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Leaves of terrestrial plants from the Pliocene shallow marine and transitional deposits of Asti (Piedmont, NW Italy)

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ABSTRACT – *This paper provides an updated taxonomic synthesis on the leaf assemblages from the shallow marine and transitional deposits of the surroundings of Asti, whose deposition took place within latest Early Pliocene and/or early Middle Pliocene (ca 3.8-3.1 Ma). The 1960s and 1990s collections from the basal part of the Arboschio quarry, stored at the Museo di Geologia e Paleontologia of the Turin University, have been thoroughly revised. In addition the fossil leaf specimens recently collected from Asti-Cascina Risso, Baldichieri-Fornace, Baldichieri-North, Castagnole Monferrato, Cerro Tanaro and Valmanera have been studied. Furthermore, a taxonomic revision of lost material from Castello d'Annone, Ferrere, San Damiano and Pralormo has been attempted on the basis of unpublished drawings by Paolo Peola (ca 1890).*

The composition of the majority of assemblages studied is rather homogeneous, so that reference is made to a collective "Asti" palaeoflora, dominated by deciduous trees which formed at least two types of plant communities: azonal riparian forests and zonal mesophytic forests. The abundance of riparian elements testifies that the leaf remains were transported by rivers to the shallow-marine bottoms, probably in occasion of strong floods. The "Asti" palaeoflora provides a good leaf signature for the "Stura Floristic Complex", previously defined on the basis of fruit and seed assemblages. Such complex represents a phase when the western margin of the Po Basin was covered by high-diversity forests of East Asian affinity, with dominant summergreen trees, indicating warm-temperate and humid conditions (mean annual temperature around 13-14 °C).

RIASSUNTO – [Foglie di piante terrestri da depositi di mare basso e di transizione del Pliocene di Asti] – *Viene presentata una sintesi tassonomica aggiornata sulle flore fogliari dei depositi di mare basso e di transizione affioranti nei dintorni di Asti, i quali si sedimentarono durante il tardo Pliocene inferiore e la prima metà del Pliocene medio (ca. 3.8-3.1 Ma). I campioni raccolti negli anni 1968-69 e 1994 nella parte basale della Cava Arboschio, conservati presso il Museo di Geologia e Paleontologia dell'Università di Torino, sono stati revisionati dal punto di vista tassonomico. Sono stati analizzati, inoltre, campioni di foglie recentemente rinvenuti a Asti-Cascina Risso, Baldichieri-Fornace, Baldichieri-Nord, Castagnole Monferrato, Cerro Tanaro e Valmanera. Sulla base dei disegni inediti di Paolo Peola (1890 circa) è stata anche tentata una revisione tassonomica di esemplari rinvenuti a Castello d'Annone, Ferrere, San Damiano e Pralormo, andati distrutti durante la Seconda Guerra Mondiale.*

La composizione della maggior parte delle associazioni studiate è piuttosto omogenea, tanto che si può far riferimento a una paleoflora collettiva di "Asti", dominata da alberi decidui che formavano almeno due tipi di comunità vegetali: foresta ripariale azonale e foresta mesofila zonale. L'abbondanza di elementi ripariali testimonia un trasporto fluviale dei resti fogliari sino ai bassi fondali marini, probabilmente in occasione di intensi eventi di piena. La paleoflora di "Asti" fornisce una buona documentazione della fisionomia fogliare del "Complesso Floristico Stura", precedentemente definito sulla base di associazioni a frutti e semi. Tale complesso corrisponde a una fase in cui il Bacino Padano occidentale era coperto da foreste ad alta diversità specifica e spiccata affinità est-asiatica, in cui gli alberi decidui erano dominanti. Questo tipo di vegetazione indica un clima temperato-caldo e umido, con temperatura media annua intorno a 13-14 °C.

INTRODUCTION

The purpose of this work is the taxonomic assessment of determinable leaf remains known from shallow marine and transitional sediments of Pliocene age in the surroundings of Asti. Sismonda (1859) reported the earliest fossil plant remains from this area: a cone assigned to *Pinus abies*? Linné and two leaves, respectively assigned to *Corylus heeri* Sismonda and *Planera ungeri* Ettingshausen. The provenance was just indicated as "Pliocene, Astésan", and only the new species *C. heeri* was said to occur at San Damiano d'Asti. Later Sismonda (1865) specified that *P. ungeri* had been collected at "Annone" (now Castello d'Annone). This material was re-examined in the monograph on Tertiary conifers of Piedmont by Peola (1893), who stated that the collection place of the *Pinus abies*? cone cited by Sismonda was "Valdondona" (now Valleandona), and suggested to

identify it as "*Pinus* sp." due to its bad state of preservation. Peola (1893) also studied two cones of unknown provenance (but in his opinion possibly coming from the Asti area) and concluded that they belonged to two new species. After my present knowledge those cones could come from several parts of Piedmont (e. g. Canavese, Biellese) and therefore they are not worth treating here, also because the original specimens have been destroyed during the World War II. Actually, this loss of material concerned almost all the rather rich palaeobotanical collection of the "Regio Museo di Geologia di Torino", which was housed in Palazzo Carignano. However, we can get useful information about its content thanks to the papers by Paolo Peola. This author also left a manuscript with a complete overview of the Tertiary flora of Piedmont, accompanied by 65 plates with drawings of plant macrofossils from that lost collection.

Peola (1896a) devoted a special work to the fossil flora of the Asti area (Astigiano), based on fossil leaves which, according to their labels, had been collected from the sites of Annone d'Asti (many specimens), Ferrere d'Asti (2), San Damiano d'Asti (6) and Pralormo (2). More precisely, the labels he found attached to the material from "Annone d'Asti" (now Castello d'Annone: Text-fig. 1) reported that it was found in "one layer thought to have the same age as the sediments which yielded the fossil whale". The densely packed leaves were preserved in a yellow sandstone, an uncommon lithology in the sandy Pliocene of Asti, which is the result of localized phenomena of diagenetic cementation. My recent efforts to re-locate the same layers around Castello d'Annone have been unsuccessful. I just observed indeterminate leaf remains in a few silty lenses enclosed in cross-bedded coarse sands, well-exposed to the West of the village. Strongly cemented layers with bedding planes covered by leaf impressions are presently in outcrop at Cerro Tanaro, about 2 km ESE of Castello d'Annone, in the Tanaro River bed. The few samples from this site show a species-poor assemblage dominated by *Fagus pliocenica* Saporta, with "*Parrotia pristina* Ettingshausen as an additional element. These two species were also included in Peola's Annone flora (sub *Fagus* spp. and *Alnus cuneata* Peola), but this clue is not sufficient to demonstrate that his specimens came from this site.

A taxonomic revision of the lost material from Castello d'Annone (Tab. 1), Ferrere, San Damiano and Pralormo (Tab. 2) has been attempted by comparison of the drawings by Peola (Text-figs 2 and 3) with analogous fossil material presently available from neighbouring localities, which are described below.

For a long time span in the 20th century there had been no progress in Pliocene palaeobotany of the Asti area, but in the 1960s, during the excavation of the Turin-Piacenza motorway, new quarries were opened to exploit the Pliocene sands; one of them, the Arboschio quarry near Cantarana, provided rich leaf assemblages from several layers. This material was collected and studied by Pavia (1970), and it is presently housed in the Museo di Geologia e Paleontologia of the Turin University. Some portions of the Arboschio section were still in outcrop in the 1990s, thus permitting collection of further material, preliminarily listed by Martinetto & Mai (in Carraro, 1996). Knobloch and Gregor (1997) provided a new taxonomic list of the Arboschio flora, and some of their revised identifications are accepted in the present work.

MATERIALS AND METHODS

The material which can be used for a synthesis on the leaf floras of the shallow marine and transitional Pliocene of Asti includes:

- the descriptions and drawings by Peola (1896a and unpubl.) of the leaves from Castello d'Annone, Ferrere, San Damiano and Pralormo (Text-figs 2 and 3);
- the 1960s and 1990s collections from the basal part of the Arboschio section (lithozone 1 by Pavia, 1970, layers A1-A3 by Martinetto & Mai (1996), both stored at the Museo di Geologia e Paleontologia of the Turin University;
- the so-far unpublished collections from Asti-Cascina Risso, Baldichieri-Fornace, Baldichieri-North, Castagnole Monferrato, Cerro Tanaro and Valmanera, also stored at the Museo di Geologia e Paleontologia of the Turin University;
- a small collection of leaf-bearing samples stored at the Museo Regionale di Scienze Naturali di Torino (MRSNT), which was just accompanied by a single label "Arboschio". The place of origin and the collector of this material are unknown; however, the lithological features, the kind of leaf association and the marine molluscs observed on most specimens perfectly agree with the features of samples from the lithozone 1 of Arboschio. Even if the cited label is doubtful, leaf assemblages of this type are known only in the Asti area, which can be suggested as the more probable geographic source. Due to the uncertain provenance of this material, only a few specimens are cited in the systematic part as coming from "?Arboschio-L1".

The leaf assemblages of the Pliocene continental sediments ("Villafranchian type-succession"), which are interfingering with the marine ones (Azzaroli, 1977; Carraro, 1996; Francavilla & Tomadin, 1970), will not be thoroughly analyzed here, since their taxonomical assessment is to be carried out together with the rich carpofloras collected in the same succession (Martinetto, 1995; Martinetto & Mai, 1996).

The separation of Pliocene leaf morphotypes has been based on the analysis of the available architectural characters, according to Hickey (1973) and Ash *et al.* (1999). Most of these morphotypes have been treated as separate species, which have been identified by comparison to the characters of Neogene taxa, described and figured in the extensive European palaeobotanical literature. Furthermore, a direct contact with some well-known specialists (L. Hably, J. Kovar-Eder, E. Knobloch, Z. Kvaček, P. Roiron, J. Van der Burgh, H. Walther, E. Velitzelos, E. Zastawniak) has been very useful in the progress of the taxonomic work. Comparison with modern leaves has been mostly limited to the reference collection recently prepared at the Earth Sciences Department of the University of Turin. Although small for a Neogene study, this collection has the advantage to show a rather broad spectrum of the leaf variability of a given species, a feature that I consider fundamental for a correct delimitation of Neogene species. Most Italian palaeobotanists of the XIX century tended to underestimate leaf variability, thus

producing an abnormal proliferation of fossil species based on leaves or leaf fragments.

The intensive study of a single fossil leaf, by comparison with those of many modern plants, has not been regarded as a successful method to obtain a reliable delimitation of fossil taxa. The large variability of modern leaf samples suggested me to observe, first of all, the whole leaf assemblage of a given locality, to single out the most typical and well-known taxa, and to analyze the variability of their recent relatives. For example, in basal layers of the Arboschio section, *Carpinus betulus* Linné is represented by typical leaves and fruits. The observation that the living representatives of this species often produce small *Betula*-like leaves led me to revise the assignment of a fossil leaf from the same assemblage (Pl. 3, fig. 6), which had been listed as *Betula* sp. by Martinetto & Mai (1996, p. 73).

In general, when a certain degree of uncertainty was present, I preferred to lump rather than divide the species. Likewise, the determinations by Peola

(1896a and unpubl.) have been revised as to include a lower number of taxa (Tab. 1). With such an approach, the variability of leaf characters of most Pliocene taxa seems to be rather similar to the one of their modern relatives.

LOCATION AND STRATIGRAPHY OF THE STUDY SITES

The hilly area which encircles the town of Asti, within a radius of 15 km, is modelled on Pliocene shallow-marine, transitional and continental sediments, which crop out only in scarce and mostly ephemeral exposures. These deposits are probably part of one or more Pliocene deltaic systems (Basilici, 1996, p. 46), hence the frequent occurrence of terrestrial plant remains in such shallow-marine sediments. Pavia & Ferrero (1996) summarized the information which is available for the marine deposits: these represent a regressive hemicycle with off-shore sandy muds at the bottom (Argille di Lugagnano Forma-

Peola, unpublished	Revised identification	Peola's pl./fig.	N° in text-fig. 1
<i>Smilax mauritanica</i> Desf.	<i>Smilax</i> sp.	13/1	1
<i>Carpinus grandis</i> Unger	<i>Ulmus affinis</i> Massalongo	13/9	2
<i>Bambusa lugdunensis</i> Saporta	<i>Bambusa lugdunensis</i> Saporta	10/9	3
<i>Bambusa astensis</i> Peola	<i>Bambusa lugdunensis</i> Saporta	10/8	4
<i>Phragmites oeningensis</i> (Al. Br.) Heer	Monocotyledones indet.	10/4	5
<i>Phragmites oeningensis</i> (Al. Br.) Heer	Monocotyledones indet.	10/5	6
<i>Carpinus grandis</i> Unger	<i>Ulmus</i> cf. <i>affinis</i> Massalongo	13/8	7
<i>Fagus ambigua</i> (Viviani) Massalongo	<i>Fagus pliocenica</i> Saporta	15/7	8
<i>Carpinus pyramidalis</i> Heer	<i>Ulmus affinis</i> Massalongo	13/11	9
<i>Corylus insignis</i> Heer	cf. <i>Rubus</i> vel <i>Alnus cecropiaefolia</i>	14/6	10
<i>Rhamnus deletus</i> Heer	<i>Alnus gaudinii</i> (Heer) Knobloch & Kvaček	53/6	11
<i>Quercus roburoides</i> Gaudin	<i>Quercus</i> cf. <i>pseudocastanea</i> Goepfert	24/14	12
<i>Arundo goeppertii</i> Heer	Monocotyledones indet.	9/11	13
<i>Juglans pedemontana</i> Peola	Dicotyledones indet.	27/8	14
<i>Fagus ambigua</i> (Viviani) Massalongo	<i>Fagus pliocenica</i> Saporta	15/8	15
<i>Pterocarya denticulata</i> (O. Web.) Heer	<i>Pterocarya paradisiaca</i> (Unger) Il'inskaja	29/1	16
<i>Pterocarya massalongi</i> Gaudin	<i>Pterocarya paradisiaca</i> (Unger) Il'inskaja	29/4	17
<i>Corylus heeri</i> Sismonda	<i>Alnus cecropiaefolia</i> (Ettingshausen) Knobloch	14/3	18
<i>Planera ungeri</i> (Kovats) Ettingshausen	<i>Zelkova zelkovaefolia</i> (Unger) Bůžek & Kotlaba	35/2	19
<i>Castanea forlivii</i> Massalongo	<i>Quercus kubinyi</i> (Kovats) Czezzott	17/8	20
<i>Fagus ambigua</i> (Viviani) Massalongo	<i>Fagus pliocenica</i> Saporta	15/10	21
<i>Quercus scillanum</i> Gaudin	<i>Quercus</i> cf. <i>pseudocastanea</i> Goepfert	25/6	22
<i>Betula brongniartii</i> Ettingshausen	cf. Rosaceae	30/14	23
<i>Diospyros brachysepalis</i> Al. Braun	Dicotyledones indet.	63/5	24
<i>Ulmus quercifolia</i> Unger	<i>Fagus pliocenica</i> Saporta	35/9	25
<i>Laurus canariensis pliocenica</i> Saporta & Marion	? <i>Laurophyllum</i> sp.	37/5	26
<i>Quercus serraefolia</i> Goepfert	Dicotyledones indet.	25/7	27
<i>Celastrus bruckmannii</i> Al. Braun	cf. <i>Alnus ducalis</i> (Gaudin) Knobloch	51/5	28
<i>Alnus cuneata</i> Peola	" <i>Parrotia</i> " <i>pristina</i> (Ettingshausen) Stur	31/4	29
<i>Leucothoe vacciniifolia</i> Unger	indeterminable	62/11	30
<i>Salix integra</i> Goepfert	cf. <i>Salix integra</i> Goepfert	32/5	31
<i>Cinnamomum lanceolatum</i> (Unger) Heer	<i>Daphnogene polymorpha</i> (Al. Braun) Ettingshausen vel <i>Ocotea heeri</i> (Gaudin) Mai	42/7	32
<i>Sterculia maiolana</i> Massalongo	cf. <i>Dombeyopsis lobata</i> Unger	46/1	33
<i>Ulmus braunii</i> Heer	cf. <i>Carpinus betulus</i> Linné	35/4	34
<i>Cinnamomum spectabile</i> Heer	<i>Daphnogene polymorpha</i> (Al. Braun) Ettingshausen	43/3	35

Tab. 1 - List of taxa from Castello d'Annone, after Peola (unpubl.). Even if the original specimens are lost, a revised identification of Peola's drawings (Text-fig. 2) is proposed in the central column on the basis of present knowledge on the composition of Pliocene leaf assemblages in the Asti area. In the right column the original numbers of plate/figure are reported. Three species were not figured by Peola (unpubl.): *Berchemia multinervis* Heer, *Cornus rhamnifolia* O. Weber and *Oreodaphne heeri* Gaudin.

tion) and shoreface yellow sands at the top (Sabbie di Asti Formation). The sandy muds yielded foraminiferal assemblages indicative of late Zanclean age (latest Early Pliocene). The shallow-marine sands, usually bearing mollusc shell concentrations, had been indicated by De Rouville as the type of the "Astian Stage" (Ferrero, 1971). The definition of Astian as a stage was abandoned in the second half of the 20th century, but the concept of "Astian facies" persists in the literature.

Foramifer and mollusc assemblages (Sampò *et al.*, 1968; Colalongo *et al.*, 1972; Pavia & Ferrero, 1996) permit to frame the Sabbie di Asti Formation of the type-area in the time span between latest Early Pliocene and early Middle Pliocene (ca 3.8-3.1 Ma). The marginal-marine facies of the Sabbie di Asti, named the "Ferrere unit" (Boano & Forno, 1996, p. 38), most probably falls within the same chronologic range.

Most layers of the Sabbie di Asti Formation contain abundant reddish impressions of wood fragments and, less commonly, also leaf fragments. Whole leaves are restricted to a few fine-grained layers or lenses (fine sands or very fine silty sands), and they lay either flat on the bedding planes (e. g. Arboschior-L1, Baldichieri-Fornace, Cerro Tanaro) or chaotically dispersed and contorted in massive sediments (Asti-Cascina Riso, Baldichieri-Nord, Castagnole Monferrato, Valmanera). The poorest assemblages are mostly made up by fragmentary or badly preserved impressions, which, at first glance, may seem impossible to determine; however, the richest ones, such as those of Arboschior-L1 and Valmanera, provide both better preserved material and a wide overview of the leaf palaeoflora, so that many problematic specimens have been identified by comparison with them.

The location of the sites where fossil leaves have been sampled is shown in Text-fig. 1, and few data concerning each outcrop and sedimentary succession are reported below:

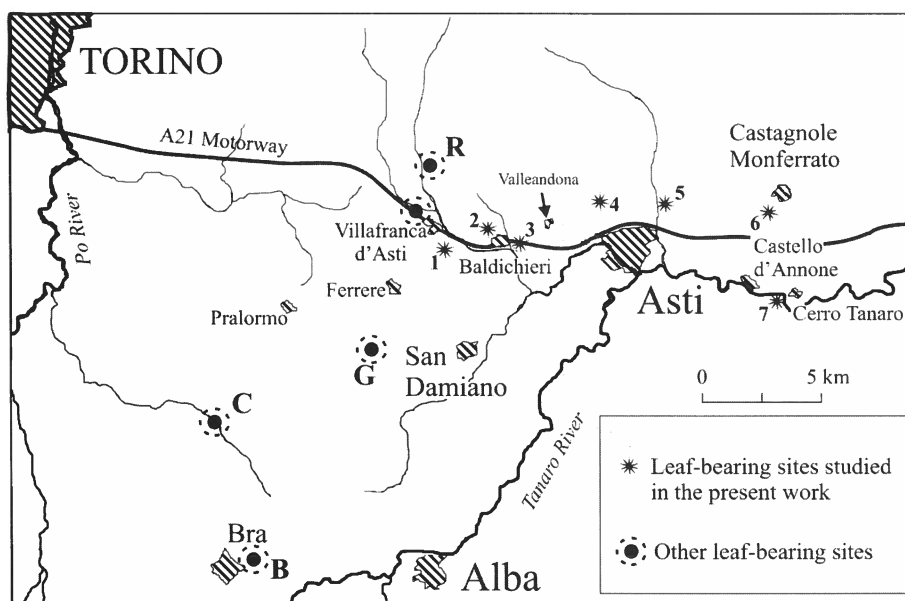
ASTI-CASCINA RISSO

A leaf-bearing layer of very fine silty sands has been discovered in February 2002 in a little natural outcrop towards the top of the steep eastern slope of the Versa stream valley, 4 km NNE of the centre of Asti. This bed is massive and the leaves are scarce, contorted and rather fragmentary. They are preserved as impressions accompanied by reddish Fe-oxides. A few complete and determinable specimens permitted to compile the list reported in Tab. 3. A succession of coarse, mainly cross-bedded, sands with a few marine pelecypods (*Aequipecten*, *Glycymeris*) is well-exposed below the leaf-bearing bed for a thickness of ca 20 meters.

ARBOSCHIO

In the late 1960s four quarries (1-4) located in the vicinity of the hamlet of Arboschior provided excellent exposures of a shallow-marine to continental Pliocene succession, which was described in detail by Pavia (1970). This author divided the 36-m-thick succession into seven lithozones and sampled rich and well-preserved leaf impressions from lithozones 1 and 4. The samples from lithozone 1 were invariably collected in quarry 1 and one of them is a large block with a bedding plane completely covered by leaf impressions (Pavia, 1970, pl. 1), whose taxonomic list is reported in Tab. 3.

In 1992-94 the outcrop, despite its bad state of exposure, was newly studied by several authors for the



Text-fig. 1 - Location of the Pliocene plant-bearing sites cited in the text. 1, Arboschior; 2, Baldichieri-North; 3, Baldichieri-Fornace; 4, Valmanera; 5, Asti-Cascina Riso; 6, Castagnole Monferrato; 7, Cerro Tanaro. B, site of the Bra flora described by Peola (1895); C, Ceresole d'Alba; G, Gherba; R, Roatto.

monographic work on the revision of the Villafranchian in the Villafranca d'Asti type-area, edited by Carraro (1996). A 44-m-thick sedimentary succession was described by Basilici (1996). Lithozone 1 (*sensu* Pavia, 1970), always rich in shells of marine molluscs, was exposed in a new quarry (closed in 1999) located 300 NW of quarry 1. New samples of fossil leaves were collected from two thin fine-grained layers (A1 and A2), located at about 10 m from the base of the section (Basilici, 1996, p. 42, fig. 19), and from mud-pebbles embedded in the overlaying coarse sands (A3). The fluvial-alluvial (and lacustrine?) sediments of lithozones 2 to 6 were poorly exposed in the 1990s, thus only a few new leaf specimens have been sampled there. On the other hand, lithozone 7 was still partly exposed in the former quarry 4, so that several impressions of leaves, fruits and seeds have been collected.

A list of the distribution and frequency of taxa, also based on field observations, was reported by Martinetto & Mai (1996, p. 73, tab. 3). Unfortunately, such a list was biased by too many typographic mistakes: the occurrences of *Acer tricuspidatum* and "*Bambusa cf. astensis*" (= "*Bambusa lugdunensis*") were referred to layer A1 instead of A2, while the occurrences of *Alnus gaudinii*, "*Betula* sp." (= *Carpinus betulus*), "*Celtis* sp." (= *C. trachytica*) and "*Pterocarya* sp." (= *P. paradisiaca*) were referred to layer A2 instead of A3. A more accurate and updated floral list for layers A1-A3, exclusively based on material which has been stored at the Museo di Geologia e Paleontologia of the Turin University, is reported in Tab. 3.

In this work the palaeoflora of lithozone 1 has been thoroughly revised, while the rich assemblages from lithozones 4 and 7 need further studies, and only the species which also occur in lithozone 1 have been examined. From now on the occurrence of fossil leaves in lithozone 1 is reported as "Arboschio-L1", while "Arboschio-L4" is referred to lithozone 4.

BALDICHIERI-NORTH

In the period 1994-2002, a sandy succession was exposed for a thickness of 14 meters in a little quarry located 1 km NW of the village of Baldichieri, 30 m to the East of the road leading to Castellero. The base and the top of the succession were characterized by extensively bioturbated sediments rich in shells of marine molluscs (e. g. *Glycymeris*, *Spondylus*); additionally, moulds of infaunal echinoids have been observed in a layer towards the top of the section. The middle part of the succession shows well preserved sedimentary structures (e. g. symmetric ripples) with several bedding planes covered by reddish impressions of wood fragments. A 10 cm-thick layer of fine sands yielded several badly preserved leaf impressions. Field observations showed that this assemblage is dominated by *Fagus*, occurring with both leaves and cupules. The list of accompanying taxa, based on collected specimens, is reported in Tab. 3.

BALDICHIERI-FORNACE

This site has been named "Baldichieri (Fornace di) near Turin" by Gregor (1990). The outcrop was located 1100 m from the centre of Baldichieri, in a ESE direction, where a quarry has been active until the year 1990. The stratigraphic section has never been described in detail; it was roughly 10-m-thick and formed by "Astian" sands, with shell concentrations in the upper part. The bottom of the succession probably approached the base of the Sabbie di Asti Formation, since it was composed by blue-grey silty sands with mummified plant remains and small-sized molluscs (not yet studied in detail) indicative of shoreface-offshore transition (G. Pavia, pers. comm.). Fruits and seeds were sieved out of such sediments both by Dr. H.-J. Gregor and the present author (Martinetto, 1995, p. 68). Leaf impressions were sampled only in 1989 from a layer of fine sands in the middle part of the section, and the resulting collection (Tab. 3) just provides a very limited documentation of the palaeoflora.

CASTAGNOLE MONFERRATO

1.5 km to the SW of the centre of Castagnole Monferrato a huge quarry exploits the Pliocene sediments, which are exposed in a thickness of about 50 m. The whole section is marine, with mollusc assemblages indicating offshore bottoms in the lower part and shallower conditions at the top. In February 2000 a few leaf impressions have been collected in the uppermost layers, formed by rather homogeneous silty sand with poorly apparent bedding planes. All the specimens have been sampled in detached blocks, apart a *Fagus* leaf which has been found in the original layer, about 5 m from the top of the section. This is the most probable origin of all the leaf-bearing blocks, which were concentrated in a narrow area and, due to the topography of the quarry, cannot originate from layers located more than 10 m below the top. In the leaf-bearing sediments the internal casts of infaunal echinoids were not uncommon (*Schizaster*) and also some closed bivalve specimens of *Venus multilamella* (Lamarck) were observed (det. Piero Damarco). The leaves (mostly complete, rarely in fragments) were usually isolated within the sediment, but a single block often provided more than one specimen, thus suggesting a simultaneous pre-burial transport of several leaves. *Fagus pliocenica* was the dominant species; the rest of the leaf palaeoflora is listed in Tab. 3.

CERRO TANARO

A leaf-bearing bed of fine silty sandstone crops out in the bed of the Tanaro River, roughly 1300 m to the West of Cerro Tanaro. It is covered by mollusc-rich sands in the typical "Astian facies", and therefore

the whole section can be assigned to the Sabbie di Asti Formation. The features of this poor leaf assemblage have been reported above.

VALMANERA

In 1997 some leaf-bearing layers were discovered during the restoration of the residential building "Villa Paolina", now hosting the WWF centre for environmental education. Such building is indicated as Cascina Bussa in the topographic maps, and it is located within a small valley named Valmanera, 5 km North of the centre of Asti (Text-fig. 1). Luckily the works were followed by some young naturalists, who recovered nearly 200 fossil leaf samples. The leaves were preserved as reddish impressions within a few layers of very fine silty sand, enclosed in a succession of coarser shallow-marine sands (Sabbie di Asti Formation), as indicated by the occurrence of *Thalassinoides domichnia* and moulds of articulated valves of the pelecypod *Chamelea gallina* (Linné). Some of the leaf specimens were contorted within the massive sediment, others were preferentially concentrated in dense clusters on quasi-horizontal bedding planes. The degree of preservation of the margin and venation were variable in different specimens, but some of them showed the finest details.

CHRONOSTRATIGRAPHIC ORDER

A three-dimensional sequence-stratigraphic scheme of the Pliocene of Asti is not yet available, thus the relative chronostratigraphic order of the sections studied can be suggested only in restricted areas, on the basis of the lateral extrapolation of sub-horizontal bedding planes. Longer-range correlation is more hazardous and suggested in a purely tentative way. The most well-assessed situation is found in the Arboschio-Baldichieri W-E transect (4 km), where lithozone 1 of Arboschio (base at 165 m a. s. l.) must be younger than the leaf-bearing layer of Baldichieri-North (160 m a. s. l.), respectively younger than the Baldichieri-Fornace section (base of the Sabbie di Asti Formation). The nearby-laying sites of Valmanera and Asti-Cascina Risso are approximately in the same stratigraphic position (upper part of the Sabbie di Asti Formation), but there are no data which would allow a precise time-correlation to the Arboschio-Baldichieri area. Even more difficult is the correlation to the leaf-bearing layers of Cerro Tanaro, which are presumably more or less coeval to the flora of Castello d'Annone (Peola, 1896a).

CONCLUSIONS

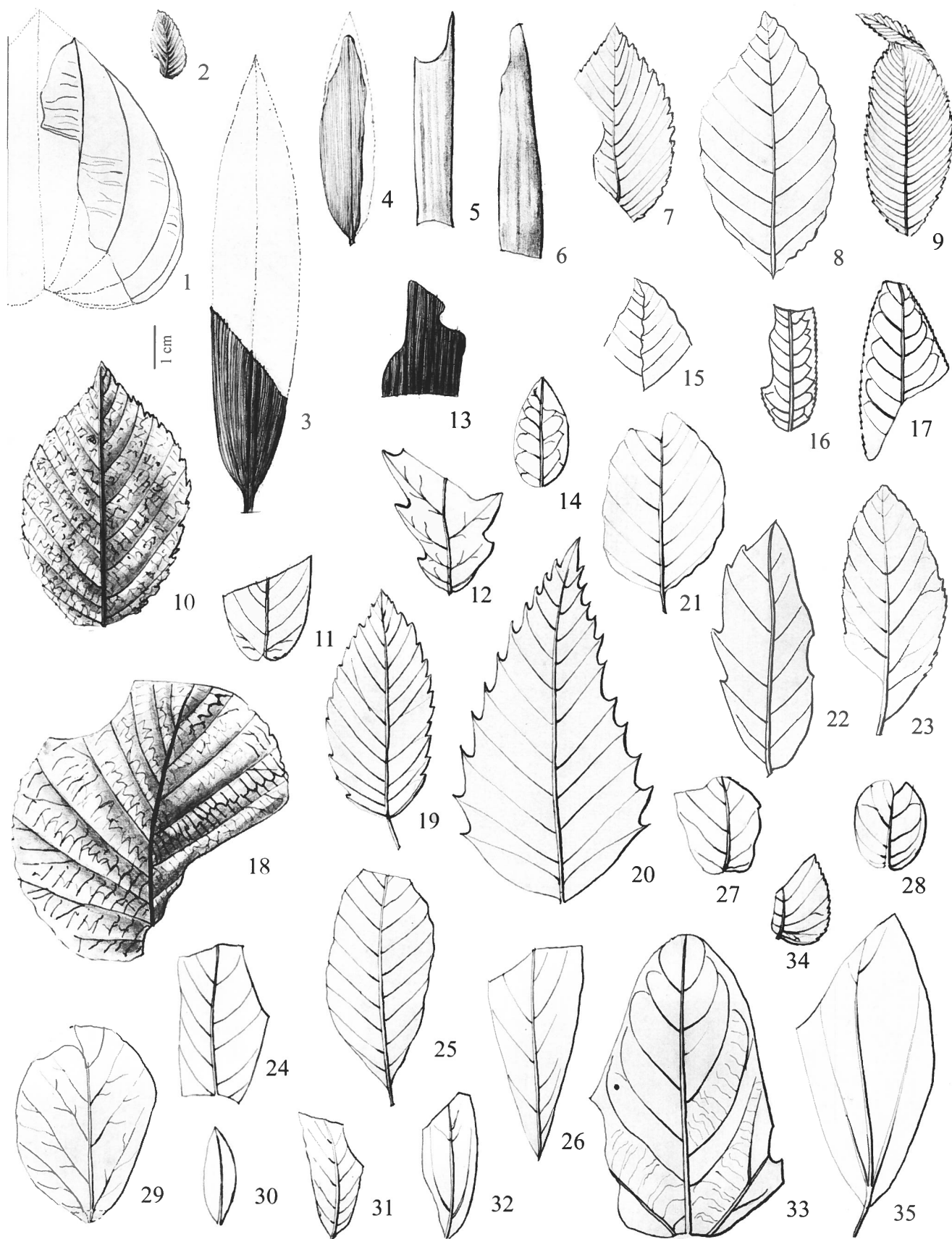
Terrestrial leaf assemblages in marine layers are useful in comparing environmental conditions on land and sea during the same time slice. The abundance of riparian elements, such as *Alnus*, *Platanus*, *Populus*, *Pterocarya* and *Salix*, in most assemblages (Cerro Tanaro and Baldichieri-Fornace excepted), testifies that the leaf remains were transported by rivers to the shallow-marine bottoms, probably in occasion of strong floods in the Villafranca d'Asti deltaic system (Basilici, 1996). The leaves of Asti-Cascina Risso, Baldichieri-North and Valmanera have been certainly embedded quickly in the terrigenous matrix, as testified by both the absence of lamination and the frequent occurrence of contorted chartaceous leaves. At Asti-Cascina Risso leaves might have been transported during a single event, while at Valmanera at least three events which produced fine-grained layers can be discerned; at the top of one of such layers a flat bedding surface covered by leaves and wood fragments occurred (not observed *in situ*). This last type of taphocoenosis is very common at Arboschio-L1 and Cerro Tanaro, but the leaves are not perfectly flat; rather, they are embedded in distinct 2 to 7 mm-thick, laminae of fine or very fine sands, which are intercalated with centimetric layers of coarse-middle sand. Therefore, also these assemblages are the result of sudden events which caused a simultaneous input of sediment and leaves on a bottom which underwent strong oscillations of the environmental energy.

The leaf assemblage of Baldichieri-Fornace had a totally different taphonomic history: some of the leaves (at least those of *Ocotea heerii*) could float freely in the marine water for several days, thus permitting the attachment and development of pseudoplanktic barnacles; afterwards, the leaves sunk down and were covered by sediments.

The next question is: how many palaeofloristic and vegetational settings are documented by the assemblages studied? Taphonomic bias and scarcity of material prevents any conclusion about Baldichieri-Fornace, Castagnole Monferrato and Cerro Tanaro. On the other hand, the Arboschio-L1 and L4, Asti-Cascina Risso, Baldichieri-North, Castello d'Annone and Valmanera assemblages are rich enough to suggest that the composition of the terrestrial vegetation might have been very similar at the time they were formed, so that the overall floristic, vegetational and environmental features can be summarized by reference to a collective "Asti" palaeoflora.

The "Asti" palaeoflora was dominated by deciduous trees which formed at least two types of plant

Text-fig. 2 - Composition of drawings from the unpublished monograph of Paolo Peola (1869-1947) showing the Pliocene leaf assemblage of Castello d'Annone. This material was stored at the Regio Museo di Geologia di Torino and has been destroyed by bombing during World War II. The original identifications by Peola and the revised ones are reported in Tab. 1.



Peola, unpublished	Revised identification	Locality	Peola's pl./fig.	N° in text-fig. 3
<i>Fagus ambigua</i> (Viviani) Massalongo	<i>Fagus pliocenica</i> Saporta	San Damiano	15/4	1
<i>Fagus gaudinii</i> Ristori	<i>Fagus pliocenica</i> Saporta	San Damiano	15/11	2
<i>Juglans acuminata</i> Al. Braun	Dicoryledones indet.	Pralormo	27/2	3
<i>Alnus nostranum</i> Unger	cf. <i>Alnus gaudinii</i> (Heer) Knobloch & Z. Kvaček	Ferrere	31/14	4
<i>Laurus princeps</i> Heer	? <i>Laurophyllum</i> sp.	San Damiano	38/6	5
<i>Ulmus</i> sp.	cf. <i>Alnus gaudinii</i> (Heer) Knobloch & Z. Kvaček	San Damiano	35/12	6
<i>Populus balsamoides</i> Goeppert	cf. <i>Populus</i>	Pralormo	33/3	7
<i>Prunus maxima</i> Peola	cf. Juglandaceae	San Damiano	40/8	8
<i>Oreodaphne heeri</i> Gaudin	<i>Ocotea heeri</i> (Gaudin) Mai	San Damiano	44/5	9

Tab. 2 - List of taxa from Ferrere, Pralormo and San Damiano as reported by Peola (unpubl.). The original drawings are shown in Text-fig. 3; see Tab. 1 for additional information.

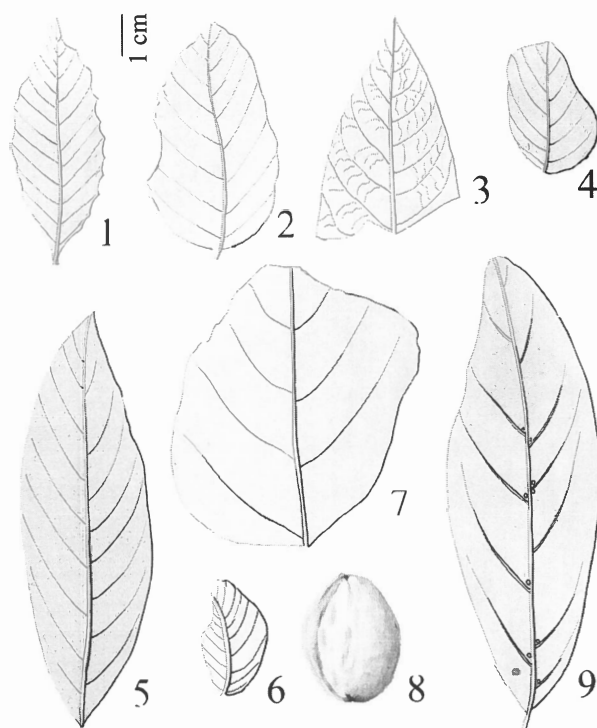
communities: azonal riparian forests (*Alnus*, *Platanus*, *Populus*, *Pterocarya*, *Salix*) and zonal mesophytic forests (*Acer campestre*, *Carpinus*, *Castanea*, *Fagus*, *Quercus*). The Ulmaceae *Celtis*, *Ulmus* and *Zelkova* could find their ecological space in both communities. In addition, evergreen elements also occur: *Daphnogene*, *Ilex*, ?*Laurophyllum*, *Ocotea*, *Pyracantha* and cf. *Quercus ilex*. They probably grew in the mesophytic forest, where *Ilex*, *Ocotea* and *Pyracantha* could contribute to the shrub layer.

The relations of the "Asti" palaeoflora with other palaeofloras of Piedmont are not easy to assess because most of them have been reconstructed on the basis of fruit and seed assemblages (Martinetto, 1995 and 1999). Palaeofloral lists based on leaves differ from those based on fruits and seeds due to taphonomic factors and to problems in taxonomy and nomenclature:

- i) Seed assemblages include both woody and herbaceous plants, while the leaf record of terrestrial herbs is almost not-existent.
- ii) The leaves of many taxa, well-documented by seeds in the Pliocene (e.g. *Actinidia*, *Styrax*, *Stewartia*, *Meliosma*, *Sabia*), are difficult to identify.
- iii) Fruits and seeds of arboreal species with characteristic leaves (*Alnus*, *Populus*, *Quercus*, *Salix*) can hardly be identified to the species level.
- iv) Fossil species based on leaves and related fruits and seeds must be designated by a different epithets (e.g. *Trigonobalanopsis rhamnoides*-*T. exacantha*), unless connection is demonstrated.

Fruit and seed floras allowed to detect only two Floristic Complexes in the Early-Middle Pliocene of Piedmont (Martinetto, 1995 and 1999): The Ca' Viettone F. C. groups 13 palaeofloras, and four of them originate from marine successions independently dated to the Early Pliocene (Breolungi, Crava di Morozzo, Pocapaglia, Sento I); the Stura F. C. groups 6 palaeofloras, including the one of Villafranca-RDB Quarry, which is independently dated to the Middle Pliocene. The definition of a characteristic leaf-association for each Floristic Complex is one of the aims of fossil leaf studies in Piedmont.

Rich leaf assemblages linked to the older "Ca' Viettone Floristic Complex" are known from Cossato (Cervo River section: Martinetto, 2001a) and from Fossano. Even if both assemblages have been just preliminarily studied, they seem to be consistently different from the "Asti" palaeoflora, first of all for the abundance of evergreen elements, in agreement with the indications of the associated carpo-



Text-fig. 3 - Composition of drawings from the unpublished monograph of P. Peola showing the Pliocene plant remains from Ferrere, Pralormo and San Damiano. Also this material was stored at the Regio Museo di Geologia di Torino and has been destroyed by bombing during World War II. The original identifications by Peola and the revised ones are reported in Tab. 2.

Arboschio-L1, layer A1		other taxa in Arboschio-L1 (lg. Pavia and Ferrero, 1968-69)		Castagnole Monferrato	
<i>Pterocarya paradisiaca</i>	2				
<i>Alnus cecropiaefolia</i>	1	<i>Liquidambar europaea</i>	3	<i>Fagus pliocenica</i>	6
<i>Alnus ducalis</i>	1	<i>Quercus? kubinyii</i>	2	<i>Alnus cecropiaefolia</i>	3
<i>Alnus gaudinii</i>	1	<i>Dombeyopsis lobata</i>	1	<i>Alnus ducalis</i>	3
<i>Fagus pliocenica</i>	1			<i>Ocotea heerii</i>	3
<i>Ocotea heeri</i>	1	Asti-Cascina Risso		<i>Populus populina</i>	2
		<i>Fagus pliocenica</i>	2	<i>Thuja saviana</i>	1
Arboschio-L1, layer A2		<i>Alnus ducalis</i>	2	<i>Carpinus cf. betulus</i>	1
<i>Fagus pliocenica</i>	8	<i>Ulmus affinis</i>	1	cf. <i>Trigonobalanopsis rhamnoides</i>	1
<i>Populus populina</i>	8	<i>Alnus gaudinii</i>	1	<i>Platanus leucophylla</i>	1
<i>Ulmus affinis</i>	8	<i>Thuja saviana</i>	1		
<i>Ocotea heeri</i>	3	<i>Zelkova zelkovaefolia</i>	1		
<i>Alnus ducalis</i>	2			San Damiano (Peola, 1896a, revised)	
" <i>Bambusa</i> " <i>lugdunensis</i>	2	Baldichieri-Fornace		<i>Fagus pliocenica</i>	2
<i>Salix varians</i>	2	<i>Ocotea heeri</i>	5	? <i>Laurophyllum</i> sp.	1
<i>Acer tricuspidatum</i> ssp. <i>lusaticum</i>	1	? <i>Laurophyllum</i> sp.	2	<i>Ocotea heeri</i>	1
<i>Alnus cecropiaefolia</i>	1	cf. <i>Trigonobalanopsis rhamnoides</i>	1	cf. <i>Alnus gaudinii</i>	1
<i>Alnus gaudinii</i>	1	<i>Fagus pliocenica</i>	1		
<i>Hedera</i> cf. <i>helix</i>	1			Valmanera	
<i>Platanus leucophylla</i>	1	Baldichieri-North			
cf. <i>Ziziphus</i>	1	<i>Ocotea heeri</i>	5	<i>Fagus pliocenica</i>	27
? <i>Laurophyllum</i> sp.	1	<i>Ulmus affinis</i>	4	<i>Alnus cecropiaefolia</i>	13
		<i>Populus populina</i>	3	<i>Alnus ducalis</i>	8
Arboschio-L1, layer A3		<i>Fagus pliocenica</i>	2	<i>Ocotea heeri</i>	8
<i>Fagus pliocenica</i>	8	<i>Fagus</i> sp. (cupules)	2	" <i>Bambusa</i> " <i>lugdunensis</i>	5
<i>Ulmus affinis</i>	7	<i>Laurophyllum?</i> sp.	2	<i>Pterocarya paradisiaca</i>	4
<i>Populus populina</i>	4	<i>Carpinus betulus</i>	1	<i>Ulmus affinis</i>	4
<i>Ocotea heeri</i>	4	<i>Platanus leucophylla</i>	1	<i>Zelkova zelkovaefolia</i>	4
<i>Zelkova zelkovaefolia</i>	3	<i>Pterocarya paradisiaca</i>	1	<i>Carpinus betulus</i>	3
<i>Carpinus betulus</i>	2	<i>Salix varians</i>	1	<i>Alnus gaudinii</i>	2
<i>Alnus gaudinii</i>	1	<i>Taiwania paracryptomerioides</i>	1	Dicotyledones indet.	2
<i>Celtis trachytica</i>	1			<i>Hedera</i> cf. <i>helix</i>	2
<i>Pterocarya paradisiaca</i>	1	Castello d'Annone (Peola, 1896a, revised)		<i>Platanus leucophylla</i>	2
<i>Quercus</i> cf. <i>pseudocastanea</i>	1	<i>Alnus cecropiaefolia</i>	10	<i>Pyracantha</i> sp.	2
<i>Salix varians</i>	1	<i>Fagus pliocenica</i>	4	<i>Acer campestre</i>	1
		<i>Ulmus affinis</i>	4	<i>Acer</i> cf. <i>integerrimum</i>	1
Arboschio-L1 (large block,		<i>Ocotea heeri</i>	3	<i>Celtis trachytica</i>	1
Pavia, 1970, pl. 1)		" <i>Bambusa</i> " <i>lugdunensis</i>	2	<i>Cornus</i> cf. <i>graeffii</i>	1
<i>Carpinus betulus</i> (leaves)	16	<i>Alnus gaudinii</i>	2	<i>Ilex</i> aff. <i>cornuta</i>	1
<i>Populus populina</i>	10	Monocotyledones indet.	2	? <i>Laurophyllum</i> sp.	1
<i>Ocotea heeri</i>	6	<i>Pterocarya paradisiaca</i>	2	<i>Populus populina</i>	1
<i>Ulmus affinis</i>	6	<i>Quercus</i> cf. <i>pseudocastanea</i>	2	<i>Quercus pseudocastanea</i>	1
<i>Pterocarya paradisiaca</i>	5	<i>Zelkova zelkovaefolia</i>	2	<i>Salix varians</i>	1
<i>Alnus cecropiaefolia</i>	4	cf. <i>Alnus ducalis</i>	1	cf. <i>Liquidambar europaea</i>	1
<i>Quercus pseudocastanea</i>	3	cf. <i>Carpinus betulus</i>	1	cf. <i>Marchantia</i>	1
<i>Acer integerrimum</i>	2	cf. <i>Dombeyopsis lobata</i>	1	cf. <i>Pteridium oeningense</i>	1
<i>Alnus ducalis</i>	2	cf. <i>Rosaceae</i>	1	cf. <i>Quercus ilex</i>	1
<i>Carpinus betulus</i> (bracts)	2	cf. <i>Rubus</i>	1		
<i>Fagus pliocenica</i>	2	cf. <i>Salix integra</i>	1		
<i>Platanus leucophylla</i>	2	cf. <i>Smilax weberi</i>	1		
<i>Salix varians</i>	2	<i>Daphnogene polymorpha</i>	1		
<i>Acer tricuspidatum</i> ssp. <i>lusaticum</i>	1	? <i>Laurophyllum</i> sp. vel <i>Trigonobalanopsis</i>	1		
<i>Daphnogene polymorpha</i>	1	<i>Parrotia pristina</i>	1		
cf. <i>Magnolia</i>	1	<i>Quercus kubinyii</i>	1		

Tab. 3 - Taxonomic list of the "Asti" leaf assemblages; the numbers indicate the abundance of each species. The lists from layers A1-A3 of Arboschio are based on material collected in 1994 and stored at the Museo di Geologia e Paleontologia of the Turin University.

logical assemblages. Another very rich leaf assemblage, which can tentatively be assigned to the Ca' Viettone Floristic Complex, is the one of Bra (Text-fig. 1), with nearly 500 specimens. Peola (1895) described this rich palaeoflora, but most of his iden-

tifications are questionable or need revision. The original material is, luckily, still conserved at the Museo Civico Craveri of Bra, and a few specimens are housed in the Museo di Geologia e Paleontologia of the Florence University.

The carpo-floras of the Stura F. C. originate from sections which also yielded leaf remains, but the diversity of such assemblages is always very low and not useful for a sound comparison with the "Asti" palaeoflora. However, the carpo-flora-bearing lower part of the Villafranca-RDB Quarry section can be correlated on a lithostratigraphic basis to the lithozone 4 of the Arboschio one (the distance is just 2 km), and therefore the Villafranca-RDB Quarry carpo-flora (assigned to the Stura F. C.) and the Arboschio-L4 leaf floras (part of the "Asti" palaeoflora) can be regarded as different signals of the same palaeoflora. In conclusion, I would suggest that the "Asti" palaeoflora provides a good leaf signature for the "Stura Floristic Complex".

The assemblages of the "Stura Floristic Complex" are interpreted as the product of high-diversity mesophytic forest of East Asian affinity, with dominant summergreen trees (Martinetto, 1996). From the climatic point of view, this ancient vegetation indicates warm-temperate and humid conditions, similar to the ones of the preceding "Ca' Viettone Floristic Complex", but with slightly lower annual temperatures, which have been estimated around 13-14 °C on the basis of modern distribution of East Asian vegetation (Wang, 1961; Wolfe, 1971; Numata, 1974).

The "Stura Floristic Complex" can be considered the macrofloral expression of the "pre-Tiberian" palynological phase of Bertoldi (1990), as confirmed by the associated pollen and fruit/seed floras in the same layers of the Stura (Bertoldi & Martinetto, 2001) and Villafranca d'Asti-RDB successions (Bertoldi, 1996; Martinetto & Mai, 1996).

SYSTEMATIC PART

Descriptions of well-known taxa have been avoided or limited to a few significant characters; the dimensions can be retrieved from the plates and, in a few cases, are reported in the text. Specific epithets have been selected by reference to the available literature on Neogene floras of Europe, in accordance to the rules of priority indicated by the ICBN (Greuter, 1994). Examination of type material in the collections has not been possible (with a few exceptions). The synonymic list includes citation of the source of the basionym and of the accepted generic combination; a few well-assessed synonyms, commonly used in the Italian Neogene, are listed separately.

Notes or abbreviations – Arboschio-L1 and Arboschio-L4 = Arboschio lithozone 1 and lithozone 4, respectively. "Asti" = surroundings of Asti; "Alba" = surroundings of Alba. lg. = *legit*; MRSNT = Museo Regionale di Scienze Naturali di Torino. PU105000-105075 = repository numbers, Museo di Geologia e Paleontologia of the Turin University.

BRYOPHYTA

Family cf. MARCHANTHIACEAE
Genus cf. MARCHANTIA Linné, 1753

cf. MARCHANTIA sp.
Pl. 1, fig. 1

A plant remain from Valmanera, preserved as an impression accompanied by some tissues replaced by Fe-oxides, has a morphology which recalls the thallus of some Hepaticae or the fern *Lygodium*, well-known as a fossil in Europe since Heer (1855). The lack of secondaries does not seem to be due to the process of preservation; rather, it is considered as a significant character to assign this specimen to the Hepaticae, and tentatively to the genus *Marchantia*. The thallus has an apparent midrib which is twice dichotomously branched, the first time in correspondence of the separation of the two visible lobes of the thallus, and the second time in a more distant position, where another separation of lobes would be originally present.

PTERIDOPHYTA

Family cf. DENNSTAEDTIACEAE Pichi Sermolli, 1970
Genus cf. PTERIDIUM Scopoli, 1760

cf. PTERIDIUM OENINGENSE (Unger, 1847) Hantke,
1954
Pl. 1, fig. 2

?1847 *Pteris oeningensis* UNGER, p. 124, pl. 37, figs 6-7.

?1954 *Pteridium oeningense* (Unger) HANTKE, pp. 40-41, pl. 1, figs 6-7.

?1970 *Pteris ruppensis* Heer - PAVIA, pl. 2, fig. 1.

An impression of a 3 cm long pinna or pinnula from Valmanera represents the single record of ferns in the marine-transitional Pliocene of the Asti area. This scarcity is indeed the result of taphonomical factors (ferns usually do not shed their foliage). In fact fern remains are more abundant in Pliocene freshwater deposits, which were formed closer to their growing stands: *Osmunda* foliage is more or less frequent in some localities of northern Piedmont (Barbania, Ca' Viettone, La Cassa and Stura di Lanzo: Martinetto, 1995) and another species occurs in the Pliocene continental deposits of the San Martino unit at Arboschio-L4 (Pavia, 1970: *Pteris ruppensis* Heer) and Villafranca d'Asti (Martinetto & Mai, 1996: "*Pteris*" sp.).

The Valmanera specimen cannot belong to *Osmunda* because its base is abruptly cut along a straight line, thus suggesting it was attached to a rachis and decurrent, instead of being petiolate as in *Osmunda*. The venation, well preserved in the apical part, shows secondaries which branch two or three times and finally reach the margin, as observed on

pinnulae of "*Pteris ruppensis* Heer" from Arboschio-L4 (Pavia, 1970); therefore the Valmanera specimen may belong to the same species.

As far as I know the validity of the name *Pteris ruppensis* Heer, 1855 has not been confirmed by recent literature. Heer (1855) himself stated that *P. ruppensis* is closely related to *Pteris oeningensis* Unger, 1847, which would have priority in the case that both epithets represent a single species. Kovar-Eder & Krainer (1990) assigned to *Pteris oeningensis* Unger some Pannonian fern specimens from Styrian Basin (Austria), which match very well the Arboschio-L4 and Villafranca specimens. These authors do not discuss the new combination *Pteridium oeningense* (Unger, 1847) Hantke, 1954, which I accept in this paper. Therefore, the *Pteridium*-like fern foliage from the San Martino Unit of the Asti Basin would be better named *Pteridium oeningense*, while the fragmentary specimen from the marine deposit of Valmanera is cautiously indicated as cf. *Pteridium oeningense*: it may indeed be assigned to many recent fern genera (e. g. *Polypodium*) on the basis of the few observable characters.

GYMNOSPERMAE

Family CUPRESSACEAE Rich. ex Bartl., 1830
Genus THUJA Linné, 1777

THUJA SAVIANA Gaudin, 1859b
Pl. 1, fig. 4

1859b *Thuja saviana* Gaudin - GAUDIN & STROZZI, pp. 12-14, pl. 1, figs 4-20; pl. 2, figs 6-7.

Occurrence – Very short sprays have been collected at Asti-Cascina Risso, Castagnole Monferrato and Baldichieri-Fornace. The specimens of the first two sites are preserved as impressions, while the third site provided coalified plant remains (compressions).

Remarks – The scaly leaves are organised in decussate pairs on flattened sprays. The opposite leaves of the lateral pairs came into contact only at the base, as typical for *Thuja saviana*, a fossil species first described on the basis of abundant foliage and ovulate cone impressions in the (?Pliocene) travertines of Massa Marittima in Tuscany (Gaudin & Strozzi, 1859b).

Brambilla (1992) reported *T. saviana* from the Pliocene of Canton Ticino (Switzerland). Similar fossils have been described as *Thuja occidentalis* Linné (modern species) from the Messinian of Carbonara Scrivia (Brambilla *et al.*, 1982) and as *Thuja* sp. from the Messinian of "Alba" (Guglielmetto & Iguera, 1994).

The terminal sprays of *T. saviana* are very similar to those of *Calocedrus suleticensis* (Brabenec) Z. Kvaček, but the first species has alternately branched sprays (Gaudin & Strozzi, 1859b), while the second shows opposite branching (Kvaček, 1999). The branching

pattern is not detectable in the "Asti" material; however, a few specimens from the "Alba" Messinian, which I would assign to the same species, show alternate branching (Guglielmetto & Iguera, 1994).

Family TAXODIACEAE Rich. ex Bartl., 1830
Genus TAIWANIA Hayata, 1906

TAIWANIA PARACRYPTOMERIOIDES Kilpper, 1968
Pl. 1, fig. 3

1968 *Taiwania paracryptomerioides* KILPPER, pp. 106-107, pl. 34, figs 18-22; pl. 36, figs 6-7; pl. 37, fig. 1.

1968 cf. *Taiwania paracryptomerioides* KILPPER, p. 107, pl. 35, figs 14, 15; pl. 37, figs 2-4.

2000 *Taiwania schaeferi* Schloemer-Jaeger - FISHER & BUTZMANN, p. 22-24, pl. 6, figs. 1-6; text-figs 16, 23.

Occurrence – A short fragment of "cryptomerioid" shoot with very thick leaves, characteristic of *Taiwania*, was recovered at Baldichieri-North in the year 2002.

Remarks – Cones of *Taiwania* had previously been found in a bed containing also detached foliage, possibly belonging to the same species, at Momello-Lanzo in NW Piedmont (Martinetto, 1995 and 1998). Fisher & Butzmann (2000) described as *Taiwania schaeferi* Schloemer-Jaeger foliage and cones of the same type, in direct connection, from the Pliocene site of Meleto in Tuscany. The use of the name *Taiwania schaeferi* for the Pliocene material of Italy seems to be hazardous because the type material of this species comes from the Paleogene of Spitzbergen. As the Italian material is very similar to the Miocene type-material of *Taiwania paracryptomerioides* from the Lower Rhine Embayment (Kilpper, 1968), it seems preferable to employ this name. The cone-bearing shoot described by Fisher & Butzmann (2000) allows to confirm the identification of sterile shoots from the Lower Rhine Embayment, assigned with doubt ("cf.") to *Taiwania paracryptomerioides* by Kilpper (1968, pl. 35, figs 14-15).

DICOTYLEDONES

Family ACERACEAE Jussieu, 1789
Genus ACER Linné, 1753

ACER CAMPESTRE Linné, 1753
Pl. 1, fig. 7

An almost complete leaf impression from Valmanera, abundantly encrusted by Fe-oxides, shows the same shape and venation pattern as modern leaves of *A. campestre*. Fossil leaves assigned to this species have been reported by Roiron (1991) from the Upper Miocene of Murat (France). Other Neogene specimens with similar characters have been assigned to

the fossil species *A. pseudocampestre* Unger and *A. subcampestre* Unger.

In Italy leaves of *A. campestre* are more common in the Pleistocene, e. g. in the earliest Middle Pleistocene of Oriolo (Martinetto & Sami, 2001) and in the "Riss-Wurm" interglacial of Re in Val Vigizzo (Benassi, 1896).

ACER INTEGERRIMUM (Viviani, 1833) Massalongo,
1858
Pl. 1, figs 10-12

- 1833 *Acerites integerrima* VIVIANI, pl. 11, fig. 6.
1858 *Acer integerrimum* (Viviani) MASSALONGO, p. 94.

1854 *Liquidambar scarabellianum* MASSALONGO, p. 21, pl. 2, fig. 1.
? 1859 *Acer sphendaminum* Massalongo - MASSALONGO & SCARABELLI, p. 343, pl. 19, figs 5, 7-8.
? 1859 *Acer sterculiacefolium* Massalongo - MASSALONGO & SCARABELLI, p. 344, pls 15-16, fig. 5; pl. 41, fig. 8.
1896 *Acer laetum* C. A. Mey - SORDELLI, p. 223, pl. 41, fig. 10.
1970 *Acer decipiens* A. Braun - PAVIA, pl. 4, fig. 2.

Occurrence – This species is represented by four specimens from Arboschio-L1 and, most probably, by a badly preserved trilobate leaf impression from Valmanera (margin not well-preserved: *Acer* cf. *integerrimum*).

Remarks – *Acer integerrimum* is rather common in the Miocene and Pliocene of several parts of Europe (Givulescu, 1979; Mai & Walther, 1988; Roiron, 1991), and it is reported until the Middle Pleistocene in Italy (Follieri, 1958). The wealth of specimens in some Late Miocene and Pliocene sites of northern and central Italy (Massalongo & Scarabelli, 1859; Gaudin & Strozzi, 1862; Fischer & Butzmann, 2000; Martinetto *et al.*, 2000) permits to state that the variation of leaf shape is rather wide. The lobes may be three to five (Pl. 1, figs 10-12), broad or narrow, with an obtuse, acute or attenuate apex. The sinuses between adjacent lobes may be acute to obtuse, angular to rounded.

In Piedmont it has been reported from the Messinian of the surroundings of Alba (Martinetto *et*

al., 2000). Other specimens referable to this species had been described by Pavia (1970) from Arboschio-L4 (sub *Acer decipiens* A. Braun) and by Peola (1895 & unpubl.) from the Pliocene of Bra (sub *Acer integrilobum* Web., *Acer santagatae* Massalongo and *Liquidambar europaeum* A. Braun var. *geoppertii*).

ACER TRICUSPIDATUM Bronn, 1838
subsp. LUSATICUM Walther, 1988
Pl. 1, figs 8-9

- 1838 *Acer tricuspidatum* BRONN, pl. 35, fig. 10a, b.
1988 *Acer tricuspidatum* Bronn subsp. *lusaticum* Walther - MAI & WALTHER, pp. 173-174, pl. 34, figs 1-4; text-figs 76-79.

1858 *Acer ponzianum* Gaudin - GAUDIN & STROZZI, p. 38, pl. 13, figs 1-2.
2000 *Acer ilnicense* Il'inskaja - FISCHER & BUTZMANN, pp. 28-29, pl. 5, fig. 10; pl. 7, figs 1-10; pl. 8, fig. 1.

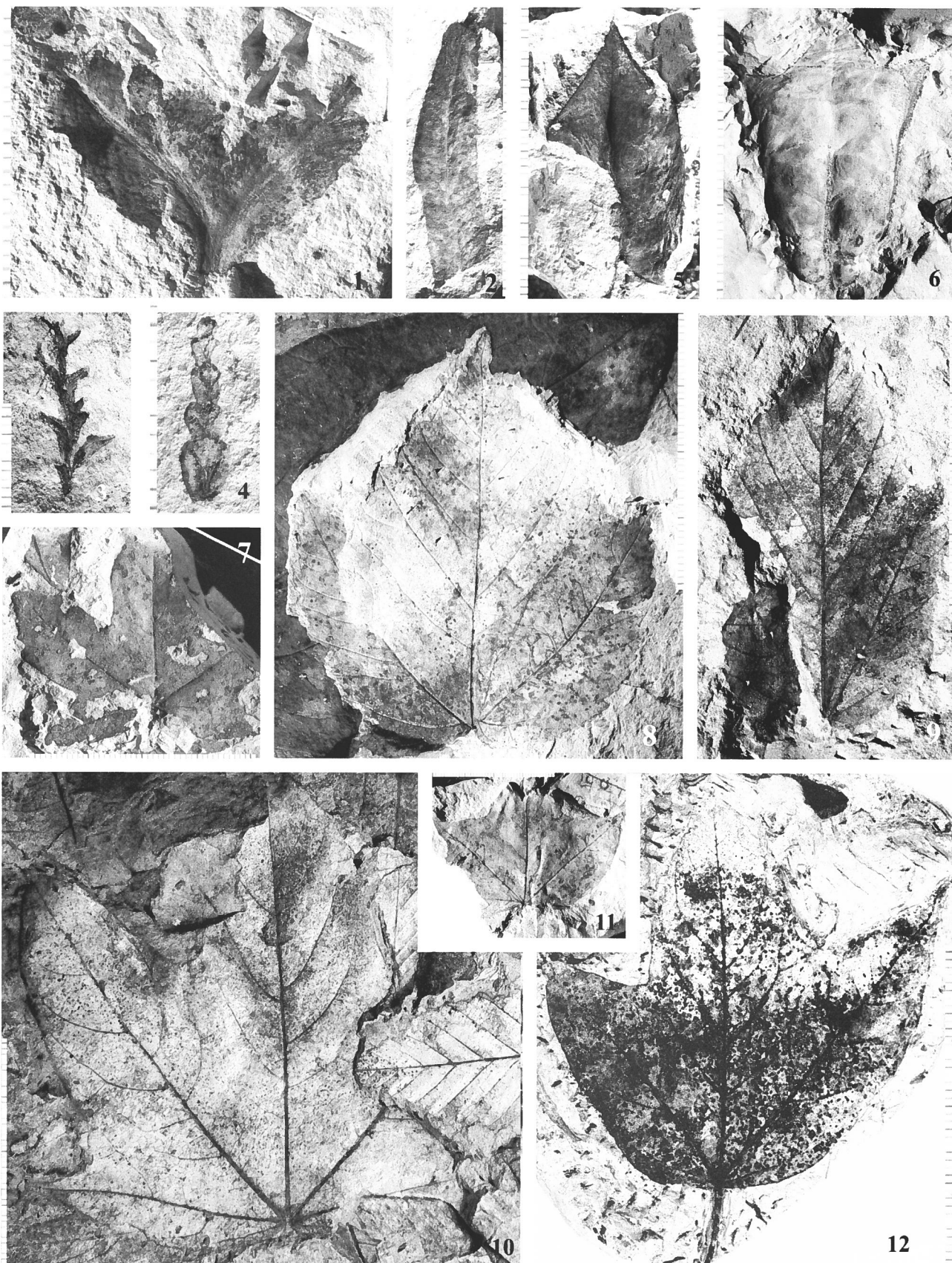
Occurrence – Two specimens from Arboschio-L1 and a well-preserved leaf impression in the collection of the MRSNT (from ?Arboschio-L1).

Remarks – The scarce material from Arboschio is identical to some specimens from the Pliocene continental sites of Barbania, La Cassa, Ceresole d'Alba, Gherba and Villafranca d'Asti (RDB quarry). This common leaf type shows the same morphology and variability as the type-material of *Acer tricuspidatum* Bronn subsp. *lusaticum* Walther from the Pliocene of Berga in NE Germany (Mai & Walther, 1988). Such leaf type was described by Gaudin & Strozzi (1858) as the new species *Acer ponzianum* Gaudin, based on two specimens from the locality of Castro near Arezzo (Tuscany), still well-preserved at the Geology and Palaeontology Museum of the Florence University. *Acer pyrenaicum* Rérolle (1884), from the late Miocene of the Eastern Pyreneans (Cerdanya Basin), can be regarded as a younger synonym of *Acer ponzianum* Gaudin. Furthermore, a rich population of leaves from the Middle Pliocene of Meleto (Upper Valdarno, Tuscany), which again represents this same taxon, was assigned by Fischer & Butzmann (2000) to *Acer ilnicense* Il'inskaja.

In conclusion, the specimens from Arboschio certainly belong to a widespread and relatively well-

EXPLANATION OF PLATE 1

- Fig. 1 - cf. *Marchantia*. Fragment of thallus from Valmanera, PU105000.
Fig. 2 - *Pteridium oeningense*. Pinnula from Valmanera, PU105001.
Fig. 3 - *Taiwania paracryptomerioides*. Shoot from Baldichieri-North, PU105002.
Fig. 4 - *Thuja saviana*. Shoot from Castagnole Monferrato, PU105003.
Figs 5-6 - *Ilex* aff. *cornuta*. 5) Valmanera, PU105004. 6) Arboschio-L4, lg. Pavia, 1968-69, PU105005.
Fig. 7 - *Acer campestre*. Valmanera, PU105006.
Figs 8-9 - *Acer tricuspidatum lusaticum*. 8) typical rounded-trilobate leaf, ?Arboschio-L1, MRSNT. 9) leaf with L:W ratio>>1, Arboschio-L1, lg. Pavia, 1968-69, PU105007.
Figs 10-12 - *Acer integerrimum*. 10) Arboschio-L1, lg. Pavia, 1968-69. 11) Four-lobed leaf, Arboschio-L4, lg. Pavia, 1968-69, PU105008. 12) Arboschio-L1, original of *Acer decipiens* by Pavia (1970, pl. 4, fig. 2).



known taxon, whose nomenclature is still controversial. If this maple leaf type is treated as a separate fossil species, the name *Acer ponzianum* Gaudin would have priority. However, Stroebitzer-Hermann (2002) recently proposed to treat this taxon as *Acer tricuspidatum* Bronn forma *pyrenaicum* (Rérôle) Stroebitzer-Hermann. In the present work, the infraspecific rank of this taxon is accepted, but the priority of the epithet "*pyrenaicum*" is doubtful, so that the material from Arboschio is, provisionally, still assigned to *Acer tricuspidatum* subsp. *lusaticum*.

Family ALTINGIACEAE Lindl., 1846

Genus LIQUIDAMBAR Linné, 1753

LIQUIDAMBAR EUROPAEA A. Braun, 1836

Pl. 2, figs 1-3

1836 *Liquidambar europaea* A. Braun in BUCKLAND, p. 315.

Occurrence – Three rather well-preserved leaf impressions have been sampled at Arboschio-L1 (lg. G. Pavia, 1968-69) and a fragment of the basal part of a leaf occurred at Valmanera. A complete and very typical leaf from Arboschio-L4, already figured by Pavia (1970), is reported in Pl. 2, fig. 3.

Remarks – Leaves of *Liquidambar* can be distinguished from those of *Acer* on the basis of rounded teeth forming a fine, regular and peculiar serration (Pl. 2, fig. 2a). The fourth order veins mostly have open terminations (rarely visible in the Arboschio specimens) and form a wide mesh, while fine rectangular to trapezoidal areoles are found in *Acer*.

In Piedmont *L. europaea* has been reported as a common element in the Messinian floras of "Alba" (Martinetto *et al.*, 2000), while in the Pliocene a few leaves occurred in the localities of Bra (Peola, 1895), Barbania and Roatto (Martinetto, 1995). In contrast to such scarcity of leaves, the fruiting heads of *Liquidambar* are very common in most Early Pliocene carpological assemblages (e.g. Breolungi, Ca' Viettone; Martinetto, 1995).

Family AQUIFOLIACEAE Bartl. 1830

Genus ILEX Linné, 1753

ILEX aff. CORNUTA Lindley & Paxt., 1850-1851

Pl. 1, figs 5-6

Occurrence – A leaf impression (Pl. 1, fig. 5), with three prickly lobes contorted into the sediment, occurs at Valmanera.

Remarks – The apex is acute, the base cordate and there is a 7 mm-long petiole. The texture is coriaceous and the venation is scarcely apparent. This last feature, in combination with the peculiar leaf shape, permits to assign this remain to *Ilex*. Observations on necroly-

sis of modern leaves of *Ilex aquifolium* Linné showed that the tertiary, and sometimes also secondary, veins are decay-prone and leaves which remain in the litter for the whole winter mostly show the sole midrib. Instead, the cuticle is very strong and decay-resistant. Probably at the time of burial the Valmanera fossil had poorly preserved fine veins, while the cuticle was still plastic and resistant, as demonstrated by the wrinkled surface recorded on the impression.

A specimen closely resembling the Valmanera one, which I would assign to the same species (Pl. 1, fig. 6), had been sampled in the continental part of the Arboschio section (Pavia, 1970: lithozone 4). The modern leaves of *I. cornuta* differ from those of other species of the same genus for the constantly low number of lateral prickly lobes and the strongly folded coriaceous lamina. Fossil leaves of this type had already been described as *Ilex* aff. *cornuta* from the Pliocene of Alsace (Geissert, 1990).

Family ARALIACEAE Jussieu, 1789

Genus HEDERA Linné, 1753

HEDERA cf. HELIX Linné, 1753

Pl. 2, figs 4-6

?1865 *Hedera strozzi* Gaudin - SISMONDA, p. 57.

Occurrence – Two specimens from Valmanera and one from Arboschio-L1 show typical features of ivy leaves.

Remarks – The first Valmanera specimen (Pl. 2, fig. 4) is an incomplete impression of a trilobate, symmetric and broadly ovate leaf. The margin is smooth and the texture coriaceous. The venation is basal actinodromous, perfect and reticulate; the three primaries are repeatedly branched, as well as the secondaries. The tertiaries form a wide-meshed reticulum. The second specimen of Valmanera is very similar to one from Arboschio-L1 (Pl. 2, fig. 5): both have a narrowly elliptic shape and show the typical venation with anastomosed primaries and secondaries. The leaf-impression of Valmanera has recorded the wrinkled surface of the cuticle, which was evidently still present during the early diagenetic phases. These specimens are identical to modern leaves of *Hedera helix* Linné, a much heterophyllous species, even within a single individual; however the high length/width ratio of the second specimen from Valmanera and of the Arboschio-L4 specimen of Pl. 3, fig. 5 is uncommon in the modern populations.

Fossil leaves of *H. helix* are reported from a few Upper Miocene and Pliocene sites of Europe (Knobloch, 1998; Kvaček *et al.*, 2002; Roiron, 1991). Some authors preferred to use palaeontological names for Neogene leaves (with unimportant differential characters), such as *H. strozzi* Gaudin in Gaudin & Strozzi, 1858, recorded also in Piedmont by Sismon-

da (1865), or *H. multinervis* Kolakovskii in Kolakovskii & Shakryl, 1978. The enormous intraspecific leaf variability would suggest to use only one name for *Hedera helix*-like fossils, however it is not sure that a mere leaf morphological analysis would provide reliable past records of this modern species (hence the open nomenclature). Kvaček *et al.* (2002) pointed out that cuticular characters, which unfortunately lack in the "Asti" specimens, can be diagnostic for individual species.

Family BETULACEAE Gray., 1821
Genus ALNUS Hill., 1753

ALNUS CECROPIAEFOLIA (Ettingshausen, 1851)
Berger, 1955
Pl. 2, figs 8-10; Text-fig. 2, n. 18

- 1851 *Artocarpidium cecropiaefolium* ETTINGSHAUSEN, p. 15, pl. 2, figs 3-4.
1955 *Alnus cecropiaefolia* (Ettingshausen) BERGER, pp. 87-88, fig. 30.

1858 *Alnus kefersteinii* (Ettingshausen) – GAUDIN & STROZZI, p. 30, pl. 2, figs 7(?), 8-9 (non pl. 4, fig. 6).
1859 *Corylus heeri* SISMONDA, p. 23, pl. 2, fig. 1.

Occurrence – Leaf impressions of this species occur at Arboschio-L1, Castagnole Monferrato and Valmanera. Also a lost specimen of *Corylus heeri* from San Damiano d'Asti (Sismonda, 1859; Peola, 1896a) can be placed here.

Remarks – The leaf architecture and its variation have been extensively described by Berger (1955) and Knobloch (1969). *A. cecropiaefolia* is characterized by rounded to widely elliptic leaves, rather similar to those of modern *Alnus glutinosa* Gaert., but characterized by an obtuse rather than retuse apex and by less prominent teeth. Though dimensions are extremely variable, the bulk of the specimens fall within the mesophyll category (see Ash *et al.*, 1999, p. 17).

Fossil leaves of *Alnus cecropiaefolia* were described from the Neogene of Piedmont for the first time by Sismonda (1859), who assigned them to a new species *Corylus heeri* Sismonda. The type specimens had been collected from two localities: Guarene and San Damiano, both reported as "Middle Miocene", but later revised as Messinian and Pliocene respectively (Peola, 1893). In a successive work Sismonda (1865) updated the occurrence of *Corylus heeri* by adding two other sites: "Caccia" (presently La Cassa) and "Felletto" (presently Feletto); again, both sites were assigned to the "Middle Miocene", but later Sacco (1888) and Peola (1896b) correctly revised them as "Villafranchian". Recent studies (Martinetto, 1994 and 1995) pointed out that the deposit of La Cassa, still well-exposed in the bed of the Ceronda stream, belongs to a *Glyptostrobus-Alnus* swamp forest facies. Very similar deposits are exposed in the bed of

the Stura di Lanzo River close to the village of Nole Canavese. Both sites are currently interpreted as Middle Pliocene, and they share the common occurrence of bedding planes nearly covered by leaves of *Alnus cecropiaefolia*. Field works carried out from 1988 to 1997 permitted to gather a considerable collection of fossil leaf specimens from Stura di Lanzo, now conserved at the Museo di Geologia e Paleontologia of the Turin University. This collection comprises roughly 30 leaves of *Alnus cecropiaefolia*, which provides a good record of its variability in the Italian Pliocene, and a reliable basis for a correct interpretation of the more fragmentary material from the Asti area. Here, the largest population is represented by 12 specimens from the Valmanera site; their size is smaller in comparison to the Stura di Lanzo and La Cassa material, which is probably a taphonomical bias due to selective transport of smaller specimens to the Valmanera marine bottom.

Alnus cecropiaefolia is also present in the Pliocene of the Upper Valdarno (Gaudin & Strozzi, 1858) and it is very common in the Neogene of Paratethys (Berger, 1855; Knobloch, 1969), especially as a component of the *Glyptostrobus-Byttneriophyllum* association (Mai, 1995, p. 553).

ALNUS DUCALIS (Gaudin, 1858) Knobloch, 1969
Pl. 3, figs 1-2; ?Text-fig. 2, n. 28

- 1858 *Rhamnus ducalis* Gaudin - GAUDIN & STROZZI, p. 39, pl. 9, figs 6-9.
1969 *Alnus ducalis* (Gaudin) Knobloch - KNOBLOCH, pp. 69-70, figs 159-165.

1865 *Alnus nostranum* Unger - SISMONDA, p. 37, pl. 11, fig. 3 (non fig. 2).
1958 *Alnus hoernesi* Stur - BERGER, p. 18, pl. 3, fig. 50.

Occurrence – Arboschio-L1, Asti-Cascina Risso, Castagnole Monferrato and Valmanera. Also a lost specimen from Castello d'Annone (Text-fig. 2, n. 28), described and drawn by Peola (unpubl.: *Celastrus brockmannii*, pl. 60, fig. 5), is most probably to be referred here.

Remarks – The characteristic leaf architecture easily permits to assign the whole leaves to *A. ducalis*, a species which has been recorded since a long time in the Neogene of Italy as *Rhamnus ducalis* Gaudin. Knobloch (1969) demonstrated its betulaceous features, and assigned it to the genus *Alnus*. The name *A. ducalis* has priority on *A. hoernesi* Stur, used by some authors even in recent works (Berger, 1958; Roiron, 1991).

In Piedmont *A. ducalis* has been reported from the Messinian Gessoso Solifera Formation of the surroundings of Alba (Martinetto *et al.*, 2000). A lost specimen from Guarene most probably came from the same formation; it had been studied and figured by Sismonda (1865: p. 37, pl. 11, fig. 3), who assigned it to *Alnus nostranum* Unger. This author evi-

dently guessed that the leaf impression had lost the apical part, but whether we remove his reconstruction, the drawing shows a perfectly symmetric emarginate apex, as typical for *A. ducalis*. Peola (1899b) reported *Alnus nostranum* Unger also for the Messinian of Monte Castello d'Alessandria, but the fragmentary state of such lost specimens and the low quality of the drawings (Peola, unpubl.) do not permit a reliable assignment to *A. ducalis*.

ALNUS GAUDINII (Heer, 1856) Knobloch & Z. Kvaček, 1976

Pl. 2, fig. 11; pl. 3, figs 3-4; Text-fig. 2, n. 11;
?Text-fig. 3, ns 4, 6

1856 *Rhamnus gaudinii* HEER, pp. 78-80, pl. 124, figs 4-15; pl. 125, figs 1, 7, 13.

1976 *Alnus gaudinii* (Heer) KNOBLOCH & Z. KVAČEK, pl. 6, figs 1, 3; pl. 7, figs 1, 5; pl. 8, fig. 4; pl. 15, figs 1-4, 7-8, 10-11, 13, 15, 17; pl. 16, figs 1-5; pl. 19, fig. 15; pl. 20, fig. 10.

Occurrence – Arboschio-L1 (Martinetto & Mai, 1996) and Valmanera, possibly also at Castello d'Annone, Ferrere and San Damiano (lost specimens described as *Rhamnus deletus*, *Alnus nostranum* and *Ulmus* sp. by Peola, 1896a and unpubl.: pl. 60, fig. 6; pl. 51, fig. 5; pl. 35, fig. 12). From Arboschio-L1 three almost complete specimens are available, while the deposit of Valmanera yielded only two fragments representing the basal part of leaves.

Remarks – This species has cherry-like leaves, however its assignment to *Alnus* has been definitely demonstrated by Knobloch & Kvaček (1976) on the basis of cuticular characters. It is extremely common in the Pliocene of Piedmont and often dominant in the swamp forest facies of several sites located to the North (Barbania, La Cassa, Levone and Stura di Lanzo: Martinetto, 1994 and 1995), North-East (Pranzalito: unpublished data), South-East (Ceresole d'Alba: Text-fig. 1) or East of Turin (RDB quarry of Villafranca d'Asti, Gherba and Roatto: Martinetto & Mai, 1996). In these leaf assemblages *Alnus gaudinii* is associated to *Acer tricuspidatum* Bronn ssp. *lusaticum* Walther and/or *Glyptostrobus europaeus* (Brongniart) Unger.

The widespread occurrence allows to trace a broad picture of the foliar variability. A peculiar feature for the Pliocene populations of Piedmont is the abundance of leaf specimens with rounded or cordate basis. Such a morphotype is represented in the Pliocene of NE Germany (Mai & Walther, 1988), while the base of the Miocene type specimens by Heer (1859) is never cordate, and seems to be more commonly convex or cuneate. At the present state I cannot define the weight of this observation for the taxonomy and nomenclature of the Italian population.

Genus CARPINUS Linné, 1753

CARPINUS BETULUS Linné, 1753 [leaves and fruits]
Pl. 3, figs 5-7; Text-fig. 2, n. 34

Occurrence – Impressions of complete leaves at Arboschio-L1 (incl. *Betula* sp. by Martinetto & Mai, 1996), two fragmentary leaves at Valmanera. *C. betulus* is also represented in both sites by the typical bracts which wrap the fruits (Pl. 3, fig. 5). Pavia (1970, p. 164, pl. 2, fig. 4) figured a well preserved leaf from Arboschio-L4.

Remarks – Abundant findings of fossil fruits with unmistakable characters prove that in the Neogene of Europe a hornbeam type related to the modern *C. betulus* was present. Biometric analysis showed that the Pliocene fruit populations were quite similar, but not identical with Middle Pleistocene and modern ones (Jentys-Szaferova, 1960). Concerning leaf architecture, various authors discussed the uniform character of leaves in several modern species of *Carpinus*, which hampers recognition of their fossil record, even in the Pliocene. Roiron (1991) assigned to *Carpinus suborientalis* Saporta some Miocene leaves from Murat; however, he guessed that they might have been produced by the same ancient plants which yielded fossil fruits assigned by him to *C. betulus*. In the Hungarian Pliocene site of Gércé, Hably & Kvaček (1997) described an analogous situation, but they preferred to use the name *Carpinus grandis* Unger for the fossil leaves associated to bracts of *C. betulus*.

In the present work, both the fruiting structures and the leaves are referred to *C. betulus*, although they

EXPLANATION OF PLATE 2

- Figs 1-3 - *Liquidambar europaea*. 1) Arboschio-L1, lg. Pavia, 1968-69, PU105009. 2a, b) Arboschio-L1, lg. Ferrero, 1968-69, PU105010. 2a: detail of teeth of the central lobe. 3) Arboschio-L4, original by Pavia (1970, pl. 5, fig. 1).
Figs 4-6 - *Hedera* cf. *helix*. 4) Incomplete trilobate leaf from Valmanera, PU105011. 5) Incomplete lanceolate leaf from Arboschio-L1, lg. Martinetto, 1994, PU105012. 6) narrowly lanceolate leaf, Arboschio-L4, lg. Pavia, 1968-69, PU105013.
Figs 7-10 - *Alnus cecropiaefolia*. 7) Ovate leaf impression, dark colour due to Fe-minerals, Valmanera, PU105014. 8) Tiny, incompletely developed, rounded leaf with obtuse apex; Valmanera, PU105015. 9) Large leaf from Arboschio-L1, lg. Martinetto, 1994, PU105016. Notice the several strong veins branching near the margin, the obtuse apex and the long petiole. 10) Leaf with cordate base from Arboschio-L1, lg. Pavia, 1968-69.
Fig. 11 - *Alnus gaudinii*. Leaf from Arboschio-L1, lg. Martinetto, 1994, PU105017.



have never been found in connection. The fruits of *C. betulus* have been sampled in several Pliocene sites scattered throughout Piedmont (Pavia, 1970; Martinetto, 1995; Cavallo & Martinetto, 2001).

Family CORNACEAE Dumortier, 1829
Genus CORNUS Linné, 1753 *sensu lato*

CORNUS cf. GRAEFFII Heer, 1859 emend. Hantke,
1954
Pl. 3, figs 8-9

- ? 1859 *Cornus graeffii* HEER, p. 79, pl. 126, fig. 4.
? 1954 *Cornus graeffii* Heer - HANTKE, pp. 79-86, pl. 14, figs 1-3.
? 1974 *Swida graeffii* (Heer) STEPHYRTZA, pp. 126-127, pl. 6, fig. 8; pl. 23, figs 6-7.

Occurrence – Two leaf specimens, lacking the base, from Arboschio-L1 and Valmanera.

Remarks – The venation is eucamptodromous, with a few arched secondaries extended up to the apex, as typical in *Cornus s. l.* (incl. *Dendrobenthamia* Hutchinson and *Swida* Opiz). Pavia (1970, pl. 4, fig. 2) assigned to the modern North-American species *Cornus rubra* Rehd. a leaf impression from Arboschio-L4. This is very similar and probably conspecific to the Arboschio-L1 and Valmanera specimens.

The leaf morphology of the nearly 50 modern species of *Cornus s. l.* is rather uniform, so that the identification of species and subgeneric taxa in the fossil state is problematic. For this reason I did not use the new combination *Swida graeffii* (Heer, 1859) Stephyrtza, 1974. Leaves from the Neogene of Europe are usually designated by a name based on fossil material. The characters of the two cited specimens from the Asti area agree with those of *C. graeffii* as re-defined by Hantke (1954). On the other hand Berger (1958) assigned to *C. graeffii* two Messinian leaves from Tuscany which seem to belong to Rhamnaceae rather than Cornaceae.

The Pliocene fruit record in Piedmont permitted to recognise four well-differentiated species of *Cornus s. l.* (Martinetto, 1995); one of them, *Swida gorbunovii*, is common in the continental Pliocene ("Villafranchiano") of the Asti Basin (Martinetto & Mai, 1996).

Family FAGACEAE Dumortier, 1829
Genus FAGUS Linné, 1753

FAGUS PLIOCENICA Saporta, 1884
Pl. 4, figs 3-6; Text-fig. 2, ns 8, 15, 21, 25; Text-fig. 3, ns 1-2

1884 *Fagus pliocenica* SAPORTA, pl. 6, figs 1-6.

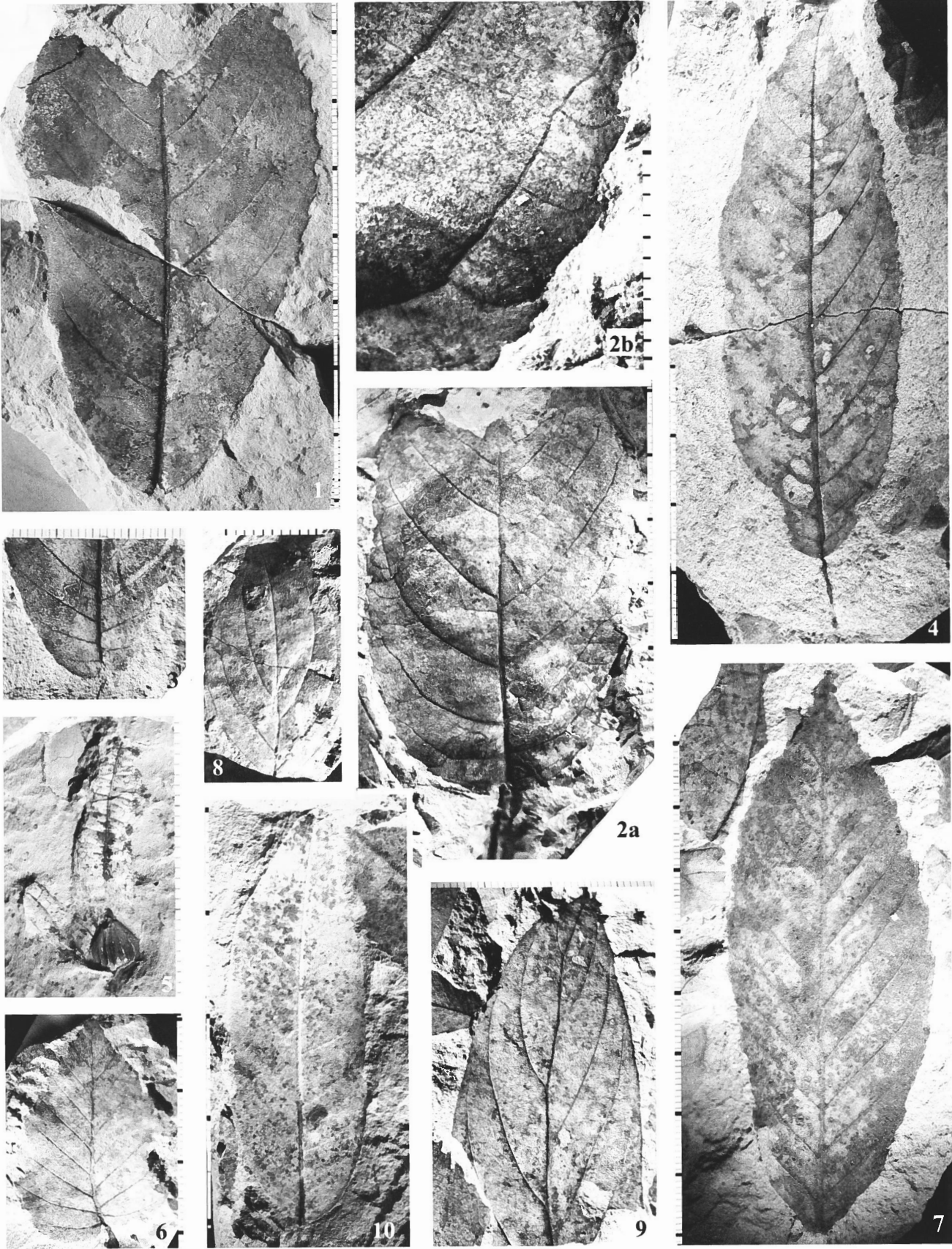
- 1858 *Fagus betulaefolia* MASSALONGO, p. 38, pl. 30, fig. 10.
1858 *Fagus chiericii* MASSALONGO, p. 39, pl. 32, fig. 5.
1858 *Fagus gussonii* MASSALONGO, p. 37, pl. 25, figs 2, 5.
1858 *Fagus incerta* MASSALONGO, p. 205, pl. 30, fig. 3.
1858 *Fagus marsilii* MASSALONGO, p. 36, pl. 9, fig. 19; pl. 21, fig. 18.
1896 *Fagus antipofi* (Abich) Heer - SORDELLI, pp. 118-120, pl. 17, figs 2-6; pl. 18, figs 7-13.
1896a *Fagus sinuata* PEOLA, pp. 8-9, pl. 3, fig. 4.

Occurrence – Arboschio-L1 (Pavia, 1970; Martinetto & Mai, 1996), Asti-Cascina Risso, Castagnole Monferrato, Cerro Tanaro, Baldichieri-North and Valmanera. Lost specimens (Peola, 1896a and unpubl.) from Castello d'Annone (*Fagus ambigua*, *Fagus gussonii*, *Fagus sinuata*, *Ulmus quercifolia*) and San Damiano (*Fagus ambigua*, *Fagus gussonii*).

Remarks – The abundant *Fagus* leaves from the Pliocene of "Asti" are similar to those of modern *Fagus sylvatica* Linné, and the broad variability of the fossil population does not seem to exceed the range of the modern species. Examination of leaf samples of *F. sylvatica* from several parts of Italy proves that most morphological characters are very variable, and this is probably the reason for the proliferation of specific epithets applied to Neogene leaves since two centuries (Knobloch, 1998, p. 26). Nevertheless, the Pliocene population from "Asti" differs from the modern ones for the higher frequency of narrowly elliptic leaf types (e.g. Pl. 4, fig. 3), so that I prefer to apply a species name based on fossil material. The selection of the appropriate epithet is a complex problem: Kvaček & Walther (1991) and Knobloch (1998) suggest two possible approaches: either use recently defined epithets, supported by careful examination (incl. cuticular analysis) of well-preserved and rich populations of fossil leaves, or select an old epithet which is appropriate to describe a fossil popula-

EXPLANATION OF PLATE 3

- Figs 1-2a,b - *Alnus ducalis*. 1) Valmanera, PU105018. 2a) Arboschio-L1, lg. Martinetto, 1994, PU105019. 2b) detail of teeth and marginal venation.
Figs 3-4 - *Alnus gaudinii*. 3) Cordate base, Valmanera, PU105020. 4) Complete leaf with convex base, Arboschio-L1, lg. Martinetto, 1994, PU105021.
Figs 5-7 - *Carpinus betulus*. 5) Fruit-bract and impression of the nut with strong ridges. Arboschio-L4, lg. Pavia, 1968-69, PU105022. 6, 7) Arboschio-L1, lg. Martinetto, 1994. Respectively, small *Betula*-like leaf (PU105023) and large elliptic leaf, PU105024.
Figs 8-9 - *Cornus cf. graeffii*. 8) Valmanera, PU105025. 9) Arboschio-L1, lg. Pavia, 1968-69, PU105026.
Fig. 10 - cf. *Quercus ilex* from Valmanera, PU105027.



tion. I decide for the second option, both as an effort to respect the rule of priority and because the studied material is unsuitable for cuticular analysis.

In the study area, Peola (1896a) defined the new species *Fagus sinuata* on the basis of a leaf from Castello d'Annone, but later (Peola, unpubl.) he wrote that such specimen would better be referred to *Fagus ambigua* (Massalongo, 1853) Massalongo, 1854. However, the name *F. ambigua* was referred by Massalongo (1854) to two leaves from the Messinian sites of Stradella (Viviani, 1833) and Senigallia, which have curved secondaries and do not permit an unquestionable assignment to *Fagus*. Several species from Senigallia (see above), reliably referred to *Fagus*, were described later by Massalongo (1858). However, the diagnoses of individual "species" are inadequate to represent the whole variable population from Senigallia, thus the search for a correct name must go further.

It is worth recalling here that two other names, commonly used in the palaeobotanical literature, are not valid: I) *Fagus feroniae* Unger, 1847 must be rejected because the two syntypes (Hably *et al.*, 2001) have been revised as *Alnus julianaeformis* (Sternberg) Z. Kvaček & Holy; II) *Fagus attenuata* Göppert, 1855 is based on a holotype which Walther & Zastawniak (1991) revised as *Alnus julianaeformis* (Sternberg) Z. Kvaček & Holy.

Saporta (1884) described a variable population of Pliocene beech leaves from central France as *Fagus pliocenica* Saporta. Such French morphotypes are very similar to those from the Pliocene of "Asti", which, in agreement with Pavia (1970), I propose to designate as *F. pliocenica*, at least until completion of the comprehensive taxonomic revision of Cenozoic *Fagus* leaves from Europe, presently in progress by Dr. Thomas Denk (pers. comm.).

In Piedmont rich assemblages of leaves, similar to the "Asti" ones and thus assignable to *F. pliocenica*, occur in the Messinian of "Alba" (Martinetto *et al.*, 2000) and in the Pliocene of Bra (Peola, 1895), Candelo (layer CO1 by Martinetto, 2001a), La Cassa and Stura di Lanzo (ca 3 m below the layer with *Alnus cecropiaefolia*, pers. observation). Comparable leaf populations are described for the Pliocene of the Rhone valley (Depape, 1922), the Frankfurt area (Mädler, 1939; Kvaček & Walther, 1991), the Lower

Rhine Basin (Laurent & Marty, 1923), and the German sites of Berga (Mai & Walther, 1988) and Willershausen (Knobloch, 1998). Some of these populations had been assigned by Kvaček & Walther (1991) to *Fagus kraeuselii* Kvaček & Walther, a species which, according to these authors, differs for the number of secondaries and the epidermal structure from three other Cenozoic species of middle Europe: *Fagus menzeli* Z. Kvaček & Walther, *Fagus saxonica* Z. Kvaček & Walther and *Fagus silesiaca* Walther & Zastawniak. Actually, I wonder whether cuticular analysis and biometry are really useful tools for the taxonomy of Neogene *Fagus* leaves, when Denk & Meller (2001) have shown that all the cupules and fruits of the European Cenozoic can be assigned to a single species: *Fagus deucalionis* Unger. Remarkably, fruits and cupules are more useful than leaves in differentiating modern species of *Fagus*.

Genus QUERCUS? Linné, 1753

QUERCUS? KUBINYII (Kovats, 1851 ex Ettingshausen, 1852) Czechtz, 1951 *sensu lato*
Pl. 4, figs 1-2; Text-fig. 2, n. 20

- 1851 *Castanea kubinyii* KOVATS, p. 178 (*nomen nudum*).
1852 *Castanea kubinyii* Kovats ex ETTINGSHAUSEN, p. 5, pl. 1, fig. 12.
1951 *Quercus kubinyii* (Kovats) CZECHTZ, p. 392, fig. 7.
1952 *Quercus kubinyii* (Kovats) BERGER, p. 92, text-fig. 47.

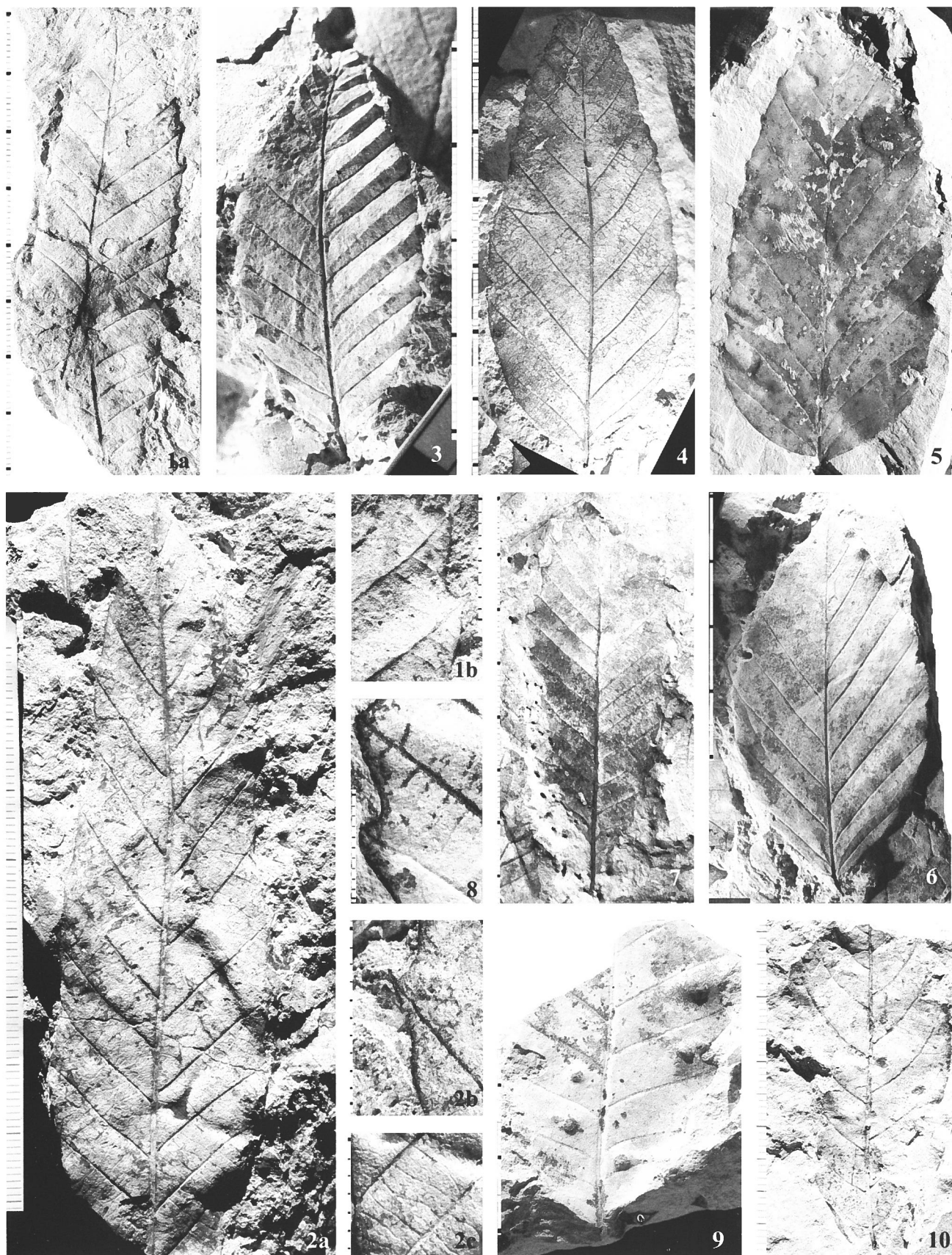
1896a *Castanea forilivii* (Massalongo) Massalongo - PEOLA, p. 9, pl. 3, fig. 5.

Occurrence – Arboschio-L1: "*Castanea* sp." by Pavia (1970); Castello d'Annone, a lost specimen assigned to *Castanea forilivii* by Peola (1896a, p. 9, pl. 3, fig. 5).

Remarks – The two available leaf specimens and the lost one (Peola, 1896a) are nearly identical to modern leaves of *Castanea sativa* Linné (samples from Piedmont), but also to several figured specimens from the European Neogene, which have been assigned to *Quercus kubinyii* (Kovats ex Ettingshausen) Czechtz. The correct generic position (*Castanea* vs *Quercus*) of this taxon has been long debated (e. g. Berger, 1952; Knobloch, 1969; Knobloch & Kvaček, 1976; Kvaček

EXPLANATION OF PLATE 4

- Figs 1, 2 - *Quercus kubinyii* from Arboschio-L1. 1) Small leaf with dense secondaries, lg. E. Ferrero, 1968-69, PU105028; 1b) detail of a tooth and craspedodromous secondaries. 2a) Large leaf, lg. Pavia, 1968-69, PU105029. 2b) detail of a tooth. 2c) Third-order venation.
Figs 3-6 - *Fagus pliocenica*. 3, 4, 6) Arboschio-L1, lg. Martinetto, 1994, PU105030, PU105031, PU105032. 5) Arboschio-L4, lg. Pavia, 1968-69, PU105033.
Figs 7-9 - *Quercus pseudocastanea*. 7) Arboschio-L1, lg. Pavia, 1968-69. 8) teeth and margin of a leaf from layer A5 of Arboschio (Martinetto & Mai, 1996), lg. Martinetto, 1994, PU105034. 9) Valmanera, PU105035.
Fig. 10 - cf. *Trigonobalanopsis rhamnoides* from Castagnole Monferrato, PU105036.



et al., 2002; Sakala and Teodoritis, 2001; Striegler, 1992; Takhtajan, 1982; Zastawniak, 1972). However, the majority of the authors preferred to assign it to *Quercus* rather than *Castanea*. This view is supported by the frequent occurrence of *Quercus* acorns associated to leaves of *Q. kubinyii* (Knobloch, 1986). Actually, the small leaves of modern *Castanea* do not differ significantly in shape, venation, and even epidermal characters (Kvaček *et al.*, 2002), from those of some oaks (*Quercus libani* Oliv. and related species).

The few leaf impressions from "Asti" cannot be regarded as a reliable Pliocene record of *Castanea sativa*, mainly because the very large leaves characteristic of this species have not been found till now. Accordingly, they are assigned to *Quercus?* *kubinyii* (Kovats ex Ettingshausen) Czeczott *sensu lato*. The specimen from Castello d'Annone could also be assigned to *Quercus gigas* Goeppert, as it is nearly identical to a specimen from the Late Miocene of Vegora (Greece), figured by Kvaček *et al.* (2002, pl. 13, fig. 2). The loss of the original specimen prevents any additional observation; nevertheless, there are no other records of *Q. gigas* in the Pliocene of Piedmont, thus also the specimen from Castello d'Annone is placed within the range of variability of *Q.?* *kubinyii*. The name *Q.?* *kubinyii* is used here, in agreement with most of the cited authors, to designate widely variable populations of fossil leaves. On the other hand, Knobloch (1986) used it in a strict sense and defined new related species (e. g. *Q. gregori* Knobloch, *Q. kucerae* Knobloch, *Q. schoetzi* Knobloch).

Genus QUERCUS Linné, 1753

QUERCUS PSEUDOCASTANEA Goeppert, 1852 emend.

Walther & Zastawniak, 1991

Pl. 4, figs 7-9; ?Text-fig. 2, ns 12, 22

1852 *Quercus pseudocastanea* GOEPPERT, p. 274, pl. 35, figs 1-2.

1991 *Quercus pseudocastanea* Goeppert – WALTHER & ZASTAWNIAK, pp. 196-170, pl. 2, figs 2-3, 5-6; pl. 3, figs 1-6; text-fig. 8.

1859 *Quercus etymodrys* Unger – MASSALONGO & SCARABELLI, p. 178, pls 22-23, figs. 1, 3, 5, 7, 10-11; pl. 31, fig. 5; pl. 42, fig. 12.

Occurrence – Rare in the lower (marine) portion of the Arboschio section and more common in its upper continental-brackish part (Martinetto & Mai, 1996). Pavia (1970) assigned these leaves to *Q. hispanica* Rérolle. At Valmanera this species is represented by an incomplete leaf impression and most probably it occurred also at Castello d'Annone (*Q. scilanthum*, *Q. roburoides* by Peola 1896a and unpubl.).

Remarks – *Quercus pseudocastanea* is better represented in other sites of Piedmont, in particular in a few Pliocene sites of the "Villafranchiano" lithostratigraphic unit: Front-Rio Secco and Vauda Canavese

(Martinetto, 1995). According to Walther & Zastawniak (1991) this species belongs to section *Cerris*, characterized by long appendices of the cupules, as in the recent *Quercus cerris* Linné. Cupules of this type have been sampled in association with leaves of *Quercus pseudocastanea* at Arboschio (lithozone 7), Front-Rio Secco and Vauda Canavese (Martinetto, 1995; Martinetto & Mai, 1996).

Family ?FAGACEAE Dumortier, 1829

Genus cf. QUERCUS Linné, 1753

cf. QUERCUS ILEX Linné, 1753

Pl. 3, fig. 10

A specimen from Valmanera, with badly visible tertiary venation, is identical in consistence, secondary eucamptodromous venation and gross-morphology to modern leaves of *Q. ilex*. However, the same basic structure is common to many plants with sclerophyllous leaves in different families. In addition, there is not a good record of *Q. ilex*-like leaves or fruits in any Pliocene site of Piedmont, and therefore it is better to wait for more diagnostic findings, which would confirm the occurrence of this modern species. The cited specimen surely represents the record of a sclerophyllous species, distinct from the rest of the palaeoflora. The possibility to assign these remains to *Trigonobalanopsis rhamnoides* (Rossmäessler) Z. Kvaček & Walther has been discarded on the basis of the widely spaced secondaries starting at open angles from the midrib, and of the obtuse rather than attenuate apex.

Genus cf. TRIGONOBALANOPSIS Z. Kvaček

& Walther, 1988

cf. TRIGONOBALANOPSIS RHAMNOIDES (Rossmäessler, 1840) Z. Kvaček & Walther, 1988

Pl. 4, fig. 10

? 1840 *Phyllites rhamnoides* ROSSMAESSLER, p. 35, pl. 8, figs. 30-31.

? 1988 *Trigonobalanopsis rhamnoides* (Rossmäessler) Z. KVAČEK & WALTHER, p. 405, pl. 40, figs 1-8; pl. 50, figs 1-4; pl. 55, figs 1-7; pl. 56, figs 1-4.

? 1931 *Tristania toscana* BANDULSKA, p. 668, pl. 40, figs 9-11.

Occurrence – Single fragmentary specimens from Castagnole Monferrato and Baldichieri-Fornace.

Remarks – The determination of this scanty material is problematic, though both specimens agree in all visible characters with leaves of *Trigonobalanopsis rhamnoides*; this species, carefully investigated by Kvaček & Walther (1988), is rather widely distributed in the Cenozoic of Europe. It has been recently confirmed also by leaf studies in the Neogene of Italy (Martinetto *et al.*, 2000; Fischer & Butzmann, 2000),

and its presence is corroborated by several Early and Middle Pliocene findings of related fructifications (Martinetto, 1999 and 2001b), assigned to *Trigonobalanopsis exacantha* (Mai) Z. Kvaček & Walther.

Family HAMAMELIDACEAE R. Br., 1818
Genus ?*PARROTIA* C. A. Mey, 1831

"*PARROTIA*" *PRISTINA* (Ettingshausen, 1851) Stur, 1867
Pl. 5, fig. 1; Text-fig. 2, n. 29

- 1851 *Styrax pristinum* ETTINGSHAUSEN, p. 19, pl. 3, fig. 9.
1867 *Parrotia pristina* (Ettingshausen) STUR, p. 192, pl. 5, fig. 3.

1896a *Alnus cuneata* PEOLA, pp. 12-13, pl. 3, fig. 7.
1970 *Parrotia fagifolia* Goeppert *sensu* Heer - PAVIA, pl. 5, fig. 5.

Occurrence – Cerro Tanaro and, most probably, Castello d'Annone (*Alnus cuneata* Peola, 1896a, pl. 3, fig. 7 and unpubl., pl. 31, fig. 4). A typical specimen from the continental sediments of Arboschio-L4, already figured by Pavia (1970), is shown in Pl. 5, fig. 1.

Remarks – The scarce value of architectural characters for the differentiation of hamamelidaceous leaves has been discussed by Tralau (1963). European scientists studying Neogene leaves generally accepted this view and used the name "*Parrotia*" *pristina* for *Parrotia*-like leaves, putting it in inverted commas, to indicate that this is a collective "species" comprising the foliage of several ancient biological species, possibly belonging to different genera.

In the continental Pliocene of Villafranca d'Asti (RDB quarry) leaves of "*Parrotia*" *pristina* have been found in a layer which yielded abundant fruits of *Parrotia reidiana* Kirchheimer. This suggests that the hamamelidaceous leaves of the Pliocene of "Asti" might have been produced by an extinct plant closely related to the modern *Parrotia persica*. In addition, the carpological record (Martinetto, 1995) proves that *Parrotia* was the most common hamamelidaceous genus in the Pliocene of Piedmont, and only a few seed specimens belong to *Distylium* and *Hamamelis*.

Family JUGLANDACEAE A. Rich. ex Kunth, 1824
Genus *PTEROCARYA* Kunth, 1824

PTEROCARYA PARADISIACA (Unger, 1849) Il'inskaja, 1962
Pl. 5, figs 2-4; Text-fig. 2, ns 16-17

- 1849 *Prunus paradisiaca* UNGER, p. 7, pl. 14, fig. 22.
1962 *Pterocarya paradisiaca* (Unger) IL'INSKAJA, p. 104.

1858 *Pterocarya massalongi* Gaudin - GAUDIN & STROZZI, p. 40, pl. 8, figs 1-6; pl. 9, fig. 2.
1859 *Juglans stoppanii* Massalongo - MASSALONGO & SCARABELLI, p. 398, pl. 34, fig. 4.

Occurrence – Arboschio-L1 (Pavia, 1970: *Pterocarya* cf. *denticulata* O. Web. *sensu* Heer and *Carya* cf.

minor Saporta; *Pterocarya* sp.: Martinetto & Mai, 1996), Valmanera and most probably at Castello d'Annone (*P. denticulata* Heer by Peola 1896a and unpubl.).

Remarks – The best preserved specimens from Arboschio-L1 and Valmanera show all the characteristic leaf architectural features pointed out by Manchester (1987, p. 87). Other less well-preserved specimens could be assigned to this species, with a lower degree of reliability, on the basis of their shape and teeth type. Pavia (1970: pl. 3, fig. 5) also reported *Carya* cf. *minor* Saporta from Arboschio (L1 and L4), but the figured specimen can be assigned to *Pterocarya paradisiaca* because the teeth are small and regular, and the termination of secondary veins always forms loops (Knobloch, 1986). The leaf basis is acute-rounded as in lateral leaflets of *Carya minor*, but this feature can also be rarely observed in extant leaflets of *Pterocarya*. In the Neogene of Europe the foliage of *Pterocarya* is usually identified as *Pterocarya paradisiaca* (e. g. Knobloch, 1969; Zastawniak, 1972; Knobloch & Kvaček, 1976). In Piedmont this species has been reported from the Messinian of the surroundings of Alba (Martinetto *et al.*, 2000), and most probably it was also represented by the lost specimens from the Messinian of Guarene and the Pliocene of Carrù, identified by Peola (1899a and 1896b) as *P. massalongii* Gaudin. Fruits assigned to *Pterocarya limburgensis* C. Reid & E. M. Reid are very common in the Pliocene of the western Po plain (Martinetto, 1995 and 1999).

Family LAURACEAE Jussieu, 1789
Genus *DAPHNOGENE* Unger, 1850

DAPHNOGENE POLYMORPHA (A. Braun, 1845)
Ettingshausen, 1851
Pl. 5, fig. 7; Text-fig. 2, n. 35

- 1845 *Ceanotus polymorphus* A. BRAUN, p. 171.
1851 *Daphnogene polymorpha* (A. Braun) ETTINGSHAUSEN, p. 12, pl. 2, figs 23-25.

Occurrence – Arboschio-L1 (Pavia, 1970) and most probably Castello d'Annone (*Cinnamomum lanceolatum* and *Cinnamomum spectabile* by Peola, 1896a and unpubl.: pl. 42, fig. 7 and pl. 43, fig. 3).

Remarks – This species is widespread in the Neogene floras of southern Europe (e.g. Massalongo & Scarabelli, 1859; Depape, 1922; Fischer & Butzmann, 2000). In Piedmont it is common in the Messinian (Martinetto *et al.*, 2000), while in the Pliocene it has been found in a few sites. The most abundant population occurs in the uppermost portion of the Arboschio section (Martinetto & Mai, 1996). The distinction from small-sized specimens of *Ocotea heeri* is based on the absence of glands at the

base of the lateral primaries, which are often extended to the apical portion of lanceolate leaves.

Knobloch & Kvaček (1976) discussed the relation of *D. polymorpha* with recent lauraceous genera and they concluded that leaf architecture and anatomy do not provide definite evidence for placement within the modern genus *Cinnamomum*.

The occurrence of *Cinnamomum* in the Neogene of Europe is firmly demonstrated by findings of endocarps named *Cinnamomum costatum* (Mai) Pinggen, Collinson & Ferguson, 1994. This last species is rather common in the Early Pliocene of Piedmont (Martinetto, 1995), and one specimen was found in the Stura di Lanzo site (?Middle Pliocene). Thus, one can guess that most leaves of *D. polymorpha* might have been produced, in this region, by *Cinnamomum* plants.

Genus OCOTEA Aubl., 1775

OCOTEA HEERII (Gaudin, 1858) Mai, 1971

Pl. 5, figs 8-10; Text-fig. 3, n. 9

1858 *Oreodaphne heerii* Gaudin - GAUDIN & STROZZI, p. 35, pl. 10, figs 5-9; pl. 11, figs 1-7.

1971 *Ocotea heerii* (Gaudin) MAI, p. 32.

1859 *Laurus oreodaphnifolia* Massalongo - MASSALONGO & SCARABELLI, p. 254, pl. 35, fig. 11.

1859 *Laurus tanorii* Massalongo - MASSALONGO & SCARABELLI, p. 255, pl. 25, fig. 1.

Occurrence – Arboschio-L1 (Pavia, 1970; Martinetto & Mai, 1996), Baldichieri-North, Baldichieri-Fornace, Castagnole Monferrato, Valmanera (8 fragmentary specimens) and most probably at San Damiano (Peola, 1896a and unpubl., pl. 44, fig. 3). Two leaves from Arboschio-L4 have been figured by Pavia (1970, pl. 5, figs 3-4).

Remarks – Fossil leaves very similar to those of the modern *Ocotea foetens* (Ait.) Baill., growing in the laurel forest of the Canary Islands. This Neogene leaf species may be reliably identified on the basis of architectural characters. It is widespread in the Neogene of southern Europe, from the Black Sea (Takhtajan, 1974) to the Rhone valley (Depape, 1922). In Italy it was described at first by Gaudin & Strozzi (1858) on the basis of material from the

Pliocene of Montaione and soon after reported for the Messinian by Massalongo & Scarabelli (1859). Later it has been reported in several Miocene and Pliocene sites (Cavara, 1886; Sordelli, 1896; Berger, 1958). In Piedmont *O. heerii* is known for the “Langhian” (in reality Aquitanian or Burdigalian) of the Collina di Torino (Sismonda, 1865; Peola, unpubl.), the Messinian of “Alba” (Peola, 1899a; Martinetto *et al.*, 2000) and the Pliocene of Cossato (Martinetto, 2001a). Fischer & Butzmann (2000) recently documented another species, *O. hradekensis* (Z. Kvaček & Bůžek) Z. Kvaček, from the Middle Pliocene of the Upper Valdarno.

Family ?LAURACEAE Jussieu, 1789

Genus ?LAUROPHYLLUM Goeppert, 1855

?LAUROPHYLLUM spp.

Pl. 5, figs 5-6; Text-fig. 2, n. 26; Text-fig. 3, n. 5

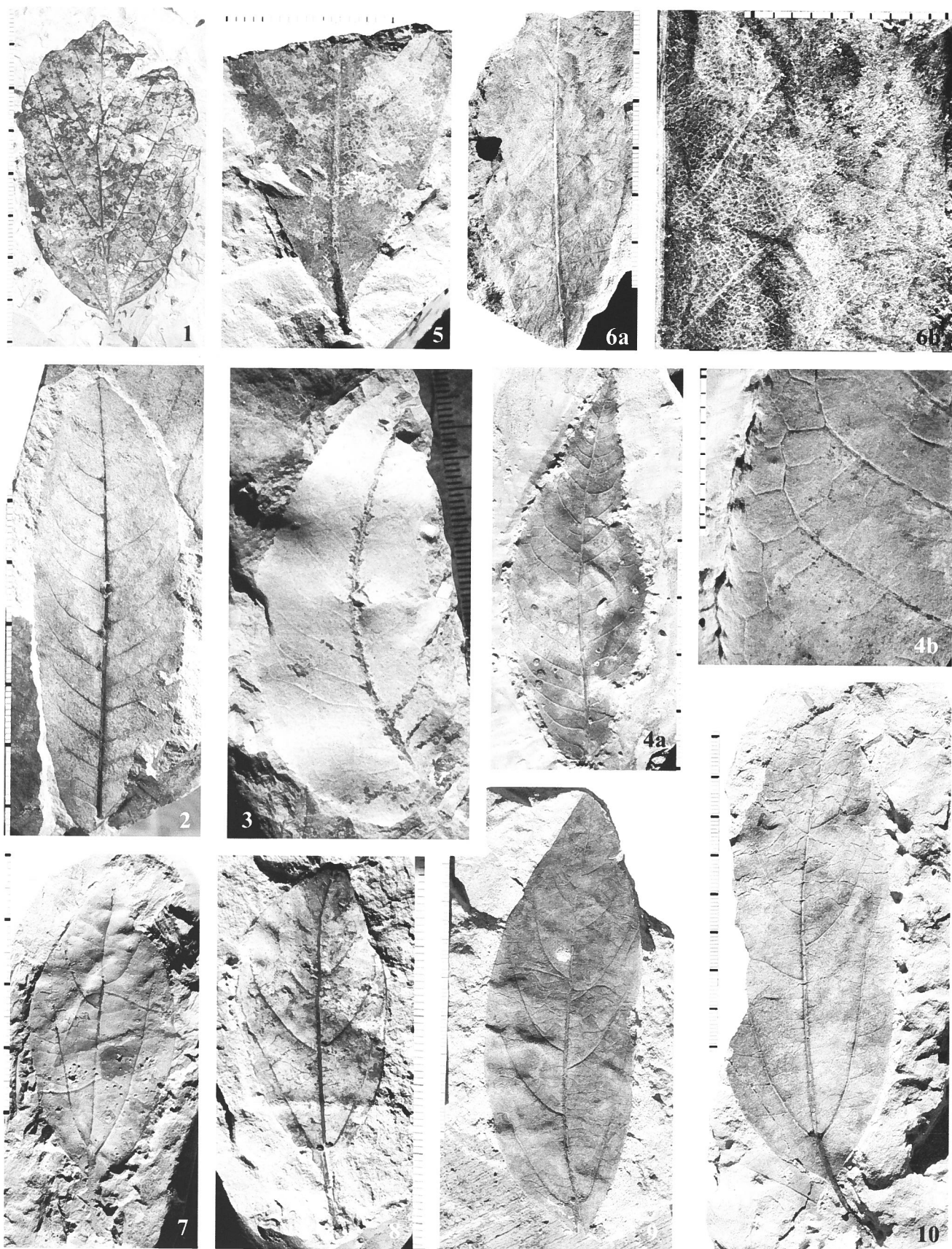
Occurrence – Arboschio-L1, Baldichieri-Fornace, Valmanera and most probably at Castello d’Annone and San Damiano (Peola, 1896a and unpubl., pl. 37, fig. 5 and pl. 38, fig. 6).

Remarks – *Laurophyllum* is a form-genus which designates coriaceous, entire-margined leaves with pinnate camptodromous (rarely acrodromous) venation. The cuticular characters are crucial for a definite assignement to the Lauraceae, otherwise this kind of leaf architecture is common to many tropical-subtropical families (Knobloch & Kvaček, 1976).

The cited occurrences in the “Asti” Pliocene are problematic because, as usual, they consist of leaf impressions without cuticle. The well-preserved and complete specimens of Arboschio-L4 had been assigned by Pavia to *Apollonias canariensis* and *Persea indica*; however I guess that it is impossible either to exclude or to confirm that such leaves belong to two different species. In addition, they cannot be assigned to modern botanical genera, but only - tentatively - placed in ?*Laurophyllum*, on the basis of a total coincidence of leaf architectural characters with several species of *Laurophyllum* reported by Knobloch & Kvaček (1976) and Fischer & Butzmann (2000). The few fragmentary specimens from Baldichieri-Fornace and Valmanera, as well as the lost specimens from

EXPLANATION OF PLATE 5

- Fig. 1 - “*Parrotia*” *pristina*. Arboschio-L4, original from Pavia (1970), pl. 5, fig. 5.
 Figs 2-4 - *Pterocarya paradisiaca*. 2) Arboschio-L1, lg. Martinetto, 1994, PU105037. 3) Valmanera, PU105038. 4a, b) Arboschio-L4, lg. Pavia, 1968-69, PU105039. 4b) detail of the margin and semicraspedodromous venation.
 Figs 5, 6 - ?*Laurophyllum* sp. 5) Leaf fragment from Valmanera, PU105040. 6a, b) Incomplete leaf from Baldichieri-Nord and detail of the third and forth-order venation, PU105041.
 Fig. 7 - *Daphnogene polymorpha*. 7) Arboschio-L4, lg. Pavia, 1968-69, PU105042.
 Figs 8-10 - *Ocotea heerii*. 8) Arboschio-L4, lg. Pavia, 1968-69, PU105043. 9, 10) Baldichieri-Fornace, PU105044, PU105045.



Castello d'Annone and San Damiano, are similar to ?*Laurophyllum* from Arboschio, but it is impossible to prove that they belong to the same species. The Neogene records of "*Laurus*" and "*Lauraceae*" published in the Italian literature of the 19th century are very difficult to confirm or revise on the basis of the sole gross-morphology. Future research must be focused on cuticular analysis of putative lauraceous compressed material, largely available for the Messinian (Brambilla *et al.*, 1982; Martinetto *et al.*, 2000) and recently found also in the Pliocene of Fossano (province of Cuneo).

Family OLEACEAE
?Genus FRAXINUS Linné, 1753

cf. FRAXINUS sp.
Pl. 6, fig. 3

A leaf fragment from Valmanera, at first glance assigned to *Pterocarya*, can be differentiated on the basis of a few characters: the course of secondaries is straight and then abruptly curved towards the apex; the serrate margin has irregularly spaced teeth of variable size.

All the characters of this fragmentary specimen agree with those observed on Miocene leaves from Eastern Germany assigned by Knobloch & Kvaček (1976) to *Fraxinus ungeri* (Gaudin) Knobloch & Z. Kvaček.

Family PLATANACEAE T. Lestib. ex Dumort, 1829
Genus PLATANUS Linné, 1753

PLATANUS LEUCOPHYLLA (Unger, 1850) Knobloch, 1971
Pl. 6, figs 1-2

- 1850 *Populus leucophylla* UNGER, p. 417.
1971 *Platanus leucophylla* (Unger) KNOBLOCH, p. 264.

1853 *Acerites deperditum* MASSALONGO, 1853, p. 4, 5, pl. 2, fig. 7.
1858 *Platanus aceroides* Goeppert - GAUDIN & STROZZI, p. 35, pl. 5, figs 4-6; pl. 6, figs 1-3.
1859 *Platanus ettingshauseni* Massalongo - MASSALONGO & SCARABELLI, p. 234, pl. 17, fig. 3; pl. 19, fig. 3.
1859 *Acer herii* Massalongo - MASSALONGO & SCARABELLI, pp. 345-353, pl. 12, fig. 5; pl. 15, figs 1-4; pl. 17, figs 1-2, 4; pl. 18, figs 1-2.
1865 *Acer trilobatum* Al. Braun - SISMONDA, p. 59, pl. 20, fig. 2.
1896 *Platanus deperdita* (Massalongo) SORDELLI, p. 39, pl. 5, figs 14-17.
1995 *Platanus platanifolia* (Ettingshausen) Knobloch, 1964 - BRAMBILLA, p. 246, specimens 10044-48, 10051.

Occurrence – Arboschio-L1 (*Platanus aceroides* Goeppert after Pavia, 1970, *Platanus* sp. after Martinetto & Mai, 1996), Baldichieri-North, Castagnole Monferrato; at Valmanera only two fragments of leaves. A typical specimen from the continental sediments of Arboschio-L4, already figured by Pavia (1970), is shown in Pl. 6, fig. 1.

Remarks – Plane leaves are unmistakable when they are complete as in Arboschio-L1 and L4, yet even small fragments can be identified on the ground of the coarse and irregular teeth with rounded sinuses (Pl. 6, fig. 2). The actinodromous suprabasal venation and the abundant and strong external secondaries are also typical.

Most plane leaves from the Neogene of central Europe seem to be referable to a single species (Knobloch, 1969; Webenau, 1995; Fischer & Butzmann, 2000), designated by the name *P. leucophylla* (Unger, 1950) Knobloch, 1971, which has priority on *Platanus aceroides* Goeppert, 1855. Further synonyms (Berger, 1958) are *Platanus deperdita* (Massalongo) Sordelli and *Platanus ettingshauseni* Massalongo. Previous records from Piedmont include several leaves, figured by Sismonda (1865) and Peola (unpubl.), from the "Langhian" (in reality Aquitanian or Burdigalian) of Torino, the "Elvetian" of Sciolze, the Messinian of Guarene and Moncalvo, and the Pliocene of Bra.

Family ROSACEAE Jussieu, 1789
Genus PYRACANTHA M. Roem., 1847

PYRACANTHA sp.
Pl. 6, figs 4-6

Occurrence – A leaf from from Arboschio-L1 and three specimens from Valmanera: a group of three leaves and two fragments of tiny leaves. The venation is always well-preserved and identical to that of modern specimens of *Pyracantha coccinea* Linné.

Remarks – The leaf architecture also suggests an affinity to Messinian specimens assigned to *Prunus nanodus* Unger and *Amygdalus pereger* Unger by Berger (1958), however I prefer to assign the «Asti» leaves to *Pyracantha* because this genus is widespread in the Pliocene fruit record of Piedmont (Martinetto, 1995 and unpubl. data). The observation that group of leaves, like that of Valmanera, are frequent under modern shrubs of *Pyracantha* gives further support to this identification.

Family ?ROSACEAE Jussieu, 1789
Genus RUBUS Linné, 1753

RUBUS sp.
Pl. 6, figs 7-8; ?Text-fig. 2, n. 10

Occurrence – A single complete leaf from Arboschio-L4; another specimen from ?Arboschio-L1, is conserved at MRSNT. Both specimens are similar to a leaf from Castello d'Annone, drawn by Peola (unpubl., pl. 14, fig. 6), and revised here as cf. *Rubus*, because Peola's drawing could also be interpreted as a betulaceous leaf.

Remarks – Compound leaves and isolated leaflets of *Rubus* are known in the Messinian of “Alba” (Cavallo *et al.*, 1995; Martinetto *et al.*, 2000). The endocarps of this genus are very frequent in most Pliocene carpofloras of Piedmont (Martinetto, 1995), and *Rubus*-like foliage occurs in a few localities of the continental Pliocene (Ca’ Viettone, Gherba).

cf. ROSACEAE

Genus ?

Text-fig. 2, n. 23

Occurrence – Peola (unpubl.), pl. 30, fig. 14. A leaf from Castello d’Annone.

Remarks – The drawing by Peola recalls a leaf of *Prunus*, but it would be hazardous to propose a generic position for this leaf, which surely represents an uncommon type in the Pliocene of Piedmont.

Family SALICACEAE Mirb., 1815

Genus POPULUS Linné, 1753

POPULUS POPULINA (Brongniart, 1822) Knobloch,
1964
Pl. 7, figs 1-5

1822 *Phyllites populina* BRONGNIART, p. 237, pl. 14, f. 4.

1964 *Populus populina* (Brongniart) KNOBLOCH, p. 601.

1970 *Populus tremula* Linné - PAVIA, pl. 3, fig. 4.

Occurrence – Arboschio-L1 (*Populus tremula* Linné and *Populus monilifera* Aiton after Pavia, 1970; *Populus* cf. *tremula* Linné and *Populus* sp. after Martinetto & Mai, 1996), Baldichieri-North (two specimens), Castagnole Monferrato (an almost complete specimen and two badly preserved ones), Valmanera.

Remarks – The available specimens have been compared with modern collections of *Populus tremula* Linné showing very broad variation of most characters, which induced me to assign the much diverse poplar leaves from the Pliocene of “Asti” to a single species. The similarity between the fossil and the modern population is so strong that one could decide to assign them to the same species, as Pavia (1970) did. Also Roiron (1991) and Zastakniak (1972) decided to assign their Late Miocene and Pliocene material to *Populus tremula*. However, I follow those authors (Fischer & Butzmann, 2000; Kovar-Eder & Krainer, 1990; Kovar-Eder *et al.*, 1994) who designated the Neogene *Populus tremula*-like leaves with the epithet *P. populina* (Brongniart) Knobloch, based on fossil material. A feeble support to such decision is provided by the lack, in the “Asti” population, of the leaf morphotype with a few large and robust teeth, which is common in modern *P. tremula*. Fischer & Butzmann

(2000) affirm that *P. populina* can be differentiated by *P. tremula* on the basis of the teeth shape.

Genus SALIX Linné, 1753

SALIX VARIANS Goeppert, 1855

Pl. 6, figs 9-11

1855 *Salix varians* GOEPPERT, p. 26, pl. 20, figs 1-2.

Occurrence – Six specimens at Arboschio-L1 (*Salix* spp. after Pavia, 1970, *Salix* spp. after Martinetto & Mai, 1996) and a small leaf from Valmanera, with a finely crenulate margin and eucamptodromous venation.

Remarks – The material from Arboschio-L1 and Valmanera is too scanty and fragmentary to assess with certainty whether it belongs to one or more non-entire margined willow species. However, a dozen of complete leaves (e. g. Pl. 6, fig. 9) are available from Arboschio-L4 (sampled by G. Pavia, 1968-69, labelled as *Salix* sp., *S. integra* Goeppert, *S. media* A. Braun, *S. cf. lavateri* A. Braun and *S. cf. varians* Goeppert). They show a morphological variation comparable to the one of the non-entire margined willow leaf population from Schossnitz, which was assigned to five different species by Goeppert (1855). Heer (1856) merged *S. arcuata* Goeppert and *S. wimmeriana* Goeppert into *S. varians* Goeppert, and Zastawniak (1972) referred to this last species also *S. acutissima* Goeppert and *S. arguta* Goeppert. Thus, the name *Salix varians* Goeppert *sensu lato* can be used to designate the Arboschio-L4 willow leaves. In addition, there is no reason to exclude that also the scanty Arboschio-L1 and Valmanera material would be referred to such species. However, individual specimens (e. g. Pl. 6, fig. 10) could also be assigned to *Salix lavateri* Al. Braun in Stizenberger, 1851, whose variability has been well-shown by Hantke (1954). The occurrence of *S. lavateri* in the Messinian of “Alba” (Martinetto *et al.*, 2000) is in need of confirmation.

cf. SALIX INTEGRA Goeppert, 1855

Text-fig. 2, n. 31

?1855 *Salix integra* GOEPPERT, p. 25, pl. 19, figs 5-7, 10-16.

A lost specimen from Castello d’Annone was assigned by Peola (1896a) to *Salix integra* Goeppert. Peola’s drawing (unpubl., pl. 32, fig. 5) is too simple and does not provide unequivocal evidence for assignement to *Salix*. Several leaves of *Salix* with entire margin have been collected in the Pliocene site of Cossato, near Biella (Martinetto, 2001a), and they seem to represent a well-differentiated species of willow which was actually growing in the western Po basin during the Pliocene.

Family ?STERCULIACEAE Bartl., 1830
Genus DOMBEYOPSIS Unger, 1850

DOMBEYOPSIS LOBATA Unger, 1850
Pl. 7, fig. 6; ?Text-fig. 2, n. 33

1850 *Dombeyopsis lobata* UNGER, p. 447.

Occurrence – Two fragmentary leaves from Arboschio-L1 and L4, described as *Cercis* sp. by Pavia (1970). Possibly also at Castello d'Annone (Text-fig. 2, n. 33), drawn by Peola (unpubl.) as '*Sterculia majolana* Massalongo'.

Remarks – The leaves from Arboschio most probably belong to same species as the ones from the RDB Quarry of Villafranca d'Asti, which were assigned by Martinetto & Mai (1996) to *Byttneriophyllum tiliaefolium* (A. Braun) Knobloch & Z. Kvaček, a widespread species in the Neogene of Eastern Europe (Givulescu & Ghiurca, 1969; Givulescu, 1992; Hably & Kovar-Eder, 1996; Knobloch, 1969; Knobloch & Kvaček, 1965). However, the six specimens available from these two sites (all incomplete) always show a symmetrical cordate base (Pl. 7, fig. 6a), and one of them (RDB) has a distinct lobe. These characters (as suggested by Z. Kvaček, pers. comm.) allow to assign the Arboschio and RDB Quarry material to *Dombeyopsis lobata* Unger. This species had been placed by Knobloch (1969) in the Sterculiaceae, and even assigned to the genus *Firmiana* Marsili; however, Z. Kvaček (pers. comm.) suggests a tiliaecous affinity. One of the syntypes of *D. lobata* has been recently figured by Hably *et al.* (2001).

Family ULMACEAE Mirb., 1815
Genus CELTIS Linné, 1753

CELTIS TRACHYTICA Ettingshausen, 1853
Pl. 7, figs 7-8

1853 *Celtis trachytica* ETTINGSHAUSEN, p. 25, pl.1, fig. 7.

Occurrence – An almost complete leaf from Arboschio-L1 (*Celtis* sp. after Martinetto & Mai, 1996) and a fragmentary specimen from Valmanera.

Remarks – In the European Neogene fossil leaves of *Celtis* have been mostly designated by the epithets *C. trachytica* Ettingshausen and *C. begonioides* Goeppert, which are considered as synonyms by Hably & Kvaček (1997). *C. trachytica* can be differentiated from the modern *Celtis australis* Linné on the basis of finer and more closely spaced teeth (Knobloch, 1998; Webenau, 1995).

Leaf impressions of *C. trachytica* (= "*C. begonioides*") have been reported for the Messinian of "Alba" (Martinetto *et al.*, 2000) and compressed specimens have been recently collected in a Pliocene leaf-bearing deposit at Fossano.

Genus ULMUS Linné, 1753

ULMUS AFFINIS Massalongo, 1854
Pl. 8, figs 1-4; Text-fig. 2, ns 2, 9

?1845 *Ulmus longifolia* UNGER, p. 101, pl. 26, fig. 5. (*Nomen illegitimum*)

1854 *Ulmus affinis* MASSALONGO, p. 19, pl. 4, fig. 8.

1854 *Ulmus affinis* MASSALONGO, p. 19, pl. 4, fig. 8.

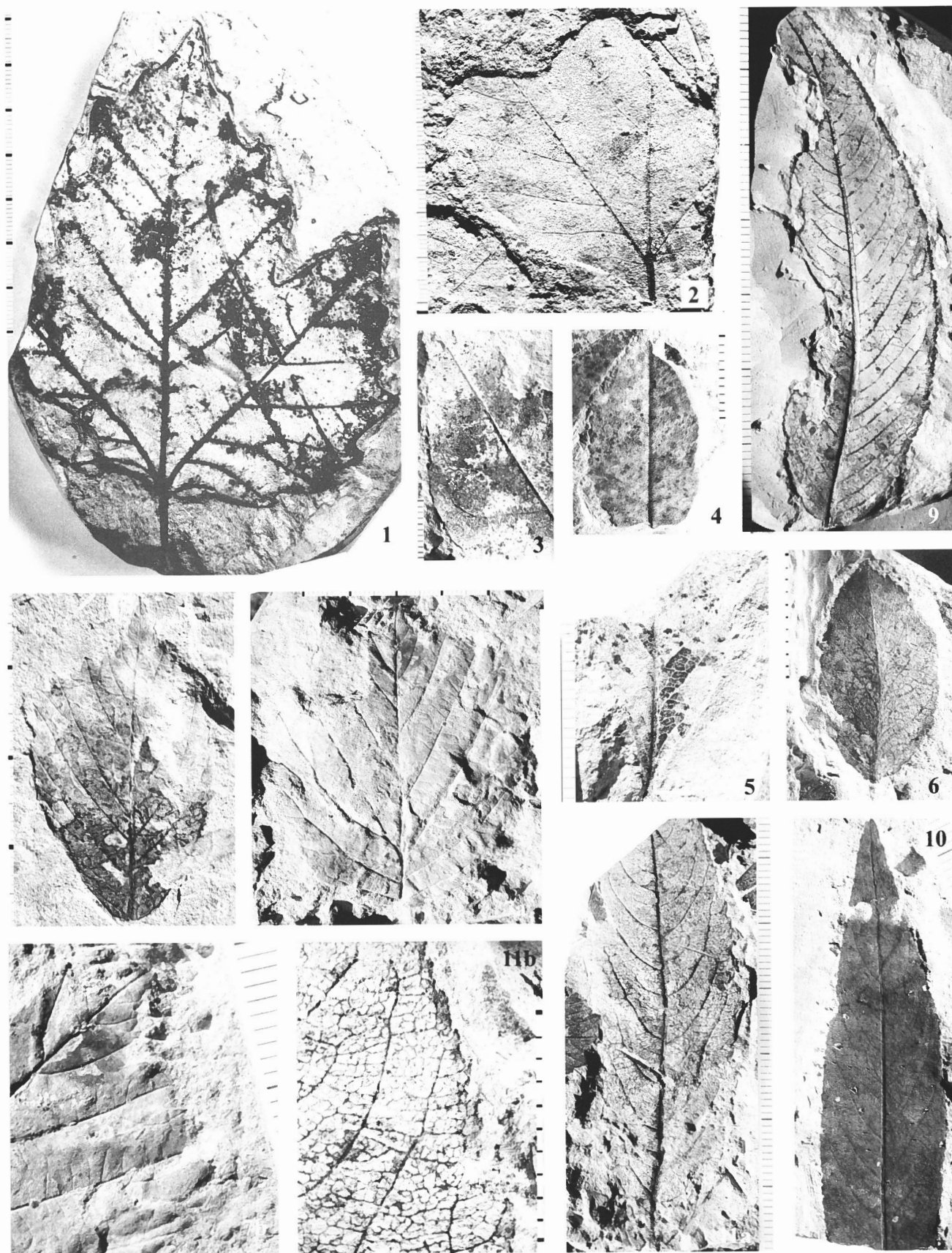
1970 *Ulmus plurinervia* Unger - PAVIA, pl. 3, fig. 3.

Occurrence – Common at Arboschio-L1 (*Ulmus plurinervia* Unger and *Ulmus longifolia* Unger after Pavia, 1970; *Ulmus* sp. after Martinetto & Mai, 1996), only a few specimens from Asti-Cascina Risso, Baldichieri-North (2 specimens, one rather well preserved: Pl. 8, fig. 3) and Valmanera. Also some lost leaves from Castello d'Annone, described by Peola (1896a) and figured in his unpublished monograph, can be tentatively assigned to this species (*Carpinus grandis* Unger, *C. pyramidalis* Heer and *Ulmus bronnii* Heer: pl. 13, fig. 11; pl. 35, figs 4, 7; less sure for pl. 13, figs 8-9).

Remarks – The diversity of the abundant elm leaves from the Pliocene of "Asti" is not larger than the one observed on a single modern elm tree (e. g. *Ulmus laevis* Pallas), so they are assigned to a single species. This can be differentiated from the modern European species on the basis of the overall slender shape, dense and numerous secondaries (Pl. 8, fig. 1) and regular, often simple, teeth (Pl. 8, fig. 2). The more or less asymmetrical base ranges from cuneate to nearly cordate (Pl. 8, fig. 4).

EXPLANATION OF PLATE 6

- Figs 1-2 - *Platanus leucophylla*. 1) Arboschio-L4, original from Pavia (1970, pl. 5, fig. 2). 2) Leaf fragment from Arboschio-L1, lg. Martinetto, 1994, PU105046.
Fig. 3 - cf. *Fraxinus* from Valmanera, PU105047.
Figs 4-6 - *Pyracantha* sp. 4, 5) Valmanera, incomplete leaves, PU105048, PU105049. 6) Arboschio-L1, lg. P. Giuntelli, 1990, PU105050.
Figs 7-8 - *Rubus* sp. 7) Arboschio-L4, lg. Martinetto, 1994, PU105051. 8) ?Arboschio-L1, MRSNT.
Figs 9-11 - *Salix varians*. 9) Arboschio-L4, lg. Pavia, 1968-69, PU105052. 10) Arboschio-L1, lg. Pavia, 1968-69, PU105053. 11a, b) Arboschio-L1, lg. Martinetto, 1994, PU105054. 11b) detail of margin and venation.



Pliocene leaves of this type from southern Piedmont have been identified by Peola (1895 and unpubl.) as *Ulmus plurinervia* Unger, 1947, and *Ulmus bronnii* Heer, 1856. Some of the "Asti" specimens are very similar to the type of *U. longifolia* Unger, 1845. However, Knobloch (1969) pointed out that the epithet *U. pyramidalis* Goeppert, 1855, must replace the older *U. longifolia* Unger, 1845, because this is an homonym of a name applied to a modern species. Goeppert (1855) described the species *U. pyramidalis* from the Miocene site of Schossnitz (now Sosnica in Poland) in association with other nine species which he hazardedly regarded as separate ones. Actually, the Schossnitz elm population does not seem to provide the same combination of characters as the "Asti" one. On the other hand, the "Asti" material shows a good agreement of characters with some of the few elm leaves described from the Messinian of Senigallia (Massalongo, 1854; Massalongo & Scarabelli, 1859). The final taxonomic assessment of such material by Massalongo (in Massalongo & Scarabelli, 1859) was absolutely not clear, however I believe that the specimens assigned to *U. affinis* Massalongo, *U. braunii* Heer, *U. elegans* Goeppert, *U. minuta* Goeppert and *U. somniorum* Massalongo could be merged into a single species. The oldest valid name for this species is *U. affinis* Massalongo, 1954, which I use to designate also the "Asti" elm species.

Genus ZELKOVA Spach, 1841

ZELKOVA ZELKOVAEFOLIA (Unger, 1843) Bůžek & Kotlaba, 1963
Pl. 7, figs 9-12; Text-fig. 2, n. 19

- 1843 *Ulmus zelkovaefolia* UNGER, p. 94, pl. 24, figs 9-13.
1963 *Zelkova zelkovaefolia* (Unger) Bůžek & Kotlaba in KOTLABA, p. 59, pl. 3, figs 7-8.

1896 *Zelkova subkeaki* Rérolle - SORDELLI, pp. 146-147, pl. 26, fig. 12.
1958 *Zelkova ungeri* (Ettingshausen) Kovats - BERGER, p. 43, pl. 13, figs 190-207.
1970 *Zelkova crenata* Spach - PAVIA, pl. 2, fig. 3.
1970 *Zelkova* aff. *acuminata* Planck - PAVIA, pl. 2, fig. 5.

Occurrence – A few specimens from Arboschio-L1 (*Zelkova crenata* Spach after Pavia, 1970), one from

Asti-Cascina Risso and four from Valmanera (only one complete). Also a lost leaf from Castello d'Annone, described and drawn by Peola (1896a and unpubl.: pl. 35, fig. 2) can be reliably assigned to this species.

Remarks – Leaves of *Zelkova* are rather easily identified for the coarsely serrate or crenate margin, with teeth varying from acute and prominent to rounded and low. A branch of the craspedodromous secondaries ends (unlike in *Quercus*) in the angular sinuses between adjacent teeth.

Zelkova zelkovaefolia is the most generally accepted name for Neogene leaves of this type in Europe (e.g. Zastawniak, 1972; Knobloch & Kvaček, 1976; Mai & Walther, 1988; Webenau, 1995). Yet several authors adopted the binomial *Zelkova ungeri* Kovats, which, according to Mai & Walther (1988), would better be used for fossil fruits. The last ones have been recorded in the Middle Pliocene of Piedmont at Villafranca d'Asti (Martinetto & Mai, 1996) and Castelletto Cervo I (Cavallo & Martinetto, 2001). Leaves of *Zelkova zelkovaefolia* have been reported from the Messinian of "Alba" (Martinetto *et al.*, 2000) and from three sites of the continental Pliocene: Arboschio-L4 (Pavia, 1970), Front-Rio Secco (Martinetto, 1995) and Villafranca d'Asti-RDB Quarry (unpublished).

Family INCERTAE SEDIS

DICOTYLEDONES gen. et sp. indet. 1 (cf. *Magnolia*)
Pl. 8, fig. 6

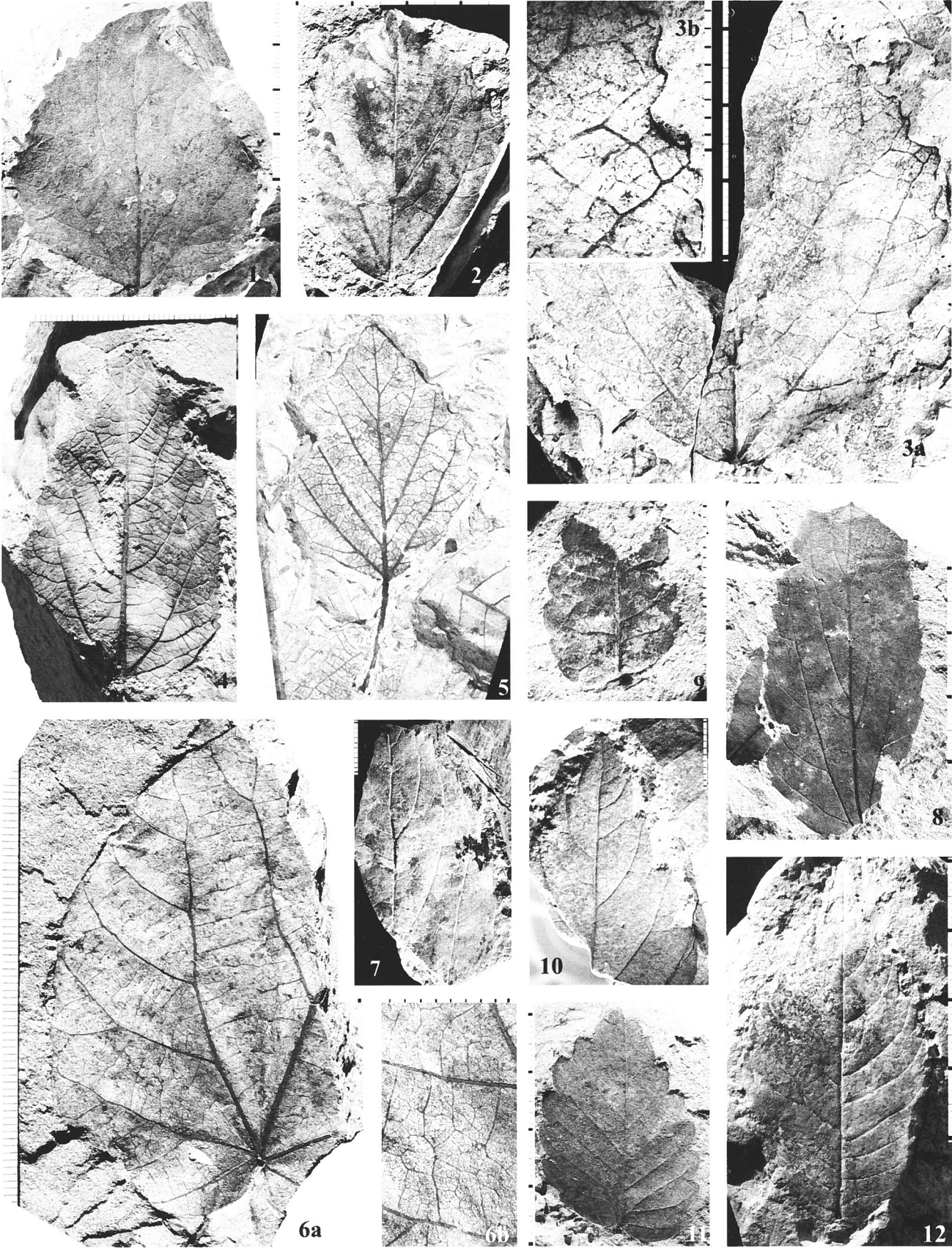
A large, entire-margined, incomplete leaf with brochidodromous venation from Arboschio-L1 resembles modern leaves of some species of *Magnolia*; however, there are no reliable differential characters, even for an assignment at family level.

DICOTYLEDONES gen. et sp. indet. 2 (cf. *Ziziphus*)
Pl. 8, fig. 5

A distinct dicotyledonous species occurring at Arboschio-L1 is represented by the impression of the basal half of an elliptic leaf with basal acrodromous venation. Z. Kvaček (pers. comm.) suggested an affinity to *Ziziphus* Miller.

EXPLANATION OF PLATE 7

- Figs 1-5 - *Populus populina*. 1) Arboschio-L1, lg. Pavia, 1968-69, PU105055. 2, 3a, b) Arboschio-L1, lg. Martinetto, 1994, PU105056, PU105057. 3b) detail of the margin and venation. 4) Leaf probably produced by a sucker-shoot, Castagnole Monferrato, PU105058. 5) Complete leaf with petiole, ?Arboschio-L1, MRSNT.
Fig. 6 - *Dombeyopsis lobata* from Arboschio-L1, lg. Pavia, 1968-69, PU105059. 6b) detail of fine venation.
Figs 7-8 - *Celtis trachytica*. 7) Leaf fragment from Valmanera, PU105060. 8) Arboschio-L1, lg. Martinetto, 1994, PU105061.
Figs 9-12 - *Zelkova zelkovaefolia*. 9) Small leaf with crenate margin from Valmanera, PU105062. 10) Apex of a leaf with serrate margin, craspedodromous venation; Arboschio-L1, lg. Martinetto, 1994, PU105063. 11) Asymmetric leaf; Arboschio-L1, lg. Martinetto, 1994, PU105064. 12) Large leaf from Valmanera, PU105065.



MONOCOTYLEDONES

Family POACEAE Barnhart., 1895
Genus "BAMBUSA" Schreb., 1789 *sensu latissimo*

"BAMBUSA" LUGDUNENSIS Saporta, 1869 emend.
Saporta & Marion, 1876
Pl. 8, figs 9-12; Text-fig. 2, ns 3-4.

1869 *Bambusa lugdunensis* SAPORTA, pp. 760-761.

1876 *Bambusa lugdunensis* Saporta – SAPORTA & MARION, pp. 224-227, pl. 23, figs 8-16.

1896a *Bambusa astensis* PEOLA, p. 5, pl. 3, fig. 3.

Occurrence – Arboschio-L1 ("*Bambusa*" cf. *astensis* Peola after Martinetto & Mai, 1996) and Valmanera.

Remarks – The lanceolate parallelodromous impressions from the two study sites are easily interpreted as the product of rather coriaceous bamboo leaves. The modern representatives of such plants are assigned to several genera with scarcely distinct leaf morphology, thus the precise generic position of the Pliocene material is difficult to assess, and the name "*Bambusa*" is used in a very broad sense.

Previous studies on the Cenozoic flora of Piedmont (Peola, 1896a, 1900 and unpubl.) indicated three bamboo species: *Bambusa alexandrina* Peola, *Bambusa astensis* Peola and *Bambusa lugdunensis* Saporta. In the light of the leaf variability shown by modern bamboo species, the different characters of the three specimens, which represent these species, do not seem to be of great relevance. I prefer to designate the "Asti" specimens as "*Bambusa*" *lugdunensis* Saporta, 1869, even if it has not yet been possible to match the material from Piedmont with the types by Saporta.

In Italy bamboo leaves have been reported from the Oligocene ("Tongriano") of Pavone d'Alessandria (Peola, 1900), the Messinian of Nizza Monferrato (Brambilla & Gallo, 2002), the Pliocene of Arboschio-L4 (*Bambusa* cf. *astensis* Peola after Pavia, 1970) and even from the early Middle Pleistocene of Oriolo near Faenza (Martinetto & Sami, 2001). In

the rest of Europe they were found in a few Miocene and Pliocene sites of Eastern Europe, in the Austrian Middle Miocene (Berger & Zabusch, 1953), in the Upper Miocene of Poland (Worobiec, 2000) and in the Neogene of southern France (Saporta & Marion, 1876; Grangeon, 1958; Roiron, 1991).

Family SMILACACEAE Vent., 1799
Genus SMILAX Linné, 1753

SMILAX WEBERI Wessel in Weber, 1855
Pl. 8, figs 7-8; ?Text-fig. 2, n. 1

1847 *Smilacites grandifolia* UNGER, p. 129, pl. 40, fig. 3 (*Nomen invalidum*).

1855 *Smilax grandifolia* (Unger) HEER, p. 82, pl. 30, fig. 8.

1855 *Smilax weberi* Wessel – WESSEL & WEBER, p. 127, pl. 21, fig. 1.

Occurrence – Two well-preserved specimens in the collection of the MRSNT, probably originating from Arboschio-L1. The stratigraphic sampling at Arboschio (Pavia, 1970; Martinetto & Mai, 1996) did not confirm the occurrence of this species in lithozone 1, while two fragmentary leaves have been collected by the present author in lithozone 7. In addition, Peola (unpubl., pl. 13, fig. 1) figured a leaf fragment from Castello d'Annone which may belong to *Smilax*.

Remarks – One of the figured specimens (Pl. 8, fig. 8) is a typical representative of *Smilax weberi* Wessel, while the other one (Pl. 8, fig. 7) has an unusual shape. However, in consideration of the consistent variation of leaf shape within modern *Smilax* species, also the second specimen is assigned to *S. weberi*. This name must be used at the place of the older one *S. grandifolia* (Unger) Heer because this is an homonym of a name applied to a modern species.

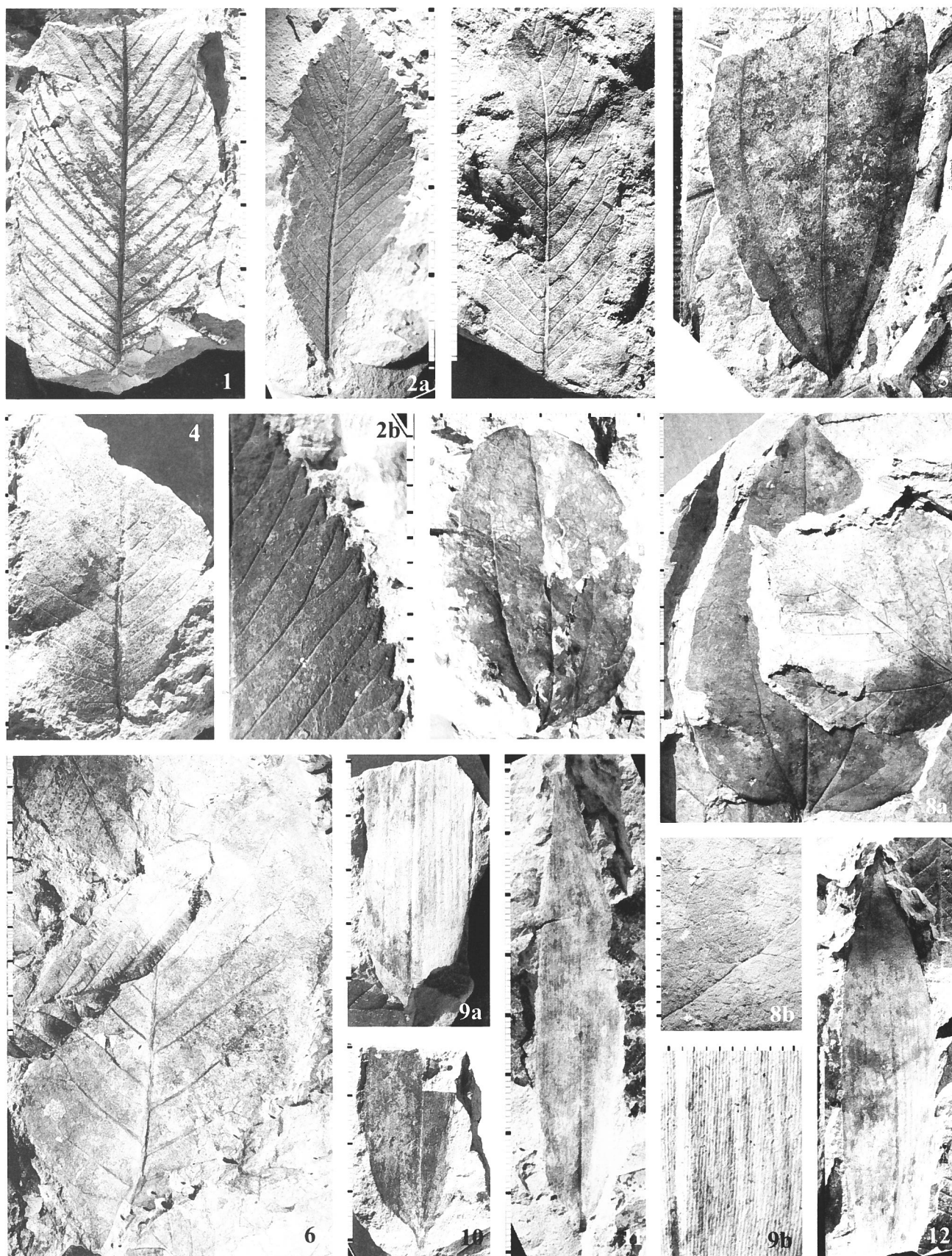
Very similar leaves from the Neogene of Tuscany have been referred to *Smilax targionii* Gaudin (Gaudin & Strozzi, 1859b; Berger, 1958).

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I thank Prof. Zlatko Kvaček for the careful review of the taxonomy and nomenclature, for the improvement of the whole manuscript, and for the help in locating 19th century bibliogra-

EXPLANATION OF PLATE 8

- Figs 1-4 - *Ulmus affinis*. 1) Valmanera, dense secondary venation, PU105066. 2a, b) Arboschio-L1, lg. Martinetto, 1994, PU105067. Leaf with both simple and composite teeth. 3) Badly preserved leaf from Baldichieri-North, with frequent dichotomous branching of secondaries, PU105068. 4) Valmanera, strongly asymmetrical base, PU105069.
- Fig. 5 - Dicotyledones gen. et sp. indet. 2 (cf. *Ziziphus*). Arboschio-L1, lg. Martinetto, 1994, PU105070.
- Fig. 6 - Dicotyledones gen. et sp. indet. 1 (cf. *Magnolia*). Arboschio-L1, lg. Pavia, 1968-69.
- Figs 7-8 - *Smilax* sp., ?Arboschio-L1, MRSNT. 7) Ovate leaf. 8a,b) Lanceolate leaf with slightly cordate base. 8b) detail of fine venation.
- Figs 9-12 - "*Bambusa*" *lugdunensis* from Valmanera, PU105072. 9a, b) Well-marked parallelodromous venation, oblique to the longitudinal furrows. 10) Base and petiole, PU105073. 11) Complete narrow leaf, PU105074. 12) broad leaf lacking the base, PU105075.



phy. I am grateful to Dr. Cecilia Binello, who collected and brought to my attention the specimens from Valmanera and discovered the leaf-bearing bed of Castagnole Monferrato. I thank Prof. Giulio Pavia for providing useful information on the 1960s collections from Arboschio and for the correction of the preliminary text. I likewise thank Dr. Lilla Hably and Dr. Bruna Merlino for reviewing the manuscript. Access to the material of the Museo Regionale di Scienze Naturali di Torino was provided through the courtesy of Dr. Daniele Ormezzano. Dr. Franca Campanino was very helpful in providing information on 19th century palaobotanical literature and on the history of the collections of the Museo di Geologia e Paleontologia of the Turin University. Dr. Elisabetta Cioppi helped me to access the Pliocene leaf collections of the Museo di Geologia e Paleontologia of the Florence University. Thanks are also due to Dr. Grzegorz Worobiec, for informations on the fossil record of bamboos in Europe, and to Dr. Dario De Franceschi, Dr. Thomas Denk, Dr. Henriette Jechorek, Dr. Guido Roghi for sending copies of 19th century papers. Financial support was provided by MIUR ex-60% funds assigned to Prof. Giulio Pavia and by the project "La diversité végétale du domaine méditerranéen: son évolution depuis 6 millions d'années", co-ordinated by Dr. Jean-Pierre Suc.

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