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THE REVISION OF THE PLIOCENE MOGI FLORA,
DESCRIBED BY NATHORST (1883) AND
FLORIN (1920)

by

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(with 7 text-figures and 10 plates)

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Abstract

The Mogi flora, first described by Nathorst (1883) and then by Florin (1920), was based on the specimens collected by the Swedish Vega Expedition in 1879 near Nagasaki, Kyushu. The author reinvestigated all the original specimens, which are deposited in the Swedish Museum of Natural History in Stockholm. These specimens are mostly well-preserved in the fine venation character, though they are leaf impressions. Through investigating them together with our additional specimens from the same locality, the author confirms 52 identifiable species, which are composed of 31 families and 40 genera. All of them are woody dicots excepting for *Metasequoia*, and are composed mostly of deciduous broad-leaved trees. *Fagus* is most predominant in number of specimens, and *Juglans*, *Carpinus*, *Zelkova*, *Liquidambar*, *Sorbus*, *Wisteria*, *Zanthoxylum*, *Acer*, *Styrax*, *Tilia* and *Diospyros* are common. A few evergreens such as *Ilex*, *Elaeocarpus* and *Symplocos* are contained, although not common.

A large proportion of the living species related to the fossil plants are inhabitants of the deciduous broad-leaved forests in central and western Japan at altitudes of 300 up to 800 meters. The comparison with the living forests concludes that the Mogi flora probably represents the lower slope vegetation somewhat apart from the coast. The climate indicated by the flora is typically temperate, with the warmth index of 100° to 110° and the coldness index of 0° to -2°. The plant-bearing sediments have no marine indications, and the age evaluation has been based principally on plant fossils. The age discussion concludes that the Mogi flora is Late Pliocene in age, based on the current systematic reinvestigation which forms the final chapter of this article.

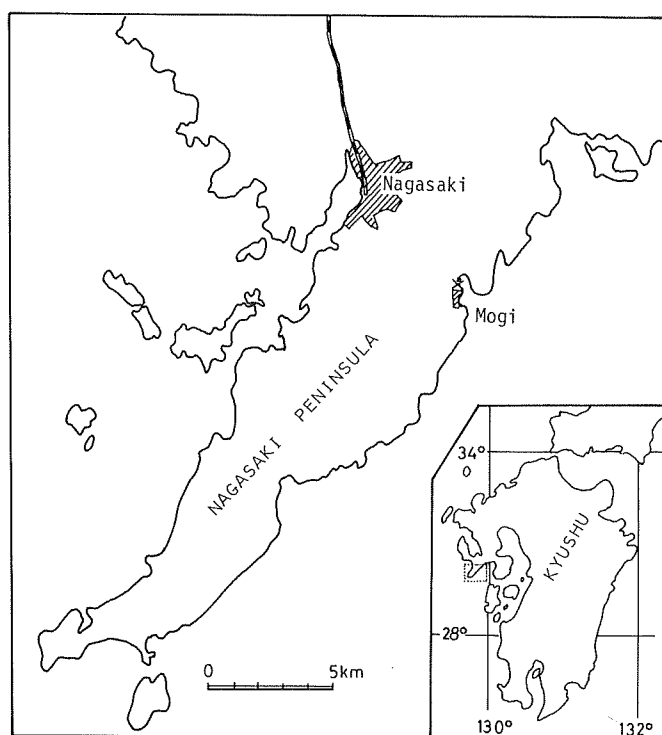
Introduction

The Mogi flora described by Nathorst (1883) is the first detailed record of Japanese Cenozoic floras. These Mogi specimens were collected by Dr. Nordenskiöld during the Swedish Vega Expedition in 1879 at the coastal area near Nagasaki City, Kyushu. Nathorst described 51 identifiable species and 16 species of uncertain genera, and further discussed on geologic age and paleoecology indicated by the flora. His publication attracted the attention of most European paleobotanists at that time, because it was the first report fully

described on Neogene flora of Japan. For instance, Saporta (1883, 1884) reviewed Nathorst's paper in detail, and discussed on many taxonomical studies, especially on *Fagus*, *Acer* and others. Ettingshausen (1884) also reviewed Nathorst's investigation, and gave the critical discussion on taxonomy. Nathorst (1884a, b) also responded to their critical reviews, with taxonomical discussions. Later, Florin (1920) revised Nathorst's taxonomical work by reinvestigation of the original specimens, and discussed on the forest composition and paleoclimate indicated by the Mogi flora.

Thereafter, two publications by Nathorst (1883) and Florin (1920) have been indispensable for the Cenozoic paleobotanical works of Japan. However, the original specimens described by them are deposited mostly at the Swedish Museum of Natural History in Stockholm, and partly at the Paleontological Museum of the University of Uppsala in Uppsala. Thus, our Japanese workers have been unable to compare directly their specimens with the originals, although it was necessary.

About 20 years ago, I visited Mogi locality to collect the additional specimens ("topotypes"), but the fossil locality was too ill-conditioned to



Text-Fig. 1 Showing the fossil localities.

collect the well-preserved specimens. Two years later Mr. T. Onoe visited there, accepting my request, and collected a number of well-preserved specimens from the same locality (Text-fig. 1). He investigated preliminarily these specimens, and then kindly entrusted me with final reinvestigation. However, these specimens include only one-third of the species listed by Nathorst, though some are new. I have hesitated to publish the revision of the Mogi flora.

In spring of 1974, I visited Stockholm to investigate the Arctic Tertiary plants stored in the Swedish Museum, comparing with those of Japan. During staying in Stockholm I had a chance to reinvestigate the original specimens of the Mogi flora, due to the courtesy of Professor B. Lundblad. Through reinvestigating the original specimens together with the additional materials collected by Mr. Onoe, I could reach a conclusion that some of the original species should be taxonomically revised. It is the purpose of this paper to describe the Mogi plants, especially in the light of fine venation characters, and further to discuss briefly geologic age of the flora.

Acknowledgments

The author wishes to express his great appreciation to Professor Britta Lundblad, the Swedish Museum of Natural History in Stockholm, who gave kindly the permission to investigate the original specimens, and to gave many facilities in the Museum and kind hospitality during his staying in Stockholm. I also acknowledge my gratitude to Dr. Hans Tralau and all the staffs of the Paleobotany Section of the Museum for giving kindly many facilities for my investigation. Acknowledgment is due to Prefessor R.N. Reymont, University of Uppsala, who gave his kind permission to investigate the original specimens described by Florin. I deeply express my gratitude to Mr. Toru Onoe, the Geological Survey of Japan, who kindly offered his collection for my study. Mr. K.E. Samuelsson of the Swedish Museum of Natural History took the photographs of some original specimens; Mr. Kazuhiko Uemura of National Science Museum in Tokyo and Mr. Kimihiko Ozaki of Yokohama National University discussed with me on the identification of several species; Mrs. Toshiko Watanabe helped me to make the typescript of the manuscript; I acknowledge their kindness. This study has been made possible through the financial support from the Ministry of Education to which I owe a real debt of gratitude: a Grant for the Abroad Research during 1973–1974, and a Grant for the Fundamental Scientific Research in 1975.

Geologic Settings

In the northern coastal area of Mogi-machi east of Nagasaki City, the so-called Mogi plant-bearing formation is distributed unconformably on olivine-basalt and its brecciated tuff covering green schist or granite. According to Tachibana (1955, 1962), the plant-bearing formation is divided into two members. The lower member consists of conglomerate, partly intercalated by thin tuff and tuffaceous siltstone beds. The lower member is 1 to 10 meters in thickness, and represents the basal deposits of the formation: all the component rocks of the conglomerate were derived from the neighbouring basement. The upper member is composed mainly of tuff, tuffaceous siltstone and sandstone; the well-preserved plants are included in tuffaceous siltstone.

The Mogi plant-bearing formation has no marine indications, and is entirely of lacustrine origin. As already stated by many authors, this formation seems to have been formed in the lake dummed-up by the Late Cenozoic volcanic sediments, which were deposited on the low relief of Paleozoic terrain. The Mogi formation is conformably covered by the Kitaura volcanic breccia, which is widely distributed north of Mogi-machi. The Kitaura volcanics are also of terrestrial origin, and include sometimes silicified woods and leaf remains though ill-preserved.

The Revision of the Mogi Flora

Tertiary leaf-paleobotany has recently progressed in investigating the fine characters of leaf architectures, as recently elaborated by Hickey (1973), Wolfe (1966, 1973), Hickey and Wolfe (1975) and others. Most of the Mogi plants, though represented only by leaf impressions, are excellently preserved in the grayish-white tuffaceous siltstone; they are suitable for clarifying their fine venation, comparing with those of the related extant species. The author has investigated the detailed characters of the Mogi specimens as far as possible, as described later in the descriptive chapter. The extant cleared-leaf slides have been provided for the comparison in our laboratory: the slide numbers are referred to the Paleobotanical laboratory of the Hokkaido University.

Nathorst (1883) described 51 identifiable species and 16 species of uncertainly referable genera in the Mogi flora, and then Florin (1920) described 16 species, of which 5 species were not described by Nathorst. Of these species identified by them two species are too fragmentary to give any specific status as far as the author restudied. Among 16 species of uncertain genera 14 species are still unable to refer to any definite genera. Through my investigation of the original and our additional specimens 52 species are identifiable: they are

Table 1 Systematic List of the Mogi flora revised by the author

Taxodiaceae	Anacardiaceae
<i>Metasequoia occidentalis</i> (Newb.) Chaney	<i>Rhus nathorsti</i> Tanai
Juglandaceae	Aceraceae
<i>Juglans japonica</i> Tanai	<i>Acer integerrimum</i> (Viv.) Massalango
Betulaceae	<i>Acer nordenskiöldi</i> Nathorst
<i>Carpinus stenophylla</i> Nathorst	Sapindaceae
<i>Carpinus subcordata</i> Nathorst	<i>Sapindus tanaii</i> Onoe
<i>Carpinus</i> sp.	Sabiaceae
<i>Ostrya shiragiana</i> Huzioka	<i>Meliosma</i> cf. <i>myriantha</i> S. et Z.
Fagaceae	Aquifoliaceae
<i>Fagus stuxbergi</i> (Nathorst) Tanai	<i>Ilex heeri</i> Nathorst
Ulmaceae	<i>Ilex lundbladae</i> Tanai
<i>Celtis nordenskiöldi</i> Nathorst	<i>Ilex onoei</i> Tanai
<i>Ulmus miopumila</i> Hu et Chaney	Rhamnaceae
<i>Ulmus</i> cf. <i>protojaponica</i> Tanai et Onoe	<i>Rhamnus</i> cf. <i>costata</i> Maxim.
<i>Zelkova ungeri</i> Kovats	Vitaceae
Magnoliaceae	<i>Vitis naumannii</i> (Nathorst) Tanai
<i>Magnolia dicksoniana</i> Nathorst	Elaeocarpaceae
<i>Magnolia elliptica</i> Tanai et Onoe	<i>Elaeocarpus florini</i> Tanai
Schisandraceae	<i>Elaeocarpus saportanus</i> (Nathorst) Tanai
<i>Kadsura protojaponica</i> Tanai	Tiliaceae
<i>Schisandra florini</i> Tanai	<i>Tilia distans</i> Nathorst
Lauraceae	Cornaceae
<i>Cinnamomum</i> cf. <i>miocenum</i> Morita	<i>Cornus megaphylla</i> Hu et Chaney
<i>Lindera miyataensis</i> Huzioka et Uemura	<i>Cornus subkousa</i> Tanai et Onoe
<i>Lindera</i> cf. <i>sericea</i> (S. et Z.) Blume	Clethraceae
Theaceae	<i>Clethra maximowiczii</i> Nathorst
<i>Stewartia submonadelpha</i> Tanai et Onoe	Ericaceae
Hamamelidaceae	<i>Enkianthus almquisti</i> (Nathorst) Tanai
<i>Liquidambar miosinica</i> Hu et Chaney	Ebenaceae
Saxifragaceae	<i>Diospyros nordqvisti</i> Nathorst
<i>Deutzia mogiensis</i> Tanai	Styracaceae
Rosaceae	<i>Styrax protoobassia</i> Tanai et Onoe
<i>Chaenomeles chloranthoides</i> (Nathorst) Huzioka	<i>Styrax protojaponica</i> Tanai
et Takahashi	Symplocaceae
<i>Prunus florini</i> Tanai	<i>Symplocos smithi</i> Florin
<i>Prunus nathorsti</i> Tanai	Caprifoliaceae
<i>Pyracantha nipponica</i> Tanai	<i>Viburnum viburnifolium</i> (Nathorst) Tanai
<i>Sorbus lesquereuxi</i> Nathorst	Insertae Sedis
Leguminosae	<i>Carpites sibiriacoffi</i> (Nathorst) Tanai
<i>Maackia onoei</i> Matsuo	
<i>Wisteria fallax</i> (Nathorst) Tanai et Onoe	
Euphorbiaceae	
<i>Sapium mogiense</i> Tanai	
Rutaceae	
<i>Zanthoxylum engleri</i> (Nathorst) Tanai	

composed of 31 families and 40 genera as shown in Table 1. The comparison of my identification with those of Nathorst (1883) and Florin (1920) is shown in Table 2.

Of the 52 species identified the most predominant is *Fagus stuxbergi*: it seems to occupy about 60 per cent of the total Mogi specimens deposited in the Swedish Museum. Judging from the stored specimens, the common members are *Juglans japonica*, *Carpinus subcordata*, *Zelkova ungeri*, *Liquidambar miosinica*, *Stewartia submonadelpha*, *Sorbus lesquereuxi*, *Wisteria fallax*, *Zanthoxylum engleri*, *Acer nordenskiöldi*, *Ilex heeri*, *Tilia distans*, and *Styrax protoobassia*. Such relative abundance of the Mogi species is generally consistent with those of the Onoe's collection; *Fagus stuxbergi* occupies more than 80 per cent of about one thousand specimens collected by Onoe. In his collection the following species make more than one per cent in relative abundance respectively: *Juglans japonica*, *Caprinus subcordata*, *Zelkova ungeri*, *Wisteria fallax*, *Acer nordenskiöldi*, *Acer integerrimum* and *Tilia distans*. These relative abundance of the species may make possible to consider the forest composition during the Mogi time.

Paleoecology

Although this report may be not aimed at the paleoecological analysis, it is significant to discuss the environments indicated by the Mogi flora. A comparison of the Mogi flora with the similar modern communities provides the basis for conclusions regarding its environment. Since most of the plants making up the Mogi flora have similar species living in China and Japan, our comparison will be made largely to the modern forests of East Asia.

All of the Mogi genera excepting *Elaeocarpus*, are now found growing luxuriantly at middle latitudes. Although several genera such as *Kadsura*, *Liquidambar*, *Sapium*, *Sapindus*, *Ilex*, *Clethra*, *Diospyros* and *Symplocos* now live at low latitudes, they regularly extend into temperate latitudes and altitudes. *Zelkova*, *Magnolia*, and *Lindera* are living in both temperate and subtropical forest in Asia. Only two genera of *Cinnamomum* and *Elaeocarpus* are luxuriant in tropical regions, and reach the southern end of the temperate forest. All of the 40 Mogi genera are east-Asiatic, and are especially living in Chinese mainland and Taiwan; but three genera, *Metasequoia*, *Liquidambar* and *Pyracantha*, are not native in Japan.

Table 3 shows the nearest living species of the Mogi plants and their modern distribution in East Asia, which is divided into 5 regions each for Japan and China, with columns also for Saghalien, Korea, and Taiwan and Ryukyu Islands. The distribution of these living related species centers from central Honshu to Kyushu in Japan. The abundant occurrence of beech leaves may allow to compare the Mogi flora with the *Fagus* zone foerest of central Honshu to Kyushu.

Table 2 Revision of the Mogi species identified by Nathorst (1883) and Florin (1920)

Nathorst (1883)	Florin (1920)	Tanai (1976)
<i>Taxites</i> sp.	<i>Taxodium distichum</i>	<i>Metasequoia occidentalis</i>
<i>Juglans sieboldiana</i>	(<i>Juglans sieboldiana</i>)	<i>Juglans nipponica</i>
<i>Juglans kjellmanni</i> (in part)		<i>Clethra maximowiczii</i>
<i>Carpinus stenophylla</i>		<i>Carpinus stenophylla</i>
<i>Carpinus subcordata</i>		<i>Carpinus subcordata</i>
<i>Carpinus</i> sp.		<i>Carpinus</i> sp.
<i>Ostrya virginiana</i>		<i>Ostrya shiragiana</i>
<i>Fagus ferruginea</i>	(<i>Fagus ferruginea</i>)	<i>Fagus stuxbergi</i>
<i>Quercus stuxbergi</i>		<i>Fagus stuxbergi</i>
<i>Celtis nordenskiöldi</i> (in part)		<i>Celtis nordenskiöldi</i>
<i>Celtis nordenskiöldi</i> (in part)		<i>Tilia distans</i>
<i>Ulmus</i> cf. <i>campestris</i>	<i>Ulmus</i> cf. <i>carpinoides</i>	<i>Ulmus miopumila</i>
	<i>Ulmus</i> sp.	<i>Ulmus</i> cf. <i>protojaponica</i>
<i>Zelkova keaki</i>		<i>Zelkova ungeri</i>
<i>Aphananthe viburnifolia</i>	<i>Viburnum erosum</i>	<i>Viburnum viburnifolium</i>
<i>Magnolia dicksoni</i>		<i>Magnolia dicksoni</i>
<i>Magnolia</i> sp.		<i>Magnolia elliptica</i>
	<i>Schisandra chinensis</i>	<i>Kadsura protojaponica</i>
<i>Lindera</i> (?) sp.		<i>Schisandra florini</i>
		<i>Cinnamomum</i> cf. <i>miocenum</i>
<i>Lindera sericea</i>		<i>Lindera miyataensis</i>
<i>Stewartia monadelpha</i>	(<i>Stewartia monadelpha</i>)	<i>Lindera</i> cf. <i>sericea</i>
<i>Liquidambar formosana</i>	<i>Liquidambar formosana</i>	<i>Stewartia submonadelpha</i>
<i>Deutzia scabra</i>		<i>Liquidambar miosinica</i>
<i>Cydonia chloranthoides</i>		<i>Deutzia mogiensis</i>
<i>Prunus buegeriana</i>		<i>Chaenomeles chloranthoides</i>
<i>Prunus</i> sp.	<i>Prunus pseudo-ceras</i>	<i>Prunus nathorsti</i>
<i>Sorbus lesquereuxi</i>	(<i>Sorbus lesquereuxi</i>)	<i>Prunus florinii</i>
<i>Dictamnus fraxinella</i>	<i>Dictamnus albus</i>	<i>Sorbus lesquereuxi</i>
<i>Sophora</i> (?) <i>fallax</i>	(<i>Sophora fallax</i>)	<i>Pyracantha nipponica</i>
		<i>Wisteria fallax</i>
<i>Zanthoxylon ailanthoides</i> (in part)		<i>Maackia onoei</i>
<i>Rhus engleri</i>		<i>Sapium mogiense</i>
<i>Rhus griffithii</i>		<i>Zanthoxylum engleri</i>
<i>Acer pictum</i>	(<i>Acer pictum</i>)	<i>Zanthoxylum engleri</i>
<i>Acer nodenskiöldi</i>		<i>Rhus nathorsti</i>
		<i>Acer integerrimum</i>
<i>Meliosma myriantha</i>		<i>Acer nordenskiöldi</i>
<i>Ilex heeri</i>		<i>Sapindus tanaii</i>
		<i>Meliosma</i> cf. <i>myriantha</i>
<i>Rhamnus costata</i>		<i>Ilex heeri</i>
<i>Vitis lubrusca</i>		<i>Ilex onoei</i>
<i>Elaeocarpus photoniaefolia</i>	<i>Elaeocarpus photoniaefolia</i>	<i>Rhamnus</i> cf. <i>costata</i>
<i>Vaccinium</i> (?) <i>saportanum</i>		<i>Vitis naumannii</i>
<i>Tilia distans</i>	<i>Tilia</i> sp.	<i>Elaeocarpus florini</i>
	<i>Cornus</i> sp.	<i>Elaeocarpus saportanus</i>
<i>Acanthopanax acerifolium</i>		<i>Tilia distans</i>
<i>Clethra maximowiczii</i>	(<i>Clethra maximowiczii</i>)	<i>Cornus subkoua</i>
<i>Tripetaleja almquisti</i>		<i>Cornus megaphylla</i>
<i>Diospyros nordqvisti</i>		<i>Liquidambar miosinica</i>
<i>Styrax obassia</i>		<i>Clethra maximowiczii</i>
<i>Styrax japonicum</i>		<i>Enkianthus almquisti</i>
	(<i>Symplocos</i> ? <i>smithi</i>)	<i>Diospyros nordqvisti</i>
<i>Clematis sibiriaeoffi</i>		<i>Styrax protoobassia</i>
<i>Viburnum</i> sp.	<i>Viburnum erosum</i>	<i>Styrax protojaponica</i>
		<i>Symplocos smithi</i>
		<i>Carpites sibiriaeoffi</i>
		<i>Viburnum viburnifolium</i>

The species in parentheses are described from the Amakusa flora by Florin (1920).

The typical forests of the *Fagus* zone are distributed from 1200–1300 meters up to 1500–1700 meters in central Honshu and Shikoku, and at elevation above 900–1000 meters in Chugoku mountain ranges and Kyushu. *Fagus crenata* is generally predominant in these forests, accompanied commonly by the deciduous broadleaved trees such as *Acanthopanax*, *Acer*, *Aesculus*, *Betula*, *Carpinus*, *Cercidiphyllum*, *Hydrangea*, *Kalopanax*, *Magnolia*, *Quercus* (deciduous), *Sorbus*, *Tilia* and *Ulmus*. Many living analogues of the Mogi plants are actually found in these forests, but few of them are confined to the *Fagus* zone.

Fagus stuxbergi (“*F. palaeocrenata*”) may represent a direct progenitor of the extant *F. crenata* in the morphological characters of leaves (Tanai, 1972, 1974), but it seems to have had a somewhat different ecological requirement from *F. crenata*, judging from the composition of the fossil flora. It is a noteworthy character that the Mogi flora contains no species similar to *Quercus mongolica*, *Acer japonicum* and others, which are common members of the extant *Fagus* zone. Thus, it is not always appropriate for the paleoecological consideration to compare the Mogi flora with the living forests of the *Fagus* zone.

Below the *Fagus* zone the typical deciduous broadleaved forests are distributed from 600–700 meters up to 1200–1300 meters in central Honshu and from 500 to 700 meters in the Chugoku mountain ranges of western Honshu. These forests are characterized by the predominance of *Castanea crenata*, as called the *Castanea* zone. Although the Mogi flora contains no leaves of chestnut, many of the Mogi plants have the related extant species in the *Castanea* zone as follows:

<i>Juglans ailanthifolia</i> (<i>J. japonica</i>)	<i>Wisteria brachybotrys</i> (<i>W. fallax</i>)
<i>Carpinus japonica</i> (<i>C. stenophylla</i>)	<i>Acer mono</i> (<i>A. integerrimum</i>)
<i>Carpinus cordata</i> (<i>C. subcordata</i>)	<i>Acer palmatum</i> (<i>A. nordenskiöldi</i>)
<i>Carpinus tchonoskii</i> (<i>Carpinus</i> sp.)	<i>Meliosma myriantha</i> (<i>M. cf. myriantha</i>)
<i>Fagus crenata</i> (<i>F. stuxbergi</i>)	<i>Ilex pedunculosa</i> (<i>I. heeri</i>)
<i>Celtis sinensis</i> var. (<i>C. nordenskiöldi</i>)	<i>Vitis lubrusca</i> (<i>V. naumannii</i>)
<i>Zelkova serrata</i> (<i>Z. ungeri</i>)	<i>Cornus controversa</i> (<i>C. megaphylla</i>)
<i>Magnolia sieboldi</i> (<i>M. dicksoniana</i>)	<i>Cornus kousa</i> (<i>C. subkousa</i>)
<i>Schisandra nigra</i> (<i>S. florini</i>)	<i>Clethra barbinervis</i> (<i>C. maximowiczii</i>)
<i>Lindera umbellata</i> (<i>L. miyataensis</i>)	<i>Enkianthus cernuus</i> (<i>E. almquisti</i>)
<i>Lindera sericea</i> var. (<i>L. cf. sericea</i>)	<i>Diospyros lotus</i> (<i>D. nordqvisti</i>)
<i>Deutzia crenata</i> (<i>D. mogiensis</i>)	<i>Styrax japonica</i> (<i>S. protojaponica</i>)
<i>Prunus jamasakura</i> (<i>P. florini</i>)	<i>Styrax obassia</i> (<i>S. protoobassia</i>)
<i>Sorbus alnifolia</i> (<i>S. lesquereuxi</i>)	

In the coastal or hilly regions below the *Castanea* zone, the

Table 3 The Modern related species of the Mogi plants and their distribution in East Asia

Mogi Species	Closely related extant Species	1	Japan							8	China						14
			2	3	4	5	6	7	9		10	11	12	13			
<i>Metasequoia occidentalis</i>	<i>M. glyptostroboides</i>											X					
<i>Juglans japonica</i>	<i>J. ailanthifolia</i>	X	X	X	X	X	X										
<i>Carpinus stenophylla</i>	<i>C. japonica</i>			X	X	X	X										
<i>Carpinus subcordata</i>	<i>C. cordata</i>		X	X	X	X	X		X	X	X			X			
<i>Carpinus</i> sp.	<i>C. tchonoskii</i>			X	X	X	X		X								
<i>Ostrya shiragiana</i>	<i>O. japonica</i>		X	X	X	X	X		X	X	X						
<i>Fagus stuxbergi</i>	<i>F. crenata</i>		X	X	X	X	X										
<i>Celtis nordenskioldi</i>	<i>C. bungeana</i>		X	X	X	X	X		X	X	X	X	X				
<i>Ulmus miopumila</i>	<i>U. pumila</i>								X	X	X				X		
<i>Ulmus</i> cf. <i>protojaponica</i>	<i>U. japonica</i>	X	X	X	X	X			X	X					X		
<i>Zelkova ungeri</i>	<i>Z. serrata</i>			X	X	X	X	X	X	X	X	X	X	X	X		
<i>Magnolia dicksoniana</i>	<i>M. sieboldii</i>				X	X	X		X		X						
<i>Magnolia elliptica</i>	<i>M. liliflora</i>										X						
<i>Kadsura protojaponica</i>	<i>K. japonica</i>					X	X	X	X								
<i>Schisandra florini</i>	<i>S. chinensis</i>	X	X	X	X				X	X	X				X		
<i>Cinnamomum</i> cf. <i>miocenum</i>	<i>C. camphora</i>				X	X	X	X			X	X					
<i>Lindera miyataensis</i>	<i>L. umbellata</i>				X	X	X	X			X	X					
<i>Lindera</i> cf. <i>sericea</i>	<i>L. sericea</i>					X	X	X									
<i>Stewartia submonadelpha</i>	<i>S. monadelpha</i>					X	X	X		X							
<i>Liquidambar miosinica</i>	<i>L. formosana</i>								X			X	X	X			
<i>Deutzia mogiensis</i>	<i>D. crenata</i>		X	X	X	X	X					X	X	X			
<i>Chaenomeles chloranthoides</i>	<i>C. japonica</i>					X	X	X									
<i>Prunus florini</i>	" <i>P. jamasakura</i> "					X	X	X									
<i>Prunus nathorsti</i>	<i>P. buergeriana</i>			X	X	X	X										
<i>Pyracantha nipponica</i>	<i>P. coccinea</i>														X		
<i>Sorbus lequereuxi</i>	<i>S. alnifolia</i>		X	X	X	X	X		X	X	X	X			X		
<i>Maackia onoei</i>	<i>M. amurensis</i>		X	X	X				X	X					X		
<i>Wisteria fallax</i>	<i>W. floribunda</i>			X	X	X	X										
<i>Sapium mogiense</i>	<i>S. japonicum</i>			X	X	X	X				X						
<i>Zanthoxylum engleri</i>	<i>Z. allanthoides</i>			X	X	X	X	X	X					X			
<i>Rhus nathorsti</i>	<i>R. sylvestris</i>				X	X	X	X	X		X						
<i>Acer integerrimum</i>	<i>A. mono</i>	X	X	X	X	X	X		X	X	X				X		
<i>Acer nordenskioldi</i>	<i>A. palmatum</i>			X	X	X	X		X	X	X						
<i>Sapindus tanaii</i>	<i>S. mukurossi</i>				X	X	X	X	X		X	X	X	X			
<i>Meliosma</i> cf. <i>myriantha</i>	<i>M. myriantha</i>			X	X	X	X		X		X	X	X	X			
<i>Ilex heeri</i>	<i>I. pedunculosa</i>				X	X	X	X			X		X				
<i>Ilex lundbladae</i>	<i>I. chinensis</i>				X	X	X				X	X	X				
<i>Ilex onoei</i>	<i>I. serrata</i>			X	X	X	X										
<i>Rhamnus</i> cf. <i>costata</i>	<i>R. costata</i>				X	X	X										
<i>Vitis naumannii</i>	<i>V. lubrusca</i>		X	X	X	X	X										
<i>Elaeocarpus florini</i>	<i>E. sylvestris</i>				X	X	X	X	X		X			X			
<i>Elaeocarpus saportanus</i>	<i>E. japonicus</i>				X	X	X	X	X		X	X	X	X			
<i>Tilia distans</i>	<i>T. kiusiana</i>				X	X	X										
<i>Cornus megaphylla</i>	<i>C. controversa</i>		X	X	X	X	X	X	X	X	X	X	X	X			
<i>Cornus subkousa</i>	<i>C. kousa</i>			X	X	X	X		X	X	X						
<i>Clethra maximowiczii</i>	<i>C. barbinervis</i>		X	X	X	X	X	X	X	X	X			X			
<i>Enkianthus almquisti</i>	<i>E. perulatus</i>						X										
<i>Diospyros nordqvisti</i>	<i>D. kaki</i>				X	X	X			X	X	X					
<i>Styrax protoobassia</i>	<i>S. obassia</i>		X	X	X	X	X		X	X	X			X	X		
<i>Styrax protojaponica</i>	<i>S. japonica</i>		X	X	X	X	X		X	X	X						
<i>Symplocos smithi</i>	<i>S. ilicifolia</i>							X									
<i>Viburnum viburnifolia</i>	<i>V. erosum</i>				X	X	X				X		X				
		4	16	28	45	43	43	15	25	19	31	12	15	9	1		

1. Saghalien and Kurile Island 2. Hokkaido 3. Northern Honshu 4. Central Honshu 5. Southern Honshu 6. Kyushu and Shikoku 7. Taiwan and Ryukyu Islands 8. Korea 9. North China 10. Central China 11. Southwest China 12. Southeast China 13. Manchuria 14. Others

evergreen broadleaved forests of the warm-temperate type are distributed from Kwanto region westward to Kyushu. Although most of them are now the secondary forests, they are a mixture of the evergreen and deciduous broadleaved trees, associated by pines, *Tsuga* and *Abies*. These forests are characterized by common occurrence of evergreen oaks, *Camellia*, *Cinnamomum*, *Eurya*, *Myrica* and others. The Mogi flora contains few evergreen trees, especially no evergreen oaks. However, in these forests, especially its upper zone, the warm-temperate trees similar to the Mogi plants are found as follows:

<i>Kandsura japonica</i> (<i>K. protojaponica</i>)	<i>Rhus sylvestris</i> (<i>R. nathorsti</i>)
<i>Cinnamomum camphora</i>	<i>Sapindus mukurossi</i> (<i>S. tanaii</i>)
(<i>C. cf. miocenum</i>)	<i>Ilex chinensis</i> (<i>I. lundbladae</i>)
<i>Stewartia monadelpha</i>	<i>Rhamnus costata</i> (<i>R. cf. costata</i>)
(<i>S. submonadelpha</i>)	<i>Elaeocarpus japonicus</i> (<i>E. saportanus</i>)
<i>Maackia amurensis</i> var. (<i>M. onoei</i>)	<i>Elaeocarpus sylvestris</i> var. (<i>E. florini</i>)
<i>Sapium japonicum</i> (<i>S. mogiense</i>)	<i>Tilia kiusiana</i> (<i>T. distans</i>)
<i>Zanthoxylum ailanthoides</i> (<i>Z. engleri</i>)	<i>Viburnum erosum</i> (<i>V. viburnifolium</i>)

Most of the above-listed species are also distributed in the secondary forests in coastal lowlands. As the Mogi flora contains no evergreen oaks, it is quite different from the evergreen forests of the coastal regions in western Honshu, Shikoku and Kyushu.

The above-noted comparison with the living forests concludes that the Mogi flora is closely similar to the slope forests of central and western Japan at altitudes of 300 up to 700–800 meters. Judging from the evidence of no evergreen oaks and two-needled pines, the Mogi forest probably represents the lower slope vegetation somewhat apart from the coast.

Considering the climatic conditions under which the comparable living forests are growing, the climate indicated by the fossil flora may be approximately presumable. We have useful records from several localities: for instance, Hiroshima, Okayama and Shimonoseki along the Seto Inland Sea and Mishima and Gifu in central Honshu. In these localities mean annual precipitation is from 1500 to 1800 mm., and mean annual temperature is from 14° to 16°C. As these localities are along the coast or on the coastal plain, the Mogi climate is probably slightly lower in mean temperature. The author (Tanai, 1970) once discussed on Oligocene climate by the warmth and coldness indices proposed by Kira (1948, 1949). Inferred from the climatic data of the above regions, the Mogi climate shows 100° to 110°C in the warmth index and 0° to –2°C in the coldness index.

Geological Age

The Mogi plant-bearing formation has been discussed on its geologic age by various authors. It contains no marine indications, and its age determination has been based principally on plant fossils. Nathorst (1883) considered first the Mogi flora to be of late Pliocene or early Pleistocene age, because most of the components are referable to the temperate species living in Japan. Comparing the Mogi flora with other Neogene floras of Japan and Europe, Florin (1920) dated it as late Pliocene age. Thereafter, his age-evaluation has been followed by many geologists and also by paleobotanists such as Yabe and Endo (1930) and Miki (1937, 1938). Especially, Miki (1938) correlated the Mogi flora to the Akashi flora (Miki, 1937), which is recently believed to be early Pleistocene in age by many authors (Huzita, 1954; Itihara, 1961).

Late Cenozoic sediments associated by various volcanics are widely distributed in shreds from central to southern Kyushu; most of them, except in a few regions, are of terrestrial origin, and yield a number of plant fossils, both leaves and reproductive organs. However, these Late Cenozoic floras have been not always fully investigated stratigraphically or paleobotanically, and furthermore the plant-bearing sediments are too locally-distributed to be correlated each other. Shuto (1962) published a comprehensive study on Late Cenozoic history of Kyushu in view of sedimentation, volcanism and geotectonics. He considered the Mogi plant-bearing formation represented the Lower Pleistocene terrestrial deposits associated by pyroxene-andesite lavas, which are widely distributed in Kyushu.

Based largely on the reproductive organs such as seeds, fruits and cones, an extensive investigation was made by Miki and Kokawa (1962): Late Pliocene and Pleistocene floras are divided into four groups by the floristic composition. It is, however, incomparable to the floristic sequences established by them, because the Mogi flora is composed mainly of leaf remains. Onoe (1972) who recently investigated the Late Cenozoic plants of southern Kyushu, recognized preliminarily three-horizons of leaf-floras, ranged from late Pliocene to early Pleistocene ages. It is unfortunate for our comparison with the Mogi flora that his preliminary report shows only floristic lists of each flora without any illustrations and descriptions of the fossil plants.

The knowledge of Late Cenozoic floras of Japan has been considerably accumulated during the recent two decades. The current systematic reinvestigation of the Mogi flora may allow a basis in regard to correlation of this flora with the Late Cenozoic floras of Honshu and Hokkaido. *Metasequoia* has such long range during the Tertiary as to be of little value in biostratigraphy as far as based on megascopic character, and it is excluded from the consideration.

Table 4 shows the known stratigraphic distribution of the Mogi dicotyledonous species that occur in Honshu and Hokkaido. Data presented in Table 4 indicate that the Mogi flora may be of Late Miocene age, if its geographic position is ignored.

In northeastern Honshu and Hokkaido the occurrence of Neogene leaves is well known, but most of the floras studied in detail are of Middle to Late Miocene age, and few are Pliocene. On the other hand, the Pliocene and Pleistocene floras are well known in western Honshu, and have been investigated mainly on the basis of reproductive organs such as seeds, cones, fruits and pollen; in relatively few cases are their leaves to provide a definitive basis for comparison with the Mogi flora. Thus, the author does not easily believe that the age relationships of the Mogi can be accurately determined only by comparison of species ranges like those given in Table 4.

It is one of the characteristic features that Mogi flora contains a number of beech leaves, all of which are referable to *Fagus stuxbergi* (= *F. palaeocrenata*). As already discussed by the author (Tanai, 1972, 1974), *F. stuxbergi* appeared first in the upper Miocene in Japanese islands, and then became gradually meagre toward the end of the Pliocene, replacing by the extant species, *F. crenata* or *F. japonica*. As far as known up to the present, *F. stuxbergi* is usually one of the dominant members in the leaf-floras of Honshu during late Miocene and early Pliocene time.

Many floras of late Miocene age have been well known in northeastern Honshu, which is situated northward by more than seven degrees in latitudes. They are represented by a number of beech leaves ("*F. palaeocrenata*"), and are composed largely of temperate genera. However, many extinct dicotyledonous genera are also contained, such as *Liquidambar*, *Sassafras*, *Catalpa*, *Liriodendron*, *Ailanthus* and others, most of which genera were flourished during middle Miocene time. The Mogi flora is rather similar to early Pliocene flora of Honshu in respect that it contains no extinct dicot genera excepting for *Liquidambar* and *Pyracantha*. For instance, the Hoki flora (Tanai and Onoe, 1961) which is most close in geographic position to the Mogi, consists of three florules, the Mitoku, the Onbara and the Ningyo-toge, ranged from late Miocene to early Pliocene; the Mogi flora shows a close resemblance in composition and components to the Mio-Pliocene Onbara and the early Pliocene Ningyo-toge florules. However, it remains still unsolved why the Mogi flora lacks several temperate trees such as *Quercus* (deciduous), *Castanea*, *Populus* and *Betula* usually common in early Pliocene floras of Honshu.

In the southern end of the Shimabara peninsula, just opposite side of the Chijiwa Bay east of Mogi, there is known a leaf-flora, the Oya flora (Takahashi, K., 1954); although it is generally similar in composition, the Oya flora

Table 4 Known stratigraphic ranges of the Mogi dicotyledonous species in Japan

Fossil species	Miocene			Pliocene	
	L	M	U	L	U
<i>Juglans japonica</i>	X	X	X	X	X
<i>Carpinus stenophylla</i>	X	X	X	X	
<i>Carpinus subcordata</i>	X	X	X	X	X
<i>Ostrya shiragiana</i>	X	X	X	X	
<i>Fagus stuxbergi</i>			X	X	
<i>Celtis nordenskiöldi</i>			X	X	
<i>Ulmus miopumila</i>		X	X		
<i>Ulmus protojaponica</i>			X	X	
<i>Zelkova ungeri</i>	X	X	X	X	X
<i>Magnolia elliptica</i>			X	X	
<i>Kadsura protojaponica</i>		X			
<i>Cinnamomum miocenium</i>		X	X	X	
<i>Lindera miyataensis</i>			X		
<i>Stewartia submonadelpha</i>			X	X	X
<i>Liquidambar miosinica</i>		X	X	X	X
<i>Chaenomeles chloranthoides</i>		X			
<i>Sorbus lesquereuxi</i>		X	X		
<i>Maackia onoei</i>		X			
<i>Wisteria fallax</i>		X	X	X	
<i>Sapium mogiense</i>			X		
<i>Acer integerrimum</i>	X	X	X	X	X
<i>Acer nordenskiöldki</i>		X	X	X	X
<i>Sapindus tanaii</i>		X			
<i>Ilex heeri</i>		X	X		
<i>Vitis naumannii</i>	X		X	X	X
<i>Tilia distans</i>		X	X	X	
<i>Cornus megaphylla</i>	X	X	X		
<i>Cornus subkousa</i>			X	X	X
<i>Clethra maximowiczii</i>			X	X	X
<i>Enkianthus almquisti</i>		X			
<i>Styrax protoobassia</i>	X		X	X	
<i>Styrax protojaponica</i>				X	
<i>Diospyros nordqvisti</i>	X	X	X	X	X
	10	21	27	22	11

contains rather commonly the leaves of the extant *Fagus crenata*. Thus, the Oya flora is younger than the Mogi and is probably correlative to the Akashi flora of Kinki district.

The Late Cenozoic (Pliocene to Pleistocene) sediments are well distributed in Kinki and Tokai districts of Honshu; they have been investigated in detail by

various authors in views of stratigraphy, paleobotany, paleontology, and even paleomagnetism. These investigations have been aimed mainly at clarifying the Plio-Pleistocene boundary in these regions. All of these results were ably summarized by Ishida et al. (Ishida and Yokoyama, 1969; Ishida, 1970). The floristic sequence is well established on the basis of both megafossils (Miki, 1941, 1948; Huzita, 1954) and pollen (Nasu, 1970; Tai, 1973). The sequences are composed of three horizons, "*Pinus trifolia* flora" (early Pliocene), "*Metasequoia* flora" (late Pliocene-early Pleistocene) and "*Paliurus* flora" (early Pleistocene) as proposed first by Miki (1948). Later it was partly revised by Kokawa (1961) and Itihara (1961): the "*Metasequoia* flora" was subdivided into two, the flourishing and declining times. The floristic changes in western Honshu well correspond with the gradual extinction of many exotic genera of dicots and conifers, although there were minor climatic fluctuations ascertained by pollen floras.

The so-called "*Metasequoia*-declining time" represented by the Akashi flora, is recently asserted by the above-noted authors to be of earliest Pleistocene age. It is the first record of the cold phase during late Cenozoic time in western Honshu. The Akashi flora contains the leaves of the extant *Fagus crenata*, and is distinctly younger than the Mogi, though generally similar in composition and components. Leaves or cupules of *Fagus stuxbergi* are contained in both the "*Metasequoia*-flourishing flora" and the "*Pinus trifolia* flora", especially common in the latter. However, the latter flora contains many genera of exotic dicots such as *Carya*, *Fortunearia*, *Liquidambar*, *Spondias* and *Nyssa*, along with many exotic conifers such as *Pseudolarix*, *Cunninghamia*, *Metasequoia* and others. These exotic dicots are less in the "*Metasequoia*-flourishing flora. These two Pliocene floras of western Honshu are considered to represent the lowland vegetation near the coast. Considering the difference of the habitat, the Mogi flora is probably correlative to the "*Pinus trifolia*" or *Metasequoia*-flourishing flora" of Kinki and Tokai districts, especially to the latter.

It is now difficult to assign definitely the age of the Mogi flora, because the leaf-floristic sequences of the late Cenozoic have not yet established in western Honshu and Kyushu. The discussion and comparison in the foregoing pages may conclude that the Mogi flora is dated as Pliocene age, probably Late Pliocene age. Further detailed investigation of the late Cenozoic floras scattered in Kyushu may revise the age evaluation of the Mogi flora.

Systematic Descriptions

Family Taxodiaceae
Genus *Metasequoia* Miki

Metasequoia occidentalis (Newberry) Chaney
(Pl.1, fig.1)

Metasequoia occidentalis (Newberry) Chaney, Trans. Amer. Philosoph. Soc., new ser., v.40, pt.30, p.225. pl.1, fig.3; pl.2, figs.1-3, and others, 1951.

Tanai & Onoe, Bull. Geol. Surv. Japan, v.10, no.4, p.276, pl.2, figs.1-3, 1959.

Taxites sp., Nathorst, Kgl. Svensk. Vet. Akad. Handl. v.20, p.35, pl.1, fig.8, 1883.

Taxodium ? *distichum* Rich., Florin, ibid. v.61, p.16, pl.1, figs.1, 2, 1920.

Florin, ditto p.30, pl.5, figs.10, 11, 1920.

Discussion: In the reinvestigation of the Mogi specimens, Florin (1920) referred *Taxites* sp. to *Taxodium* ? along with two additional specimens. These three specimens are distinctly referable to the genus *Metasequoia* in the decussate arrangement of leaves. A single foliage shoot identified to *Metasequoia* is also found in our collection. Though no cone is found, these Mogi species are identifiable to *M. occidentalis*, which is common in the Tertiary of Japan.

Collection: Hypotype, G.S.J. no. 4701.

Family Juglandaceae

Genus *Juglans* Linn.

Juglans japonica Tanai

(Pl.1, figs.6, 7; text-fig.2, a)

Juglans japonica Tanai J. Fac. Sci., Hokkaido Univ., ser.4, v.11, no.2, p.275, pl.6, figs.9, 10, 1961.

Huzioka, Tertiary floras of Japan, Miocene floras. p.191, pl.29, figs.6-9, 1963.

Huzioka, J. Min. Coll. Akita Univ., ser.A, v.3, p.67, pl.4, fig.1, 1964.

Tanai & N. Suzuki, Palaeont. Soc. Jap. Spec. Pap. no.10, p.12, pl.18, fig.4, 1965.

Tanai & N. Suzuki, J. Fac. Sci., Hokkaido Univ., ser.4, p.325, 1972.

Huzioka & Takahashi, Bull. Nat. Sci. Mus., v.16, p.131, 1973.

Huzioka & Uemura, ditto, v.17, p.348, pl.4, figs.1, 4, 1974.

Juglans sieboldiana Maxim. fossilis Nathorst, Kgl. Svensk. Vet. Akad. Handl., v.20, p.37, pl.1, figs.13-18, 1883.

Florin, ditto, v.61, p.17, pl.2, fig.8, 1920.

Juglans sp., Tanai & Onoe, Geol. Surv. Japan Rept. no.187, p.21, pl.11, fig.4, 1961.

Discussion: The Leaflets described as *Juglans sieboldiana* Maxim. from Mogi and Amakusa are referred to *J. japonica* as already pointed out by the author (Tanai, 1961). These leaflets closely resemble those of the extant *J. ailanthifolia* Carr. of northeastern Asia in shape and venation, but somewhat differ in more densely arranged teeth of margin (text-fig. 2, a, b). *J. japonica* has been recently reported in common from the Miocene of Japan as shown in the above synonymy list, and is probably a direct progenitor of the extant *J. ailanthifolia*.

Nathorst (1883) established *J. kjellmanni*, based on the leaflets of Mogi: according to his description, these specimens are entire in margin, and resemble

leaflets of the extant *J. regia* Linn. distributed from southeastern Europe to China. The reinvestigation of these original specimens shows, however, that they are distinctly serrate in margin. One of the specimens (Nathorst, 1883: pl. 1, fig. 12) is referred to the genus *Clethra* as discussed in later pages. Others (Nathorst, 1883: pl. 1, figs. 10, 11; these two are represented by an leaflets and its incomplete counterpart) doubtlessly represent a terminal leaflet of *Juglans*, and are probably identical to *J. japonica* in margin and venation character. Although the epithet, "*kjellmani*", has a nomenclature priority for these *Juglans* leaflets, the original specimens of *J. kjellmani* do not well preserve the marginal character. Thus, it is better the epithet, "*japonica*", is still retained.

Family Betulaceae
Genus *Carpinus* Linn.
Carpinus stenophylla Nathorst
(Text-fig. 2, c, d)

Carpinus stenophylla Nathorst. Kgl. Svensk. Vet. Akad. Handl., v.20, p.41, pl.3, fig.16, 1883.

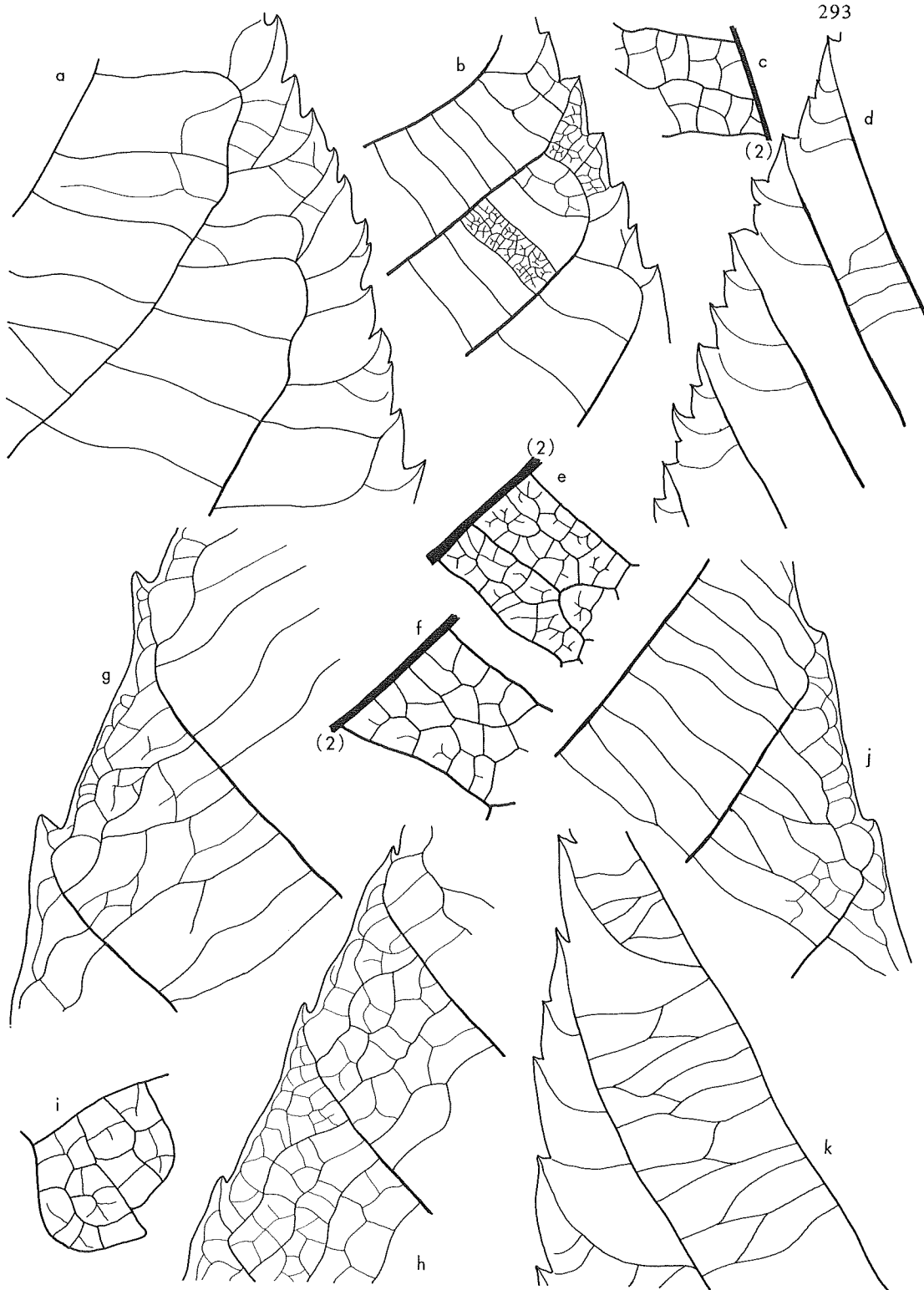
Discussion: The original specimen, though lacking the basal part, is distinguishable from *C. subcordata* in narrower shape and marginal serration with less teeth. As already pointed out by the author (Tanai & N. Suzuki, 1965), this original specimen is closely related to the modern *C. japonica* Maxim., but it is somewhat distant from the typical leaves of the extant species, especially in the areolation (text-fig. 2, c, e).

Collection: Lectotype, Swedish Museum of Natural History, Paleobotany Section (Nathorst, 1883: pl. 3, fig. 16).

Carpinus subcordata Nathorst
(Pl.1, figs.2, 3)

Text-fig. 2 The details of venation characters of fossils and their related extant species (1).

- a. *Juglans japonica* Tanai. X 5 (Nathorst, 1883: pl.1, fig.13).
- b. *Juglans ailanthifolia* Carr. X 5 (H.U.P.B. no.510)
- c, d. *Carpinus stenophylla* Nathorst. c. X 15, d. X 5 (Nathorst, 1883: pl.3, fig.16).
- e. *Carpinus japonica* Maxim. X 15 (H.U.P.B. no.717).
- f. *Carpinus cordata* Blume. X 15 (H.U.P.B. no.7).
- g. *Fagus stuxbergi* (Nathorst) Tanai. X 6 (Nathorst, 1883: pl.4, fig.6).
- h, i. *Fagus stuxbergi* (Nathorst) Tanai. h. X 6, i. X 20 (Nathorst, 1883: pl.5, fig.2).
- j. *Fagus stuxbergi* (Nathorst) Tanai. X 6 (Nathorst, 1883: pl.4, fig.7).
- k. *Ostrya shiragiana* Huzioka. X 5 (Nathorst, 1883: pl.3, fig.2).



Carpinus subcordata Nathorst. Kgl. Svensk. Vet. Akad. Handl., v.20, p.39, pl.2, figs.13-16, 18, 20 (excluding pl.2, fig.17; pl.3, fig.3), 1883.

Huzioka et Uemura. Bull. Natl. Sci. Mus. v.16, p.707, pl.4, fig.8, 1973 (see synonymy).

Sorbus lesquereuxi Nathorst (in part). Kgl. Svensk. Vet. Akad. Handl., v.20, p.57, pl.3, fig.11 only, 1883.

Discussion: The reinvestigation of the original specimens reveals that all of their leaves excluding two are closely related with the extant *Carpinus cordata* Bl. in double serrate margin with aciculate teeth and cordate base. A leaf (Nathorst, 1883: pl. 2, fig. 13) which was invalidly illustrated, has double serrate teeth, and represents a small leaf of *C. subcordata*. A fragmentary bract appears to be included in *C. subcordata* by its venation character.

C. subcordata has been commonly found from the Neogene of East Asia on the basis of leaves and bracts, though reported sometimes under various names. All of the synonymy was recently shown by Huzioka and Uemura (1973). A single leaf described as *Sorbus lesquereuxi* from Mogi (Nathorst, 1883: pl. 3, fig. 11) is identical with *C. subcordata*.

Collections: Lectotype, Swedish Museum of Natural History, Paleobotany Section (Nathorst, 1883: pl. 2, fig. 14); hypotype G.S.J. no. 4702.

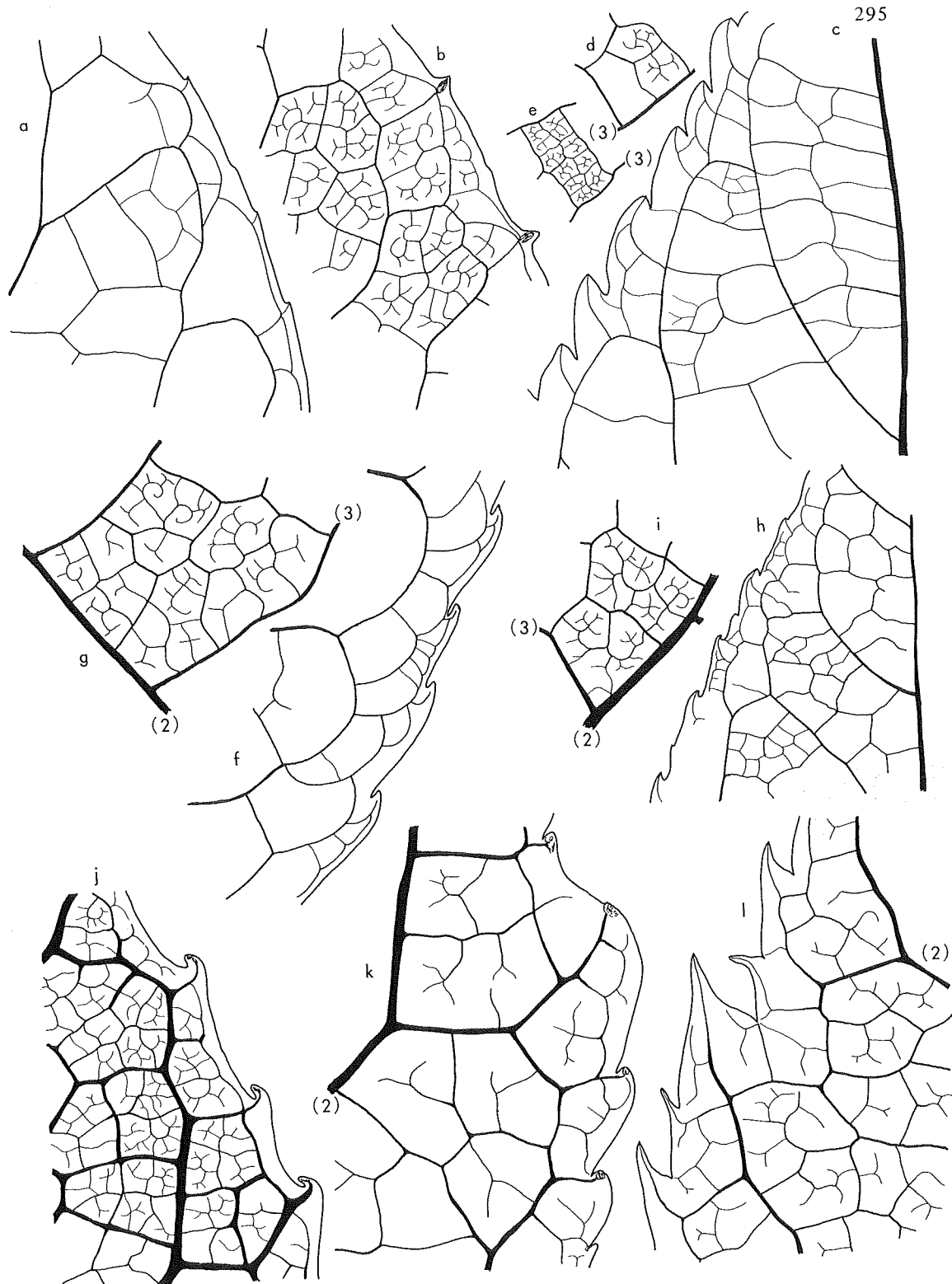
Carpinus sp.
(Pl.1, fig.9)

Carpinus sp., Nathorst. Kgl. Svensk. Vet. Akad. Handl. v.20, p.41, pl.2, fig.19, 1883.

Discussion: A single incomplete leaf described as *Carpinus* sp. by Nathorst, is similar to the extant *C. tchonoskii* Maxim. or *C. laxiflora* (S. et Z.) Blume, especially to the former in the marginal serration. A single bract similar to *C. tchonoskii* is found in our collection. These leaf and bract specimens are identical to *C. subyedoensis* Konno, which has been commonly found in the Miocene and the lower Pliocene of Japan by various authors including the present author (Tanai, 1961). However, "*Carpinus subyedoensis*" is the nomen nudum, because Konno (1931) showed only the illustration with no descrip-

Text-fig. 3 The details of venation characters of fossils and their related extant species (2).

- a. *Schisandra florini* Tanai. X 6 (Florin, 1920: pl.6, fig.12).
- b. *Schisandra chinensis* (Rupr.) Baill. X 6 (H.U.P.B. no.272).
- c, d. *Celtis nordenskiöldi* Nathorst. c. X 5, d. X 7.5 (Nathorst, 1883: pl.15, fig.2).
- e. *Celtis bungeana* Blume. X 7.5 (H.U.P.B. no.217).
- f, g. *Liquidambar miosinica* Hu et Chaney. f. X 6, g. X 15 (Nathorst, 1883: pl.8, fig.5).
- h, i. *Liquidambar miosinica* Hu et Chaney. h. X 3, i. X 20 (G.S.J. hypotype no.4711).
- j. *Liquidambar formosana* Hance. X 10 (H.U.P.B. no.34).
- k. *Liquidambar styraciflua* Linn. X 10 (H.U.P.B. no.33).
- l. *Kalopanax pictus* (Blume) Nakai. X 10 (H.U.P.B. no.15).



tion of the characters. In place of the epithet "*subyedoensis*", *C. konnoi* Suzuki (Suzuki, 1961) may be valid, but this taxonomic problem shall be discussed in other paper.

Collection: G.S.J. no. 4703.

Genus *Ostrya* Scop.
Ostrya shiragiana Huzioka
 (Text-fig. 2, k)

Ostrya shiragiana Huzioka. Trans. Proc. Palaeont. Soc. Japan, N.S., no.13, p.121, p.13, figs.7, 8, 1954.

Ostrya virginiana Willd. fossilis Nathorst. Kgl. Svensk. Vet. Akad. Handl. v.20, p.42, pl.3, fig.2, 1883.

Carpinus subcordata Nathorst (in part). *ibid.* p.39, pl.2, fig.17; pl.3, fig.3 (excluding pl.2, figs.13-16, 18, 20), 1883.

Discussion: A single leaf described as *Ostrya virginiana* Willd. fossilis is doubtlessly referred to the genus *Ostrya* in marginal serration and venation character: especially tertiary veins branch well from the secondaries near the margin. This Mogi specimen is related with the extant *O. japonica* Sargent of Japan and *O. virginiana* Willd. of the eastern United States, but is somewhat narrower than the averaged leaves of these extant species. Considering the variation of foliar shape, the Mogi specimen is referred to *O. shiragiana*, which is common in the Miocene of Japan. Two leaves of *Carpinus subcordata* from Mogi (Florin, 1920) are identical with *O. shiragiana* in all characters.

Family Fagaceae
 Genus *Fagus* Linn.
Fagus stuxbergi (Nathorst) Tanai, comb. nov.
 (Pl.1, figs.4, 5, 8, 10; text-fig.2, g-j)

Text-fig. 4 The details of venation characters of fossils and their related extant species (3)

a. *Pyracantha nipponica* Tanai. X 6 (Nathorst, 1883: pl.13, fig.7).

b, c. *Pyracantha coccinea* Roem. b. X 6, c. X 15 (H.U.P.B. no.111).

d. *Lindera umbellata* Thunb. X 10 (H.U.P.B. no.9).

e, f. *Lindera miyataensis* Huzioka et Uemura. e. X 5, f. X 10 (G.S.J. hypotype no.4709).

g, h. *Lindera* cf. *sericea* Blume. g. X 6, h. X 14 (Nathorst, 1883: pl.8, fig.3).

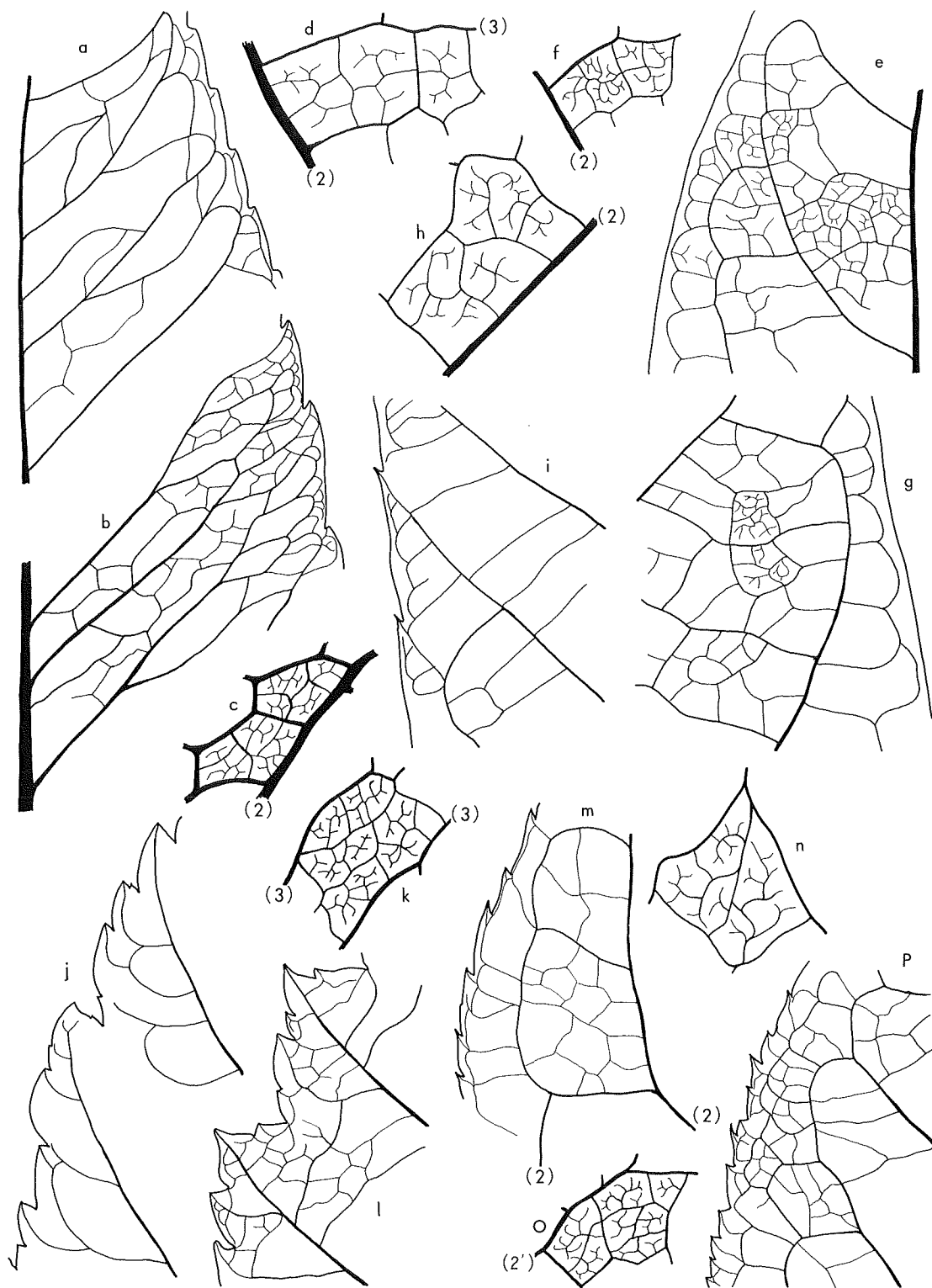
i. *Meliosma* cf. *myriantha* S. et Z. X 5 (Nathorst, 1883: pl.3, fig.17).

j. *Sorbus lesquereuxi* Nathorst. X 5 (Nathorst, 1883: pl.3, fig.10).

k, l. *Sorbus alnifolia* S. et Z. k. X 15, l. X 5 (H.U.P.B. no.54).

m, n. *Prunus nathorsti* Tanai. m. X 4, n. X 15 (Nathorst, 1883: pl.11, fig.9).

o, p. *Prunus buergeriana* Miq. o. X 15, p. X 4 (H.U.P.B. no.720).



Quercus stuxbergi Nathorst, Kongl. Svensk. Vet. Akad. Handl. v.20, p.44, pl.3, figs.18-20; pl.4, figs.4-9 (excluding figs.1-3), 1883.

Fagus ferruginea Ait. fossilis Nathorst. *ibid.* p.43, pl.4, figs.11-24; pl.5, figs.1-11; pl.6, fig.1.

Fagus palaeocrenata Okutsu, Tanai. Birbal Sahni Inst. Spec. Publ. no.1, p.70, pl.4, fig.4; pl.5, figs.1, 2, 4, 6, 7, 1974 (see synonymy).

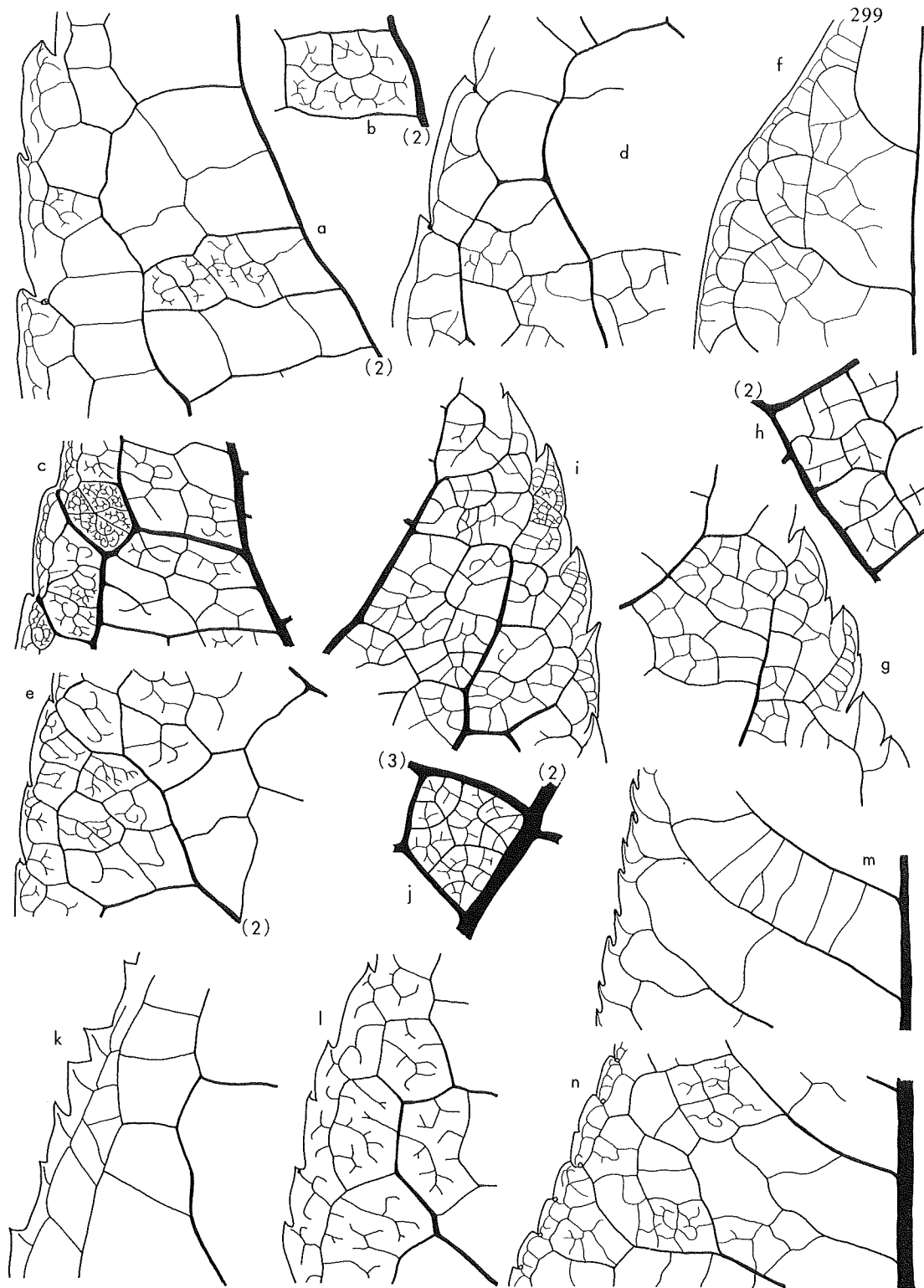
Discussion: All the original specimens of *Quercus stuxbergi*, excluding three fragmentary ones (Nathorst, 1883; pl.4, figs.1-3), do not show any characters of *Quercus*, but are distinctly referred to *Fagus* in the margin and venation characters. Especially, as shown in text-fig. 2, the secondary veins of these specimens arise up suddenly near the margin, and their branches usually enter marginal teeth which are minute and not aristate. Nathorst (1883) compared *Q. stuxbergi* with the extant *Q. glauca* Blume and *Q. stenophylla* Blume of Japan; however, the leaves of these two modern oaks are usually more lanceolate in shape and with aristate teeth in which the secondary veins end directly. Thus, most leaves described as *Q. stuxbergi* are quite indistinguishable from the leaves of *Fagus ferruginea* Ait. fossilis from same locality, and represent only rather narrow beech leaves having acute or cuneate base.

As already discussed in several time by the author (Tanai, 1960, 1961, 1974), the leaves of *F. ferruginea* from Mogi locality have been included in *F. palaeocrenata* Okutsu (Okutsu, 1955) in the secondary venation, leaf index and marginal character, which species is commonly known in the Upper Miocene and the Lower Pliocene of Japan. However, *F. stuxbergi* emended here has a nomenclature priority for such serrate-toothed leaves similar to the extant *F. crenata* Blume.

Collections: Lectotype, Swedish Museum of Natural History, Paleobotany Section (Nathorst, 1883, pl. 4, fig. 9); hypotypes G.S.J. nos. 4704, 4705.

Family Ulmaceae Genus *Celtis* Linn.

Text-fig. 5 The details of venation characters of fossils and their related extant species (4)
a, b. *Elaeocarpus saportanus* (Nathorst) Tanai. a. X 6, b. X 20 (Nathorst, 1883: pl.11, fig.6).
c. *Elaeocarpus japonicus* S. et Z. X 6 (H.U.P.B. no.65).
d. *Elaeocarpus florini* Tanai. X 5 (Nathorst, 1883: pl.9, fig.5).
e. *Elaeocarpus sylvestris* (Lour.) Poir. X 5 (H.U.P.B. no.66).
f. *Wisteria fallax* (Nathorst) Tanai et Onoe. X 5 (Nathorst, 1883: pl.10, fig.12).
g, h. *Tilia distans* Nathorst. g. X 6, h. X 20 (Nathorst, 1883: pl.6, fig.6).
i, j. *Tilia kiusiana* Mak. et Shiras. i. X 5, j. X 15 (H.U.P.B. no.101).
k. *Enkianthus almqvistii* (Nathorst) Tanai. X 15 (Nathorst, 1883: pl.9, fig.13).
l. *Enkianthus perulata* Schneid. X 15 (H.U.P.B. no.495).
m. *Zanthoxylum engleri* (Nathorst). X 5 (Nathorst, 1883: pl.2, fig.5).
n. *Zanthoxylum ailanthoides* S. et Z. X 5 (H.U.P.B. no.294).



Celtis nordenskiöldi Nathorst
(Pl.2, fig.3; text-fig.3, c, d)

Celtis nordenskiöldi Nathorst (in part). Kgl. Svensk. Vet. Akad. Handl. v.20, p.47, pl.15, fig.2 only (excluding pl.6, figs.14-17), 1883.

Discussion: Among the original specimens described as *Celtis nordenskiöldi*, only one specimen is confirmable to belong to the genus *Celtis* in the venation characters, and the other three are referred to *Tilia distans* as discussed later. A single specimen from Mogi by Nathorst (pl. 15, fig. 2) shows a characteristic feature of *Celtis*: lateral primary and secondary veins form regularly loops near the margin; tertiary veins are nearly perpendicular to the midvein; fine veinlets branch more than two times in the quadrangular areoles; marginal teeth are rather obtuse. This specimen is closely similar to leaves of the extant *C. bungeana* Blume and *C. sinensis* Pers.

C. nordenskiöldi redesignated here is closely similar to *C. miobungeana* Hu et Chaney from the Miocene Shanwang flora of China (Hu et Chaney, 1938), which species has been sometimes used in the Neogene of Japan. These two species are probably conspecific as already pointed out by the author (Tanai & Suzuki, 1965). However, an original specimen remained here is too incomplete to endure as a type, although the epithet, *nordenskiöldi*, has a nomenclatural priority. Avoiding the future taxonomical confusion, it is rather better to adopt the epithet, *miobungeana*, for the fossil leaves similar to the extant *C. bungeana*.

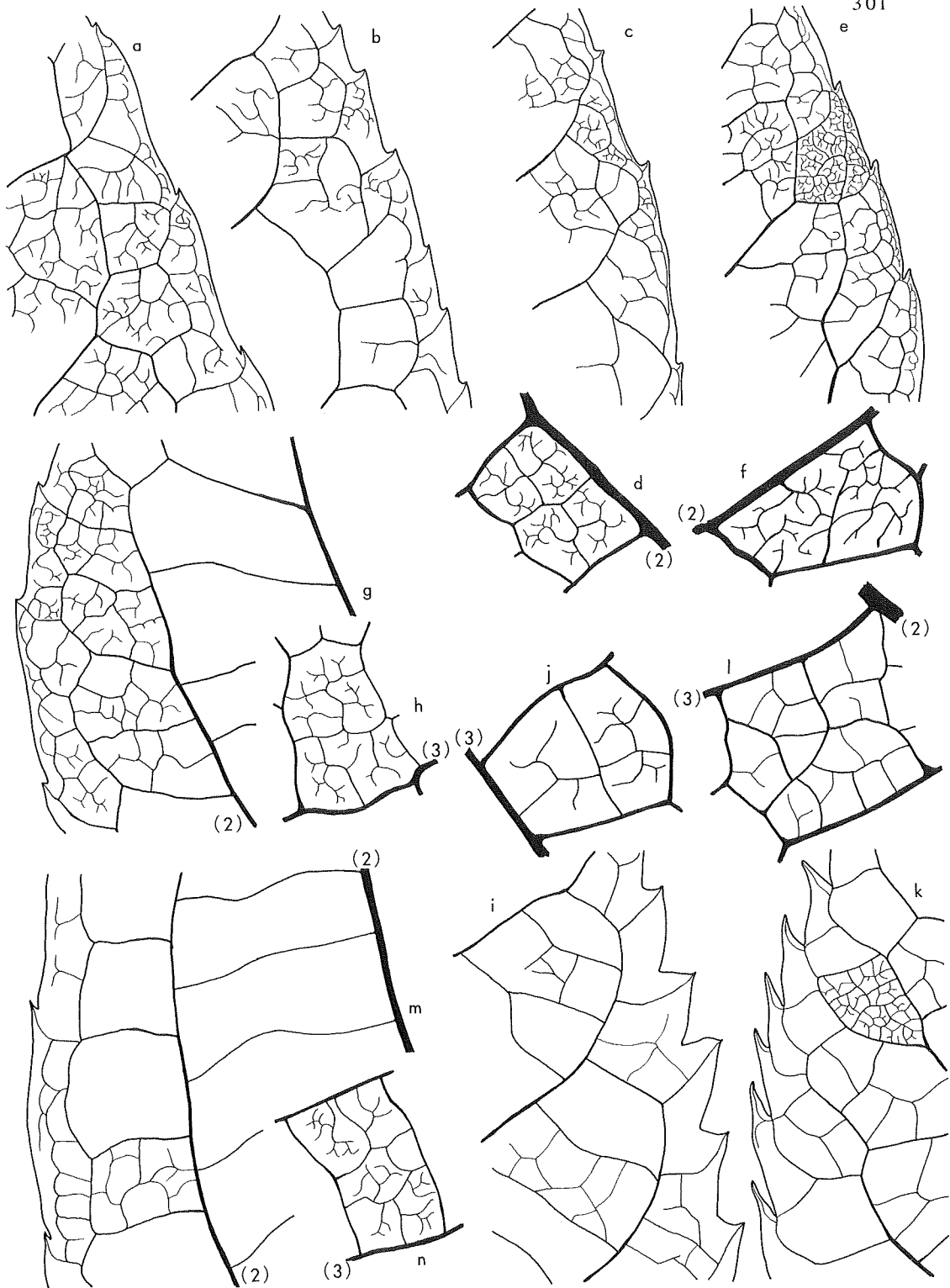
Collection: Lectotype, Swedish Museum of Natural History, Paleobotany Section (Nathorst, 1883; pl. 15, fig. 2).

Genus *Ulmus* Linn.
Ulmus miopumila Hu et Chaney

Ulmus miopumila Hu et Chaney. Palaeont. Sinica, n. ser. A, no.1, p.39, pl.14, figs.2, 3, 1938.

Text-fig. 6 The details of venation characters of fossils and their related extant species (5)

- a. *Ilex chinensis* Simons. X 5 (H.U.P.B. no.69).
- b. *Ilex lundbladae* Tanai. X 5 (G.S.J. holotype no.4725b).
- c, d. *Ilex onoei* Tanai. c. X 5, d. X 12.5 (G.S.J. holotype no.4734).
- e, f. *Ilex nipponica* Makino. e. X 5, f. X 12.5 (H.U.P.B. no.708).
- g, h. *Styrax japonica* S. et Z. g. X 6, h. X 12.5 (H.U.P.B. no.78).
- i, j. *Clethra maximowiczii* Nathorst. i. X 5, j. X 15 (Nathorst, 1883: pl.11, fig.19).
- k, l. *Clethra barbinervis* S. et Z. k. X 5, l. X 15 (H.U.P.B. no.1).
- m, n. *Styrax protojaponica* Tanai. m. X 6, n. X 12.5 (Nathorst, 1883: pl.14, fig.7).



Ulmus cf. *campestris* Sm., Nathorst. Kgl. Svensk. Vet. Akad. Handl., v.20, p.46, pl.7, fig.1, 1883.

Ulmus cf. *carpinoides* Goeppert, Florin, ibid. v.61, p.31, pl.5, figs.12-14, 1920.

Discussion: The elm leaves from Mogi cited above, are identical with *Ulmus miopumila* in their shape and marginal serration, though they have more secondary veins than the type specimens. *U. miopumila* closely related with the extant *U. pumila* Linn. of East Asia, is distinguishable from *U. subparvifolia* Nathorst and *U. protojaponica* Tanai et Onoe in the marginal serration.

Recently the author (Tanai & Wolfe, in press) reinvestigated all the Neogene species of *Ulmus* in North America by their foliar character, especially by venation and marginal serration. *U. miopula* is probably related with *U. owyheensis* H. V. Smith from the Miocene of the western United States.

Ulmus cf. *protojaponica* Tanai et Onoe

Ulmus protojaponica Tanai et Onoe. Geol. Surv. Jap. Rept. 187, p.38, pl.10, figs.2, 5, 1961.

Ulmus sp., Florin. Kgl. Svensk. Vet. Akad. Handl. v.61, p.31, pl.5, fig.15, 1920.

Discussion: A single leaf described as *Ulmus* sp. from Mogi (Florin, 1920) is probably referable in its large size to *U. protojaponica*, which is common in the Upper Miocene of Japan.

Genus *Zelkova* Spach.

Zelkova ungeri Kovats

(Pl.2, fig.7)

Zelkova ungeri Kovats. Jahrb. d.k.k. Geol. Reinsanst. bd.2, p.178, 1851.

Kovats. Die fossile Flora von Erdöbenye. p.27, pl.5, figs.1-12; pl.6, figs.1-6, 1856.

Tanai. J. Fac. Sci., Hokkaido Univ., ser.4, v.11, no.2, p.322, pl.18, figs.1-4, 6-9, 11, 1961.

Zelkova keaki Sieb. et Zucc. fossils Nathorst. Kgl. Svensk. Vet. Akad. Handl. v.20, p.45, pl.3, fig.1; pl.7, figs.2-6, 1883.

Discussions: Most leaves of *Zelkova* from the Neogene of Japan have been referred to *Z. ungeri*, which was originally compared with the Caucasian *Z.*

Text-fig. 7 The details of venation characters of fossils and their related extant species (6)

a. *Rhus nathorsti* Tanai. X 6 (Nathorst, 1883: pl.13, fig.10).

b, c. *Ilex heeri* Nathorst. b. X 6, c. X 15 (Nathorst, 1883: pl.10, fig.7).

d, e. *Ilex pedunculosa* Miq. d. X 6, e. X 15 (H.U.P.B. no.70).

f, g. *Symplocos smithi* Florin. f. X 4, g. X 20 (pl.9, fig.1).

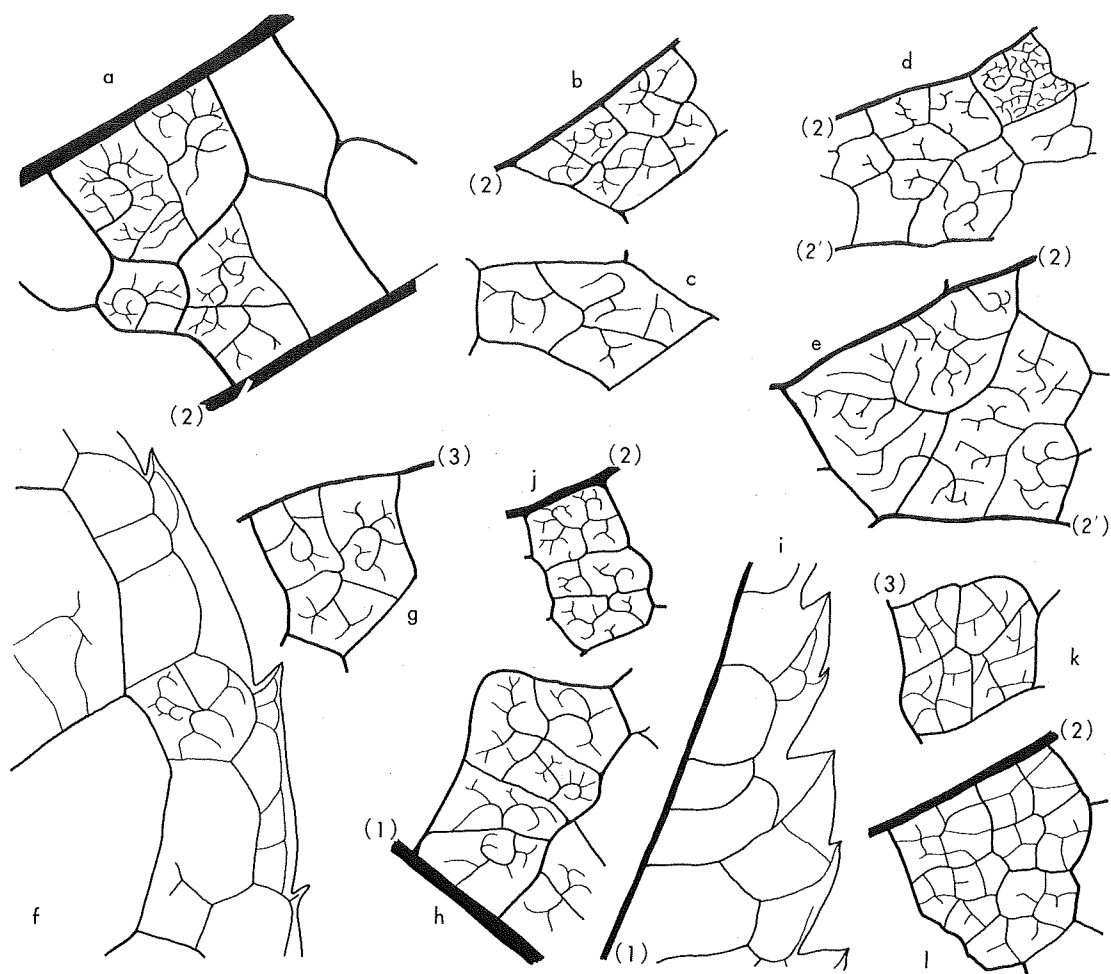
h. *Acer nordenskiöldi* Nathorst. X 15 (Nathorst, 1883: pl.11, fig.14).

i. *Acer nordenskiöldi* Nathorst. X 5 (Florin, 1920: pl.4, fig.4).

j. *Acer palmatum* Thunb. X 15 (H.U.P.B. no.243).

k. *Acer integerrimum* (Viviani) Massalongo. X 12.5 (Nathorst, 1883: pl.12, fig.5).

l. *Acer mono* Maxim. X 12.5 (U.S.G.S. no.8609).



carpinifolia Spach (Kovats, 1856). *Z. carpinifolia* differs generally from the East Asiatic *Z. serrata* Makino in having rounded-toothed leaves, although such distinction is not always definitive because of the intermediate character. Actually, most of the original specimens of *Z. ungeri* from Erdöbenye (Kovats, 1856) have large, rather dentate teeth (both the apical and basal sides of the tooth convex).

All of the Mogi specimens with one exception (Nathorst, 1883: pl.7, fig.6) have rather acute, incurved teeth, and show a close remblance of the extant *Z. serrata*. However, Miocene leaves of *Zelkova* from Japan have largely dentate teeth, as shown in the case of the Yoshioka flora (Tanai and N. Suzuki, 1963: pl.17, figs.1-12; pl.18, figs.1-8; pl.19, figs.3, 6a, 6b). Further detailed investigation may reveal that Neogene *Zelkova* in Japan should be separated into two species.

Collection: Hypotype, G.S.J. no. 4706.

Family Magnoliaceae

Genus *Magnolia* Linn.

Magnolia dicksoniana Nathorst

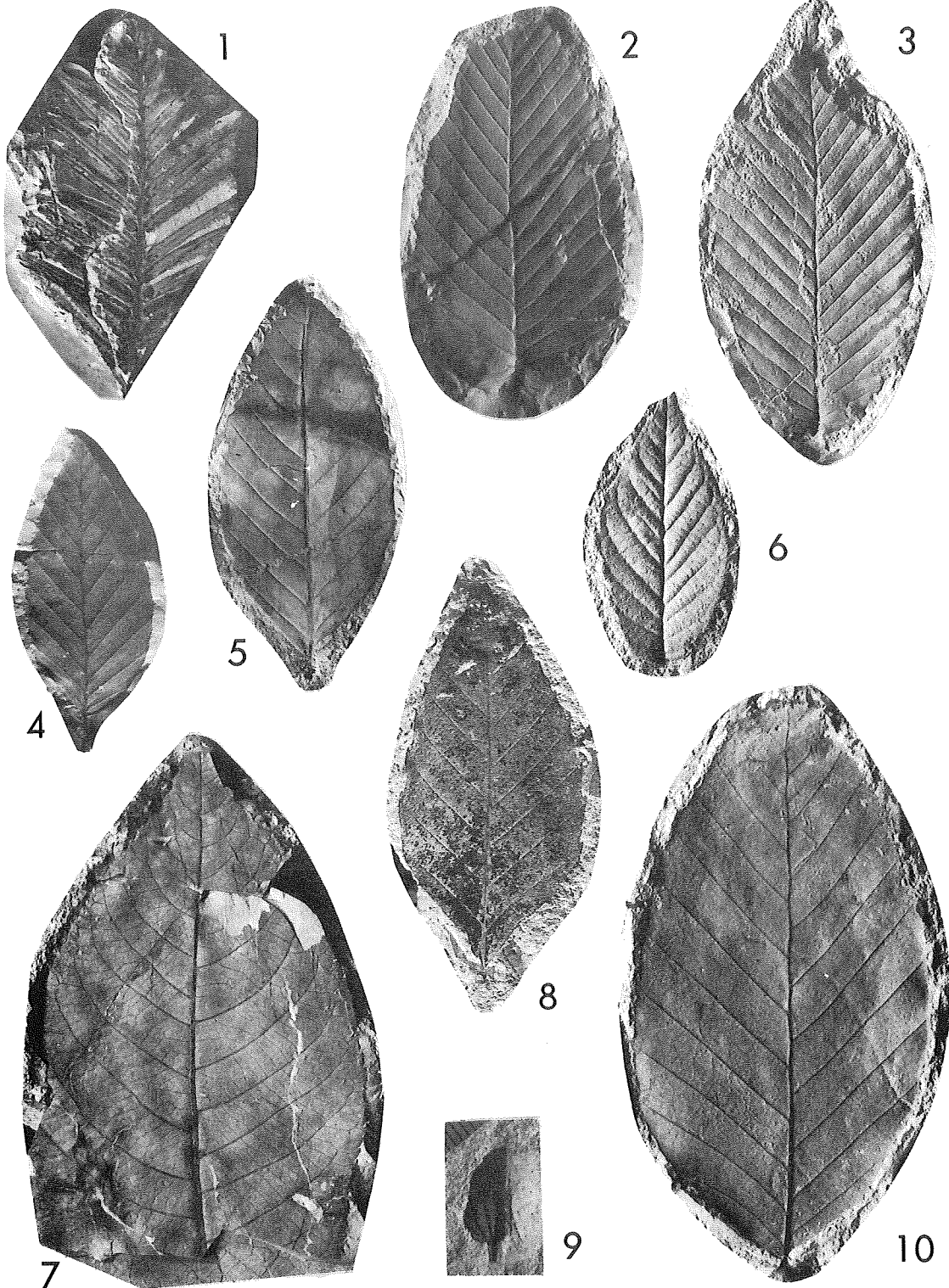
Magnolia dicksoniana Nathorst. Kgl. Svensk. Vet. Akad. Handl. v.20, p.68, pl.13, figs.1-3; text-fig.4, 1883.

Discussion: This species was established by Nathorst on the basis of three fragmentary leaves. These specimens are too ill-preserved to reinvestigate their generic or specific status, and are unable to clarify the venation character. The restoration of these specimens shown by Nathorst (1883, p.67, text-fig.4) seems to be similar to leaves of the extant *Magnolia sieboldii* K. Koch (=M.

Explanation of Plate 1

(all natural size)

- Fig. 1 *Metasequoia occidentalis* (Newberry) Chaney. Hypotype, G.S.J. no.4701.
- Fig. 2 *Carpinus subcordata* Nathorst. Hypotype, G.S.J. no.4702.
- Fig. 3 *Carpinus subcordata* Nathorst. Lectotype, S.M.N.H. (Nathorst, 1883: pl.2, fig.14).
- Fig. 4 *Fagus stuxbergi* (Nathorst) Tanai. Hypotype, G.S.J. no.4704.
- Fig. 5 *Fagus stuxbergi* (Nathorst) Tanai. Hypotype, S.M.N.H. (Nathorst, 1883: pl.4, fig.7).
- Fig. 6 *Juglans japonica* Tanai. Hypotype, S.M.N.H. (Nathorst, 1883: pl.1, fig.13).
- Fig. 7 *Juglans japonica* Tanai. Hypotype, S.M.N.H. (Nathorst, 1883: pl.1, fig.16).
- Fig. 8 *Fagus stuxbergi* (Nathorst) Tanai. Lectotype, S.M.N.H. (Nathorst, 1883: pl.4, fig.9).
- Fig. 9 *Carpinus* sp. G.S.J. no.4703.
- Fig. 10 *Fagus stuxbergi* (Nathorst) Tanai. Hypotype, G.S.J. no.4705.



parviflora S. et Z.), which is distributed from Kwanto to Kyushu, Japan.

Collection: Lectotype, Swedish Museum Natural History, Paleobotany Section (Nathorst, 1883: pl.13, fig.3).

Magnolia elliptica Tanai et Onoe
(Pl.10, fig.5)

Magnolia elliptica Tanai et Onoe. Geol. Surv. Jap. Rep. 187, p.40, pl.12, figs.1, 5, 1961.

Magnolia sp., Nathorst. Kgl. Svensk. Vet. Akad. Handl. v.20, p.68, pl.12, fig.1.

Discussion: An incomplete leaf described as *Magnolia* sp. is doubtlessly referred to the genus *Magnolia* in its shape and venation. It is identical to *M. elliptica* which resembles leaves of the extant *M. kobus* Dc. of Japan and *M. liliflora* Desr. of China, though is incomplete.

Collection: Hypotype, G.S.J. no. 4762a.

Family Schisandraceae

Genus *Kadsura* Juss.

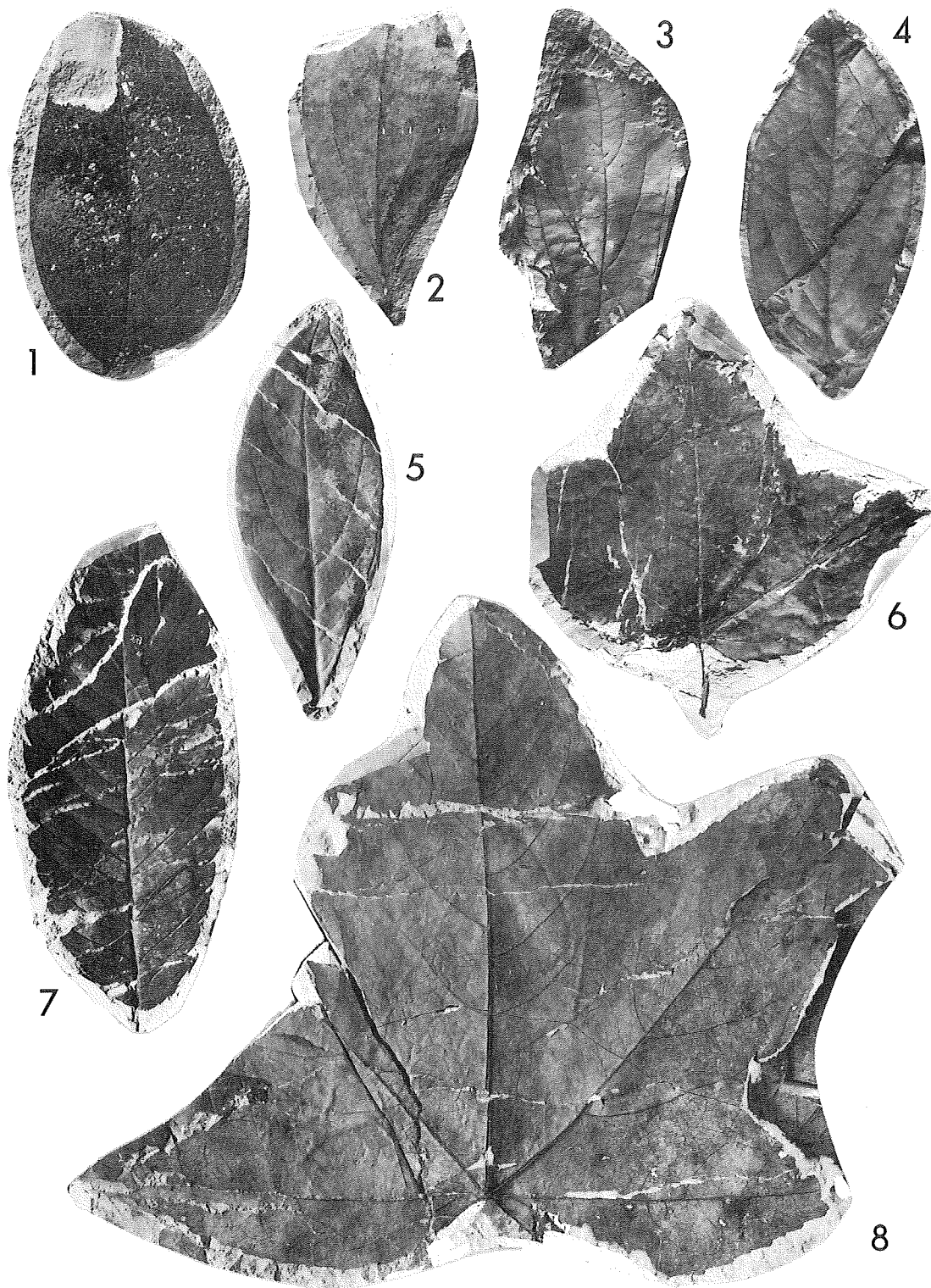
Kadsura protojaponica Tanai, sp. nov.

(Pl.2, fig.1; pl.10, fig.2)

Description: Leaves ovate in shape, somewhat inequilateral, 6 (estimated) to 7.1 cm long, 3.1 to 3.3 cm wide; apex acute; base rounded but somewhat abruptly cuneate along the petiole; midvein stout, somewhat arcuate; secondary veins rather thin, 5 or 6 pairs, irregularly spaced, gently curving up, frequently flexuous at the points jointing with tertiary veins, joining the superadjacent secondary at acute angle, these secondary loops enclosed by tertiary and quaternary arches; branches from the tertiary or quaternary arches entering the marginal teeth; tertiary veins coarsely reticulate, enclosing quaternary areolation; ultimate veinlets indistinctly preserved; margin except

Explanation of Plate 2
(all natural size)

- Fig. 1 *Kadsura protojaponica* Tanai. Paratype, S.M.N.H.
- Fig. 2 *Cinnamomum* cf. *miocenum* Morita. G.S.J. no.4708.
- Fig. 3 *Celtis nordenskiöldi* Nathorst. Lectotype, S.M.N.H. (Nathorst, 1883: pl.15, fig.2)
- Fig. 4 *Styrax protojaponica* Tanai. Holotype, G.S.J. no.5760.
- Fig. 5 *Lindera miyataensis* Huzioka et Uemura. Hypotype, G.S.J. no.4709.
- Fig. 6 *Liquidambar miosinica* Hu et Chaney. Hypotype, G.S.J. no.4710.
- Fig. 7 *Zelkova ungeri* Kovats. Hypotype, G.S.J. no.4706.
- Fig. 8 *Liquidambar miosinica* Hu et Chaney. Hypotype, S.M.N.H. (Nathorst, 1883: pl.9, fig.1).



basal half remotely serrate with minute and aristate teeth; petiole nearly missing.

Discussion: A single incomplete leaf from Mogi is referred to the genus *Kadsura* characterized by shape, venation and marginal serration. This specimen stored in the Swedish Museum of Natural History, was not determined by Nathorst. A single well-preserved leaf and its counterpart identical to this Mogi specimen was recently found from the Miocene of Iki island, Kyushu. The above description for new species was based together on these specimens.

K. protojaponica is closely similar to leaves of the extant *K. japonica* (Thunb.) Dunal which is distributed in the warm-temperate forest of Japan and China; but it differs in marginal teeth. This new species resembles *Schisandra florini* described below in venation characters, but is distinguishable in foliar shape and marginal serration.

Collections: Holotype, U.H.M.P. no. 25971; paratype, Swedish Museum of Natural History, Paleobotany Section.

Genus *Schisandra* Michx.

Schisandra florini Tanai, sp. nov.

(Pl.9, fig.5; text-fig.3, a)

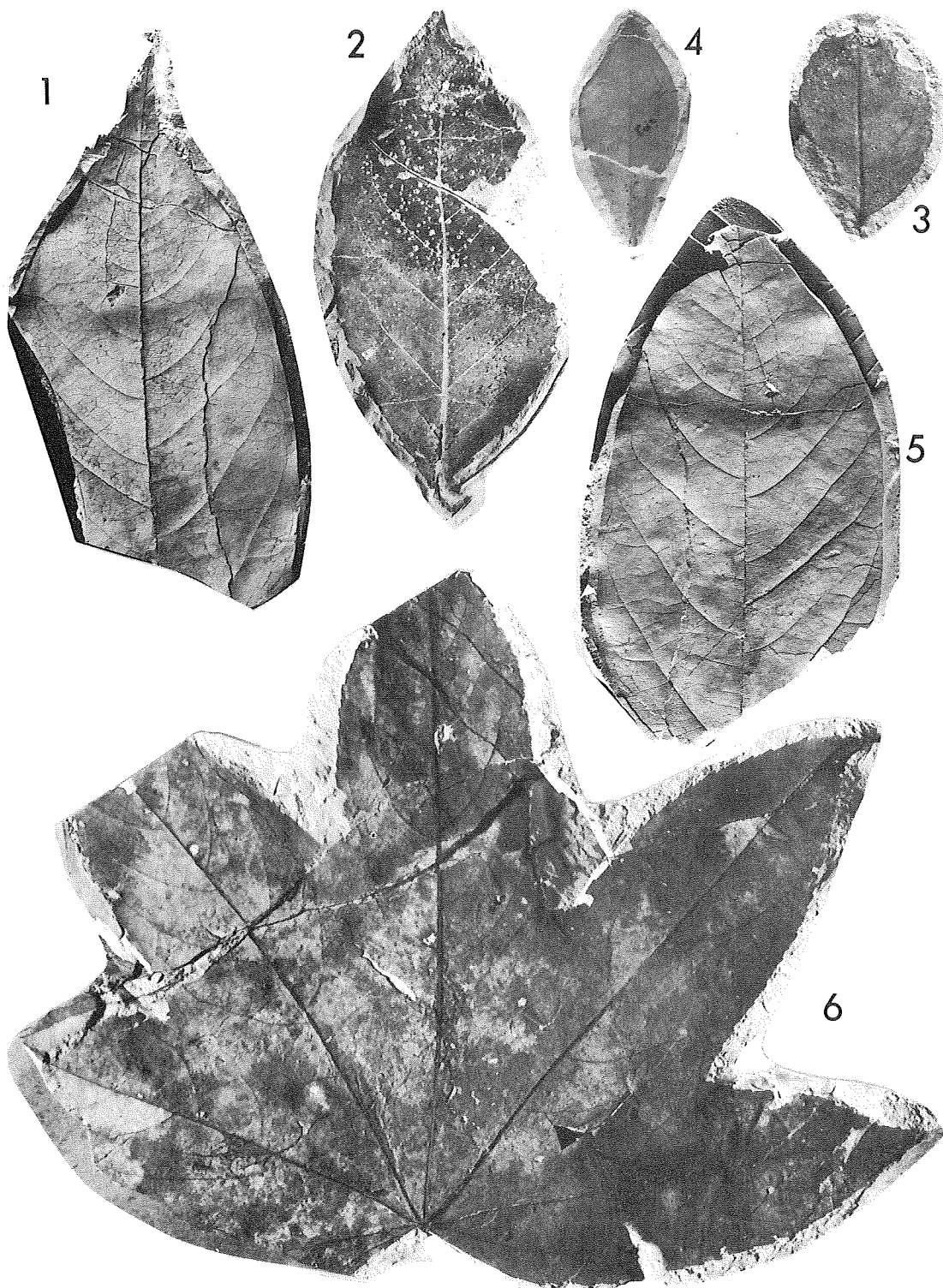
Schizandra chinensis (Rupr.) Baill., Florin. Kgl. Svensk. Vet. Akad. Handl., v.61, p.31, pl.6, figs.11-13, 1920.

Description: Leaves obovate to broadly elliptical in general outline, 5.5 to 9.5 cm. (estimated) long and 2.2 to 4.6 cm. wide, acute at apex, acute or slightly cuneate at base; midvein distinct, nearly straight; secondary veins 5 or 6 pairs, irregularly spaced, diverging from the midvein at acute angles, arising up and nearly parallel to the margin, joining the superadjacent secondary at acute angle, outside these secondary loops several arches of tertiary and quaternary veins well developing along the margin; tertiary veins forming coarse areoles, which enclose quaternary areolation; margin remotely serrate with minute, obtuse teeth; petiole more than 0.5 cm. long.

Explanation of Plate 3

(All natural size unless otherwise stated)

- Fig. 1 *Lindera* cf. *sericea* (S. et Z.) Blume. S.M.N.H. (Nathorst, 1883: pl.8, fig.3).
- Fig. 2 *Prunus nathorsti* Tanai. Holotype, S.M.N.H. (Nathorst, 1883: pl.11, fig.9).
- Fig. 3 *Pyracantha nipponica* Tanai. Hypotype, G.S.J. no.4714.
- Fig. 4 *Enkianthus almqvistii* (Nathorst) Tanai. X 3/4 Hypotype, G.S.J. no.4753.
- Fig. 5 *Lindera* cf. *sericea* (S. et Z.) Blume. a counterpart of Fig. 2 specimen.
- Fig. 6 *Liquidambar miosinica* Hu et Chaney. X 2/3 Hypotype, G.S.J. no.4711.



Discussion: These two leaves are doubtlessly referred to the genus *Schisandra* by their shape, characteristic venation and remotely serrate margin. These leaves closely resemble those of the extant *S. chinensis* (Rupr.) Baill. and *S. repanda* (S. et Z.) Radlk. Three leaves described as *S. chinensis* from Mogi by Florin are identical with *S. florini*, though one of them (Florin, 1920: pl. 6, fig. 11) is somewhat larger than those of the extant similar species. The above description of the new species is based on our collection together with Florin's specimen.

Few fossil leaves of *Schisandra* have been reported from the Tertiary of the world. Huzioka (1964) described two incomplete leaves of *Schisandra* from the Lower Miocene Aniai flora of Akita Prefecture; his specimens differ in having bigger dentate teeth.

Collections: Holotype, G.S.J. no. 4707; Museum of Paleontology, University of Uppsala.

Family Lauraceae
Genus *Cinnamomum* Blume
Cinnamomum cf. *miocenum* Morita
(Pl.2, fig.2)

Cinnamomum miocenum Morita. Jour. Geol. Geogr., v.9, p.6, pl.1, fig.6, 1931.

Lindera (?) sp., Nathorst. Kgl. Svensk. Vet. Akad. Handl. v.20, p.48, pl.8, fig.4, 1883.

Discussion: A fragmentary leaf described as *Lindera* (?) sp. belongs doubtlessly to the family Lauraceae by the tri-plinerved characters. In our collection there is an incomplete leaf similar to Nathorst's specimens. These two specimens show well-developed fine venation with small quadrangular areoles; they are referable not to *Lindera* but to *Cinnamomum*, and are probably identifiable to *C. miocenum* which is commonly found in the Miocene of Japan.

Collection: Hypotype, G.S.J. no. 4708.

Explanation of Plate 4
(all natural size)

Fig. 1 *Prunus florini* Tanai. Holotype, G.S.J. no.4713.

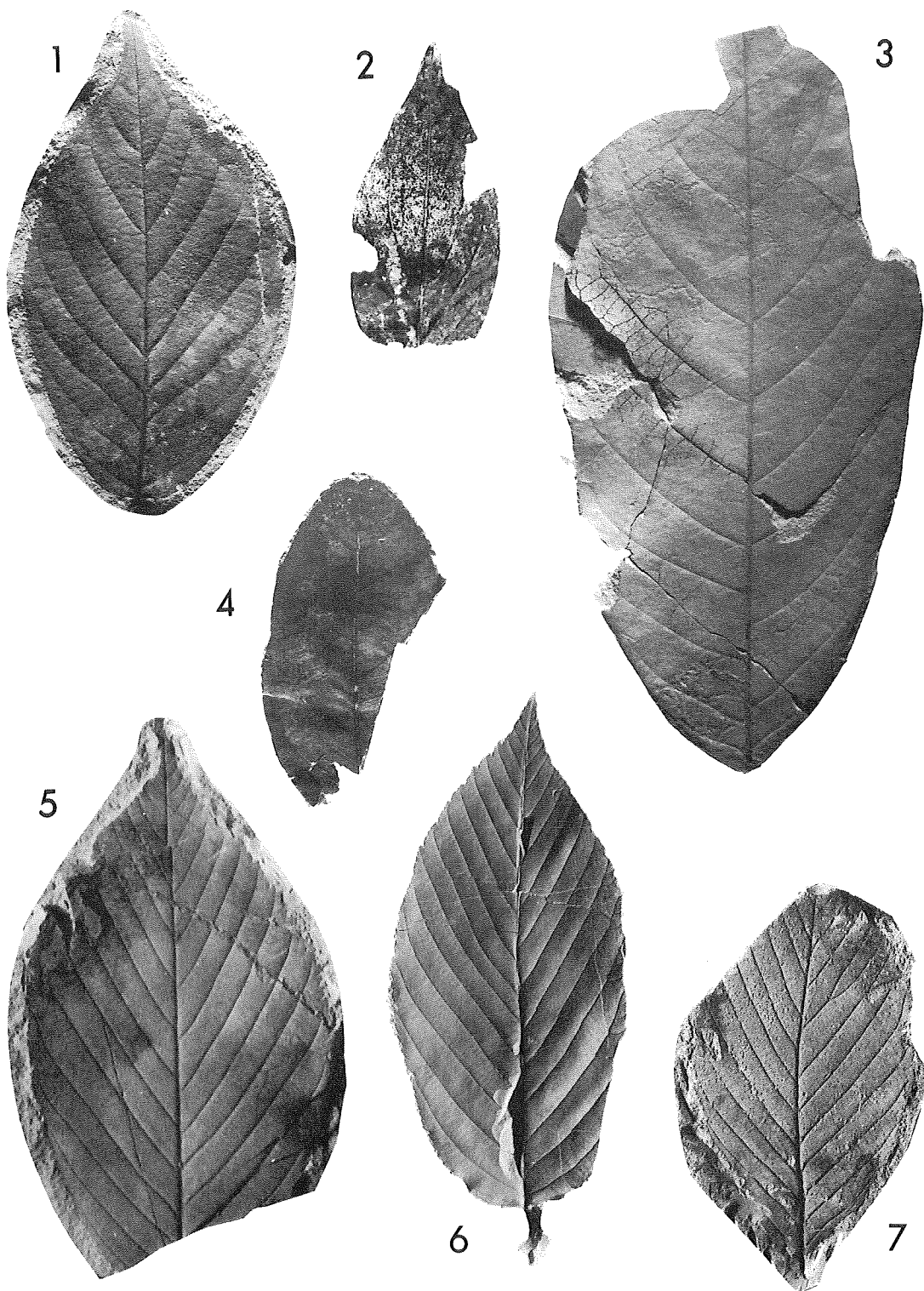
Fig. 2 *Deutzia mogiensis* Tanai. Holotype, G.S.J. no.4712.

Fig. 3 *Sapium mogiense* Tanai. Paratype, G.S.J. no.4721b.

Fig. 4 *Maackia onoei* Matsuo. Hypotype, G.S.J. no.4718

Figs. 5, 6. *Sorbus lesquereuxi* Nathorst. Hypotypes, G.S.J. nos.4715, 4716.

Fig. 7 *Sorbus lesquereuxi* Nathorst. Lectotype, S.M.N.H. (Nathorst, 1883: pl.3, fig.13).



Genus *Lindera* Thunb.*Lindera miyataensis* Huzioka et Uemura

(Pl.2, fig.5; text-fig.4, e, f)

Lindera miyataensis Huzioka et Uemura. Bull. Nat. Sci. Mus. v.16, no.4, p.712, pl.10, figs.2-4, 1973.

Supplementary description: Leaves oblong to linear-oblong in general shape, acute at apex, acute and slightly decurrent at base, 5 to 11.5 cm. long (estimated), 2 to 4.7 cm. wide; midvein strong, nearly straight; secondary veins about 7 pairs, irregularly spaced, diverging from the midvein at angles of about 30 degrees on the lower and at about 50 degrees on the upper part of blade, gently curving up, joining the superadjacent secondary at acute angle; the middle two or three pairs of the secondaries thicker than others; secondary loops enclosed by tertiary and quaternary arches; intersecondary veins diverging from the midrib at wider angles of 80 to 90 degrees, then connecting with the tertiaries; most of the tertiary among intersecondary spaces irregularly percurrent; the fourth- and fifth-order veins forming quadrangular or pentagonal meshes of medium size; the ultimate veinlets branching two or three times; margin entire; texture thin.

Discussion: Two leaves in our collection belong doubtlessly to the Lauraceae in characteristic venation, and are identical to *Lindera miyataensis* described from the Upper Miocene of Akita Prefecture (Huzioka & Uemura, 1973). The finer venation below the secondary veins was not shown in the original description, but it is preserved in the Mogi specimens. The above-described characters are supplemented.

L. miyataensis, as already stated by Huzioka & Uemura (1973) is closely similar to the extant *L. umbellata* Thunb. in foliar shape and venation characters. Leaves of the extant *L. glauca* Blume are also similar to *L. miyataensis* in general appearance, but are distinguishable by finer and more stout areolation and none or simple veinlets. The most related species, *L. umbellata*, is distributed from Honshu to Kyushu, extending into China.

Collection: Hypotype, G.S.J. nos. 4709.

Explanation of Plate 5

(all natural size)

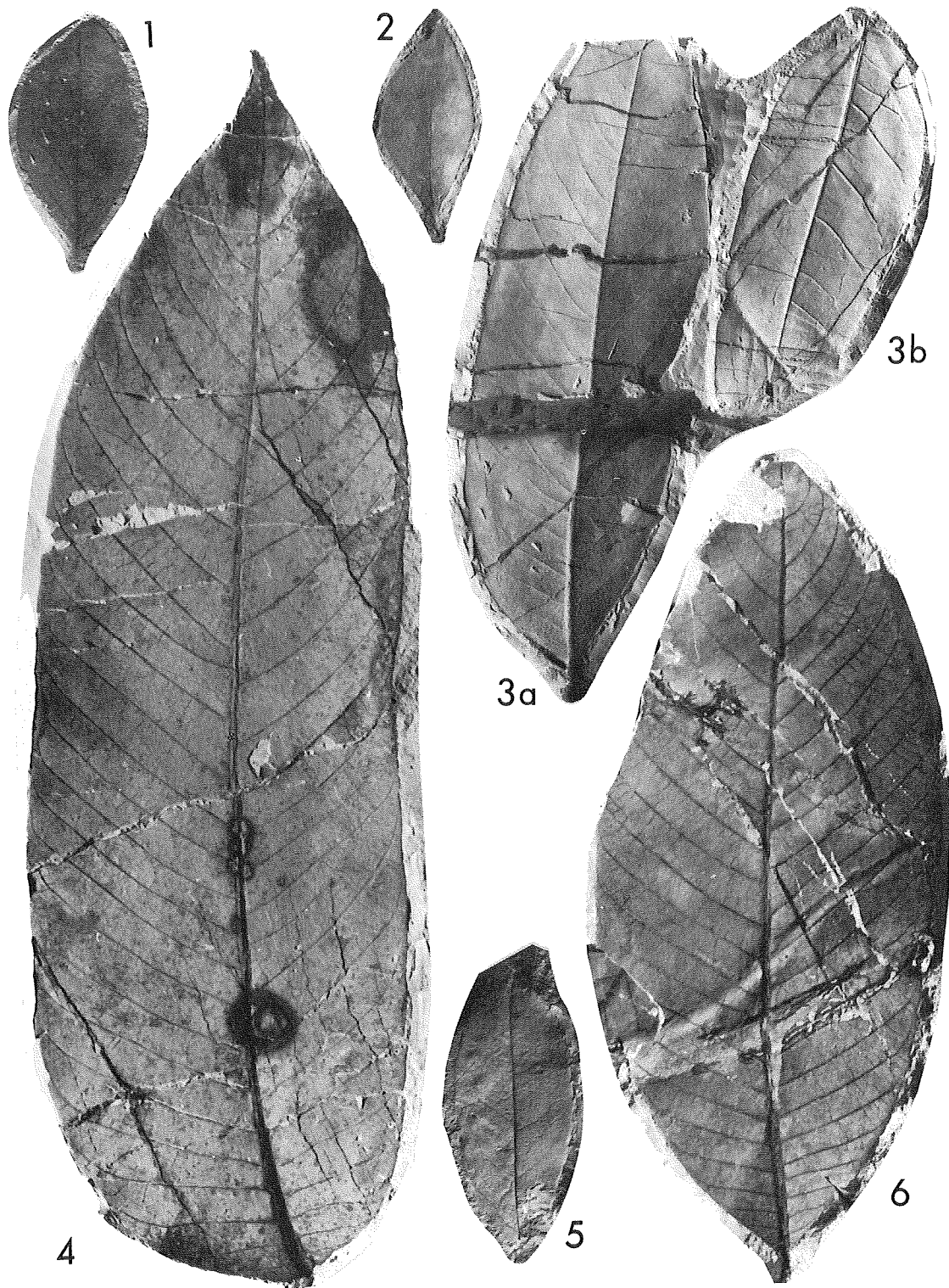
Figs. 1, 2 *Enkianthus almqvisti* (Nathorst) Tanai. Hypotypes, G.S.J. nos.4754, 4755.

Fig. 3a, b *Sapindus tanaii* Onoe. Hypotype, G.S.J. no.4731a, b.

Fig. 4 *Rhus nathorsti* Tanai. Holotype, G.S.J. no.4724.

Fig. 5 *Elaeocarpus florini* Tanai. Hypotype, G.S.J. no.4735.

Fig. 6 *Rhus nathorsti* Tanai. Hypotype, G.S.J. no.4726.



Lindera cf. *sericea* (S. et Z.) Blume
(Pl.3, figs.1, 5; text-fig.4, g, h)

Lindera sericea Blume fossilis, Nathorst. Kgl. Svensk. Vet. Akad. Handl. v.20, p.47, pl.8, fig.3 (excluding fig.2), 1883.

Discussion: An incomplete leaf of *Lindera sericea* was illustrated with the restoration based on a specimen and its counterpart by Nathorst (1883, pl. 8, fig. 3). These two specimens belong apparently to the family Lauraceae in the venation character. The reinvestigation of the original specimens reveals that the tertiary veins are retroflexed or coarsely reticulate, enclosing polygonal areoles formed by fourth- and fifth-order veins, and the ultimate veinlets are branching several times. Considering foliar shape and the above-described venation, Nathorst's specimens are most closely similar to the extant *Lindera sericea*; but they are lacking in basal part of the blade to identify definitely.

Family Theaceae
Genus *Stewartia* Linn.
Stewartia submonadelpha Tanai et Onoe

Stewartia submonadelpha Tanai et Onoe. Geol. Surv. Jap. Rept. 187, p.53, pl.18, fig.6, 1961.

Tanai. J. Fac. Sci., Hokkaido Univ. ser.4, v.11, p.375, pl.25, fig.9, 1961 (see synonymy).

Huzioka et Uemura. Bull. Natl. Sci. Mus., v.16, p.12, fig.9, 10, 1973.

Stewartia monadelpha Sieb. et Zucc. fossilis Nathorst. Kgl. Svensk. Vet. Akad. Handl. v.20, p.66, pl.14, figs.11, 12, 1883.

Florin. ditto, v.61, p.26, pl.5, fig.4, 1920.

Diospyros nordqvisti Nathorst (in part). Kgl. Svensk. Vet. Akad. Handl., v.20, p.51, pl.14, fig.3 only, 1883.

Diospyros kaki L. fossilis Florin (in part). ditto, v.61, p.27, pl.5, figs.5, 6, 1920.

Discussion: These Mogi and Amakusa specimens described as *Stewartia monadelpha* were already included in *S. submonadelpha* by the author (Tanai, 1961), which is common in the Upper Tertiary of Japan. *S. submonadelpha* closely resembles leaves of the extant *S. monadelpha* Sieb. et Zucc. and *S.*

Explanation of Plate 6
(all natural size)

Fig. 1 *Rhus nathorsti* Tanai. Paratype, G.S.J. no.4725a.

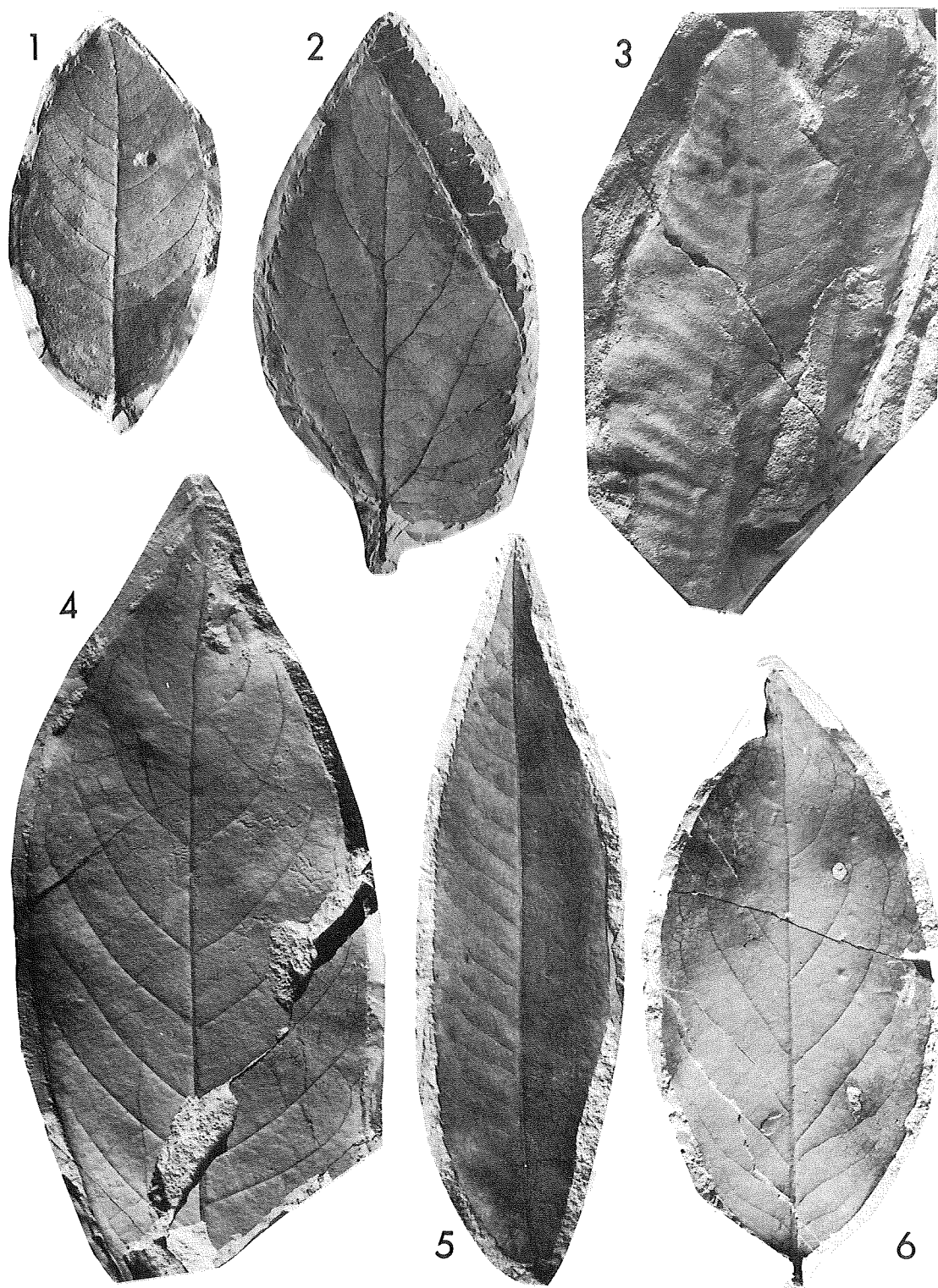
Fig. 2 *Tilia distans* Nathorst. Hypotype, G.S.J. no.4736.

Fig. 3 *Zanthoxylum engleri* (Nathorst) Tanai. Lectotype, S.M.N.H. (Nathorst, 1883: pl.10, fig.1).

Fig. 4 *Sapium mogiense* Tanai. Holotype, G.S.J. no.4721a.

Fig. 5 *Zanthoxylum engleri* (Nathorst) Tanai. Hypotype, G.S.J. no.4723.

Fig. 6 *Diospyros nordqvisti* Nathorst. Hypotype, G.S.J. no.4756.



serrata Maxim. of Japan., and also resembles those of the extant *S. pseudo-camellia* Maxim. though generally smaller in size.

Some leaves described as *Diospyros* listed in above synonymy are remotely serrate as far as the author examined, and are included in *S. submonadelpha* by their venation characters. A single specimen of probable capsule described as *Stewartia* sp. from Mogi (Florin, 1920: pl. 6, figs. 5, 6) may be included in *S. submonadelpha* by its character and size.

Family Hamamelidaceae

Genus *Liquidambar* Linn.

Liquidambar miosinica Hu et Chaney

(Pl.2, figs.6, 8; pl.3, fig.6; text-fig.3, f-i)

Liquidambar miosinica Hu et Chaney. Pal. Sinica, New Ser. A, no.1, p.46, pl.23, figs.1, 2, 1938.

Tanai et N. Suzuki. Tertiary floras of Japan, Miocene floras, p.128, pl.23, figs.6, 8, 11 (see synonymy), 1963.

Liquidambar formosana Hance, Nathorst. Kgl. Svensk. Vet. Akad. Handl., v.20, p.55, pl.8, figs.6-9, 1883.

Florin. ditto, v.61, p.20, pl.3, fig.4; pl.6, fig.4, 1920.

Acanthopanax acerifolium Nathorst. ditto, v.20, p.54, pl.8, fig.5; pl.9, figs.1, 2, 1883.

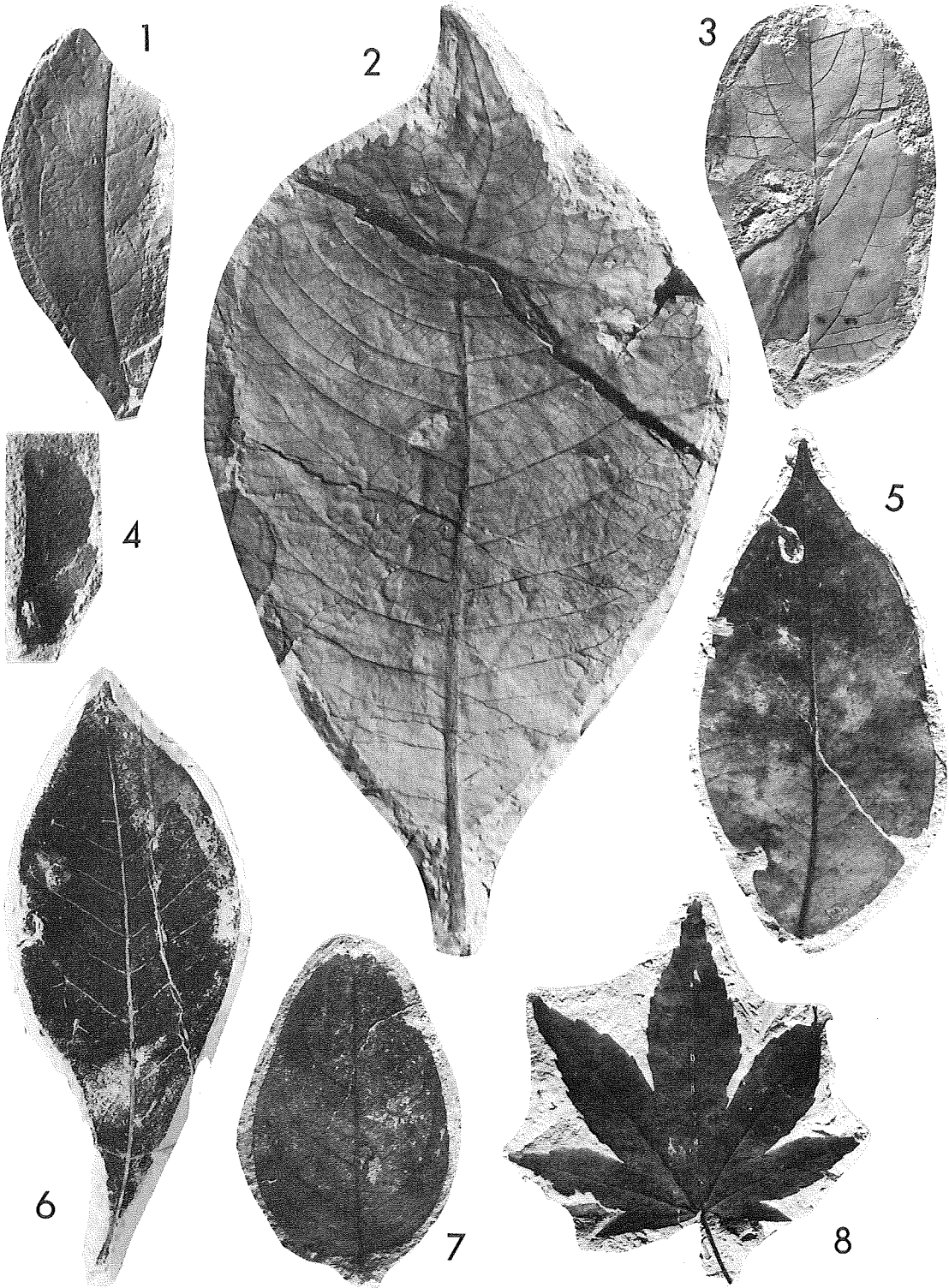
Discussion: The examination of the original specimens of *Acanthopanax acerifolium* revealed that they belong apparently to the genus *Liquidambar*: margin is serrate with incurved, obtuse teeth accompanied by glands; the fine veinlets are once forking within quadrangular or pentagonal areoles; marginal looping of the secondary and tertiary veins is different from that of the genus *Kalopanax*. Nathorst (1883) compared *A. acerifolium* with the extant *A. ricinifolium* S. et z. (= *Kalopanax pictus* (Thunb.) Nakai), but *A. acerifolium* is closely consistent with the trilobed specimens described as *Liquidambar formosana* in the above-noted characters excepting for five lobation.

The pattern of the ultimate veinlets in the areoles are somewhat similar

Explanation of Plate 7

(all natural size unless otherwise stated)

- Fig. 1** *Symplocos smithi* Florin. Hypotype, G.S.J. no.4761.
- Fig. 2** *Clethra maximowiczii* Nathorst. Hypotype, G.S.J. no.4740.
- Fig. 3** *Tilia distans* Nathorst. Lectotype, S.M.N.H. (Nathorst, 1883: pl.6, fig.15).
- Fig. 4** *Acer nordenskiöldi* Nathorst. X 2 Hypotype, G.S.J. no.4729.
- Fig. 5** *Ilex heeri* Nathorst. Hypotype, G.S.J. no.4728b.
- Fig. 6** *Ilex onoei* Tanai. Holotype, G.S.J. no.4734.
- Fig. 7** *Maackia onoei* Matsuo. Hypotype, G.S.J. no.4719.
- Fig. 8** *Acer nordenskiöldi* Nathorst. Hypotype, G.S.J. no.4728a.



each other between the extant *Kalopanax pictus* and *Liquidambar formosana*, but the former areoles are twice larger than those of the latter (text-fig. 3, j, 1). All of the tri- and five-lobed leaves from Mogi are closely similar to the extant *L. formosana* in size of the areoles, although fine veinlets are generally more slender.

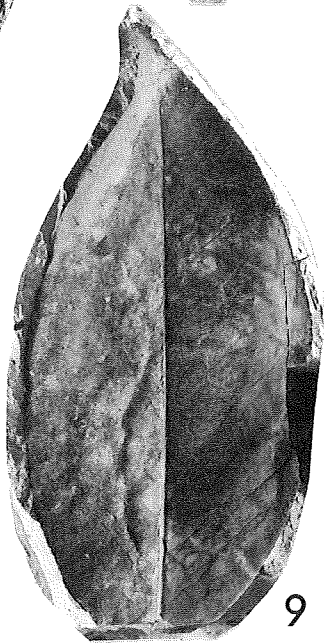
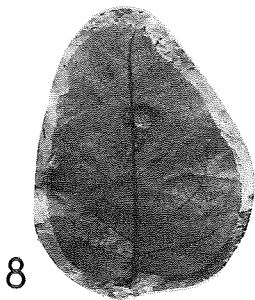
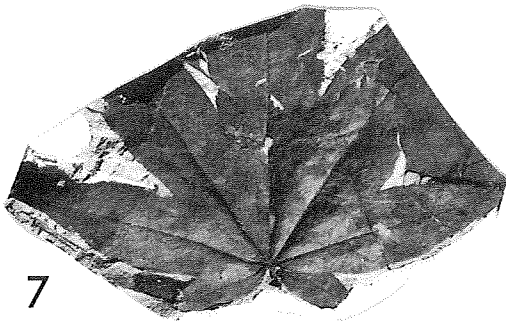
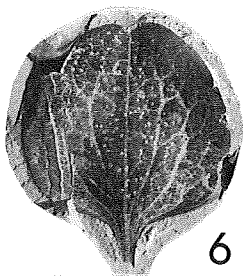
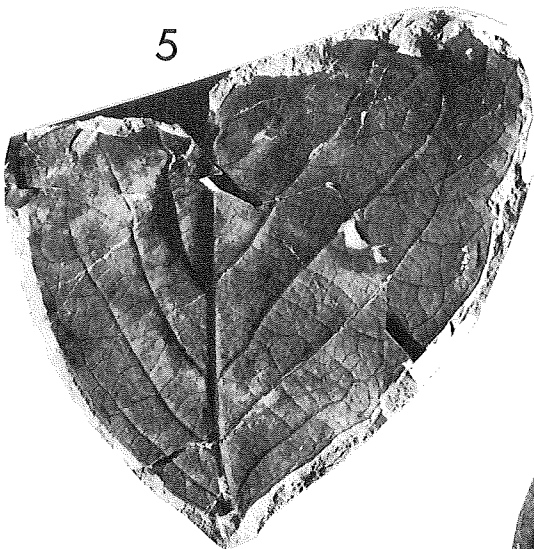
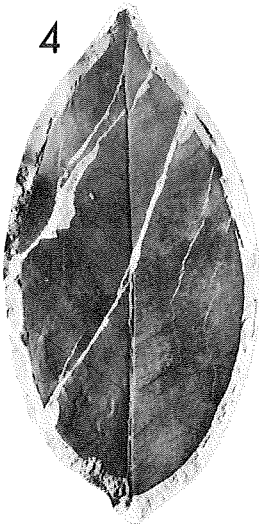
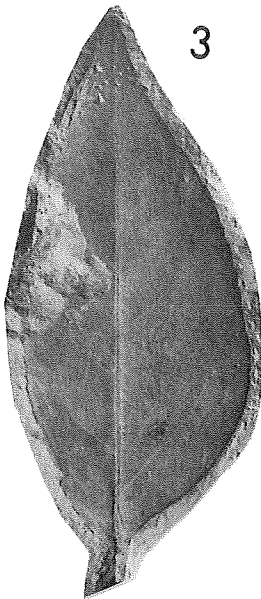
Leaves referred to the genus *Liquidambar* have been commonly reported from the Tertiary of Japan, especially abundant in the middle Miocene. They are represented mostly by trilobed and rarely by five-lobed leaves. The trilobed specimens have been compared with extant *L. formosana* by many authors; while the five-lobed specimens were comparable with the extant *L. styraciflua* L. of the eastern United States by several authors, although the author was against this comparison (Tanai, 1967). *L. formosana* bears sometimes five-lobed leaves, especially on the young shoots. However, *L. formosana* is fairly distinguishable in fine veinlets and areoles from *L. styraciflua* (text-fig. 3, j, k), although it is represented by tri- or five-lobed leaves. In our Mogi collection there are also both tri- and five-lobed specimens as in Nathorst's collections. Accordingly, the Mogi specimens are comparable to the extant *L. formosana*, and are referred to *L. miosinica* originally described from the Miocene Shanwang flora of China. The epithet "*acerifolium*" for these fossil leaves of *Liquidambar* may have a nomenclature priority, but it was once given for a living *Liquidambar* by Maximowicz (1866), which is now invalid.

The trilobed leaves of *Liquidambar* from the East Asia in the Tertiary are very variable in shape and extension of lobes, based on which characters many specific names have been proposed by many authors. Recently, based on foliar morphological characters, Huzioka (1974) divided these trilobed leaves into four groups. However, the four groups seem to be difficult to separate completely only by foliar characters, and should be further investigated in

Explanation of Plate 8

(all natural size unless otherwise stated)

- Fig. 1 *Clethra maximowiczii* Hypotype, S.M.N.H. (Nathorst, 1883: pl.1, fig.12)
- Fig. 2 *Enkianthus almqvisti* (Nathorst) Tanai. X2 Lectotype, S.M.N.H. (Nathorst, 1883: pl.9, fig.13)
- Fig. 3 *Ilex hundbladae* Tanai. Holotype, G.S.J. no.4725b.
- Fig. 4 *Ilex heeri* Nathorst. Hypotype, G.S.J. no.4733.
- Fig. 5 *Styrax protoobassia* Tanai et Onoe. Hypotype, G.S.J. no.4759.
- Fig. 6 *Carpites sibiriakoffi* (Nathorst) Tanai. Holotype, S.M.N.H. (Nathorst, 1883: pl.9, fig.3)
- Fig. 7 *Acer nordenskiöldi* Nathorst. Lectotype, S.M.N.H. (Nathorst, 1883: pl.11, fig.14).
- Fig. 8 *Wisteria fallax* (Nathorst) Tanai et Onoe. Hypotype, G.S.J. no.4720.
- Fig. 9 *Ilex heeri* Nathorst. Lectotype, S.M.N.H. (Nathorst, 1883: pl.10, fig.7).



detail.

Collections: Hypotypes G.S.J. nos. 4710, 4711; Swedish Museum of Natural History, Paleobotany Section (Nathorst, 1883; pl. 9, fig. 1)

Family Saxifragaceae

Genus *Deutzia* Thunb.

Deutzia mogiensis Tanai, sp. nov.

(Pl.4, fig.2)

Deutzia scabra Thunb. fossilis, Nathorst. Kgl. Svensk. Vet. Akad. Handl. v.20, p.55, pl.7, fig.10, 1883.

Description: Leaves broadly lanceolate to ovate in general shape, acuminate at apex, rounded or slightly cordate at base, 5.5 to 7.2 cm. long and 1.9 to 2.4 cm. wide; midvein stout, nearly straight; secondary veins stout except slender basal ones, about 7 or 9 pairs, irregularly spaced, diverging from the midvein at rather narrow angles on the lower part and at obtuse angles on the upper, gently curving and arising upward, then joining the superadjacent secondary at nearly right angle; the secondary loops enclosed by the tertiary arches; one or two intersecondary veins in each secondary arches; the tertiaries very irregular, connecting with the secondaries or intersecondaries; fourth-order veins coarsely reticulate, enclosing the areolation of fifth-order veins; the ultimate fine veinlets ill-preserved; margin serrate with acute teeth in which the branches from the tertiary arches end; petiole missing.

Discussion: A single leaf in our collection, though somewhat incomplete, is doubtlessly referable to the genus *Deutzia* in foliar shape, venation and marginal characters. As far as investigated under the microscope, the specimen seems to be hairy on the underside of the leaf. A specimen described as *D. scabra* Thunb. by Nathorst (1883) is closely similar to our specimen, and is conspecific, considering a wide variation shown by leaves of the extant *Deutzia*. The above description is based on these two specimens.

Explanation of Plate 9

(all natural size)

Fig. 1 *Symplocos smithi* Florin. Hypotype, S.M.N.H.

Fig. 2 *Tilia distans* Nathorst. Hypotype, G.S.J. no.4734.

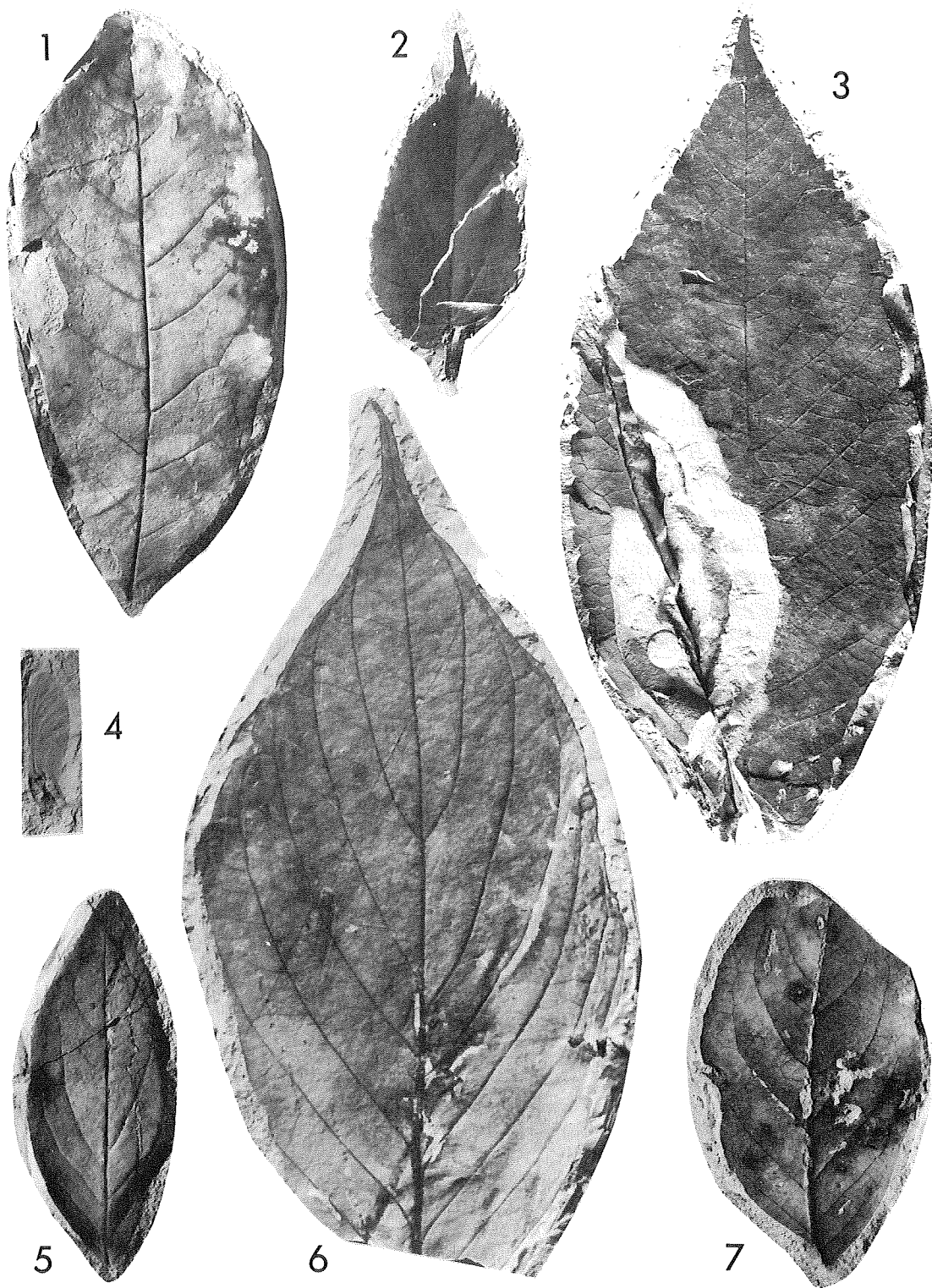
Fig. 3 *Clethra maximowiczii* Nathorst. Lectotype, S.M.N.H. (Nathorst, 1883: pl.11, fig.19).

Fig. 4 *Acer nordenskiöldi* Nathorst. Hypotype, G.S.J. no.4730.

Fig. 5 *Schisandra florini* Tanai. Holotype, G.S.J. no.4707.

Fig. 6 *Cornus megaphylla* Hu et Chaney. Hypotype, G.S.J. no.4739.

Fig. 7 *Diospyros nordqvisti* Nathorst. Lectotype, S.M.N.H. (Nathorst, 1883: pl.14, fig.2).



Deutzia mogiensis closely resembles leaves of the extant *D. crenata* S. et Z. and *D. scabra* Thunb. var. *sieboldiana* (Maxim.) Makino living in Japan. This new species is the first record of the genus *Deutzia* from the Tertiary of Japan. *Collections*: Holotype, G.S.J. no. 4712; Paratype, Swedish Museum of Natural History, Paleobotany Section (Nathorst, 1883; pl. 7, fig. 10).

Family Rosaceae
Genus *Chaenomeles* Lindl.

Chaenomeles chloranthoides (Nathorst) Huzioka et Takahashi

Chaenomeles chloranthoides (Nathorst) Huzioka et Takahashi. Bull. Nat. Sci. Mus., v.16, p.139, pl.2, figs.10, 11, 11a, 1973.

Cydonia chloranthoides Nathorst. Kgl. Sv. Vet. Akad. Handl., v.20, p.57, pl.7, fig.7, 1883.

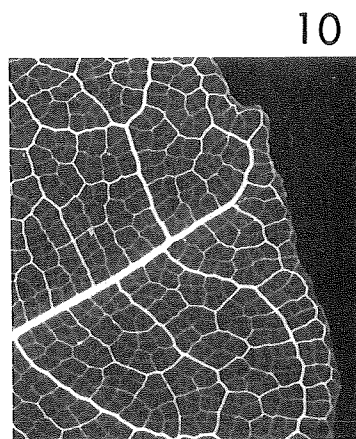
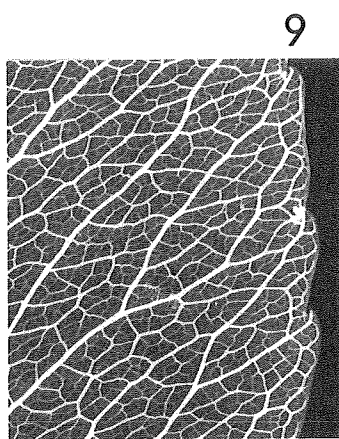
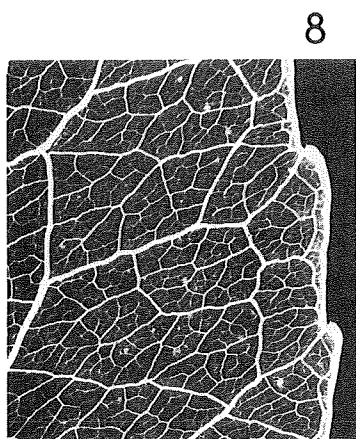
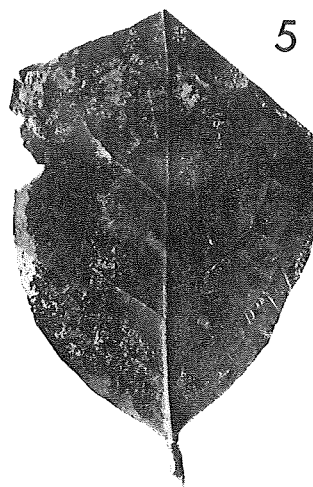
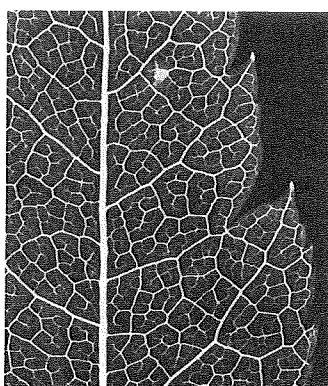
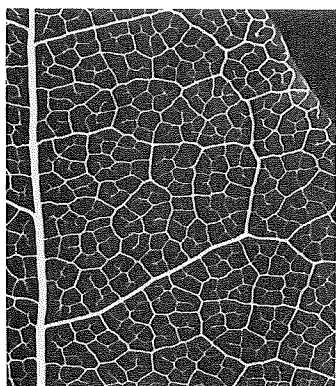
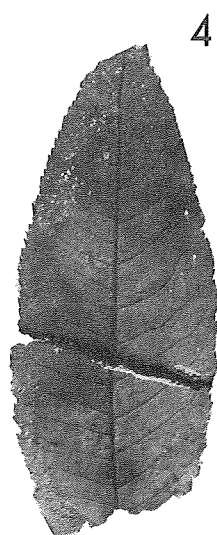
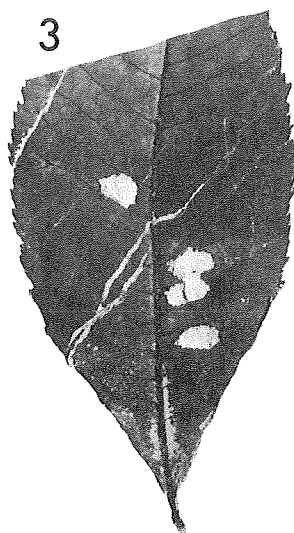
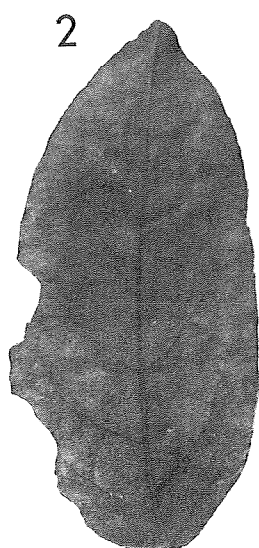
Discussion: The original specimen described as *Cydonia chloranthoides* is evidently referred to the genus *Chaenomeles* as far as the author reinvestigated: it is characterized by secondary veins, well-developed areolation and incurved, rather obtuse teeth on margin. This Mogi specimen closely resembles leaves of the extant *Chaenomeles japonica* (Thunb.) Lindl. and *C. speciosa* (Sweet) Nakai. However, the original specimen is too fragmentary to designate as a species well established. Recently, Huzioka and Takahashi (1973) referred the Mogi species to *Chaenomeles* on the basis of two fragmentary leaves from the Miocene Shimonoseki flora, western Honshu. Their specimens are also too incomplete to clarify its specific character.

Collection: Lectotype, Swedish Museum of Natural History, Paleobotany Section (Nathorst, 1883, pl. 7, fig. 7).

Explanation of Plate 10

(all figures natural size unless otherwise stated)

- Fig. 1 *Diospyros nordqvisti* Nathorst. Hypotype, G.S.J. no.4557.
- Fig. 2 *Kadsura protojaponica* Tanai. Holotype, U.H.M.P. no.25971. the Middle Miocene Chojabaru formation, Iki island, Nagasaki Prefecture.
- Fig. 3 *Clethra maximowiczii* Nathorst. Hypotype, G.S.J. no.4763.
- Fig. 4 *Zanthoxylum engleri* (Nathorst) Tanai. Hypotype, G.S.J. no.4722.
- Fig. 5 *Magnolia elliptica* Tanai et Onoe. Hypotype, G.S.J. no.4762a.
- Fig. 6 *Acer mono* Maxim. X5 H.U.P.B. no.248.
- Fig. 7 *Acer palmatum* Thunb. X5 H.U.P.B. no.243.
- Fig. 8 *Elaeocarpus photoniaefolia* Hook. et Arn. X5 H.U.P.B. no.474.
- Fig. 9 *Pyracantha coccinea* Roem. X5 H.U.P.B. no.111.
- Fig. 10 *Fagus sylvatica* Linn. X5 H.U.P.B. no.24.



Genus *Prunus* Linn.*Prunus florini* Tanai, sp. nov.

(Pl.4, fig.1)

Prunus sp., Nathorst. Kgl. Svensk. Vet. Akad. Handl. v.20, p.56, pl.11, fig.8, 1883.*Prunus pseudo-ceras* Lindl. fossilis Nathorst. Bih. K. Svensk. Vet. Akad. Handl., v.9, p.13, 1884.*Prunus pseudo-ceras* Lindl., Florin. Kgl. Svensk. Vet. Akad. Handl. v.61, p.21, pl.3, figs.8-10, 1920.

Description: Leaves obovate to obovate-oblong in shape, 5.2 to 7.6 cm. long and 2.7 to 4.1 cm. wide, rounded at the base, acuminate at the apex; midrib stout, nearly straight; secondary veins prominent, about 9 subopposite pairs, diverging from the midrib at angles of 40 to 65 degrees, near the margin joining the superadjacent secondaries at obtuse angle, and these loops enclosed by tertiary and quaternary arches; tertiary veins irregularly percurrent or sometimes forked; quaternary veins forming irregularly polygonal areoles; margin finely serrate with small, acute teeth; petiole missing.

Discussion: As already described by Nathorst (1884) and Florin (1920), the specimens from Mogi and Amakusa are closely similar to the extant *Prunus pseudo-ceras* Lindl. living in China. However, these specimens are also similar to leaves of the extant *P. jamasakura* Sieb., ex. Koidz., of central and western Japan, or to those of its variety species. The modern cherry trees are highly variable in leaf shape and other characters, and their specific taxonomy has been frequently confused because of hybridization. Although the Mogi and Amakusa specimens may belong to the lineage of the *P. pseudo-ceras*, it is better not to refer to the extant species.

The cherry leaves have been frequently reported from the Tertiary of Japan. *P. florini* is somewhat similar to some type of *P. rubeshibensis* Tanai et N. Suzuki described from the Pliocene of northeastern Hokkaido (Tanai and N. Suzuki, 1965), but is distinguishable in base and marginal serration.

Collection: Holotype, G.S.J. no. 4713.

Prunus nathorsti Tanai, sp. nov.

(Pl.3, fig.2; text-fig.4, m, n)

Prunus buergeriana Miq. fossilis Nathorst. Kgl. Svensk. Vet. Akad. Handl. v.20, p.56, pl.11, fig.9, 1883.

Description: Leaf oblong in shape, 8 cm. long and 3.7 cm. wide acute both at the apex and the base; midvein stout, nearly straight; secondary veins 7 subopposite pairs, diverging at angle of about 50 degrees, curving up near the margin, forming a loop with branch of superadjacent secondary at acute angle,

the secondary loops enclosed by tertiary arches, branches from these arches entering marginal teeth; intersecondary veins slender, nearly parallel to the secondary; tertiaries coarsely reticulate; quaternary veins random reticulate; ultimate veinlets mostly more than thrice branching; margin finely serrate with acute teeth; petiole stout, more than 5 mm. long.

Discussion: A single specimen of *Prunus*, as pointed out by Nathorst (1883), is closely similar to the extant *P. buergeriana* Miq. of Japan in shape, venation and marginal characters, but is somewhat more slender in secondary veins than those of the species. This specimen also resembles leaves of the extant *P. ssiori* Fr. Schm. of northern Japan, but distinctly differs in acute base and non-spiny teeth.

Among a number of fossil *Prunus* reported from East Asia, *P. nathorsti* is similar to *P. protoossiori* Tanai et Onoe of the Upper Miocene and the Lower Pliocene, but is distinguishable in base and margin characters. One of the specimens described as *P. protoossiori* from the Rubeshibe flora (Tanai & N. Suzuki, 1965: pl. 18, fig. 3) is probably included in *P. nathorsti*.

Collection: Holotype, Swedish Museum of Natural History, Paleobotany Section (Nathorst, 1883: pl.11, fig.9).

Genus *Pyracantha* M. Roem.

Pyracantha nipponica Tanai, sp. nov.

(Pl.3, fig.3; text-fig.4, a)

Dictamnus fraxinella Pers. fossilis Nathorst. Kgl. Svensk. Vet. Akad. Handl. v.20, p.64, pl.13, figs.6-9, 1883.

Dictamnus albus L., Florin. ditto, v.61, p.22, pl.3, figs.11, 12, 1920.

Description: Leaves linear-oblong to oblong, somewhat asymmetrical in general outline, 3.2 to 6.5 cm. (estimated) long and 1.5 to 2.7 cm. wide; apex acute; base asymmetrically cuneate to obtuse; midrib thick, prominent, nearly straight; secondary veins rather thin, numerous, irregularly spaced, diverging from the midvein at angles of 45 to 60 degrees, flexuous, forking once or twice, near the margin uniting or reaching marginal teeth or sinus bottom; intersecondary veins composite; the tertiaries random reticulate, enclosing irregular-sized areoles of fourth-order veins; the ultimate veinlets indistinct, once or twice branching; margin crenulate with obtuse teeth; petiole thick, but in complete.

Discussion: The specimens described as *Dictamnus* from Mogi and Amakusa by Nathorst and Florin show the characteristic venation as shown in text-fig. 4, and are referable to the genus *Pyracantha*. These leaves are closely similar in venation and margin to the extant *P. coccinea* Roem. (text-fig. 4, b, c) and *P.*

crenulata (D. Don) Roem., though somewhat different in foliar shape. The genus *Pyracantha* is distributed in southern Europe and Asia: *P. coccinea* is from southern Europe to western Asia, and *P. crenulata* is in central and southwestern Asia, extending into India.

P. nipponica is the first fossil record of this genus in East Asia. The fossil leaves of *Pyracantha* have been scarcely known in the Tertiary of the world. *P. nipponica* is distinguishable in foliar shape from *Pyracantha* sp. described from the Late Miocene Krynki flora of Ukraine (Kryshtofovich & Baikovskaya, 1965).

Collection: Holotype, Swedish Museum of Natural History, Paleobotany Section (Nathorst, 1883: pl. 113, fig. 6); hypotype, G.S.J. no. 4714.

Genus *Sorbus* Linn.

Sorbus lesquereuxi Nathorst (Pl.4, figs.5-7; text-fig.4, j)

Sorbus lesquereuxi Nathorst. Kgl. Svensk. Vet. Akad. Handl., v.20, p.57, pl.3, figs.7-10, 12-15; 11, 15, fig.1 (excluding pl.3, fig.10), 1883.

Florin. ditto, v.61, p.21, pl.3, fig.7, 1920.

Konno. in Honma, Geology of Central Shinano. pl.16, fig.8, 1931.

Sorbus protoalnifolia Tanai et N. Suzuki. Palaeont. Soc. Jap., Spec. Pap., no.10, p.32, pl.21, fig.3, 1965.

Huzioka. J. Min. Colleg., Akita Univ. ser. A, v.5, p.59, pl.7, fig.2, 1972.

Huzioka et Uemura. Bull. Natl. Sci. Mus. v.6, p.714, pl.11, figs.3, 4, 1973.

Discussion: This species is, though somewhat variable in shape, characterized by double serrate margin and well-developed percurrent tertiary veins, and is closely related to the extant *Sorbus alnifolia* Sieb. et Zucc., as already pointed out by Nathorst (1883). The secondary veins of the fossil leaves bifurcate sometimes within the principal teeth, not entering directly the teeth, as in the modern leaves (text-fig. 4, k, l).

S. protoalnifolia described from the Miocene of Hokkaido, Honshu and Korea (Tanai & N. Suzuki, 1965; others) is indistinguishable from *S. lesquereuxi* in all foliar characters.

Collections: Lectotype, Swedish Museum of Natural History, Paleobotany Section (Nathorst 1883; pl. 3, figs. 7, 13); hypotypes, G.S.J. nos. 4715, 4716; no. 4717.

Family Leguminosae

Genus *Maackia* Rupr.

Maackia onoei Matsuo (Pl.4, fig.4; pl.7, fig.7)

Maackia onoei Matsuo. Tertiary floras of Japan, p.240, pl.52, fig.7, 8, 1963.

Discussion: Two legumen leaflets in our collection are distinguishable from *Wisteria fallax* by oval shape and stronger ultimate veinlets; they are referable to *Maackia onoei*, which is closely similar to the extant *M. amurensis* Rupr. of Japan. A single specimen described as *Phellodendron amurense* Rupr. from Mogi (Florin, 1920) is closely similar to *M. onoei* excepting for somewhat longer apex, and may be included in *Maackia*.

Collections: Hypotypes, G.S.J. nos. 4718, 4719.

Genus *Wisteria* Nutt.

Wisteria fallax (Nathorst) Tanai et Onoe

(Pl.8, fig.8; text-fig.5, f)

Wisteria fallax (Nathorst) Tanai et Onoe. Geol. Surv. Jap. Rept. 187, p.45, pl.10, fig.6; pl.14, figs.2-4, 1961.

Tanai. J. Fac. Sci., Hokkaido Univ., ser. 4, v.11, p.348, pl.25, fig.4, 1961 (see synonymy).

Sophora (?) *fallax* Nathorst. Kgl. Svensk. Vet. Akad. Handl. v.20, p.58, pl.10, figs.11, 12; pl.12, figs.1, 2, 1883.

Discussion: Four legumen leaflets described by Nathorst were already referred to the genus *Wisteria* by the author (Tanai & Onoe, 1961). Though the legumes are sometimes difficult to do their generic assignment only by the leaflets, the Mogi specimens are referable to *Wisteria* in the foliar shape and venation characters. *W. fallax* has been commonly found in the Neogene of Japan.

Collections: Lectotype, Swedish Museum of Natural History, Paleobotany Section (Nathorst, 1883: pl. 10, fig. 12); hypotype, G.S.J. no. 4720.

Family Euphorbiaceae

Genus *Sapium* P. Br.

Sapium mogiense Tanai, sp. nov.

(Pl.4, fig.3; pl.6, fig.4)

Exocoecaria japonica J. Mueller fossilis Nathorst. Kgl. Svensk. Vet. Akad. Handl. v.20, p.48, pl.10, fig.13; pl.13, fig.5, 1883.

Sapium japonica Pax et Hoffm., Okutsu. Saito Ho-on Kai Mus. Res. Bull. no.19, p.161, pl.12, fig.1; pl.13, fig.1; pl.14; fig.3, 1940.

K. Suzuki. Sci. Rept. Fac. Art & Sci., Fukushima Univ., no.10, p.76, pl.17, fig.4, 1961.

Baikovskaya. Late Miocene floras from southern Primorye. p.77, pl.17, figs.4, 10, 1974.

Description: Leaf elliptical in general outline, acute at apex, obliquely obtuse at base, 14 cm long and 5.2 cm wide; midvein thick, straight; secondary veins stout, 11 pairs, opposite to subopposite, diverging from the midvein at angles 50 to 65 degrees, then gently curving up, joining superadjacent secondaries at right angles to form large marginal loops, outside of which the tertiaries form

more than twice smaller areoles along the margin; the tertiaries in intercostal area irregularly percurrent, sometimes forking at the middle; the fourth-order veins forming quadrangular or pentagonal areoles with the tertiaries; ultimate veins fine, once or twice branching; margin entire; petiole missing.

Discussion: A well-preserved leaf and its counterpart in our collection are referable to the genus *Sapium* by their venation characters, though the glands near the margin are not preserved. These specimens are closely similar to leaves of the extant *S. japonicum* Pax. et Hoffm., but differ in somewhat dense tertiaries and more branching veinlets. As far as reinvestigated, two small leaves described as *Phyllites ailanthoides* by Nathorst (1883, pl. 8, figs. 14, 15) may be included in this new species. Two incomplete leaves of *Exocoecaria japonica* from Mogi (Nathorst, 1883) are included in *S. mogiense*.

Collection: Holotype, G.S.J. no. 4721a; paratype, no. 4721b.

Family Rutaceae

Genus *Zanthoxylum* Linn.

Zanthoxylum engleri (Nathorst) Tanai, comb. nov.

(Pl.6, figs.3, 5; pl.10, fig.4; text-fig.5, m)

Rhus engleri Nathorst. Kgl. Svenska Vet. Akad. Handl. v.20, no.2, p.59, pl.10, fig.1, 1883.

Zanthoxylon ailanthoides S. et z. fossilis Nathorst, ibid. p.63, pl.2, figs.4-9, 1883.

Fagara ailanthoides Engl., Konno. In Homma, Geology of Central Shinano, pl.4, figs.4-6; pl.7, fig.8, 1931.

Discussion: Six specimens described as *Zanthoxylon ailanthoides* S. et Z. fossilis from Mogi are doubtlessly referred to the genus *Zanthoxylum*: they have marginal glands on each, minute, incurved teeth. The examination of a type specimen of *Rhus engleri* Nathorst reveals that the margin is distinctly finely serrate with incurved teeth, and branches from looping secondary or tertiary veins enter the marginal teeth. These characters, along with numerous, slender secondary veins, evidently show that *Rhus engleri* is identical with *Zanthoxylum*. Several leaflets identical with *Z. engleri* are also found in our collection.

These Mogi specimens are closely similar to leaflets of the extant *Z. ailanthoides* Sieb. et Zucc. in general characters, but are distinguishable in having more acute teeth and narrower base. *Z. engleri* somewhat resembles *Z. oblongatum* Tanai from the Oligocene of eastern Hokkaido (Tanai, 1970), but is distinguishable in larger size and numerous secondary veins.

Collections: Lectotype, Swedish Museum of Natural History, Paleobotany Section (Nathorst, 1883: pl. 10, fig. 1); hypotypes, G.S.J. nos. 4722, 4723.

Family Anacardiaceae

Genus *Rhus* Linn.*Rhus nathorsti* Tanai, sp. nov.

(Pl.5, figs.4, 5; pl.6, fig.1; text-fig.7, a)

Rhus griffithsii Hook. fossilis Nathorst. Kgl. Sv. Vet. Akad. Handl. v.20, p.58, pl.13, figs.10, 11; pl.14, fig.13, 1883.

Description: Leaflets oblong to elliptical in general shape, 11.7 to 17.7 cm. long and 4.8 to 5.5 cm. wide; apex abruptly pointed, base asymmetrical, broadly rounded in lateral leaflets, and nearly symmetrically acute in terminal leaflets; midvein stout and thick, nearly straight or slightly arcuate; secondary veins distinct, 18 to 24 pairs, opposite to subopposite, diverging from the midvein at nearly right angle on the basal part of blade, and 40 to 50 degrees on the middle and upper parts, near the margin abruptly arising up and forming distinct marginal loops; tertiary veins rather distinct, irregularly percurrent and mostly forked; quaternary veins forming irregular-sized and polygonal areoles with the tertiaries; veinlets showing complicated patterns, and branching more than three times (Text-fig. 7, a); margin entire; petiolules thick but short.

Discussion: Several well-preserved leaflets from our collection are doubtlessly referred to the genus *Rhus* by their shape and vein characters; especially they are related to the modern *R. sylvestris* Sieb. et Zucc. in the characters of veinlets. Three incomplete leaflets described as *R. griffithsii* Hook. fossilis by Nathorst (1883) match well with *R. nathorsti* in all characters, and are included in this new species.

Leaflets of the genus *Rhus* have been described under various names from the Neogene of East Asia; *R. nathorsti* is somewhat similar to *R. miosuccedanea* Hu et Chaney, which is common in the Middle Miocene of Japan. However, *R. miosuccedanea* has generally narrower leaflets with slender secondary veins.

Collection: Holotype G.S.J. no. 4724; Paratype, no. 4725a; no. 4726.

Family Aceraceae

Genus *Acer* Linn.*Acer integerrimum* (Viviani) Massalongo

(Text-fig.7, k)

Acer integerrimum (Viviani) Massalongo. Massalongo & Scarabelli. Stud. Flora foss. geol. Strat. Senigall. p.341, pl.18, fig.3; pl.41, fig.10, 1859.

Walther, Abh. Staatl. Mus. Mineral. Geol. Dresden, v.19, p.107, pl.22, figs.1-5; pl.23, figs.1-7; pl.26, figs.1-4, 1972 (see synonymy).

Acer pictum Thunb. fossilis Nathorst. Kgl. Svensk. Akad. Handl., v.20, p.60, pl.12, figs.2-8, 1883.

Florin. *ibid.* v.61, p.24, fig.5, 1920.

Acer sp., Florin. *ibid.* p.24, pl.4, fig.6, 1920.

Acer sp., Florin. *ibid.* p.32, pl.6, figs.7, 8, 1920.

Discussion: The leaves and samaras closely similar to the extant *Acer mono* Maxim., have been commonly described from the Neogene of East Asia; most of these specimens have been referred to *A. subpictum* Saporta. However, the epithet, *subpictum*, is doubtlessly "nomen nudum", because Saporta (1873) only listed *A. subpictum* in the Pliocene flora of France, without any description and figures. It was very curious why Hu and Chaney (1938) adopted the epithet "*subpictum*" for the Shanwang species. As recently discussed in detail by Walther (1972), the epithet, *integerrimum*, is valid for the fossil maple closely related to the extant *A. mono*.

The Mogi and Amakusa leaves closely resemble those of *A. mono* in foliar characters including fine venation (text-fig. 7, k, l), and are referable to *A. integerrimum*. A single leaf of *Acer* sp. from Amakusa (Florin, 1920) is five lobed with a basal pair of very small lobes, but is identical with *A. integerrimum* in all other characters. A samara specimen and its counterpart described as *Acer* sp. from Mogi (Florin, 1920) are closely similar to samaras of the extant *A. mono* in general shape, oval seed and extension angles of wings, and are included in *A. integerrimum*.

Collection: G.S.J. no. 4727.

Acer nordenskiöldi Nathorst

(Pl.7, figs.4, 8; pl.8, fig.7; pl.9, fig.4; text-fig.7, h, i)

Acer nordenskiöldi Nathorst. Kgl. Svensk. Vet. Akad. Handl. v.20, p.60, pl.11, figs.10-16 (excluding fig.17), 1883.

Miki, Jap. J. Botany, v.8, p.322, pl.9A; text-fig.8 P-Q, 1937.

Hu et Chaney. Palaeont. Sinica, n. ser. A, v.1, p.60, pl.34, figs.1, 6, 1938.

Tanai. Geol. Surv. Japan Rept. no.163, pl.16, fig.2, 1955.

Tanai et Onoe. *ibid.* no.187, p.47, pl.15, fig.1; pl.17, fig.2, 1961.

Tanai. J. Fac. Sci., Hokkaido Univ., ser.4, v.11, p.358, pl.28, fig.6, 1961.

Huzioka. J. Min. Coll., Akita Univ., ser.A, v.5, p.64, 1972.

Huzioka et Uemura. Bull. Natl. Sci. Mus. v.6, p.719, pl.14, fig.9, 1973.

Baikovskaya. Late Miocene floras of South Primorye. p.85, pl.19, figs.3, 8-10; pl.29, fig.8; text-fig.17, 1974.

Acer cf. *nordenskiöldi* Nathorst, Nathorst. Palaeont. Abhandl., v.4, p.34, pl.10, figs.13, 14, 1888.

Liquidambar europaeum Al. Br., Florin. ditto, v.61, p.20, pl.3, fig.5, 1920.

Acer palmatum Thunb., Florin. *ibid.* p.23, 36, pl.4, figs.1-4.

Konno. in Honma. Geology of central Shinano. pl.4, fig.9; pl.13, fig.8, 1931.

Miki. Jap. J. Bot. v.11, p.283, text-fig.17 B-Cd, 1941.

Takahashi. Mem. Fac. Sci., Kyushu Univ., ser. D, v.5, p.60, pl.7, figs.5-7b, 1954.

Acer ornatum Carr., Huzioka. J. Fac. Sci., Hokkaido Univ., ser.4, v.7, p.133, pl.23, fig.9,

1943.

Tanai. Trans. Proc. Palaeont. Soc. Jap., N.S., no.8, p.234, pl.22, figs.10, 11, 1952.

Tanai. Geol. Surv. Jap. Rept. no.163, pl.16, figs.5, 6; pl.17, fig.10, 1955.

Acer protopalmatum Suzuki. Sci. Rept. Fukushima Univ., no.10, p.83, pl.18, figs.6-9, 1961.

Discussion: The original specimens do not always preserved well the marginal character, but the cautious reinvestigation reveals their margin is double serrate as shown in text-fig. 7, i. The fine veinlets are branching three or four times in the quadrangular or pentagonal areoles as in leaves of the extant *Acer palmatum* Thunb. (text-fig. 7, j) *A. nordenskiöldi* is closely similar to the extant *A. palmatum* in foliar shape and venation, though generally somewhat coarser in marginal serration than in the extant species. *A. palmatum* is distributed in East Asia, and has many varieties. As it is difficult to compare accurately the fossils with modern variety, fossil leaves and samaras closely similar to *A. palmatum* are better to be included in *A. nordenskiöldi*.

A. nordenskiöldi is common in the Neogene of East Asia: the fossils listed in the above synonymy are included in *A. nordenskiöldi*. These leaves are mostly 7-lobed, but a pair of basal lobes are very smaller than others. The related living *A. palmatum* is 5 to 7 lobed, but var. *amoenum* (Carr.) Ohwi is 7 (rarely 9) lobed and var. *matsumarae* (Koidz.) Makino is 7 to 9 (rarely 5) lobed. Suzuki (1961) established *A. protopalmatum* on the basis of five lobation, but *A. protopalmatum* is included in *A. nordenskiöldi*. A five-lobed leaf described as *Liquidambar europaeum* from Amakusa (Florin, 1920) is referable to *A. nordenskiöldi* in the following characters: the marginal serration is rather larger, without glands and fine veinlets are different from those of *Liquidambar*.

Collections: Lectotype, Swedish Museum of Natural History, Paleobotany Section (Nathorst, 1883: pl. 11, fig. 14); hypotypes G.S.J. nos. 4728a, 4729, 4730; 4732.

Family Sapindaceae
Genus *Sapindus* Rupr.
Sapindus tanaii Onoe
(Pl.5, fig.3a, b)

Sapindus tanaii Onoe. Geol. Surv. Jap. Rept. no.253, p.52, pl.12, figs.5-7; text-fig.3, 1974.

Discussion: Two leaflets from our collection are identical to *Sapindus tanaii*, which is closely similar to the extant *S. mukurossi* Gaert. of East Asia. *S. tanaii* somewhat resembles *Rhus miosuccedanea* in general appearance, but differs in the character of slender tertiary veins (not percurrent) and fine veinlets. As far as reinvestigated by the author, no fossil leaflets referable to *Sapindus* is found in the collection of the Swedish Museum.

Collection: Hypotype, G.S.J. no. 4731a, b.

Family Sabiaceae
Genus *Meliosma* Blume
Meliosma cf. *myriantha* S. et Z.
(Text-fig.4, i)

Meliosma myriantha S. et Z. fossilis Nathorst. Kgl. Svensk. Akad. Handl. v.20, p.37, pl.3, fig.17, 1883.

Discussion: An incomplete leaf, as described by Nathorst, is probably referred to *Meliosma myriantha* by venation character and marginal serration with aristate teeth as shown in text-fig. 4, i. Several leaf specimens referable to *M. myriantha* have been reported from the Late Miocene of Japan, but most of them are not well-preserved.

Family Aquifoliaceae
Genus *Ilex* Linn.
Ilex heeri Nathorst
(Pl.7, fig.5; pl.8, figs.4, 9; text-fig.7, b, c)

Ilex heeri Nathorst. Kgl. Sv. Vet. Akad. Handl., v.20, p.62, pl.10, figs.7-10; pl.11, fig.3, 1883.

Nathorst. Bihany till K. Svensk Vet. Akad. Handl., v.9, p.12, 1884.

Konno. in Honma. Geology of central Shinano., pl.4, fig.3; pl.13, fig.4, 1931.

Huzioka. Tertiary floras of Japan, Miocene floras, p.208, pl.36, fig.6, 1963.

Huzioka. J. Min. Colleg., Akita Univ., ser.4, v.5, p.62, pl.7, fig.9, 1972.

Ilex pedunculosa Miq., Florin. Kgl. Sv. Vet.-Akad. Handl., 61, p.23, pl.4, fig.9, 1920.

Discussion: The original specimens described by Nathorst (1883) show characteristic venation, and they are closely related to those of the extant *I. pedunculosa* Miq. (text-fig. 7, d, e) and *I. rotunda* Thunb., especially to the former. The tertiary veins of the *I. heeri* are irregular-sized and orthogonal or pentagonal-reticulate, and the fourth-order veins form also irregularly orthogonal or pentagonal areoles, in which veinlets branch two or three times.

Several well-preserved specimens referable to *I. heeri* are also found in our collection. A single leaf referred to *I. pedunculosa* Miq. from the Pliocene of Amakusa island (Florin, 1920) is indistinguishable from *I. heeri*.

Collections: Lectotype, Swedish Museum of Natural History, Paleobotany Section (Nathorst, 1883: pl.10, fig.7); hypotypes G.S.J. nos. 4728b, 4733.

Ilex lundbladae Tanai, sp. nov.
(Pl.8, fig.3; text-fig.6, b)

Description: Leaf prolongly ovate in general shape, somewhat inequilateral, acuminate at apex, broadly cuneate and slightly asymmetrical at base, 7.1 cm. long and 3 cm. wide; midvein stout, nearly straight, slightly grooved on the lower and middle parts of the blade; secondary veins thin, not prominent, about 7 pairs, irregularly spaced, diverging from the midvein at 40 to 50 degrees, arising flexuously up near the margin and joining the superadjacent secondary at right or acute angles; the secondary loops enclosed irregularly by tertiary arches; a thin intersecondary vein sometimes diverging from the midvein; tertiary veins indistinct, coarsely reticulate; fourth-order veins and fine veinlets ill-preserved; margin serrate with minute, obtuse teeth in which the branch from secondary or tertiary arches end; petiole missing.

Discussion: A single leaf in our collection closely resembles some evergreen leaves of the genus *Ilex* in the venation and marginal characters. It is closely similar to leaves of the extant *I. integra* Thunb. and *I. chinensis* Simons., especially more close to the latter in general shape (text-fig. 6, a). Several fossil species of *Ilex* have been described from the Tertiary of Japan, but they are distinguishable from this new species.

The close extant species, *I. chinensis*, is now distributed in central and southwestern Honshu, extending into China. *I. lundbladae* is named in the honor of Professor B. Lundblad, who afforded kindly many facilities for the writer's research in Stockholm.

Collection: Holotype, G.S.J. no. 4725b.

Ilex onoei Tanai, sp. nov.

(Pl. 7, fig. 6; text-fig. 6, c, d)

Description: Leaf obovate-elliptical in shape, 8.5 cm. (estimated) long and 3.4 cm. wide, gradually narrowed toward apex and base; apex somewhat incomplete but apparently acute; base gradually narrowed and slightly decurrent; midvein stout, slightly arcuate on the lower part but nearly straight on the upper; secondary veins distinct but rather slender, 15 opposite to subopposite pairs, diverging from the midvein at angles of 50 to 55 degrees at the middle of the blade, slightly flexuous, near the margin abruptly arising up to join the superadjacent secondaries at nearly right angle; secondary loops enclosed by tertiary arches, branches from tertiary arches entering marginal teeth; marginal ultimate veins thin, irregularly looping; tertiary veins distinct; fourth- and fifth-order veins forming irregularly sized, quadrangular or pentagonal areoles; ultimate veinlets irregularly branching more than thrice within the areoles; margin remotely serrate with minute, obtusely pointed teeth excepting basal part; petiole thick, 8 mm. long; texture chartaceous.

Discussion: A single well-preserved leaf in our collection is referred to the genus *Ilex* with some hesitation, because it is closely similar in venation and marginal serration to leaves of some extant species of *Ilex* distributed in Japan. This fossil leaf closely resembles leaves of some types of *I. serrata* Thunb. and *I. nipponica* Makino, especially of the latter (text-fig. 6, e, f). Taxonomy on the genus *Ilex* of Japan, has been not always settled up to the present, because *Ilex* is very variable not only in foliage but in other characters. Actually our leaf shows a close resemblance to leaves of "*I. nemotoi* Makino", which is now included in *I. serrata* by Ohwi (1970).

Collection: Holotype, G.S.J. no. 4734.

Family Rhamnaceae

Genus *Rhamnus* Linn.

Rhamnus cf. *costata* Maxim.

Rhamnus costata Maxim., Nathorst. Kgl. Svensk. Vet. Akad. Handl. v.20, p.61, pl.1, fig.19; pl.2, fig.2, 1883.

Discussion: As pointed out by Nathorst, these two fragmentary leaves are closely comparable to those of the extant *Rhamnus costata* Maxim. living in Honshu and Shikoku, Japan. Two species of *Rhamnus* were described from the Upper Miocene of Honshu, but they are distinguishable from the Mogi specimens.

Family Vitaceae

Genus *Vitis* Linn.

Vitis naumanni (Nathorst) Tanai

Vitis naumanni (Nathorst) Tanai. Geol. Surv. Jap. Rept. no.163, pl.15, fig.11, 1955.

Tanai et N. Suzuki. Palaeont. Soc. Jap. Spec. Pap. no.10, p.41, pl.11, fig.3, 1965.

Vitiophyllum naumanni Nathorst. Palaeont. Abhandl., v.4, p.17, fig.2, 1888.

Vitis lubrusca Linn., Nathorst. Kgl. Svensk. Vet. Akad. Handl. v.20, p.61, pl.7, figs.8, 9, 1883.

Discussion: The Mogi specimens of *V. lubrusca* were already placed in synonymy with *V. naumanni* by the author (Tanai and N. Suzuki, 1965), based on their similar shapes and well-defined venation characters. As *Vitiophyllum naumanni* was referred to the genus *Vitis* without any discussion by the author (Tanai, 1955), *Vitis naumanni* has been the nomen nudum. Furthermore, the original specimen of *Vitiophyllum naumanni* was unfortunately lost in the Geological Survey of Japan during the Second World War.

The author (Tanai and Suzuki, 1965) reported several well-preserved leaves as *V. naumanni* with the description of detailed characters from the Late

Tertiary of northeastern Hokkaido. Thus, the author designates *Vitis naumannii* by selecting one of them as the neotype (H.U.M.P. no. 25824).

Family Elaeocarpaceae
Genus *Elaeocarpus* Linn.
Elaeocarpus florini Tanai, sp. nov.
(Pl.5, fig.5; text-fig.5, d)

Elaeocarpus photoniaefolia Hook. et Arn. fossilis Nathorst. Kgl. Svensk. Vet. Akad., v.20, p.64, pl.9, fig.5, 1883.

Florin. ditto, v.61, p.25, pl.5, figs.1-3; p.33, pl.6, figs.14, 14a, 1920.

Description: Leaves oblong to linear-oblong in general outline, acute at the apex, attenuate to obtuse at the base, 5.5 to 9 cm. long (estimated) and 2 to 3.9 cm. wide; midvein stout, nearly straight but slight arched on the apical part; secondary veins thick, 6 to 8 subopposite to opposite pair, somewhat irregularly spaced, diverging from the midrib at angles of about 40 degrees on the middle of the blade, nearly straight and then abruptly curving upward at about two-thirds-way to the margin, joining the superadjacent secondary at acute angle, outside of secondary loops tertiary arches distinct but quaternary arches thin; a thin branch from secondary or tertiary arches reaching each sinus of marginal serration; one or two composite intersecondary veins thin, diverging from the midvein; tertiary veins thin, forming random reticulate, enclosing fine veinlets; ultimate veinlets ill-preserved but branching more than three times; margin serrate with minute and rather obtuse teeth, base of sinus sometimes thickening with glands; petiole missing; texture firm.

Discussion: Two Mogi and three Amakusa specimens described as *Elaeocarpus photoniaefolia* are doubtlessly referred to *Elaeocarpus* by their venation, marginal serration and glands. These specimens most closely resembles leaves of the extant *E. sylvestris* (Lour.) Poir. in foliar shape and venation characters, though less acute in marginal serration than in the extant species. As pointed out by Nathorst (1883) and Florin (1920), the fossil leaves are similar in shape and marginal characters to the extant *E. photoniaefolia* Hook. et Arn. of the Bonin (Ogasawara) islands, but differs in the details of the tertiary venation. Thus, the Mogi and Amakusa specimens are established as a new species, based on the above-described characters. A single specimens in our collection is referable to this new species in venation and serration, though somewhat narrower and smaller than Florin's specimens.

The close living species, *E. sylvestris*, is one common member of the evergreen forest in southern Japan, and is distributed from southern Kwantō to Ryukyu islands, extending into Taiwan and southern China.

Collections: Holotype, Palaeont. Museum of University of Uppsala (Florin, 1920: pl. 5, fig. 1); hypotype, G.S.J. no. 4735.

Elaeocarpus saportanus (Nathorst) Tanai, comb. nov.
(Text-fig.5, a, b)

Vaccinium (?) *saportanum* Nathorst. Kgl. Svensk. Vet. Akad. Handl. v.20, p.52, pl.11, figs.5, 6, 1883.

Discussion: Two incomplete leaves described as *Vaccinium* (?) *saportanum* show characteristic venation, and are referable to the genus *Elaeocarpus*. The reinvestigation of the original specimens reveals that the marginal teeth are rather obtuse with glandular thickening of sinus, and that the areolation is somewhat imperfect, enclosing well-branching veinlets. These leaves are closely related to those of the extant *E. japonicus* Sieb. et Zucc. (text-fig. 5, c), which is distributed from Kii Peninsula to Ryukyu islands, extending into Taiwan and southern China.

E. saportanus is closely similar to *E. notoensis* Ishida described from the Middle Miocene Noroshi flora of central-north Honshu (Ishida, 1970), but differs in tertiary venation: in *E. saportanus* the tertiaries are generally perpendicular to or with wide divergence to the midvein as similar as in *E. japonicus*, while they are coarsely reticulate in *E. notoensis*. The above-described species, *E. florini*, is also distinguishable from *E. saportanus* in tertiary venation and marginal serration.

Collection: Lectotype, Swedish Museum of Natural History, Paleobotany Section (Nathorst, 1883: pl. 11, fig. 6).

Family Tiliaceae

Genus *Tilia* Linn.

Tilia distans Nathorst

(Pl.6, fig.2; pl.7, fig.3; pl.9, fig.2; text-fig.5, g, h)

Tilia distans Nathorst. Kgl. Svensk. Vet. Akad. Handl. v.20, p.65, pl.6, figs.5-13, 1883.

Florin. ditto, v.20, p.25, pl.2, fig.9, 1920.

Konno. in Honma. Geology of Shinano. pl.14, fig.4, 1931.

Huzioka. J. Fac. Sci., Hokkaido Univ. ser.4, v.7, p.121, pl.21, figs.1-4, 7, 8, 1943.

Celtis nordendkiöldi Nathorst. (in part). Kgl. Svensk. Vet. Akad. Handl. v.20, p.47, pl.6, figs.14-17, (excluding pl.15, fig.2), 1883.

Spiraea (?) *petersoni* Florin (in part). ditto, v.61, p.20, pl.2, figs.5, 7 (excluding fig.6), 1920.

Discussion: *Tilia distans* has been frequently reported from the Neogene of Japan and other regions of northeastern Asia; but this specific name has been

misused by various workers including the author. It is partly due to the fact that most of the original specimens from Mogi are incomplete and furthermore are not always validly illustrated in their venation characters. As far as the author reinvestigated the original specimens, *T. distans* is characterized by the followings: leaves are obliquely cordate at the base; most of lateral primary and secondary veins do not enter directly marginal teeth, forming irregularly loops near the margin; fine veinlets are none or linear in the quadrangular areoles (text-fig. 5, h). Comparing with leaves of the extant *Tilia* species, *T. distans* shows a most close resemblance to *T. kiusiana* Makino et Shirasawa, which is living in western Honshu, Shikoku and Kyushu.

Most of the leaves described as *T. distans* from East Asia are doubtful or distinguishable from *T. distans*, excluding the leaves listed in the above synonymy. The original specimens of *Celtis nordenskiöldi* Nathorst, excluding one specimen, show the above-described characters, and are included in *T. distans*. A fragmentary bract of *Tilia* was illustrated from Mogi by Nathorst (1883, pl. 6, figs. 3), and may be referred to *T. distans*. Two leaves described as *Spiraea* (?) *petersoni* Florin from Amakusa (Florin, 1920) are indistinguishable from *T. distans* in all characters.

Collections: Lectotype, Swedish Museum of Natural History, Palaeobotany Section. (Nathorst, 1883: pl. 6, fig. 5); Hypotypes, G.S.J. nos. 4736, 4737; no. 4738.

Family Cornaceae
Genus *Cornus* Linn.
Cornus megaphylla Hu et Chaney
(Pl.9, fig.6)

Cornus megaphylla Hu et Chaney. Palaeont. Sinica, n. ser. A, no.1, p.71, pl.48, figs.3-6; pl.49, fig.2, 1938.

Discussion: A single leaf from our collection is identical with *Cornus megaphylla* in its larger size, number of the secondaries and characteristic tertiary venation. This Mogi specimen closely resembles leaves of the extant *C. controversa* Hemsley and *C. brachypoda* C. A. Meyer of Japan, especially to the former.

Collection: Hypotype G.S.J. no. 4739.

Cornus subkousa Tanai et Onoe

Cornus subkousa Tanai et Onoe. Geol. Surv. Jap. Rept. 182, p.53, pl.3, fig.4, 1961.

Cornus sp., Florin. Kgl. Svensk. Vet. Akad. Handl. v.61, p.26, pl.3, fig.2; p.34, pl.6, figs.9, 10, 1920.

Discussion: Three leaves of *Cornus* sp. described from Mogi and Amakusa by Florin (1920) are referred to *C. subkousa*: they are distinguishable from the above *C. megaphylla* by their oval shape and less number of the secondary veins. *C. subkousa* closely resembles the extant *C. kousa* Buerger, ex. Miq., widely distributed in East Asia.

Family Clethraceae

Genus *Clethra* Linn.

Clethra maximowiczii Nathorst

(Pl.7, fig.2; pl.8, fig.1; pl.9, fig.3; pl.10, fig.3; text-fig.6, i, j)

Clethra maximowiczii Nathorst. Kgl. Svensk. Vet. Akad. Handl. v.20, p.51, pl.11, figs.18-20, 1883.

Florin. ditto, v.61, no.1, p.26, pl.2, fig.11, 1920.

Tanai and N. Suzuki. Palaeont. Soc. Japan, Spec. Paper, no.10, p.44, pl.6, fig.1 (see synonymy), 1965.

Juglans kjellmani Nathorst (in part). Kgl. Svensk. Vet. Akad. p.38, pl.1, fig.13 (excluding figs.10, 11), 1883.

Discussion: Three leaves from Mogi and one leaf from Amakusa apparently belong to the genus *Clethra*: they are characterized by cuneate base, irregularly percurrent tertiary veins, and coarsely serrate margin with somewhat aristate teeth. The tertiary and fourth-order veins are rather thin but distinct; the fourth order veins form quadrangular or pentagonal areoles with the fifth order veins, including a single or once forking veinlets. In general outline *C. maximowiczii* somewhat resembles leaves of the genus *Juglans*, such as the extant *J. ailanthifolia* Carr., but differs in rather thin venation, coarse serration and coarse areoles. One specimen described under *Juglans kjellmani* Nathorst from Mogi is unseparable from *C. maximowiczii* in venation and marginal characters.

Collections: Lectotype, Swedish Museum of Natural History, Paleobotany Section (Nathorst, 1883: pl. 11, fig. 19), hypotypes, G.S.J. nos. 4740, 4752, 4763.

Family Ericaceae

Genus *Enkianthus* Lour.

Enkianthus almquisti (Nathorst) Tanai, comb. nov.

(Pl.3, fig.4; pl.5, figs.1, 2; pl.8, fig.2; text-fig.5, k)

Tripetaleja almquisti Nathorst (in part). Kgl. Svensk. Vet. Akad. Handl., v.20, p.52, pl.9, figs.6, 12, 13 (excluding pl.14, fig.4), 1883.

Enkianthus koreanus Huzioka. J. Min. Colleg., Akita Univ., ser. A., v.5, p.72, pl.10, fig.8, 1972.

Discussion: The reinvestigation of the original specimens described as *Tripetaleja almquisti* Nathorst reveals that they do not belong to the genus *Tripetaleja* but to the genus *Enkianthus*: the margin is serrulate with irregular-sized, minute teeth; the secondary veins are flexuous and form large loops with the superadjacent secondaries, enclosed by the tertiary and quaternary arches near the margin. Huzioka (1972) established a new species of *E. koreanus* from the Middle Miocene of northeastern Korea, but the Korean species is indistinguishable from *E. almquisti* in all morphologic characters.

The genus *Enkianthus* is now distributed in East Asia and Himalaya region with about 10 species. *E. almquisti* is closely similar in foliar shape and venation to *E. subsessile* Makino and *E. campanulatus* Nichols, which are mainly living in Honshu.

Collections: Lectotype, Swedish Museum of Natural History Palaeobotany Section (Nathorst, 1883: pl. 9, fig. 13); hypotypes, G.S.J. nos. 4753, 4754, 4755.

Family Ebenaceae

Genus *Diospyros* Linn.

Diospyros nordqvisti Nathorst

(Pl.6, fig.6; pl.9, fig.7; pl.10, fig.1)

Diospyros nordqvisti Nathorst (in part). Kgl. Svensk. Vet. Akad. Handl., v.20, p.51, pl.8, fig.1; pl.14, figs.1, 2, 4, 5 (excluding pl.14, fig.3), 1883.

Konno. in Honma, Geology of central Shinano. pl.14, figs.7, 8, 1931.

Diospyros kaki Linn., Florin (in part). Kgl. Svensk. Vet. Akad. Handl., v.61, p.27, pl.3, fig.6 (excluding pl.5, figs.5, 6), 1920.

Konno. in Honma, Geology of central Shinano. pl.16, fig.2, 1931.

Takahashi. Mem. Fac. Sci., Kyushu Univ., ser. D, v.5, p.63, pl.8, figs.3, 1954.

Murai. Rept. Tech., Iwate Univ., v.16, p.52, pl.19, figs.5, 6, 1963.

Diospyros miokaki Hu et Chaney (in part). Palaeont. Sinica, new ser. A, no.1, p.72, pl.46, figs.1, 2 (excluding fig.3), 1938.

Tanai. J. Fac. Sci., Hokkaido Univ., ser.4, v.11, p.381, 1961.

Tanai et N. Suzuki. Tertiary floras of Japan, Miocene floras, p.147, pl.10, fig.17, 1963.

Huzioka. *ibid.* p.213, pl.38, fig.11; pl.40, fig.10, 1963.

Matsuo. *ibid.* p.242, pl.56, figs.1, 2, 1963.

Huzioka. J. Min. Coll. Akita Univ., ser. a, v.3, p.98, pl.17, fig.4, 1964.

Huzioka. *ibid.* v.51, p.73, pl.9, fig.11, 1972.

Discussion: The original specimens excluding one are doubtlessly referred to the genus *Diospyros* in their shape and venation characters. These leaves show most close resemblance to those of the extant *D. lotus* Linn. in the sense of inconspicuous tertiary venation, but are also similar to the extant *D. kaki*

Thunb. in general shape. A single specimen (pl. 14, fig. 3) has serrate margin as far as the author investigated, and is excluded from *D. nordqvisti*.

The leaves of *Diospyros* have been commonly reported from the Tertiary of East Asia, and all the specimens based on the above-listed citations are included in *D. nordqvisti*. Especially, Miocene leaves of *Diospyros* from Japan and Korea have been frequently referred to *D. miokaki*, which was originally described from the Miocene Shanwang flora of China (Hu et Chaney, 1938). *D. miokaki* is essentially indistinguishable from *D. nordqvisti* in all foliar characters. It should be, however, noted that one of the Shanwang paratype (pl. 46, fig. 3; paratype no. 135), stored in the Museum of Paleontology, University of California, is excluded from *D. miokaki* because of having serrate margin.

Collections: Lectotype, Swedish Museum of Natural History, Palaeobotany Section (Nathorst, 1883: pl. 14, fig. 2); hypotypes, G.S.J. nos. 4756, 4757.

Family Styracaceae

Styrax protojaponica Tanai, sp. nov.

(Pl.2, fig.4; text-fig.6, m, n)

Styrax japonicum S. et Z. fossilis, Nathorst. Kgl. Svensk. Vet. Akad. Handl., v.20, p.50, pl.14, figs.6-8, 1883.

Description: Leaves obovate to ovate in general shape, acute at both apex and base, 5.7 to 8 cm. long (estimated) and 3.5 to 3.6 cm. wide; midvein stout, straight; the secondary veins rather slender, about six subopposite pairs, irregularly spaced, especially widely spaced at the middle of blade, diverging at acute angles from the midvein, gently curving along the margin, then joining superadjacent secondaries at acute angle to form large marginal loops, outside of which tertiary and quaternary veins forming small loops along the margin; intercostal tertiaries irregularly and obliquely percurrent; the fourth-order veins thin, forming quadrangular areoles of large size; ultimate veinlets branching several times; margin remotely serrate with minute teeth, in which the fifth-order veins from the marginal loops end; petiole missing.

Discussion: A single well-preserved leaves in our collection is referable to the genus *Styrax* in general shape and venation. It closely resembles to leaves of the extant *S. japonica* S. et Z. in general character, but is somewhat different in branching character of the ultimate veins. Three fragmentary leaves described as *S. japonicum* by Nathorst (1883) are doubtlessly included in this new species.

Collections: Holotype, G.S.J. no. 4760; paratype, S.M.N.H. (Nathorst, 1883: pl. 14, fig. 7).

Styrax protoobassia Tanai et Onoe
(Pl.8, fig.5)

Styrax protoobassia Tanai et Onoe. Geol. Surv. Japan Rept., no. 187, p.56, pl.18, figs.1, 8, 1961.

Tanai. J. Fac. Sci., Hokkaido Univ., ser.4, v.11, no.2, p.384, pl.31, fig.5, 1961
(see synonymy).

Styrax obassia Sieb. et Zucc. fossilis Nathorst. Kgl. Svensk. Vet. Akad. Handl., v.20, p.50, pl.10, figs.2-6; pl.11, fig.7, 1883.

Phyllites sp., Florin. ditto, v.61, p.34, pl.6, fig.15, 1920.

Discussion: These Mogi specimens closely similar to the extant *Styrax obassia* Sieb. et Zucc., was already referred to *S. protoobassia* by the author (Tanai, 1961). Although *S. protoobassia* is variable in foliar shape, it is characterized by irregularly spaced secondary veins, well-developed tertiary veins and remotely serrate margin with minute teeth.

Collection: Hypotype G.S.J., no. 4759; no. 4764.

Family Symplocaceae
Genus *Symplocos* Jacq.
Symplocos smithi Florin
(Pl.7, fig.1; pl.9, fig.1; text-fig.7, f, g)

Symplocos smithi Florin. Kgl. Sv. Vet. Akad. Handl., v.61, no.1, p.27, pl.4, figs.10, 11, 1920.

Discussion: A single leaf unillustrated by Nathorst, is referred to *Symplocos smithi* by the characteristic venation and marginal serration: the secondary veins develop well the marginal loops, outside which the tertiary veins form once or twice smaller loops near the margin; fine veinlets are more than twice branching in irregularly pentagonal areoles; margin is rather remotely serrate with acute and minute teeth. Florin (1920) established a new species, *S. smithi*, based on two well-preserved leaves from Amakusa, but he doubted his final generic assignment for them, adding a question mark on its generic name. The reinvestigation of the original specimens shows, however, that they are soundly referred to the genus *Symplocos*, and are closely similar to *S. ilicifolia* Hayata living in Taiwan.

Collections: Holotype, Museum of Paleontology, University of Uppsala (Florin, 1920: pl.4, fig.10); hypotype, Swedish Museum of Natural History, Paleobotany Section; hypotype, G.S.J. no.4761.

Family Caprifoliaceae

Genus *Viburnum* Linn.*Viburnum viburnifolium* (Nathorst) Tanai, comb. nov.

Aphananthe viburnifolia Nathorst. Kgl. Svensk. Vet. Akad. Handl., v.20, p.46, pl.6, fig.2, 1883.

Viburnum sp., Nathorst. ditto, p.53, pl.6, fig.20, 1883.

Viburnum erosum Thunb. ditto, v.61, p.28 and 34, pl.3, fig.1; pl.6, figs.2, 3, 1920.

Discussion: An incomplete leaf described as *Aphananthe viburnifolia* by Nathorst is referable to the genus *Viburnum* in the venation and marginal characters, and is closely similar to leaves of the extant *V. erosum* Thunb. as already pointed out by Florin (1920). In this specimen the marginal teeth are very small and spiny, and the tertiary veins are mostly simply percurrent; while in *Aphananthe aspera* the marginal teeth are large and abruptly cuspidate, and the tertiaries are convexly percurrent and sometimes forking. An fragmentary specimen of *Viburnum* sp. described by Nathorst is included in *V. viburnifolium*, though its upper half is lacking. It seems better that *V. viburnifolium* is represented by two specimens figured by Nathorst (1883). Three leaves of *V. erosum* reported from Mogi and Amakusa (Florin, 1920) are included in *V. viburnifolium* by venation and marginal characters.

Collections: Lectotype, Swedish Museum of Natural History, Paleobotany Section (Nathorst, 1883: pl. 6, fig. 2); G.S.J. no. 4762b.

Insertae Sedis

Carpites sibriakoffi (Nathorst) Tanai, comb. nov.

(Pl.8, fig.6)

Clematis sibriakoffi Nathorst. Kgl. Svensk. Vet. Akad. Handl., v.20, p.69, pl.9, fig.3, 1883.

Discussion: A well-preserved specimen described as *Clematis sibriakoffi* by Nathorst (1883) shows a characteristic venation; he compared it with leaves of the extant *C. paniculata* Thunb. of Japan or *C. ochroleuca* Ait. of North America. However, as far as reinvestigated by the author, this specimen does not resemble any leaves of *Clematis* in venation character: all of the secondary veins are astringent toward the base to enter a thick "petiole". Such venation appears to be seen in some monocot leaves, and also in calyx or petal of dicots. Further investigation shall decide to determine its generic position.

Collection: Lectotype, Swedish Museum of Natural History, Paleobotany Section (Nathorst, 1883: pl. 8, fig. 6).

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