovary hairy; stigmas recurved outside on long and erect style; abortive pistil well developed, showing vestiges of a style and stigmas.

5) Fr. hairy when young, becoming glabrous later; nutlets keeled-convex.

6) Cotyls. incumbent, circinate perpendicularly.

7) Lf. undivided and oblong, or 3-lobed, entire or slightly serrate, deciduous or evergreen, usu. glaucous beneath; the length of petiole variable (ca. 1/7–1/2 as long as blade in *A. oblongum* and 1/3–1 in *A. buergerianum*).

Table 8. The important characters of Sect. *Integrifolia*, Sect. *Palmata* Ser. *Laevigata*, Sect. *Laurina* and Sect. *Decandra*.

	Integrifolia	Palmata Ser. Laevigata	Laurina	Decandra
Sexuality	Andromonoecious		Androdioecious	
Bud-scales	9–13–paired	4–paired	7–11–paired	ca. 9–paired
Inflorescence	Dense-flowered broad panicle	Loose-flowered panicle	Dense-flowered panicle	Raceme
	From terminal and lateral buds with 2–3 pairs of leaves		From lateral buds without leaves	
Stamens	8 (7–10)	8 (7, 9)	6 (4–8)	10–12
Nutlets	Keeled-convex	Round-convex		
Cotyledons	Circinate perpendicularly	Circinate horizontally		

A. decandrum, *A. machilifolium* Hu et Cheng and *A. longicarpum* Hu et Cheng.

Metcalf (1932), who recognized 15 species in Southern China under Sect. *Integrifolia*, divided the section into Ser. *Trinervium* Metcalf and Ser. *Penninervium* Metcalf, but the division was very artificial only based on that the leaves are 3-nerved or penninerved at the base. Therefore, for instance, *A. cordatum* and *A. laevigatum* which are considered closely related to each other were put into different series.

In my conception, the species of Gen. *Acer* with oblong and entire leaves should be distributed into Sect. *Integrifolia*, Sect. *Palmata* Ser. *Laevigata*, Sect. *Laurina* and Sect. *Decandra*. The important characters of these sections are compared in Table 8.

Thus, of the species with oblong and entire leaves, only *A. oblongum* and its allies¹⁾ remain now in Sect. *Integrifolia*. I would indicate that though many species has been so far described under Sect. *Integrifolia*, most of the description was very incomplete on the above mentioned characteristics.

Pojarkova (1933) separated *A. buergerianum* and the related species from Sect. *Spicata* and established for them Ser. *Trifida* Pojark. which she put in Sect. *Trilobata* Pojark. with another series, Ser. *Tatarica* Pojark. Momotani (1962b) made a combination Sect. *Integrifolia* Ser. *Trifida* (Pojark.) Momotani. I agree with him on this change, but I think there is no need to distinguish Ser. *Trifida* in Sect. *Integrifolia*, because the difference of the species of Ser. *Trifida* from *A. oblongum* and its allies (Ser. *Integrifolia* sensu Momotani) lies only in that the leaves of the former are 3-lobed and those of the latter not divided. And moreover the leaves of the former are sometimes not lobed while those of the latter are often 3-lobed in the vigorous shoots or in the young stage. I found also that the woods of *A. buergerianum* and *A. oblongum* are alike in their ray types and the distribution of crystals.

Under Sect. *Integrifolia* Ser. *Oblongae* Hu et Cheng, Hu et Cheng (1948) described the following new species: *A. amoenum*, *A. hilaense*, *A. kuikiangense* and *A. kwangnanense*. To ascertain their proper position in Gen. *Acer*, however, further investigation may be necessary.

Note: 1) *A. oblongum* in a wide sense is considerably variable mainly in the shape, nervation and hairiness of the leaves and the shape and size of the fruits, and to each of the variations the following different names were given: *A. coriaceifolium* Lév., *A. hypoleucum* Hayata, *A. itoanum* Hayata, *A. litseaefolium* Hayata, *A. albopurpurascens* Hayata, *A. cinnamomifolium* Hayata, *A. lucidum* Metcalf, *A. sinooblongum* Metcalf and *A. sycopseoides* Chun.

Sect. *Syriaca* Ogata, nom. provis.

Acer Sect. *Campestris* Pax—Pax (1886: 219; 1902: 54), pro parte—Schneider (1907: 229), pro parte—Rehder (1940: 571), pro parte.

Acer Sect. *Spicata* Pax—Pax (1902: 8), ad *A. pentapomicum* ex Brandis tantum.

Acer Group *Campestris* (Pax)—Rehder (1927: 563), pro parte.

Acer Sect. *Goniocarpa* Pojarkova Ser. *Monspessulana* Pojarkova (1933: 240, 355), pro parte.

Acer Sect. *Microcarpa* Pojarkova Ser. *Sinensia* Pojarkova (1933: 236, 339), ad *A. pentapomicum* Stew. tantum.

Acer Sect. *Acer* Ser. *Campestris* (Pax) Rehder (1949: 415), pro parte.

Acer Sect. *Platanoidea* Pax Ser. *Pubescentia* Pojarkova—Pojarkova (1949: 594), ad *A. pentapomicum* Stew. ex Brandis tantum.

Acer Subgen. *Acer* Sect. *Platanoidea* (Pax) Momotani Ser. *Monspessulana* (Pojark.) Momotani (1962b: 185), pro parte.

- 1) Andromonoecious.
- 2) Bud with 9–13 pairs of imbricate scales.
- 3) Infl. ca. 15-fl. small panicle from terminal and lateral buds with a few pairs of lvs.
- 4) Fl. unknown.
- 5) Fr. small; nutlets keeled-convex.
- 6) Cotyls. incumbent, circinate perpendicularly.
- 7) Lf. 3-lobed, coarsely serrate or minutely sinuate on almost the whole margin except the base.
- 8) Wood. a) Ray short-fusiform, usu. attaining 5 cells wide, 400μ high and at max. 6 cells wide, 650μ high. b) Crystals very rich and distributed almost evenly throughout annual rings.

9) *A. syriacum* Boiss. et Gaill. in Palestine region, *A. orientale* L. in Greece, *A. persicum* Pojark. in S. Iran and *A. pentapomicum* Stew. ex Brandis in N.W. Himalaya.

I have not yet enough knowledge of this section to publish it formally here. For the present, I would include the four species above mentioned in it. The former three species have been treated as the relatives of *A. monspessulanum* group and the remaining *A. pentapomicum* has been related to *A. sinense* group or *A. pubescens* group.

The species of the present section, however, differ from any of them at least in the number of bud-scales. The 3-lobed leaves resemble apparently those of *A. monspessulanum* group but usually serrate or minutely sinuate on almost the whole margin instead of being entire or serrate only in the upper part, and look somehow different from the latter.

Another most conspicuous thing is that the wood of *A. syriacum*, according to the only one specimen I examined, contains very abundant crystals, which are distributed almost evenly throughout annual rings. In Gen. *Acer*, crystals are relatively abundant in the wood of Sect. *Trifoliata*, Sect. *Indivisa* and Sect. *Integrifolia*. In these sections, however, crystals are usually restricted to the terminal several layers of annual rings. Therefore, it may be said that this section occupies a unique position in Gen. *Acer*, in the point of the distribution of crystals in the wood, if the fact above mentioned is ascertained in more specimens.

I guess, from the number of bud-scales and the whole impression of leaves, that this section has some relation to Sect. *Integrifolia*, rather than to *A. monspessulanum* group (Sect. *Goniocarpa* Ser. *Monspessulana*).

All the species of this section are more or less isolated geographically from one another and each occupies a relatively small area.

Sect. *Trifoliata* Pax (1885: 326, sub *Extrastaminalibus*; 1886: 203; 1893: 271; 1902:

29), pro parte—Rehder (1905: 181, pro parte; 1907: 25; 1940: 584)—Schneider (1907: 209), pro parte—Koidzumi (1911: 56), sub *Extrastaminalibus*—Fang (1934: 143; 1939: 231, excl. *A. pentaphyllo* Diels).

Acer Sect. *Negundo* (Boehm.) Maximowicz (1880: 450), ut *Acer* Sect. *Negundo* (Moench) Maxim., pro parte, excl. basonym.

Negundo auct. non Boehm., Nicholson (1881: 815), pro parte.

Acer Sect. *Coelocarpa* Pax (1885: 328; 1886: 253; 1889: 80, pro parte).

Acer Group *Trifoliata* (Pax)—Rehder (1927: 576).

Acer Sect. *Trifoliata* Ser. *Grisea* Pojarkova (1933: 240, 363).

Acer Sect. *Trifoliata* Ser. *Mandshurica* Pojarkova (1933: 240, 363, ut Ser. *Manshurica* Pojark.; 1949: 617).

Acer Sect. *Acer* Ser. *Trifoliata* (Pax) Rehder (1949: 427).

Acer Subgen. *Acer* Sect. *Trifoliata* (Pax) Momotani (1962b: 187).

- 1) Androdioecious.
- 2) Bud big; scales 11–15-paired, imbricate.
- 3) Infl. dense-fld. small (13–19-fld.) panicle, loose-fld. (5–9-fld.) raceme or not stalked, 1–3-fld. umbel, from terminal and lateral buds with usu. 1 pair, rarely 2 pairs of lvs., almost at the same time with lvs., hairy or glabrous; bract and bracteole fairly developed.
- 4) Fl. big. a) Perianth yellow or yellowish green; seps. 6; pets. 6. b) Sts. 10–14, usu. 12, exserted; anths. big, linear-oblong, smw. scabrous. c) Disc thick, roundish with sts. inserted at the inside. d) Pistil: style long; stigmas usu. upright at first and divergent later; abortive pistil in ♂ very small, usu. covered with a tuft of long hairs.
- 5) Fr. big; nutlets strongly convex with thick woody walls, hairy or glabrous.
- 6) Cotyls. incumbent, circinate perpendicularly.
- 7) Lf. 3-foliolate; lflets. oblong, coarsely serrate.

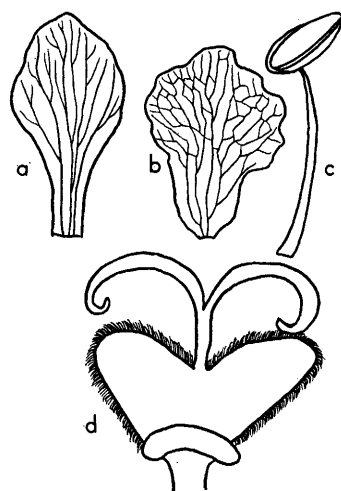


Fig. 26. *A. nikoense* ($\times 3.5$). a~c: ♂; a: sepal, b: petal, c: stamen, d: pistil of ♀.

8) Wood. a) Ray smw. irregular-fusiform, usu. attaining 4–5 cells wide, 350–800 μ high according to specimens, and at max. 6 cells wide, 1100 μ high. b) Crystals usu. rich mainly in the terminal portion of annual rings. c) Starch-storing fibers rather rich.

9) *A. sutchuense* Franch. in C. China; *A. mandshuricum* Maxim. in Manchuria and Corea; *A. griseum* (Franch.) Pax in C. China; *A. triflorum* Komarov in Manchuria and Corea; *A. nikoense* Maxim. in Japan¹⁾.

This section is different in almost all the important characters but for the leaves from the other 2 sections, Sect. *Negundo* and *Cissifolia*, which have also foliolate leaves.

Pojarkova (1933) divided this section into 2 series, Ser. *Grisea* and Ser. *Mandshurica* distinguished respectively by being hairy or glabrous in the inflores-

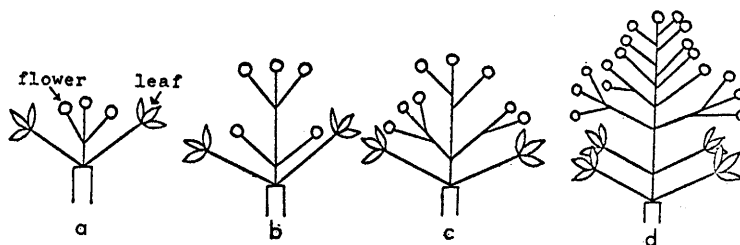


Fig. 27. Schematic figures of the inflorescence of Sect. *Trifoliata*.

cences and the nutlets of the fruits. She included *A. griseum*, *A. triflorum* and *A. nikoense* in the former series, and *A. sutchuense* and *A. mandshuricum* in the latter. But, any other essential differences between the two series are not found now, so that I have some doubts to separate them.

Among the five species, only *A. sutchuense* has dense-flowered paniculate inflorescences accompanied often with 2 pairs of leaves (Fig. 27 d). The inflorescences of the other species are fewer-flowered racemes usually with only 1 pair of leaves (Fig. 27 a~c), but in this case, the inflorescence with more than 5 flowers has 2- or 3-flowered ramifications in the lowest branches as shown in Fig. 27 c. In the inflorescence of the species but for *A. sutchuense*, the female one is composed mostly of 3 flowers, sometimes of 1, 2 or more than 3, and the male one composed mostly of 3 to 7, sometimes of less, or more up to 9. The peduncle of *A. nikoense* is usually very short, at most 5 mm long and often sessile. On the inflorescence of this section, it can be said that there is a trend of reduction in the number of flowers, the length of peduncles and the number of leaves accompanied.

The number of each element in a flower is many in this section in comparison with other sections. The stamens are 10 to 14²⁾ and usually 12. The sepals and the petals are usually 6 respectively.

The five wood specimens of *A. nikoense* and some small twig specimens of *A. sutchuense* and *A. griseum*, which I examined, contained all likewise rich crystals and the amount was much next to that of *A. syriacum* among all the species examined of Gen. *Acer*. Yamabayashi (1938: 191, 193) mentioned that crystals are often or sometimes found in the woods of *A. mandshuricum* and *A. triflorum*. According to Yamauchi (1962: 9), however, the crystals in the wood of *A. nikoense* are very rare. Further study may be necessary to decide that rich crystals in the wood are a constant character of this section.

Note: 1) Pojarkova (1933: 363) mentioned the name *A. (Ser. Grisea) megalocarpum* Rehd. and its locality Himalaya. Rehder (1911: 98) reported *A. nikoense* var. *megalocarpum* Rehd. not from Himalaya but from C. China. I do not know the source of the name and the locality of the species cited by Pojarkova.

2) Fang (1939: 233) wrote in the description of *A. sutchuense* that stamens are 12 to 16.

Sect. *Lithocarpa* Pax (1885: 328, sub *Perigynis*; 1886: 249; 1893: 272; 1902: 170), pro parte—Rehder (1905: 181; 1940: 583), excl. *A. piloso* Maxim.—Schneider (1907: 240),

excl. *A. piloso* Maxim.—Fang (1934: 143; 1939: 224), excl. *A. piloso* Maxim.

Acer Sect. *Saccharina* auct. non Pax, Koehne (1893: 382), ad *A. diabolicum* Bl. tantum.

Acer Sect. *Diabolica* Koidzumi (1911: 64), sub *Extrastaminalibus*.

Acer Group *Lithocarpa* (Pax)—Rehder (1927: 575), excl. *A. piloso* Maxim.

Acer Sect. *Lithocarpa* Ser. *Villosa* Pojarkova (1933: 236), nom. nud.

Acer Sect. *Acer* Ser. *Lithocarpa* (Pax) Rehder (1949: 426), excl. *A. piloso* Maxim.

Acer Subgen. *Acer* Sect. *Lithocarpa* (Pax) Momotani Ser. *Lithocarpa* Momotani (1962b: 187), excl. *A. piloso* Maxim.

Acer Subgen. *Acer* Sect. *Lithocarpa* Ser. *Diabolica* (Koidz.) Momotani (1962b: 187).

- 1) Dioecious, lacking sts. in ♀ fl.
- 2) Bud with 8-12 pairs of imbricate scales.
- 3) Infl. usu. 5-11-fl. raceme smt. with 2- or more-fl. ramifications in the lower part¹⁾ from lateral buds without lvs., smw. before lvs.; bract and bracteole fairly common.

4) Fl. big. a) Perianth usu. separate, but connate in ♂ of *A. diabolicum*; seps. usu. 5, smt. 4; pets. usu. 5, smt. 4. b) Sts. usu. 8, smt. 7, 9 or 10, exserted in ♂, lacking in ♀; anths. smooth. c) Disc thin, flat, with sts. inserted upon it. d) Pistil: ovary usu. thick hairy²⁾; style short or very short; stigmas divergent outside; abortive pistil in ♂ much reduced to a very small tuft of hairs.

5) Fr. big; nutlets keeled-convex and covered with stiff hairs, but elliptic-convex and glabrous only in *A. thomsonii*.

6) Cotyls. incumbent and circinate perpendicularly.

7) Lf. 3- or 5-lobed and coarsely serrate, but 3-lobed or undivided with entire margin in *A. thomsonii*.

8) Wood. a) Ray irregular-fusiform usu. attaining 8 cells wide, 400-900 μ high according to specimens, and at max. 9 cells wide, 1200 μ high. b) Crystals not found. c) Starch-storing fibers rather rich. d) Latex present in young tissue.

9) *A. thomsonii* Miq. in E. Himalaya; *A. villosum* Wall. in W. to C. Himalaya; *A. franchetii* Pax in C. China; *A. schoenermarkiae* Pax in S. China³⁾; *A. sinopurpurascens* Cheng in E. China; *A. diabolicum* Bl. in Japan.

Sect. *Arguta* Rehder (1905) and then Sect. *Diabolica* Koidzumi (1911) were

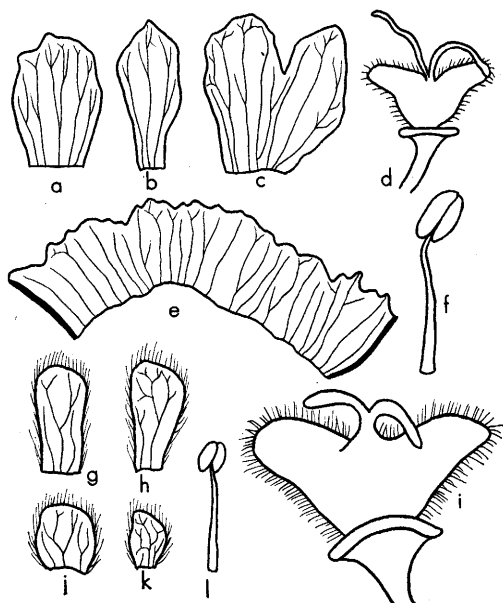


Fig. 28. *A. diabolicum* (a~d: ♀; e~f: ♂) and *A. franchetii* (g~i: ♀; j~l: ♂). a~g~j: sepal; b~h~k: petal; f~l: stamen; c~e: connate perianth; d~i: pistil. ($\times 3.5$, except d $\times 2$).

isolated from Sect. *Lithocarpa* Pax. The first section has been accepted thereafter. Koidzumi put Sect. *Diabolica*, which was represented only by *A. diabolicum*, under his large group *Extrastaminalia* and Sect. *Lithocarpa* sensu Rehder under his another large group *Intrastaminalia*. But he was clearly incorrect, because the latter section whose stamens are inserted upon the disc should be placed in the *Extrastaminalia*. Momotani (1962b) made a combination, Sect. *Lithocarpa* Ser. *Diabolica* (Koidz.) Momotani and distinguished it from the typical series in having the connate perianth in the male flowers. But it is a question, at least in the case of this section, whether a series should be distinguished only by that the perianth is connate or not. There is no doubt that *A. diabolicum* is an immediate relative of most of Ser. *Lithocarpa* sensu Momotani.

Among the species of this section, *A. thomsonii* is considered somewhat apart phylogenetically from the others, rather than *A. diabolicum*. Though the species of Sect. *Lithocarpa* are generally characterized by the 3- to 5-lobed, more or less hairy and coarsely serrate leaves and the nutlets of fruits covered with stiff hairs, only *A. thomsonii* has the shallowly 3-lobed or sometimes undivided, glabrous or nearly so and far less serrate or almost entire leaves and the quite glabrous fruits.

Rehder's opinion (1905: 181) that *A. pilosum* Maxim. may be placed, judging from the Maximowicz's original figure, in Sect. *Lithocarpa* instead of Sect. *Spicata*, to which it has been referred by Pax, was followed by Schneider (1907), Fang (1939) and Momotani (1962b). The species was included in Sect. *Trilobata* Ser. *Trifida* by Pojarkova in 1933 and in Sect. *Platanoidea* Ser. *Pubescentia* by the same author in 1949. The specimen of this species at least provided with flowers or/and fruits⁴⁾ seems to be only once collected so far in Prov. Kansu, China by Piasezky in 1875, on which Maximowicz's description and figure (1880: 436; 1882: 560, Tab. 27) were based. I question the actual existence of the species. According to the original figure, the male and female inflorescences emanate from different axillary leafless buds in the same branch. But in all the species of Gen. *Acer*, such inflorescence type is never found. The species of the axillary leafless inflorescence type are always dioecious or androdioecious, and in the andromonoecious species the male and female flowers are generally produced on the same inflorescence which emanates from terminal and lateral buds and is accompanied with 1-3 pairs of leaves. The characteristically 3-lobed leaves are extremely similar to those of *A. (Sect. Pubescentia) stenolobum* (cf. Fig. 22 & 29), while the convex fruits covered

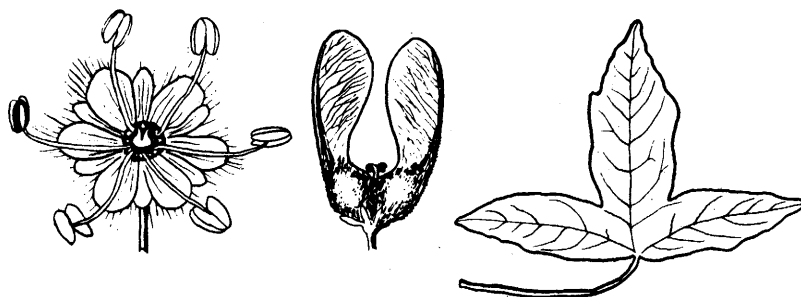


Fig. 29. *A. pilosum*. (Maximowicz, 1882).

with thick hairs are like those of Sect. *Lithocarpa*, differing those of *A. stenolobum* which are flat and almost glabrous. It is also strange, according to the figure, that the flowers are 6-merous in sepals, petals and stamens, and the fruits grow considerably big while male flowers bloom in the same twig. Thus, I guess that *A. pilosum* might be artificially made up probably from *A. stenolobum* and a species of Sect. *Lithocarpa*.

As above mentioned, the perianth in the staminate flowers of *A. diabolicum* is connate and campanulate. In this case, it is often described that sepals are connate and petals wanting (e.g. Rehder, 1940: 583). But the campanulate perianth is really made by the adnation of both sepals and petals. The fact is proved by the relatively numerous lobulation and nervation in the perianth (Fig. 28 e), and moreover it is difficult to think that the petals are wanting only in *A. diabolicum* among the species of Sect. *Lithocarpa*. The perianth is sometimes divided partly to the base. The perianth in the female flowers of this species is also sometimes connate (Fig. 28 c).

Such a differentiation seen in the perianth of male flowers of *A. diabolicum* is accompanied with the reduction of the peduncle and axis of the inflorescence, which is fascicled raceme.

Koehne (1893) placed *A. diabolicum* in Sect. *Saccharina* under the reason of having the connate perianth. Koidzumi (1911b: 60) referred to the relation between Sect. *Diabolica* and Sect. *Saccharina*, and mentioned that the latter is somewhat apart phylogenetically from the former in not having latex in the young tissue. Momotani (1962b) placed Sect. *Lithocarpa* just before Sect. *Saccharina*. In my conception, Sect. *Lithocarpa* and Sect. *Saccharina* are remotely related phylogenetically from the viewpoint of the

sexuality, the number of bud-scales, the inflorescence type, the shape of fruits, the ray type and the existence or absence of latex.

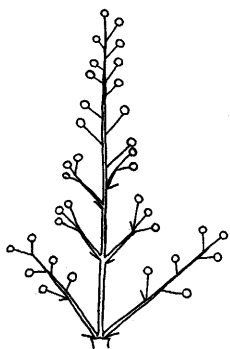


Fig. 30. A male inflorescence of *A. villosum*.

- Note: 1) But, I saw a male inflorescence of one specimen of *A. villosum* which had very many flowers and stout branches in the lower part (Fig. 30).
 2) But, I have not examined the flowers of *A. thomsonii* whose fruits are glabrous.
 3) Fang (1939: 226) regarded *A. schoenermarkiae* as a synonym of *A. franchetii*.
 4) According to Fang (1939: 225), only the seeds of *A. pilosum* were collected near the same locality of the type specimen by Purdom and the plants from them were raised at The Arnold Arboretum.

Sect. *Macrophylla* (Pojark.) Ogata, stat. nov.

Acer Sect. *Lithocarpa* Pax Ser. *Macrophylla* Pojarkova (1933: 236), nom. nud.

Acer Subgen. *Sphendamnus* Rafinesque (1836: 48).

Acer Sect. *Spicata* Pax—Pax (1886: 182; 1902: 8), ad *A. macrophyllum* Pursh tantum—Schneider (1907: 196), ad *A. macrophyllum* Pursh tantum—Rehder (1940: 574), *A. macrophyllum* Pursh tantum.

Acer Group *Spicata* (Pax)—Rehder (1927: 566), ad *A. macrophyllum* Pursh tantum.

Acer Sect. *Acer* Ser. *Spicata* (Pax) Rehder (1949: 418), ad *A. macrophyllum* Pursh tantum.

Acer Subgen. *Acer* Sect. *Macrophylla* (Pojark.) Momotani (1962b: 184), cum descr. Lat.

1) Andromonoecious.

2) Bud with 8–10 pairs of imbricate scales.

3) Infl. ca. 50-fld. cylindric-elongated panicle from terminal and lateral buds with a few pairs of lvs., smw. after or almost at the same time with lvs., glabrous; bract and bracteole fairly well developed.

4) Fl. big. a) Perianth yellow; seps. 5, smt. 6, glabrous; pets. 5, smt. 6, glabrous. b) Sts. 9–11, usu. 10, exserted in ♂; anths. smooth; fils. hairy from the middle downwards. c) Disc thick, roundish with sts. inserted at the inside. d) Pistil: ovary hairy; style long and erect; stigmas divergent outside, oft. coiled; abortive pistil distinct in ♂, showing vestiges of a style and stigmas.

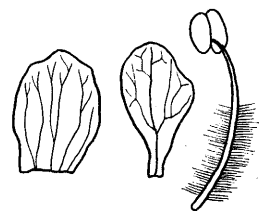


Fig. 31. The sepal, petal and stamen of *A. macrophyllum* ($\times 3.5$).

5) Fr. big; nutlets convex, covered with stiff hairs, the pericarp hard.

6) Cotyls. accumbent, folded, greenish yellow.

7) Lf. deeply 3–5-lobed, the lobes entire but sinuate and smt. lobulate; petiole 2/3–1 as long as blade.

8) Wood. a) Ray smw. irregular-fusiform, usu. attaining 4 cells wide, 600μ high, and at max. 5 cells wide, 850μ high. b) Crystals rather few. c) Latex present in young tissue.

9) Only one species, *A. macrophyllum* Pursh, endemic to the Pacific N. America.

Pojarkova (1939) separated *A. macrophyllum* from Sect. *Spicata* and referred it to Sect. *Lithocarpa*, as Ser. *Macrophylla*. Momotani (1962b) raised the series to an independent section and located it at a position apart from both Sect. *Spicata* and Sect. *Lithocarpa*¹⁾. But the two authors made no mention of the reason on these changes.

The present section seems apparently very different from Sect. *Lithocarpa* rather than from Sect. *Spicata*, judging from the sexuality, the inflorescence type and the folding manner of cotyledons. But it is clear from other characters that the relation between Sect. *Macrophylla* and Sect. *Spicata* is remote. On the other hand, both Sect. *Macrophylla* and Sect. *Lithocarpa* have many imbricate bud-scales and convex nutlets covered with stiff hairs, and moreover they are characterized by having latex in the young tissue. As judged keenly by Pojarkova, these two sections are probably in a near relationship. The ray of the former section is narrower than that of the latter, but they resemble in the irregularity.

Note: 1) In Momotani's system, Sect. *Spicata*, *Macrophylla* and *Lithocarpa* are arranged respectively in the third, the eighth and the twelfth section.

Sect. *Laurina* Ogata, Sect. nov.

Acer Sect. *Integrifolia* Pax—Pax (1886: 207; 1902: 31), ad *A. niveum* Bl. tantum—

Schneider (1907: 213), ad *A. niveum* Bl. in adnota tantum.

Acer Sect. *Integrifolia* Pax Ser. *Oblonga* Pojarkova (1933: 238), nom. nud., ad *A. niveum* Bl. tantum.

Acer Subgen. *Acer* Sect. *Integrifolia* (Pax) Momotani Ser. *Integrifolia*—Momotani (1962b: 185), ad *A. niveum* Bl. tantum.

Planta androdioecia. Gemmae perulae 7–11-jugae, imbricatae. Inflorescentia paniculata, aphylla lateralis. Sepala (3–)5, petala (3–)5, stamina 4–8, vulgo 6. Discus planus, extrastaminalis. Ovarium hirsutum. Stigmata prope sessilia, divergentia, recurvata. Samarae alae anguste divergentes. Folia oblonga, integerrima, acuminata, basi rotundata.

Typus: *A. laurinum* Hassk.

- 1) Androdioecious¹⁾.
- 2) Bud with 7–11 pairs of imbricate scales.
- 3) Infl. 30–50-fl. panicle from lateral buds without lvs.; bract and bracteole fairly developed.
- 4) Fl. a) Perianth pale yellow; seps. (3–)5; pets. (3–)5. b) Sts. 4–8, usu. 6, long exserted, inserted upon disc. c) Disc flat. d) Pistil: ovary densely hairy; stigmas nearly sessile; abortive pistil in ♂ present.
- 5) Fr. big, hairy; nutlets ovate.
- 6) Cotyls. unknown.
- 7) Lf. undivided, oblong, entire, and glaucous or light-blue grey beneath.
- 8) Wood²⁾. a) Ray attaining 4 cells wide, 30 cells high b) Crystals rather rich (?).
- c) Starch-storing fibers rather rich (?).
- 9) Only 1 species, *A. laurinum* Hassk., in the Malay Pen., Sumatra, Java, Borneo, Celebes, Timor, Mindanao and Luzon.

It has been shown by Bloembergen (1954: 592) that the name *A. laurinum* Hassk. has a priority to *A. niveum* Bl. which was almost consistently used for the present species.

The exact description and good illustration of this species were given by Blume (1847: 193; Tab. 167) and Bloembergen (1948: 3–4). It is obvious that this species does not belong to Sect. *Integrifolia*, to which all the specialists in Gen. *Acer* including Pax, Pojarkova and Momotani referred it only for the reason that it has oblong and entire leaves. But, Bloembergen (l.c.) suggested its relation to Sect. *Lithocarpa* (cf. Sect. *Integrifolia*).

This section certainly resembles Sect. *Lithocarpa* in the many imbricate bud-scales, the axillary leafless inflorescence and the shape of the disc, but differs from it in the dense-flowered paniculate inflorescence and the narrow ray. To know the relation of the sections, a thorough examination must be made on the folding manner of cotyledons, the ray type, the existence of latex in the young tissue and so on.

Note: 1) According to Bloembergen (1948: 3), the inflorescence is either male or female, but rarely with few flowers of the other sex.

2) According to Janssonius (1908: 407–408).

Sect. Decandra (Hu et Cheng) Ogata, stat. nov.

Acer Sect. *Integrifolia* Pax Subsect. *Decandrae* Hu et Cheng (1948: 206).

Acer Sect. *Integrifolia* auct. non Pax, Merrill (1932: 47)—Fang (1934: 141; 1939: 132), ad *A. decandrum* Merr.—Metcalf (1938: 609), ad *A. decandrum* Merr.

Acer Subgen. *Acer* Ser. *Decandria* Momotani (1962b: 179), nom. nud., in clave ad *Sereis* tantum.

- 1) Androdioecious.
- 2) Bud with ca. 9 pairs of imbricate scales.
- 3) Infl. 7–20-fl. raceme from lateral buds without lvs.; bract and bracteole fairly well developed.
- 4) Fl. a) Perianth: tepals 10–12, usu. 10, seps. and pets. smw. indistinct in the shape. b) Sts. 10–13¹⁾, long exserted; anth. small, nearly smooth. c) Disc developed, smw. mounded, with sts. inserted upon it²⁾. d) Pistil: ovary hairy; stigmas nearly sessile, divergent outside from the base; abortive pistil in ♂ small but present, showing the vestiges of stigmas.
- 5) Fr. big; nutlets smw. convex, finely nerved, glabrous or nearly so.
- 6) Cotyls. unknown.
- 7) Lf. undivided, oblong, 3-nerved at the base, glaucous beneath; petiole ca. 1/3 as long as blade.
- 8) Wood unknown.
- 9) Only 1 species, *A. decandrum* Merr., endemic to Hainan Isl., S. China.

This section is quite different from Sect. *Integrifolia*, to which it was often referred, in the sexuality, the axillary leafless inflorescence, the number of flower elements, the relative position of stamens to the disc, the shape of disc, the nearly

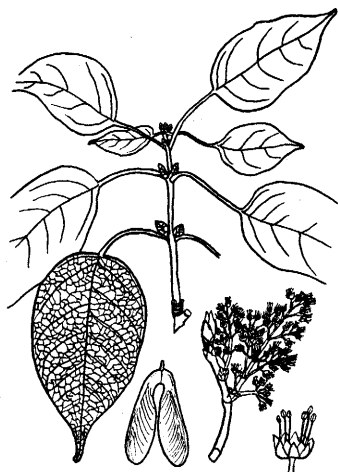


Fig. 32. *A. (Sect. Laurina) laurinum* (Bloembergen, 1948).

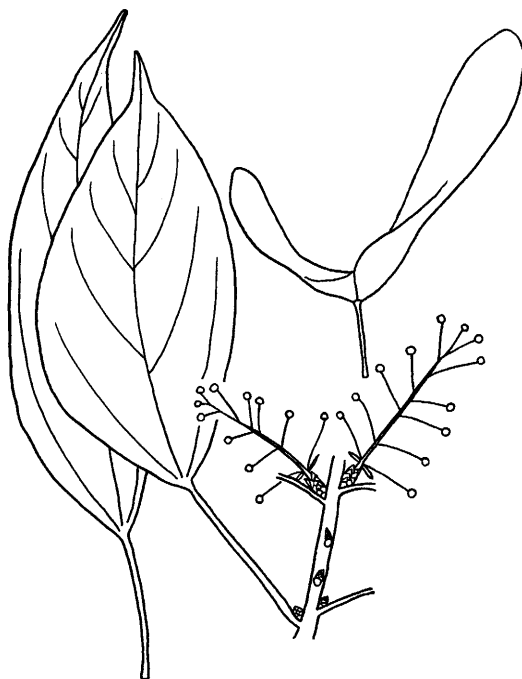


Fig. 33. *A. (Sect. Decandra) decandrum* ($\times \frac{2}{3}$).

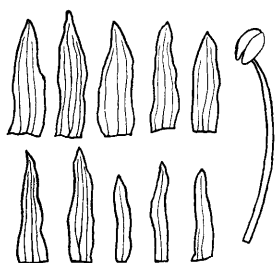


Fig. 34. *A. decandrum* (♂, $\times 7$), showing the whole tepals in one flower and one stamen.

sessile stigmas and the shape and size of fruits, only except for the resemblance of the undivided oblong leaves. It is possibly considered that this section may be nearly allied to Sect. *Lithocarpa* or Sect. *Laurina*.

Only *A. decandrum* Merr. endemic to Hainan Isl. in Southern China is now a distinct species belonging to this section³⁾. I have seen 3 specimens of this species; one bearing male flowers (W.-T. Tsang, Jun. 10, 1928, in Herb. TI) and the other two, female flowers in the younger twigs and at the same time mature fruits in the older twigs (M. Nakayama, Oct. 15 & 18, 1949, in Herb.

TOFO). A very queer thing was found in all of these specimens: the leaves are not completely opposite, but almost always somewhat alternate (Fig. 33). I can not know at present whether such a habit, which I have never seen nor heard in any other species of Gen. *Acer*, is a constant character of the present species. But, a figure of this species illustrated by Merrill and Chun (1935, Plate 56) shows also some alternate leaves in the younger twigs.

What is considered as another peculiarity is that the fruits of this species seem often not to be developed regularly, one carpel imperfectly growing. The four mature fruits I have seen show all very asymmetric features, and in the illustration by Merrill and Chun above cited, among 5 fruits only one develops the normal 2-winged samara and the other 4 do only one carpel of the ovary, with the vestige of the other half. Such asymmetric development was also observed in *A.* (Sect. *Laurina*) *laurinum* (Bloembergen, 1948: 3).

Note: 1) The number of stamens was described to be 10, rarely 12 by Merrill (1932: 47) and 8 to 12 by Fang (1939: 142). In my examination of 4 male flowers from a herbarium specimen, it was 10 (in 2 flowers), 12 and 13.

2) Both Merrill (l.c.) and Fang (l.c.) said that the disc is intrastaminal, but I observed that the stamens are inserted upon the roundish disc at the outer margin.

3) Under Sect. *Integrifolia* Subsect. *Decandrae*, Hu et Cheng (1948) listed *A. machilifolium* Hu et Cheng and *A. longicarpum* Hu et Cheng, with *A. decandrum*. The former two species were said to be distributed in Southern China (Prov. Yunnan), but I have any more knowledge about them.

Sect. *Indivisa* Pax (1885: 327, sub *Intrastaminalibus*; 1886: 213; 1893: 271; 1902: 33), ad *A. carpinifolium* Sieb. et Zucc. tantum—Schneider (1907: 215), ad *A. carpinifolium* Sieb. et Zucc. tantum—Rehder (1940: 580).

Acer Sect. *Carpinifolia* Koidzumi (1911a: 17), sub *Intrastaminalibus*—Pojarkova (1933: 238).

Acer Group *Indivisa* (Pax)—Rehder (1927: 572).

Acer Sect. *Acer* Ser. *Indivisa* (Pax) Rehder (1949: 424).

Acer Subgen. *Carpinifolia* (Koidz.) Momotani (1962b: 188).

1) Androdioecious.

2) Bud with 9-13 pairs of imbricate scales; terminal bud oft. wanting.

3) Infl. loose-fld. raceme (usu. 9-15-fld. in ♂ and 5-9-fld. in ♀) from terminal and lateral buds with 1 pair (rarely 2 pairs) of lvs., almost at the same time with lvs., glabrous; bract and bracteole fairly common.

4) Fl. a) Perianth greenish pale yellow; seps. mostly 4, hairy outside; pets. mostly 4 in ♀ and oft. much reduced in ♂, slightly hairy outside, seps. and pets. smt. connate partly. b) Sts. 4-10, mostly 6 in ♂ and smw. variable in ♀; anths. big and linear-oblong, nearly smooth; fils. short, included. c) Disc flat with sts. at the outside, lobed at the insertion of sts., but smt. surrounding weekly some of sts.

d) Pistil: ovary smw. hairy, becoming glabrous later; stigmas nearly sessile, spreading upright at first and divergent outside later; abortive pistil quite absent in ♂.

5) Fr. glabrous; nutlets compressed-flat.

6) Cotyls. accumbent, plane or nearly so, green.

7) Lf. undivided, oblong, acuminate, doubly serrate, penninerved; petiole relatively short, usu. 1.5 cm long or so.

8) Wood. a) Ray big-fusiform with rather smooth margin, usu. attaining 10-20 cells wide and 1000-2000 μ high according to specimens, and at max. 25 cells wide or more and 3600 μ high or more. b) Crystals rather rich in the terminal portion of annual rings. c) Starch-storing fibers rich.

9) Only 1 species, *A. carpinifolium* Sieb. et Zucc., endemic to Japan.

According to Pax's original description, the main characteristics of Sect. *Indivisa* are that the disc is intrastaminal, the leaves undivided or rarely 3-lobed and entire or weekly serrate, and the inflorescence terminal and raceme. He (1902) arranged 9 species in this section. But 6 species of them were transferred into Sect. *Macrantha* by Rehder (1911, 1927) and 1 into Sect. *Arguta* by Pojarkova (1933). This change is acceptable today. On the remaining 2 species, *A. distylum* and *A. carpinifolium*, Rehder put the former in Sect. *Integrifolia* and the latter in Sect. *Indivisa*. Before Rehder, Koidzumi (1911a) separated *A. carpinifolium* from Sect. *Indivisa* and established a new section, Sect. *Carpinifolia*, for it. It is undoubtedly incorrect that Rehder put *A. distylum* in Sect. *Integrifolia*, but *A. distylum* does not agree to the above mentioned characteristics of Sect. *Indivisa* (cf. Sect. *Distyla*). On the other hand, *A. carpinifolium* agrees mostly to them, though the leaves are strongly and doubly serrate, so that it is appropriate to apply Sect. *Indivisa* to *A. carpinifolium* after Rehder and to consider Sect. *Carpinifolia* as a synonym.

A. carpinifolium is exclusively characterized by having penninerved leaves closely

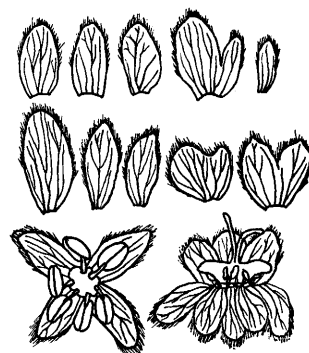


Fig. 35. *A. carpinifolium*. Upper row: the whole tepals in one ♂ flower ($\times 2$); middle: the same in a ♀ flower ($\times 2$); lowest left: ♂ flower ($\times 2$); lowest right: ♀ flower ($\times 1.5$).

similar to those of Gen. *Carpinus* (Fam. *Betulaceae*). Momotani (1262a: 101; 1962b: 188) regarded this as composing one of 3 subgenera of Gen. *Acer*, Subgen. *Carpinifolia*, with Subgen. *Acer* and *Negundo*, taking the protein components of the seed into consideration. To these characteristic features of this species, the remarkably big wood ray is added, which is sharply distinguished in the size from that of all the other species of Gen. *Acer*.

The number of tepals and stamens are considerably variable according to individuals. The correct or complete description is not made in this respect by most authors except Hall (1961). For instance, Rehder (1940) mentioned, "Fls. apetalous, 4-merous; sts. 5-6". I examined 40 male flowers collected from 5 trees and 20 female flowers from 3 trees, all in different localities, and obtained the result in Table 9. Of 40 male flowers, sepals were 4 in 39 flowers and 5 in 1, petals were 0 in 31 flowers, 1 in 6, 2 in 2 and 4 in 1, and stamens were 5 in 5 flowers, 6 in 31, 7 in 3 and 8 in 1. In the 3 male flowers examined by Hall (1961), sepals were 4, petals 1, 2 or 4 and stamens 6 or 7. So far as this is concerned, the Rehder's description is correct to some degree. But in female flowers, petals were mostly 4 and stamens considerably variable. The stamens of female flowers seem quite sterile with very small anthers about half of those of male flowers and may be only accidental elements. The petals of male flowers are generally much reduced not only in the number but in the size. The male flowers show no vestiges of pistils, as those of Sect. *Cissifolia* and *Negundo*.

Table 9. The number of the sepal, petal and stamen of *A. carpinifolium*.

	Sepal		Petal						Stamen								
	4	5	0	1	2	3	4	5	4	5	6	7	8	9	10		
A (♂) 9 fls.	9	1	7	2			1			1	8		1				
B (♂) 1 fl.																	
C (♂) 4 fls.	4		4									4					
D (♂) 19 fls.	19		15	4							3	15		1			
E (♂) 7 fls.	7		5		2						1	4		2			
Total	39	1	31	6	2		1			5	31	3	1				
F (♀) 8 fls.	5	3					8				2	3	1	1	1		
G (♀) 7 fls.	6	1					6	1			2	2	2	1			
H (♀) 5 fls.	5						5		1	3	1						
Total	16	4					19	1	1	3	5	5	3	2	1		

Scaly leaves are occasionally present, especially in the plants of young stage and the vigorously elongated shoots. They sometimes take the position opposite to normal leaves or appear even in the twigs with flowers, instead of normal leaves. They are caducous.

?Sect *Pentaphylla* Hu et Cheng (1948: 208)—Momotani (1962b: 187), in adnota.

Acer Sect. *Negundo* (Boehm.) auct. non Maxim., Fang (1934: 143), ut Sect. *Negundo*

K. Koch, ad *A. pentaphyllum* Diels tantum.

Acer Sect. *Trifoliata* auct. non Pax, Fang (1939: 231), ad *A. pentaphyllum* Diels tantum.

- 1) Sexuality unknown.
- 2) Bud unknown.
- 3) Infl. corymboso-panicle from terminal and lateral buds.
- 4) Fl. unknown.
- 5) Fr. nutlets 5–6 mm in diameter, strongly convex, puberulous; wings ca. 2 cm long, 8 mm wide, glabrous, spreading at right angle.
- 6) Cotyls. unknown.
- 7) Lf. 5-foliolate; lflets. lanceolate, 5–8 cm long, 1.52 cm wide, cuneate at the base, obtuse or obtusely acuminate at the apex, glaucous beneath; petiole 5–8 cm long; petiolule 5–10 mm long.
- 8) Wood unknown.
- 9) *A. pentaphyllum* Diels in S.W. China (W. Szechuan).

To this section belongs only one species *A. pentaphyllum* Diels, of which, to my regret, I have seen no specimen. The characters mentioned above depend upon the descriptions of the original author Diels (1931: 212) and Fang (1939: 232).

Fang wrote, "leaflets digitate, 4–7 usually 5 or 6 leaflets on each petiole", instead of Diels' description, "Folia 5-phylla, pinnis petiolulatis". But I can not imagine the species of Gen. *Acer* which has the leaves with even-numbered leaflets in the normal condition. The meaning of Fang's word "digitate" is somewhat vague, the condition of which Diels made no mention of. Fang placed this species in Sect. *Negundo* at first (1934: 143) and then (1939: 231) transferred it into Sect. *Trifoliata*. If the leaves are really digitate, this species should not be placed in these sections, at least in the former section whose leaves are 3–9-pinnate.

The margin of leaflets may be entire or nearly so, judging from that these authors described nothing of it. If the leaves are really digitate, and if it is permitted to stretch my imagination, this species may be a kind of deformities which is derived from one of the species belonging to Sect. *Palmata*. In the species of Sect. *Palmata*, there is occasionally found a form whose leaves are deeply lobed nearly to the base of the blade (e.g. *A. amoenum* Carr. f. *palmatipartitum* (Koidz.) Ogata), and in Japan, some deformed cultivated forms have been raised, which have digitately foliolate and petiolulate leaves just like the problem species. In this case, the margin of leaflets may be either entire or serrate. The size of fruits and convex nutlets described above accord also well with the characteristic of Sect. *Palmata*.

Part 3. The phylogenetic relation among the sections of the Genus *Acer*

The phylogenetic relation among the sections of the whole Gen. *Acer* was discussed by Pax (1885), Koidzumi (1911b) and Pojarkova (1933), but these three authors' views are very different from one another as shown in App. 2. It is easily noticed in Pax's and

Koidzumi's schemes (App. 2) that the genus is at first divided into 4 or 2 large groups mainly based on the relative position of stamens to the disc. As stated before (cf. p. 100), however, such importance can not be attached to this character. Generally, in the case of Gen. *Acer*, a single or a few characters, at least exomorphic ones, which mean evolutionary major trends governing the whole genus are not found. Therefore it may be said that there is fundamentally a defect in these two authors' schemes. Another defect found in them is that a too simple phylogenetic relation among sections was considered respectively by the two authors. As indicated also by Pojarkova as to this respect, the sections of Gen. *Acer* as they are were established through far more complicated process. The chief cause of these defects comes perhaps from that both Pax and Koidzumi lacked correct understandings of the essential form of each section, in other words, that the classification of sections by them was very imperfect owing to that it was based mainly on the shape of leaves and the superficial appearance of inflorescences which are quite unreliable characters in this case.

The same defects are pointed out in the reports of Almstedt (1933) and Hall (1951-1961) who dealt with the phylogenetic problems of Gen. *Acer* in the studies respectively of the ramification of inflorescences and of the floral anatomy, both based on a relatively small number of species. It is most important, in the phylogenetic study of Gen. *Acer*, to examine many characters of many species. Taking up any one of the characters of inflorescences, flowers, bud-scales and so on, it seems apparently to be arranged in a single phylogenetic line. For instance, in the inflorescence type, there are found various types from the terminal and leafy one to the lateral and leafless one as if they were arranged in a single line showing an evolutionary trend throughout the genus, combined with the differentiation of the ramification manner and the sexuality. When many characters of many species were examined, however, it is understood that inflorescence types should be regarded only as a minor trend among sections in a near relationship.

Pojarkova considered that Gen. *Acer* has differentiated from the ancient *Sapindaceae* possessing actinomorphic flowers and 2-partite winged fruits and that Sect. *Platanoidea* and *Lithocarpa* (both sensu Pojarkova) are the least differentiated ones, more approaching the initial type, judging from that only in the representatives of these two sections of Gen. *Acer* there are found the latex, the mucilaginousness of the walls in epidermal cells, the stamens attached in the middle of the disc and the special structure of the hairs and glands, and that all these features are also characteristic of the present *Sapindaceae*. Her phylogenetic scheme (App. 2) based on an accurate recognition of the characters of Gen. *Acer* is very excellent in comparison with the other authors' ones. Especially her excellent idea is expressed in the point that some hypothetical progenitors of the allied series were proposed.

Against the remarkable variability of exomorphic characters, wood anatomical characters show a high consistency through Gen. *Acer*. Judging from the general conservativeness and high stability, Gen. *Acer* is regarded to be originally and still now a well confined group as a genus. Therefore I can not agree to the division of Gen.

Acer into some genera on the ground of a part of exomorphic characters and especially the separation of Gen. *Negundo* insisted on by many authors.

Generally, most sections of Gen. *Acer* are clearly distinguished exomorphically from one another. This fact means that the ancient forms which may have linked the today's sections more closely had been almost completely lost, and accordingly it is often difficult to know the correct relation among sections. Here, I consider the following 6 groups which may differ largely from one another in the phylogenetic development.

- Group A: Sect. *Macrantha*, *Distyla*, *Parviflora*, *Spicata*, *Palmata*, *Glabra*, *Arguta*, *Negundo*, *Cissifolia*, *Trilobata* and *Rubra*.
- Group B: Sect. *Platanoidea*, *Campestris* and *Pubescentia*.
- Group C: Sect. *Acer*, *Goniocarpa* and *Saccharina*.
- Group D: Sect. *Integrifolia*, *Syriaca* and *Trifoliata*.
- Group E: Sect. *Lithocarpa*, *Macrophylla*, *Laurina* and *Decandra*.
- Group F: Sect. *Indivisa*.

The Group A is still very variable. The sections included in it may be generally characterized by the small number of bud-scales (except Sect. *Trilobata* and *Rubra*), the leaves with relatively minute serrations (except Sect. *Palmata* Ser. *Laevigata*) and the rays which are more or less irregular-fusiform. It may be well said to be one of the characteristics of this group that most of the sections included in it (namely those except only for Sect. *Palmata*) have soft and light woods¹⁾. On the other hand, the sections of the other groups have more or less harder and heavier woods.

Sect. *Macrantha* containing many species which are full of variety is conjectured to be the nearest to the ancestor of this group, and Sect. *Distyla*, *Parviflora* and *Spicata* all consisting of a small number of species have been probably derived from Sect. *Macrantha* in the way of the phylogenetic development. In the latter 3 sections, the inflorescence is compound (elongated panicle) and the sexuality is andromonoecious, while Sect. *Macrantha* is characterized by the elongated raceme and androdioecism. Pojarkova (1933) referred the species of Sect. *Distyla* and *Parviflora* to Sect. *Macrantha* (cf. p. 53, Table 6).

According to Momotani (1962b), the species of Sect. *Macrantha*, *Distyla*, *Parviflora*, *Spicata*, *Glabra* and *Arguta* show a close affinity in the components of seed proteins (App. 2). The species of Sect. *Glabra* and *Arguta* were regarded to be closely related by Pojarkova (1933) and Momotani (1962b), and I agree to this opinion, though the characters of both the sections are very different especially in the inflorescence type and flowers (cf. p. 124, Sect. *Glabra*).

Sect. *Palmata* is also differentiated into many species mainly distributed in Eastern Asia. This section is considerably apart from the sections mentioned above in the thick and round disc with stamens attached on the inner margin, the folding manner of cotyledons and the hard woods. And besides, in Momotani's diagram showing the affinity of seed proteins among species (App. 2), the species of Sect. *Palmata* are situated in the distant places from the species of the sections mentioned above including Sect. *Macrantha*

(but, of the 3 series of Sect. *Palmata*, Momotani examined only the species of Ser. *Palmata*). Accordingly, Sect. *Palmata* may be thought to have a different origin from the sections of this group. But, as indicated by Pojarkova (1933: 266)²⁾, Ser. *Sinensia* of Sect. *Palmata* is considered to have a little relationship with Sect. *Spicata* in their origin, in the point of some resemblance found in the whole appearance of leaves and inflorescences, though these characters are not very reliable.

Sect. *Negundo* and *Cissifolia* have foliolate leaves, but the early few pairs of the leaves next to cotyledons, at least the first pair, are always simple. Besides, these 2 sections resemble each other in the inflorescence type which is lateral with a tendency towards leafless one and in the shape of fruits, but differ especially in the ray type. I think these sections derived from a common ancestor which had simple leaves.

Sect. *Trilobata* and Sect. *Rubra* have relatively many bud-scales. The disc of the former section which is thick and somewhat furrowed with stamens on the inner margin resembles that of Sect. *Spicata* (Plate 4, D & 7, B). This fact suggests that the ancestors respectively of Sect. *Trilobata* and *Spicata* may have been nearly allied. The umbel-like inflorescence of Sect. *Rubra* in which the peduncle and axis are completely absent is supposed to have been derived from a racemose one. The reduction of the peduncle and axis of the inflorescence were accompanied with the transition from the terminal and leafy inflorescence into the lateral and leafless one.

In the Group B, there is no doubt that Sect. *Platanoidea* and *Campestris* are closely related, judging from their many common characters such as the imbricate bud-scales of 5-8 pairs, the terminal, leafy and loose-broad paniculate inflorescence, the disc with stamens attached in the middle and the presence of the latex in the young tissue, but these sections are differentiated from each other in the shape of leaves and fruits. In Sect. *Pubescentia*, the number of stamens is specified to be 5, instead of 8 in the former 2 sections. According to Pojarkova, the latex is not found in Sect. *Pubescentia*.

The sections of the Group C are fairly well allied with one another especially in the ray type and considered to be derived immediately from a common ancestor.

There are not very clear evidences that the sections of the Group D are closely related, but for that they have many imbricate bud-scales. Sect. *Integrifolia* and *Syriaca* give a similar impression in the appearance of leaves. Sect. *Integrifolia* and *Trifoliata* have flowers whose discs are thick and round with stamens inserted on the inner margin, though this characteristic of the disc is also found in Sect. *Palmata*. The flowers of Sect. *Syriaca* are unknown to me. Sect. *Trifoliata* which has 3-foliate leaves and big fruits with thick woody pericarps is much specialized. But, the early leaves next to cotyledons of this section are also simple as the case of Sect. *Negundo* and *Cissifolia*.

In the Group E, inflorescences are specialized into the lateral and leafless type except those of Sect. *Macrophylla* in which they are terminal and leafy. The sections of this group have many imbricate bud-scales and strongly convex nutlets, and are considered to be in a fairly near relation. It is ascertained that Sect. *Lithocarpa* and *Macrophylla*

have the latex in the young tissue.

Sect. *Indivisa* included in the Group F holds a unique position in having the peculiar shape of leaves which resemble those of Gen. *Carpinus* (*Betulaceae*) and very big wood rays in comparison with those of the other maples.

Note: 1) The morphological difference between soft and light woods and hard and heavy woods of maples is not clear under the microscope. In North America, the soft maple means *A. rubrum* or *A. saccharinum* and the hard maple does *A. saccharum* or its allied species, in the commercial viewpoint.

2) But, Ser. *Sinensia* was included in Sect. *Spicata* by Pojarkova.

Literatures

- ADANSON, M. (1963). Familles des plantes.
- ALMSTEDT, M.F. (1933). An anatomical study of the inflorescence of the certain species of *Acer*. 1-17, Plate 1-9. (Thesis. Cornell University, not printed).
- BENTHAM, G. and HOOKER, J.D. (1862). Genera plantarum ad exemplaria imprimis in herbariis kewensibus servata definita 1.
- BLOEMBERGEN, S. (1948). *Aceraceae*. Fl. Malesiana ser. 1, 4: 3-4.
- (1954). In addenda, corrigenda et emendanda. *ibid.*: 592.
- BLUME, C.L. (1847). Rumphia 3.
- BOEHMER, G.R. (1760). In Ludwig, Defin. Gen. Pl. ed. auct. emend.
- BOUCHÉ, C.D. (1879). In Gartenflora.
- BUCHENAU, F. (1861). Morphologische Bemerkungen über einige *Acerineen*. Bot. Zeit. 19: 265-286.
- DE CANDOLLE, A.P. (1824). Prodromus systematis naturalis regni vegetabilis 1.
- DIELS, L. (1931). Miscellanea sinensia. IV. Notizbl. Bot. Gart. Berlin 11: 208-215.
- ENDLICHER, S.L. (1836-1840). Genera plantarum secundum ordines naturales disposita.
- FANG, W.P. (1934). (Geographical distribution of Chinese *Acer*). (Jour. Bot. Soc. China 1): 139-158.
- (1939). A monograph of Chinese *Aceraceae*. Contr. Biol. Lab. Sci. Soc. China. Bot. Ser. 11: 1-346.
- FORBES, F.B. and HEMSLEY, W.B. (1886-1888). An Enumeration of all the plants known from China proper, Formosa, Hainan, Corea, the Luchu Archipelago, and the Island of Honkong, together with their distribution and synonymy (*Ranunculaceae-Compositae*). Jour. Linn. Soc. Bot. 23: 1-521.
- FRANCHET, A. (1884). Plantae Davidianae ex Sinarum imperio 1.
- HALL, B.A. (1951). The floral anatomy of the genus *Acer*. Amer. Jour. Bot. 38: 793-799.
- (1954). Variability in the floral anatomy of *Acer negundo*. *ibid.* 41: 529-532.
- (1961). The floral anatomy of *Dipteronia*. *ibid.* 48: 918-924.
- HU, H.H. and CHENG, W.C. (1948). New and noteworthy species of Chinese *Acer*. Bull. Fan. Mem. Inst. Biol. n. ser. 1: 199-212.
- IKUSE, M. (1956). Pollen grains of Japan.
- INOKUMA, T. (1928). (On the anatomical characters of the broad-leaved trees found in University Forest in Chiba, University of Tokyo). (Thesis. University of Tokyo, not printed).
- JANSSONIUS, H.H. (1908). Mikrographie des Holzes der auf Java vorkommenden Baumarten 2.
- KOCH, K. (1869). Dendrologie 1.
- KOHNE, E. (1893). Deutsche Dendrologie.
- KOIDZUMI, G. (1911a). Revisio *Aceracearum* Japonicarum. Jour. Coll. Sci. Univ. Tokyo 32-1: 1-75, Plate 1-33.
- (1911b). Observations on the *Aceraceae*. Bot. Mag. Tokyo 25: 42-61, 97-113.
- KRIBS, D.A. (1935). Salient lines of structural specialization in the wood rays of Dicotyledons. Bot. Gaz. 96: 547-557.
- LINNAEUS, C. (1753). Species plantarum.
- (1754). Genera Plantarum.
- MAXIMOWICZ, C.J. (1880). Diagnoses plantarum novarum asiaticarum. III. Bull. Acad. Sci. St. Pétersb. sér. 3, 26: 420-542.
- (1882). do. IV. *ibid.* 27: 425-560, Tab. 27.

- MERRILL, E.D. (1932). A fourth supplementary list of Hainan plants. *Lingnan Sci. Jour.* 11: 37-61.
- and CHUN, W.Y. (1935). Additions to our knowledge of the Hainan flora. II. *Sunyatsenia* 2: 203-332, Plate 36-71.
- METCALF, F.P. (1932). *Acer* (Section *Integrifolia* Pax) for southeastern China. *Lingnan Sci. Jour.* 11: 193-210, Plate 3.
- (1938). Geographical distribution of *Acer* (Section *Integrifolia* Pax) in China. *Lingnan Sci. Jour.* 17: 609-613.
- METCALFE, C.R. and CHALK, L. (1950). Anatomy of the Dicotyledons 1.
- MIQUÉL, F.A.W. (1865-1866). *Prolusio florae Iaponicae*. In Miquel, *Ann. Mus. Bot. Lugd. Bat.* 2: 69-212.
- MOENCH, K. (1794). *Methodus plantas horti botanici et agri Marburgensis, a staminum situ describendi*.
- MOMOTANI Y. (1961). Taxonomic study of the genus *Acer*, with special reference to the seed proteins. I. Taxonomic characters. *Mem. Coll. Sci. Univ. Kyoto, ser. B*, 28: 455-470.
- (1962a). do. II. Analysis of protein. *ibid.*, 29: 81-102.
- (1962b). do. III. System of *Aceraceae*. *ibid.*, 29: 177-189.
- NICHOLSON, G. (1881). The Kew arboretum. The Maples. *Gard. Chron. n. ser.* 16: 815.
- NIEUWLAND, J.A. (1911). Box-elder, real and so-called. *Amer. Midl. Nat.* 2: 129-142.
- (1914). Critical notes on new and old genera of plants. I. *ibid.* 3: 170-197.
- OGATA, K. (1964). On the varieties of *Acer mono* Maxim. found in Japan. 1-3. *Jour. Geobot.* 12: 94-97, 13: 15-18, 13: 34-38.
- (1965a). On *Acer pycnathum* K. Koch. *ibid.* 13: 102-109.
- (1965b). A dendrological study on the Japanese *Aceraceae*, with special reference to the geographical distribution. *Bull. Tokyo Univ. For.* 60: 1-99.
- PAX, F. (1885). Monographie der Gattung *Acer*. Allgemeiner Teil. *Engler's Bot. Jahrb.* 6: 287-374.
- (1886). do. Spezieller Teil. *ibid.* 7: 177-263.
- (1889). Nachträge und Ergänzungen zu der Monographie der Gattung *Acer*. *ibid.* 11: 72-83.
- (1893). *Aceraceae*. In *Engler's Nat. Pflanzenfam.* III-5: 263-272.
- (1902). *Aceraceae*. *Engler's Pflanzenreich* IV-163, Ht. 8: 1-89.
- PEARSON, R.S. and BROWN, H.P. (1932). Commercial Timbers of India 1.
- PLOWMAN, A.B. (1915). Is the box elder a maple? A study of the comparative anatomy of *Negundo*. *Bot. Gaz.* 60: 169-192, Plate 5-10.
- POJARKOVA, A.I. (1933). Botanico-geographical survey of the maples in USSR, in connection with the history of the whole genus *Acer* L. *Act. Inst. Bot. Acad. Sci. USSR, ser. 1, fasc. 1*: 224-374.
- (1949). *Aceraceae*. In *Fl. URSS* 14: 508-622, 746.
- RAFINESQUE, C.S. (1808). In *Med. Repos.* New York, hex. 2, 5: 352.
- (1836). *New flora and botany of North America* 1.
- REHDER, A. (1905). The maples of eastern continental Asia. In *Sargent, Trees and Shrubs* 1: 131-181.
- (1907). do. *ibid.* 2: 25-27.
- (1911). *Aceraceae*. In *Sargent, Plantae Wilsonianae* 1: 83-98.
- (1922). New species, varieties and combinations from the herbarium and the collections of the Arnold Arboretum. *Jour. Arn. Arb.* 3: 207-224.
- (1927). *Manual of cultivated trees and shrubs*. ed. 1.
- (1940). do. ed. 2.
- (1949). *Bibliography of cultivated trees and shrubs*.
- SARGENT, C.S. (1905). *Manual of the trees of North America*.
- SCHNEIDER, C.K. (1907). *Aceraceae*. In *Schneider's Illustriertes Handbuch der Laubholzkunde* 2: 192-245.
- SIEBOLD, P.F. and ZUCCARINI, J.G. (1845). *Florae Japonicae Familiae Naturales* 1.
- SMALL, J.K. (1933). *Manual of the southeastern flora*.
- TAKIZAWA, S. (1952). Chromosome studies in the genus *Acer* L. I. The chromosome constitution of the genus *Acer*. *Jour. Fac. Sci. Hokkaidô University ser. V*, 6: 249-272.
- TSOONG, P.C. (1954). A new *Acer* from China. *Kew Bull.* 1954: 83.
- WARSOV, G. (1903). Systematisch-anatomische Untersuchungen des Blattes bei der Gattung *Acer* mit

- besondererer Berücksichtigung der Milchsaftelemente. Beih. Bot. Zentralb. 15: 493-601.
- WATARI, S (1936). Anatomical studies on the vascular system in the petioles of some species of *Acer*, with notes of the external morphological features. Jour. Fac. Sci. Univ. Tokyo. Sect. III, 5: 1-73.
- YAMABAYASHI, N. (1938). (Identification of Corean Woods). (Bull. For. Exp. Sta. Chosen 27): 1-471, Plate 1-60.
- YAMAUCHI, F. (1962). Anatomical identification of the woods in Japanese *Acer*. Misc. Rep. Res. Inst. Natur. Resources 58-59: 3-11, Plate 1-10.
- YANAGITA, Y. (1929). Illustration of the seedling of Forest Trees, 19. Jour. Soc. For. 11: 371-375.

カエデ属の分類学的研究 (摘要)

緒 方 健

カエデ属の分類に関する体系的研究は、Pax の Monographie der Gattung *Acer* (1885-6) によって基礎が築かれた。彼 (1902) は 114 種を 13 の節 (Section) に分かって記載したが、節の分類に疑問点が多く、Rehder (1905-49), 小泉 (1911), Pojarkova (1933), 桃谷 (1962) によって修正が加えられてきた。

私は、これまで注目されてきた主要な外部形態を総合的に観察検討するとともに、材の性質についても研究し、カエデ属の分類体系について一層の修正を試みた。その結果、カエデ属を 26 節に分けた。

本論文では、第 1 部において、カエデ属の一般的性質を解説し、第 2 部において、各節を各論的にとり扱い、第 3 部において、節間の系統関係を論じた。終りに、冬芽、花および材に関する写真を付した。

第 1 部 カエデ属の一般的性質

1. 冬芽: 冬芽の鱗片の枚数は各節に固有で次の 5 つのタイプに分けられる。Type A. 鱗片は常に 2 対 (Sect. *Macrantha* 外 4 節); Type B. 約 3 対 (Sect. *Spicata*, *Negundo*); Type C. 約 4 対 (Sect. *Glabra*, *Palmata*); Type D. 約 5-8 対 (Sect. *Rubra* 外 6 節); Type E. 約 10 対 (Sect. *Lithocarpa* 外 8 節)。

2. 花序: 花序の位置、付随する葉の数、分枝の状態によってほぼ次の 6 つのタイプに分けられる。(1) T(2-3)C type. 花序は頂芽および側芽から出て、2-3 対の葉を伴う複合花序である (Sect. *Parviflora* 外 13 節)。(2) T(1)C type. 同上で、付随する葉は 1 対である (Sect. *Distyla*, Sect. *Palmata* Ser. *Palmata*)。(3) T(1)S type. 花序は頂芽および側芽から出て、1 対の葉を伴う単一花序である (Sect. *Macrantha*, *Indivisa*)。(4) L(0)C type. 花序は側芽だけから出て、葉を伴わない複合花序である (Sect. *Laurina*)。(5) L(1)S type. 花序は側芽だけから出て、1 対の葉を伴う単一花序である (Sect. *Arguta* ♀)。(6) L(0)S type. 花序は側芽だけから出て、

葉を伴わない単一花序である (Sect. *Arguta*, ♂, *Decandra*, *Rubra*)。若干の節は、これらの中間型の花序をもつ。ただしこれらの花序型を単一線上に並べて進化の系統を論ずることはできない。また花序の外形を重く見た Pax や Rehder の分類には誤りが多い。

3. 性: 次の3型があり、上記の花序型と関係がある。(1) 雄花両性花同株型 (*Andromonoecious*)。カエデ属の場合、雄花と両性花は同一花序上にある (T(2-3)C および T(1)C の型の花序をもつ節)。(2) 雄花両性花異株型 (*Androdioecious*)。両性花の雄ずいはしばしば著しく退化する (Sect. *Trifoliata* 外7節)。(3) 雌雄異株型 (*Dioecious*) (Sect. *Negundo*, *Cissifolia*)。

4. 花: 花の各要素(萼片, 花弁, 雄ずい, 花盤)の数, 形は各節に固有である。従来, 雄ずいと花盤の相対的位置関係がきわめて重く考えられてきたが, この性質だけをそれほど重要視することには賛成できない。

5. 果実: 果実の室部の形は, 各節に特有で, 単にふくらんでいるか平坦であるか, また表面がなめらかであるか筋ばっているかの差違が, 實際上, 節の分類に役立つ。Pax や Rehder の節の分類では, しばしばこの性質が無視されている。

6. 胚: 種子は胚乳を欠き, 種皮の内部は, 子葉と幼根が占めている。子葉はふつう地上性 (*epigeal*) であるが, *Acer saccharinum* においてのみ地下性 (*hypogeal*) である。室部のふくらんだ果実では, 子葉は一般に倚位 (*incumbent*) で, ふつう一度内側に巻きこんだのち反巻している。室部の平坦なものでは, 子葉は側位 (*accumbent*) で, 2枚の子葉はただ合わさっただけか, 部分的に折りたたまれるだけで, 巻くことはない。

7. 葉: 若干の種は複葉を有するが, これらでも子葉に次ぐ数葉, 少なくとも第1葉は常に単葉である。鱗片葉がときに見られ, とくに Sect. *Palmata* Ser. *Sinensia* および Ser. *Laevigata*, Sect. *Indivisa* などに多い。Pax の節の分類では, 葉形が重視されているが, 葉形は多様に変化し信頼できない。

8. 材: 材の性質はカエデ属を通じきわめて一定で, 種の識別はしばしば困難であるが, 放射組織, 結晶を含んだ柔細胞ストランド, 澱粉繊維において, 多少とも各節に固有な性質が認められた。

a) 放射組織。Kribs (1935) のいう典型的な同性第1型で, 単列, 多列放射組織とも平伏細胞のみからなる。材の第1年輪部では, どの種においても, ほとんど単列放射組織のみを有する。成熟した材において, 多列放射組織の最大巾および形は, 各節に固有である。例えば Sect. *Macrantha* では最大巾はふつう3細胞巾程度で, 不規則な紡錘形であるが, Sect. *Indivisa* では10~20細胞巾に達し, 比較的なめらかな紡錘形をなす。

b) 結晶。材部における結晶は, 低い細胞がじゅず状に10~20個連なった柔細胞ストランドに含まれている。22の節の材を調べたところ, 10の節には結晶が全くみられなかった。残りの節では, 結晶の量および分布に差違が認められる。Sect. *Syriaca*, *Trifoliata*, *Integrifolia*, *In-*

divisa の材には結晶が多く、とくに *Sect. Syriaca* では材全体に一樣に分布する。その他の節では、結晶は年輪の終縁部にのみ見出される。

c) 澱粉繊維。カエデ属では、どの種でも、材に澱粉を貯えた繊維がかなり多量に存在する。しかし、顕微鏡切片を作成するにあたって、軟化のために煮沸処理を行なった材では澱粉がとけてしまうので、澱粉の存在はこれまであまり気づかれなかった。澱粉繊維は、年輪の終縁部に数層ないし 10 数層および道管の周辺に分布している。澱粉繊維について私の観察したところを記すと、(1) 根材にはとくに多い。(2) あて材にはない、(3) 分布は 1 本の木でも一樣でない、(4) 柔細胞的な機能を有する。澱粉繊維は他の繊維にくらべ、やや細胞膜が厚いが、全体の形、膜孔の数と配列に違いがなく、形態的にはやはり繊維状仮道管と考えられる。澱粉繊維は、*Sect. Palmata*, *Platanoidea*, *Indivisa* 等に比較的多い。

(付) 乳液。乳液は、*Sect. Platanoidea*, *Campestris*, *Lithocarpa*, *Macrophylla* においてのみ、葉や若枝の組織にみられる。

第 2 部 カエデ属の分類体系

ここでは、26 節の各節ごとに第 1 部でとりあげた性質を記載し、配属される種をあげ、従来の分類に対する批判を行なった。*Sect. Palmata* Ser. *Laevigata*, *Sect. Laurina*, *Sect. Decandra*, *Sect. Syriaca*, *Sect. Distyla* の 4 節と 1 列は、ここで新しく設定されたものである。はじめの 3 者は、葉が常緑、無裂、全縁であるというだけで、従来の著者により例外なく *Sect. Integrifolia* にいれられてきたが、重要な性質において互いに異なっている。*Sect. Syriaca* は、*A. monspessulanum* の仲間として扱われてきたが、冬芽の鱗片の数や材の性質からみて両者の関係は遠いと思われる。*Sect. Distyla* にいれられるただ 1 種の *A. distylum* は、これまで *Sect. Indivisa*, *Macrantha*, *Integrifolia*, *Spicata* と転々と異なった節に置かれてきたが、独立の節を構成すると考える。*Sect. Pentaphylla* の存在については疑問がある。

第 3 部 節間の系統関係

Pax (1885), 小泉 (1911b), Pojarkova (1933) はそれぞれカエデ属の節間における系統関係を論じたが、これら 3 者の考えは、たがいに著しく異なっている。その中では、Pojarkova の考えがすぐれていると思われる。Pax, 小泉の欠点は、少数の性質を重視したことで、この欠点は、花序型から系統を論じた Almqvist (1933), 花の解剖的性質から系統を論じた Hall (1951-61) の欠点にも通じる。カエデ属内の系統関係を論じる際には、(1) 多くの種類について、(2) 多くの性質を観察することが重要である。外部形態の多様さに比し、材の均一性はきわめて高い。材の性質の一般的な保守性から考えて、カエデ属は、ひじょうによくまとまった属であり、一部の外部形態を基にしてカエデ属をいくつかの属に分けること、とくに、多くの著者が *Negundo* 属を認

めることには賛成できない。

今日、外部形態的に多様に分化した節の間を結びつけるべき祖先形の多くが失われており、節間の系統関係を論じることが、なかなか困難であるが、私は、一応、大きく系統を異にする次の6つのグループを考えたい。A群: Sect. *Macrantha*, *Distyla*, *Parviflora*, *Spicata*, *Palmata*, *Glabra*, *Arguta*, *Negundo*, *Cissifolia*, *Trilobata*, *Rubra*; B群: Sect. *Platananoidea*, *Campestris*, *Pubescentia*; C群: Sect. *Acer*, *Goniocarpa*, *Saccharina*; D群: Sect. *Integrifolia*, *Syriaca*, *Trifoliata*; E群: Sect. *Lithocarpa*, *Macrophylla*, *Laurina*, *Decandra*; F群: Sect. *Indivisa*.

A群はなおきわめて多様である。とくに *Macrantha* が変化に富んだ多くの種を含み、この群の祖形に近いことが想像され、少数種からなる *Distyla*, *Parviflora*, *Spicata* は、*Macrantha* から派生したと思われる。*Palmata* はかなり分化が進んでいる。また *Glabra* と *Arguta* および *Negundo* と *Cissifolia* はそれぞれ近縁である。*Trilobata*, *Rubra* はそれぞれに特殊化している。B群では、*Platanoidea* と *Campestris* が、多くの共通の性質からみて、きわめて近い関係にある。ただ葉形などにおいて、両者は判然と分化している。*Pubescentia* は雄ずいのが5数に特殊化している。C群はよくまとまったグループで、共通の祖先から直接に分化したと思われる。D群の3節は、たがいに関係がやや遠く、とくに3出複葉をもった *Trifoliata* の特殊化は著しい。E群は、*Macrophylla* を除いて、花序が葉を伴わない側生型に分化し、比較的よくまとまっている。F群の *Indivisa* は、クマシデ属（カバノキ科）に似た特異な葉をもつこと、材の放射組織がきわめて大きいことなどにおいて特殊である。

Appendix 1. The each author's system of Gen. *Acer*

Pax (1902)

- Sect. 1. *Spicata* Pax
 2. *Palmata* Pax
 3. *Trifoliata* Pax
 4. *Integrifolia* Pax
 5. *Indivisa* Pax
 6. *Rubra* Pax
 7. *Negundo* (Boehm.) Maxim.
 8. *Glabra* Pax
 9. *Platanoidea* Pax
 10. *Campestris* Pax
 11. *Macrantha* Pax
 12. *Lithocarpa* Pax
 13. *Saccharina* Pax

Koidzumi (1911)

I. Intrastaminalia

- Sect. 1. *Glabra* Pax
 2. *Parviflora* Koidz.
 3. *Indivisa* Pax
 4. *Carpinifolia* Koidz.
 5. *Macrantha* Pax
 6. *Palmatoidea* Koidz.
 7. *Lithocarpa* Pax
 8. *Arguta* Rehd.

II. Extrastaminalia

- Sect. 9. *Negundo* (Boehm.) Maxim.
 10. *Cissifolia* Koidz.
 11. *Rubra* Pax
 12. *Saccharina* Pax
 13. *Spicata* Pax
 14. *Palmata* Pax
 15. *Integrifolia* Pax
 16. *Trifoliata* Pax
 17. *Campestris* Pax
 18. *Platanoidea* Pax
 19. *Diabolica* Koidz.

Pojarkova (1933)

- Sect. *Platanoidea* Pax
 Ser. *Picta* Pojark.

- Platanoidea
- Quinqueloba Pojark.
- Campestris (Pax) Pojark.
- Pubescentia Pojark.
- Sect. Lithocarpa Pax
 - Ser. Villosa Pojark.
 - Macrophylla Pojark.
- Sect. Gemmata Pojark.
 - Ser. Velutina Pojark.
 - Pseudoplatani Pojark.
 - Trautvetteriana Pojark.
- Sect. Microcarpa Pojark.
 - Ser. Spicata (Pax) Pojark.
 - Sinensia Pojark.
- Sect. Trilobata Pojark.
 - Ser. Tatarica Pojark.
 - Trifida Pojark.
- Sect. Integrifolia Pax
 - Ser. Oblonga Pojark.
- Sect. Palmata Pax
 - Ser. Palmata
- Sect. Macrantha Pax
 - Ser. Parviflora (Koidz.) Pojark.
 - Tegmentosa Pojark.
 - Micrantha Pojark.
 - Crataegifolia Pojark.
- Sect. Carpinifolia Koidz.
 - Ser. Carpinifolia
- Sect. Goniocarpa Pojark.
 - Ser. Opulifolia Pojark.
 - Monspessulana Pojark.
- Sect. Saccharina Pax
 - Ser. Saccharum Pojark.
- Sect. Trifoliata Pax
 - Ser. Grisea Pojark.
 - Mandshurica Pojark.
- Sect. Arguta Rehd.
 - Ser. Arguta
- Sect. Glabra Pax
 - Ser. Glabra
- Sect. Rubra Pax

Ser. Rubra

Saccharina Pojark.

Sect. Cissifolia Koidz.

Ser. Cissifolia

Sect. Negundo (Boehm.) Maxim.

Ser. Negundo

Rehder (1949)

Sect. I. Acer

Ser. 1. Platanoidea (Pax) Rehd.

2. Campestris (Pax) Rehd.

3. Saccharina (Pax) Rehd.

4. Spicata (Pax) Rehd.

5. Palmata (Pax) Rehd.

6. Glabra (Pax) Rehd.

7. Integrifolia (Pax) Rehd.

8. Indivisa (Pax) Rehd.

9. Macrantha (Pax) Rehd.

10. Arguta (Rehd.) Rehd.

11. Lithocarpa (Pax) Rehd.

12. Rubra (Pax) Rehd.

13. Trifoliata (Pax) Rehd.

Sect. II. Negundo (Boehm.) Maxim.

Momotani (1962)

Subgen. I. Acer

Sect. 1. Glabra (Pax) Momotani

Ser. 1. Glabra

2. Arguta (Rehd.) Momotani

Sect. 2. Macrantha (Pax) Momotani

Ser. 1. Rufinervia Momotani

2. Macrantha

3. Micrantha (Pojark.) Momotani

Sect. 3. Spicata (Pax) Momotani

Ser. 1. Parviflora (Koidz.) Momotani

2. Spicata

Sect. 4. Rubra (Pax) Momotani

Sect. 5. Trilobata (Pojark.) Momotani

Sect. 6. Palmata (Pax) Momotani

Ser. 1. Palmata

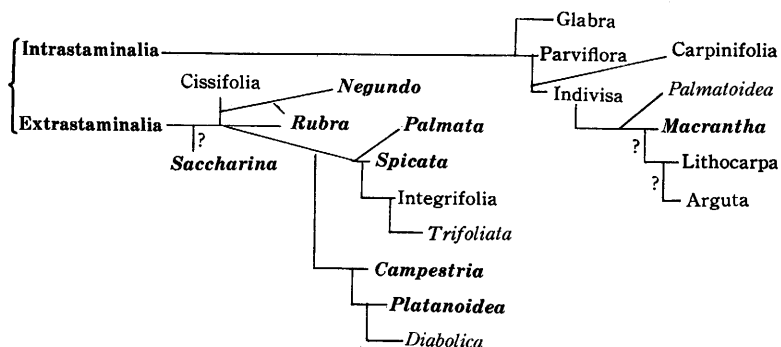
2. Sinensia (Pojark.) Momotani

Sect. 7. Acer

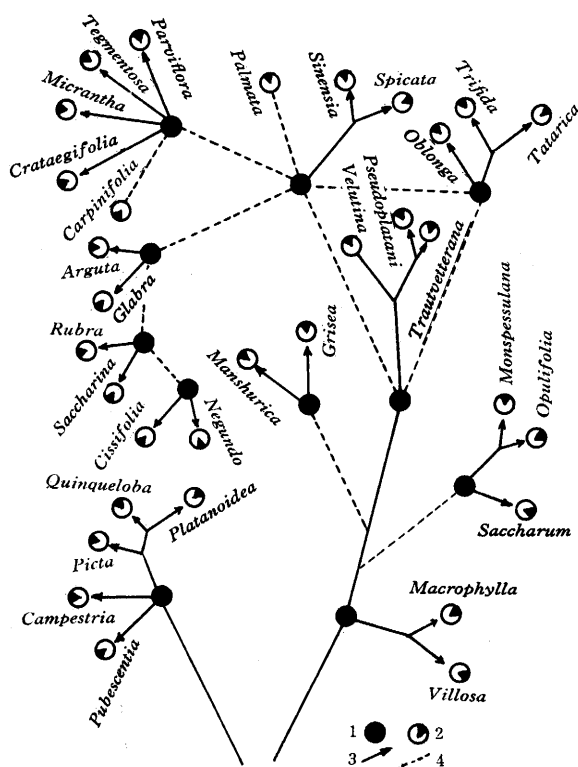
Ser. 1. Velutina (Pojark.) Momotani

-

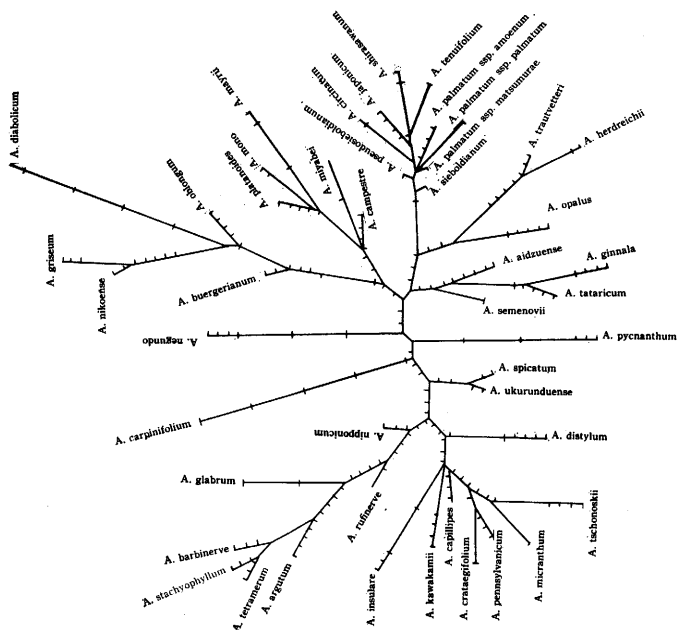




Koidzumi (1911). I. *Intrastaminalia*: Discus intrastaminalis. Stamina hypogyna vel in flore ♂ tantum perigyna. Flores cum foliis nascentes vel paullo tantum praecociore. Gemmae perulae interiores elongatae. II. *Extrastaminalia*: Discus extrastaminalis, rarius valde abortivus vel nullus.



Pojarkova (1933). 1: the hypothetical common progenitors of the allied series. 2: the present series of Gen. *Acer*. 3: the origin of a group of series from a single progenitor. 4: the more distant alliance between the different groups of maples.



Momotani (1962). Diagram showing the affinity of seed proteins among the species of Gen. *Acer*. This diagram does not show any phylogenetic relation.

Appendix 3. Sections, series and species of Gen. *Acer* recognized in this paper

Gen. Acer

Sect. *Macrantha* Pax (p. 111).

Ser. *Macrantha* (p. 112): *A. davidii* Franch.; *A. laxiflorum* Pax; *A. grosseri* Pax; *A. wardii* W.W. Smith; *A. metcalfei* Rehd.; *A. chienii* Hu et Cheng; *A. kawakamii* Koidz.; *A. insulare* Makino; *A. crataegifolium* Sieb. et Zucc.; *A. hookeri* Miq.; *A. pectinatum* Wall.; *A. tegmentosum* Maxim.; *A. pennsylvanicum* L.

Ser. *Rufinervia* (Momotani) Ogata (p. 113): *A. sikkimense* Miq.; *A. rubescens* Hayata; *A. morifolium* Koidz.; *A. capillipes* Maxim.; *A. rufinerve* Sieb. et Zucc.

Ser. *Micrantha* Pojark. (p. 114): *A. maximowiczii* Pax; *A. tschonoskii* Maxim.;
A. micranthum Sieb. et Zucc.

Sect. *Distyla* Ogata (p. 115): *A. distylum* Sieb. et Zucc.

Sect. Parviflora Koidz. (p. 116): *A. nipponicum* Hara.

Sect. *Spicata* Pax (p. 117): *A. caudatum* Wall.; *A. ukurunduense* Trautv. et Meyer;
A. spicatum Lam.

Sect. Palmata Pax (p. 119).

Ser. Sinensia (Pojark.) Ogata (p. 120): *A. sinense* Pax; *A. campbellii* Hook. f. et Thoms. ex Brandis; *A. erianthum* Schw.; *A. flabellatum* Rehd.; *A. tutcheri* Duthie; *A. wilsonii* Rehd.

- Ser. Palmata** (p. 121): *A. robustum* Pax; *A. pseudosieboldianum* Komarov; *A. takeshimense* Nakai; *A. ishidoyanum* Nakai; *A. nudicarpum* Nakai; *A. sieboldianum* Miq; *A. japonicum* Thunb.; *A. tenuifolium* (Koidz.) Koidz.; *A. shirasawanum* Koidz.; *A. palmatum* Thunb.; *A. amoenum* Carr.; *A. circinatum* Pursh; *A. serrulatum* Hayata; *A. oliverianum* Pax; *A. schneiderianum* Pax et K. Hoffm.; *A. heptalobum* Diels; *A. pubipalmatum* Fang; *A. pauciflorum* Fang; *A. ceriferum* Rehd.; *A. chingii* Hu; *A. confertifolium* Merr. et Metcalf; *A. johnedwardianum* Metcalf.
- Ser. Laevigata** Ogata (p. 122): *A. laevigatum* Wall.; *A. fabri* Hance; *A. reticulatum* Champ.; *A. dimorphifolium* Metcalf; *A. cordatum* Pax.
- Sect. Glabra** Pax (p. 124): *A. glabrum* Torr.
- Sect. Arguta** Rehd. (p. 125): *A. tetramelum* Pax; *A. stachyophyllum* Hiern; *A. acuminatum* Wall. ex D. Don; *A. barbinerve* Maxim. *A. argutum* Maxim.
- Sect. Negundo** (Boehm.) Maxim. (p. 126): *A. negundo* L.
- Sect. Cissifolia** Koidz. (p. 128): *A. henryi* Pax; *A. cissifolium* (Sieb. et Zucc.) K. Koch.
- Sect. Trilobata** Pojark. (p. 129): *A. tataricum* L.; *A. semenovii* Regel et Herder; *A. ginnala* Maxim.; *A. aidzuense* (Franch.) Nakai.
- Sect. Rubra** Pax (p. 130).
- Ser. Rubra** (p. 131): *A. rubrum* L.; *A. pycnanthum* K. Koch.
- Ser. Eriocarpa** (Raf.) Ogata (p. 132): *A. saccharinum* L.
- Sect. Platanoidea** Pax (p. 132): *A. longipes* Franch. ex Rehd.; *A. amplum* Rehd.; *A. tenellum* Pax; *A. catalpifolium* Rehd.; *A. fulvescens* Rehd.; *A. acutum* Fang; *A. chunii* Fang; *A. tibetense* Fang; *A. cappadocicum* Gleditsch; *A. turkestanicum* Pax; *A. mono* Maxim.; *A. okamotoanum* Nakai; *A. truncatum* Bunge; *A. lobelii* Tenore; *A. divergens* Pax; *A. platanoides* L.
- Sect. Campestris** Pax (p. 135): *A. miaotense* Tsoong; *A. miyabei* Maxim.; *A. campestre* L.
- Sect. Pubescentia** (Pojark.) Ogata (p. 136): *A. pubescens* Franch.; *A. regelii* Pax; *A. stenolobum* Rehd.
- Sect. Acer** (p. 138).
- Ser. Acer** (p. 139): *A. pseudoplatanus* L.
- Ser. Velutina** (Pojark.) Ogata (p. 139): *A. velutinum* Boiss.; *A. caesium* Wall. ex Brandis; *A. trautvetteri* Medw.; *A. herdreichii* Orph. ex Boiss.
- Sect. Goniocarpa** Pojark. (p. 139).
- Ser. Opulifolia** Pojark. (p. 140): *A. opalus* Mill.; *A. hispanicum* Pourr.; *A. obtusatum* Waldst. et Kit. ex Willd.; *A. tauricolum* Boiss. et Bal.; *A. hyrcanum* Fish. et Mey.; *A. stevenii* Pojark.
- Ser. Monspezzulana** Pojark. (p. 140): *A. monspessulanum* L.; *A. cinerascens* Boiss.; *A. assyriacum* Pojark.; *A. turkomanicum* Pojark.
- Sect. Saccharina** Pax (p. 141): *A. saccharum* Marsh.; *A. grandidentatum* Nuttall ex

Torr. et Gray; *A. barbatum* Michx.; *A. nigrum* Michx. f.; *A. leucoderme* Small.

Sect. Integrifolia Pax (p. 142): *A. oblongum* Wall. ex De Candolle; *A. buergerianum* Miq.; *A. paxii* Franch.

Sect. Syriaca Ogata (p. 144): *A. syriacum* Boiss. et Gaill.; *A. orientale* L.; *A. perisicum* Pojark.; *A. pentapomicum* Stew. ex Brandis.

Sect. Trifoliata Pax (p. 145): *A. sutchuense* Franch.; *A. mandshuricum* Maxim.; *A. griseum* (Franch.) Pax; *A. triflorum* Komarov; *A. nikoense* Maxim.

Sect. Lithocarpa Pax (p. 147): *A. thomsonii* Miq.; *A. villosum* Wall.; *A. franchetii* Pax; *A. schoenermarkiae* Pax; *A. sinopurpurascens* Cheng; *A. diabolicum* Bl.

Sect. Macrophylla (Pojark.) Ogata (p. 150): *A. macrophyllum* Pursh.

Sect. Laurina Ogata (p. 151): *A. laurinum* Hassk.

Sect. Decandra Ogata (p. 153): *A. decandrum* Merr.

Sect. Indivisa Pax (p. 154): *A. carpinifolium* Sieb. et Zucc.

?**Sect. Pentaphylla** Hu et Cheng (p. 156): *A. pentaphyllum* Diels.

Appendix 4. List of wood specimens for anatomical studies¹⁾

Sect. *Macrantha*

A. davidii Franch.

N. China: collector unknown (T. 10813).

A. crataegifolium Sieb. et Zucc.

Chiba, Japan: collector unknown.

Ehime, Japan: S. Naitô (T. 9789).

*Saitama, Japan: K. Ogata.

A. pennsylvanicum L.

W. Virginia, U.S.A.: D. Lord (T. 11913).

Michigan, U.S.A.: H.S. Newins (T. 11914).

Tennessee, U.S.A.: McInturff & Alexander (T. 11917).

Pennsylvania, U.S.A.: R.L. Robacker (T. 11922).

A. morifolium Koidz.

Isl. Yakushima, Japan: Y. Yanagita (T. 7342).

A. capillipes Maxim.

Saitama, Japan: collector unknown.

do.: K. Ogata (T. 11545, 11856, 11904).

A. rufinerve Sieb. et Zucc.

Saitama, Japan: K. Ogata (T. 11537, 11903).

do.: collector unknown (T. 12553).

*do.: K. Ogata (T. 11849).

A. tschonoskii Maxim.

Saitama, Japan: K. Ogata (T. 11541, 11895).

A. micranthum Sieb. et Zucc.

Saitama, Japan: K. Ogata (T. 11540, 11889).

*do (T. 11848).

Sect. *Distyla*

A. *distylum* Sieb. et Zucc.

Saitama, Japan: collector unknown.

do.: K. Ogata (T. 11531, 11868, 11890).

Sect. *Parviflora*

A. *nipponicum* Hara

Saitama, Japan: T. Inokuma (T. 8552).

do.: K. Ogata (T. 11542).

Sect. *Spicata*

A. *ukurunduense* Trautv. et Mey.

Saitama, Japan: K. Ogata (T. 11539, 11892).

A. *spicatum* Lam.

Pennsylvania, U.S.A.: R.L. Robacker (T. 11923).

Sect. *Palmata*

A. *pseudosieboldianum* Komarov

Kyonggi Do, Korea: collector unknown (T. 5827).

Corea: collector unknown.

A. *sieboldianum* Miq.

Saitama, Japan: collector unknown.

do.: K. Ogata (T. 11532, 11897).

A. *japonicum* Thunb.

Hokkaido, Japan: collector unknown.

Saitama, Japan: K. Ogata (T. 11905).

do.: collector unknown (T. 12558).

A. *tenuifolium* (Koidz.) Koidz.

Saitama, Japan: K. Ogata (T. 11535, 11819, 11888).

A. *shirasawanum* Koidz.

Saitama, Japan: K. Ogata (T. 11538, 11893).

do.: collector unknown (T. 12557).

A. *palmatum* Thunb.

Kagoshima, Japan: collector unknown (T. 2650).

Chiba, Japan: collector unknown.

Saitama, Japan: K. Ogata (T. 11902, 11909).

Japan: collector unknown.

do.

do.

A. *amoenum* Carr.

Hokkaido, Japan: collector unknown.

Saitama, Japan: K. Ogata (T. 11898, 11899).

*do. (T. 11879).

A. circinatum Pursh

Oregon, U.S.A.: K.L. Chambers (T. 11924, 11929).

Sect. *Glabra*

A. glabrum Torr.

Colorado, U.S.A.: W.L. Stern (T. 11925, 11926, 11927).

Sect. *Arguta*

A. argutum Maxim.

Nagano, Japan: Fujioka & Etô (T. 7494).

Saitama, Japan: K. Ogata (T. 11533, 11823, 11900).

Sect. *Negundo*

A. negundo L.

Tokyo, Japan (cult.): collector unknown (T. 1035).

New York, U.S.A.: Brown & Stark (T. 11915).

Sect. *Cissifolia*

A. cissifolium (Sieb. et Zucc.) K. Koch

Fukushima, Japan: collector unknown (T. 6410).

do.: M. Fujioka (T. 7246).

Saitama, Japan: K. Ogata (T. 11536, 11891).

Sect. *Trilobata*

A. tataricum L.

Hungary: collector unknown (T. 7959).

Yugoslavia: collector unknown (T. 11553).

A. ginnala Maxim.

Corea: collector unknown.

Sect. *Rubra*

A. rubrum L.

Kentucky, U.S.A.: collector unknown (T. 11920).

A. pycnanthum K. Koch

Kyoto, Japan (cult.): Y. Momotani (T. 11551).

*Gifu, Japan: K. Ogata (T. 11930).

A. saccharinum L.

U.S.A.: H.P. Brown (T. 2927).

do.: A. Koehler (T. 3042).

Wisconsin, U.S.A.: collector unknown (T. 11918).

Sect. *Platanoidea*

A. mono Maxim. var.

Hokkaido, Japan: collector unknown.

Kangwon Do, Corea: collector unknown.

Corea: collector unknown.

Japan: collector unknown.

do.

- A. mono Maxim. var. marmoratum (Nichols.) Hara
Chiba, Japan: collector unknown.
- A. mono Maxim. var. connivens (Nichols.) Hara
Saitama, Japan: K. Ogata (T. 11534).
- A. mono Maxim. var. trichobasis Nakai
Saitama, Japan: K. Ogata (T. 11894).
- A. mono Maxim. var. ambiguum (Pax) Rehd.
Saitama, Japan: K. Ogata (T. 11546).
*do. (T. 11838).
- A. platanoides L.
Hungary: collector unknown (T. 7955).
Yugoslavia: collector unknown (T. 11557).
- Sect. *Campestris*
 - A. miyabei Maxim.
Hokkaido, Japan: T. Inokuma (T. 8787).
Iwate, Japan: T. Inokuma (T. 8587).
 - A. campestre L.
Yugoslavia: collector unknown (T. 11558).
Tokyo, Japan (cult.): K. Ogata (T. 11906).
*do.
Hungary: collector unknown (T. 7954).
- Sect. *Acer*
 - A. pseudoplatanus L.
Hungary: collector unknown (T. 7956).
Yugoslavia: collector unknown (T. 11554).
- Sect. *Goniocarpa*
 - A. opalus Mill.
Italy: A. Pavari (T. 8031).
 - A. obtusatum Waldst. et Kit.
Yugoslavia: collector unknown (T. 11555).
 - A. monspessulanum L.
Yugoslavia: collector unknown (T. 11556).
- Sect. *Saccharina*
 - A. saccharum Marsh.
U.S.A.: H.P. Brown (T. 2926).
Michigan, U.S.A.: A.J. Panshin (T. 11916).
 - A. grandidentatum Nuttall ex Torr. et Gray
Texas, U.S.A.: H. Nogle (T. 11921).
 - A. nigrum Michx. f.
Indiana, U.S.A.: collector unknown (T. 11919).
- Sect. *Integrifolia*

A. oblongum Wall. ex De Candolle
Loochoo: T. Kaneshi (T. 3377).

A. buergerianum Miq.
Tokyo, Japan (cult.): collector unknown (T. 909).
do.: K. Ogata (T. 11908).
*do.

Sect. Syriaca

A. syriacum Boiss. et Gaill.
Israel: A. Fahn (T. 11550).

Sect. Trifoliata

A. nikoense Maxim.
Fukushima, Japan: T. Inokuma (T. 11358).
Saitama, Japan: collector unknown.
do.: (T. 12551).
do.: K. Ogata (T. 11544, 11887).
*do.

Sect. Lithocarpa

A. diabolicum Bl.
Fukushima, Japan: T. Inokuma (T. 6412).
Saitama, Japan: K. Ogata (T. 11843, 11901).
*do.: (T. 11842).
*Tokyo, Japan (cult.): K. Ogata.

Sect. Macrophylla

A. macrophyllum Pursh
Oregon, U.S.A.: W.L. Stern (T. 11928).

Sect. Indivisa

A. carpinifolium Sieb. et Zucc.
Fukushima, Japan: M. Fujioka (T. 7201).
Saitama, Japan: K. Ogata (T. 11547, 11896).
do.: collector unknown (T. 12552).
do.
Chiba, Japan: collector unknown.

Note: 1) All of the specimens obtained from small twigs are omitted in this list. Specimens deposited in the Institute of Forest Botany, Faculty of Agriculture, University of Tokyo, Japan (TOFOW) are shown by the sign T. accompanied with TOFOW number, in parentheses. Root woods are marked with an asterisk (*).

Explanation of plates

Plate 1-2: bud; Plate 3-11: flower; Plate 12-25: wood.

Plate 1.

- A) A. (Sect. *Macrantha* Ser. *Micrantha*) *tschonokii* Maxim.
- B) A. (Sect. *Parviflora*) *nipponicum* Hara
- C) A. (Sect. *Spicata*) *ukurunduense* Trautv. et Mey.
- D) A. (Sect. *Palmata* Ser. *Palmata*) *japonicum* Thunb.

Plate 2.

- A) A. (Sect. *Palmata* Ser. *Palmata*) *shirasawanum* Koidz.
- B) A. (Sect. *Cissifolia*) *cissifolium* (Sieb. et Zucc.) K. Koch
- C) A. (Sect. *Platanoidea*) *mono* Maxim. var. *trichobasis* Nakai
- D) A. (Sect. *Trifoliata*) *nikoense* Maxim.

Plate 3.

- A) A. (Sect. *Macrantha* Ser. *Rufinervia*) *rufinerve* Sieb. et Zucc. (♂)
- B) do. (♀)
- C) A. (Sect. *Macrantha* Ser. *Micrantha*) *tschonokii* Maxim. (♂)
- D) A. (Sect. *Macrantha* Ser. *Micrantha*) *micranthum* Sieb. et Zucc. (♂)

Plate 4.

- A) A. (Sect. *Distyla*) *distylum* Sieb. et Zucc. (♂)
- B) A. (Sect. *Parviflora*) *nipponicum* Hara (♂)
- C) do. (♀), stamens falling off.
- D) A. (Sect. *Spicata*) *ukurunduense* Trautv. et Mey. (♂)

Plate 5.

- A) A. (Sect. *Palmata* Ser. *Palmata*) *japonicum* Thunb. (♂)
- B) A. (Sect. *Palmata* Ser. *Palmata*) *shirasawanum* Koidz. (♂)
- C) A. (Sect. *Palmata* Ser. *Palmata*) *amoenum* Carr. (♂)
- D) A. (Sect. *Palmata* Ser. *Palmata*) *palmatum* Thunb. (♀)

Plate 6.

- A) A. (Sect. *Arguta*) *argutum* Maxim. (♂)
- B) do.
- C) A. (Sect. *Negundo*) *negundo* L. (♂)
- D) A. (Sect. *Cissifolia*) *cissifolium* (Sieb. et Zucc.) K. Koch (♂)

Plate 7.

- A) A. (Sect. *Cissifolia*) *cissifolium* (Sieb. et Zucc.) K. Koch (♀)
- B) A. (Sect. *Trilobata*) *aidzuense* (Franch.) Nakai (♂)
- C) A. (Sect. *Rubra* Ser. *Rubra*) *pycnanthum* K. Koch (♂)
- D) do. (♀)

Plate 8.

- A) A. (Sect. *Platanoidea*) *mono* Maxim. var. *connivens* (Nichols.) Hara (♂)
- B) A. (Sect. *Platanoidea*) *mono* Maxim. var. *mayrii* (Schw.) Sugimoto (♂)
- C) A. (Sect. *Platanoidea*) *truncatum* Bge. (♀)
- D) A. (Sect. *Campestris*) *campestre* L. (♂)

Plate 9.

- A) A. (Sect. *Campestris*) *campestre* L. (♀)
- B) A. (Sect. *Campestris*) *miyabei* Maxim. (♂)
- C) A. (Sect. *Integrifolia*) *buergerianum* Miq. (♂)
- D) do. (♀)

Plate 10.

- A) A. (Sect. *Trifoliata*) *nikoense* Maxim. (♂)
- B) do., stamens removed partly.
- C) do. (♀)
- D) A. (Sect. *Lithocarpa*) *diabolicum* Bl. (♂)

Plate 11.

- A) A. (Sect. *Lithocarpa*) *diabolicum* Bl. (♂)
- B) A. (Sect. *Indivisa*) *carpinifolium* Sieb. et Zucc. (♂)
- C) do. (♀)
- D) do.

Plate 12 (×65)

- A) A. (Sect. *Indivisa*) *carpinifolium* Sieb. et Zucc.
- B) A. (Sect. *Macrantha*) *crataegifolium* Sieb. et Zucc.
- C) A. (Sect. *Macrantha*) *tschonoskii* Maxim. (pith to the 3rd ring), Plate 12, C and D, and Plate 13 from the same disc.
- D) do. (the 1st ring).

Plate 13 (×65)

- A) A. (Sect. *Macrantha*) *tschonoskii* Maxim.
- B) do.
- C) do.
- D) do.

Plate 14 (×65).

- A) A. (Sect. *Lithocarpa*) *diabolicum* Bl. (pith to the 1st ring), Plate 14 and 15 from the same disc.
- B) do. (the 1st to the 2nd ring)
- C) do. (the 20th to the 21st ring)
- D) do. (the early part of the 1st ring)

Plate 15 (×65)

- A) A. (Sect. *Lithocarpa*) *diabolicum* Bl. (the early part of 2nd ring)
- B) do. (the 3rd ring)
- C) do. (the 8th ring)
- D) do. (the 20th ring)

Plate 16.

- A) A. (Sect. *Cissifolia*) *cissifolium* (Sieb. et Zucc.) K. Koch (the dissection of rays by the intrusion of fibers) (×250)
- B) A. (Sect. *Indivisa*) *carpinifolium* Sieb. et Zucc. (the dissection of rays by the intrusion of fibers (×25)
- C) A. (Sect. *Macrantha* Ser. *Rufinervia*) *rufinerve* Sieb. et Zucc. (×65)
- D) A. (Sect. *Macrantha* Ser. *Micrantha*) *micranthum* Sieb. et Zucc. (×65)

Plate 17 (×65).

- A) A. (Sect. *Distyla*) *distylum* Sieb. et Zucc.
- B) A. (Sect. *Parviflora*) *nipponicum* Hara
- C) A. (Sect. *Spicata*) *ukurunduense* Trautv. et Mey.
- D) A. (Sect. *Palmata* Ser. *Palmata*) *japonicum* Thunb.

Plate 18 (×65).

- A) A. (Sect. *Glabra*) *glabrum* Torr.
- B) A. (Sect. *Arguta*) *argutum* Maxim. (immature)
- C) do.
- D) A. (Sect. *Negundo*) *negundo* L.

Plate 19 (×65)

- A) A. (Sect. *Cissifolia*) *cissifolium* (Sieb. et Zucc.) K. Koch (immature rays in the 4th ring)
- B) do. (mature)
- C) A. (Sect. *Trilobata*) *ginnala* Maxim.
- D) A. (Sect. *Rubra* Ser. *Rubra*) *pycnanthum* K. Koch.

Plate 20 (×65).

- A) A. (Sect. *Rubra* Ser. *Eriocarpa*) *saccharinum* L.
- B) A. (Sect. *Platanoidea*) *mono* Maxim.
- C) A. (Sect. *Campestris*) *campestre* L.
- D) A. (Sect. *Acer*) *pseudoplatanus* L.

Plate 21 (×65).

- A) A. (Sect. *Goniocarpa* Ser. *Monspessulana*) *monspessulanum* L.

- B) A. (Sect. Goniocarpa Ser. Opulifolia) obtusatum Waldst. et Kit. ex Willd.
- C) A. (Sect. Saccharina) nigrum Michx. f.
- D) A. (Sect. Integrifolia) buergerianum Miq.

Plate 22 ($\times 65$).

- A) A. (Sect. Syriaca) syriacum Boiss. et Gaill.
- B) A. (Sect. Trifoliata) nikoense Maxim.
- C) A. (Sect. Lithocarpa) diabolicum Bl.
- D) A. (Sect. Macrophylla) macrophyllum Pursh

Plate 23.

- A) A. (Sect. Indivisa) carpinifolium Sieb. et Zucc. ($\times 65$)
- B) A. (Sect. Trifoliata) nikoense Maxim. (crystals in transverse section) ($\times 65$)
- C) do. (crystals in radial section) ($\times 65$)
- D) do. (crystals in tangential section) ($\times 250$)

Plate 24.

- A) A. (Sect. Palmata Ser. Palmata) shirasawanum Koidz. (starch-storing fiber) ($\times 65$)
- B) A. (Sect. Palmata Ser. Palmata) palmatum Thunb. (do.) ($\times 65$)
- C) A. (Sect. Campestris) campestre L. (do.) ($\times 250$)
- D) A. (Sect. Decandra) decandrum Merrill (starch grains in the cells of pith)

Plate 25 ($\times 65$).

- A) A. (Sect. Integrifolia) buergerianum Miq. (starch-storing fibers in root wood)
- B) A. (Sect. Platanoidea) mono Maxim. (starch grains in medullary sheath)
- C) A. (Sect. Palmata Ser. Palmata) shirasawanum Koidz. (the lack of starch grains in tension wood)
- D) A. (Sect. Arguta) argutum Maxim. (starch grains not yet deposited in the wood of this year, on Jul. 6)

