NEW CONTRIBUTIONS TO THE CIOCADIA MIDDLE MIOCENE FLORA (PART FOUR)

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Abstract. Some taxa from the middle Miocene Ciocadia flora of the Oltenia province, Romania, including leaves and fruits, have been systematically described in detail, or re-evaluated and updated in order to include modern taxonomic revisions on three characteristic families, Betulaceae, Juglandaceae and Fabaceae. New leaf macroremains of *Carpinus grandis* Unger sensu Heer, *Engelhardia orsbergensis* (Wessel & Weber) Jähnichen, Mai & Walther and *Podocarpium podocarpum* (Al. Braun in Buckland) Herendeen, winged fruits of *Carpinus betulus* Linnaeus *fossilis* Engelhardt & Kinkelin, *Carpinus neilreichii* Kováts, *Engelhardia macroptera* (Brongniart) Unger, and pods of *Leguminocarpum regeli* (Heer) Dotzler, are recorded and figured, and careful analytical discussion has been made on the paleoecology, phytostratigraphy and occurrence in Romania.

Keywords: National Museum of Geology (NMG), plant megafossils, winged disseminules, venation patterns, insect damage types (DTs).

Rezumat. Noi contribuţii la flora Miocenului mediu de la Ciocadia (partea a patra). Prezenta lucrare ştiinţifică însumează studii sistematice asupra câtorva taxoni fosili din flora Miocenului mediu de la Ciocadia, situată în nordul Olteniei, România. Astfel, au fost realizate descrieri detaliate dar şi revizuiri sau reevaluări moderne ale unor specii de frunze şi fructe fosile emblematice pentru familiile Betulaceae, Juglandaceae şi Fabaceae. Taxonii cercetaţi sunt *Carpinus grandis* Unger sensu Heer, *Engelhardia orsbergensis* (Wessel & Weber) Jähnichen, Mai & Walther şi *Podocarpium podocarpum* (Al. Braun in Buckland) Herendeen (frunze fosile), *Carpinus betulus* Linnaeus *fossilis* Engelhardt & Kinkelin, *Carpinus neilreichii* Kováts şi *Engelhardia macroptera* (Brongniart) Unger (involucre fructifere) şi păstăi de legume fosile aparţinând speciei *Leguminocarpum regeli* (Heer) Dotzler. Toate resturile paleobotanice au fost înregistrate în colecţia MNG, figurate în prezenta lucrare şi mai multe consideraţii analitice au fost elaborate cu privire la paleoecologia, fitostratigrafia şi distribuţia acestora în România.

Cuvinte cheie: Muzeul Naţional de Geologie (MNG), plante fosile megascopice, structuri reproducătoare aripate, nervaţiune foliară, tipuri de distrugeri ale frunzelor de către insecte.

INTRODUCTION

A new study of the fossil leaves and fruits stored within the NMG Collections from the middle Miocene section outcropping near Ciocadia village (Gorj County, Southern Carpathian Foredeep, SW Romania) is presented. The aim of this new investigation is to characterize some fossil taxa and to interpret the flora and vegetation of Ciocadia uplands during the Miocene time. The results of the research are partially summarized in the chapter 'remarks and discussions', devoted to each analysed taxon, as well as generally in the conclusions chapter at the end of this paper. All the specimens were collected by the author during the interval 2002 to present. The geologic framework of the region is relatively well known, and was subject of many publications focused on regional stratigraphic relationships (POPESCU, 1953; TUDOR, 1955; MARINESCU, 1969; ŢICLEANU, 1984; HUICĂ, 1994).

MATERIAL AND METHODS

The present paper concerns both the examination of newly collected material from the Ciocadia Valley site, and the revision of leaf and winged fruits taxa described in previous publications, according to the latest taxonomical studies. The current revision is based on the original collection of fossil plant specimens housed within the collections of the National Museum of Geology, Geological Institute of Romania, Bucharest, organized by the author of the collections, specimen numbers and taxonomic names.

The observations over vein architecture (primary, secondary, tertiary and higher-order venation) were made over a magnifying lens or by using light microscope. The morphological descriptions follow the schemes proposed by DILCHER (1974), HICKEY (1979) and WING et al. (1999). Systematic organization and taxonomic terminology in this article are based on the works of KUBITZKI (1993) and TAKHTAJAN (2009).

RESULTS IN SYSTEMATIC PALEOBOTANY

Order **Betulales** Bromhead 1838 (Corylales Dumortier 1829)
Family **Betulaceae** S. F. Gray 1821 nom. cons.
Genus *Carpinus* Linnaeus 1753

Carpinus grandis Unger 1850 sensu Heer 1856
Fig. 1a

1952 *Carpinus grandis* Unger 1850; Berger, p. 87, Pl. I, Figs. 19-22, 24-27, Pl. II, Fig. 23.
1990 *Carpinus grandis* Unger 1850 sensu Heer 1856; Givulescu, p. 66-67, Pl. XXVIII, Figs. 7-8; Pl. XXXVI, Fig. 2.
1994 *Carpinus grandis* Unger 1850 sensu Heer 1856; Belz & Mosbrugger, p. 90-92, Pl. VI, Fig. 1, Text-Fig. 36 (h-l)

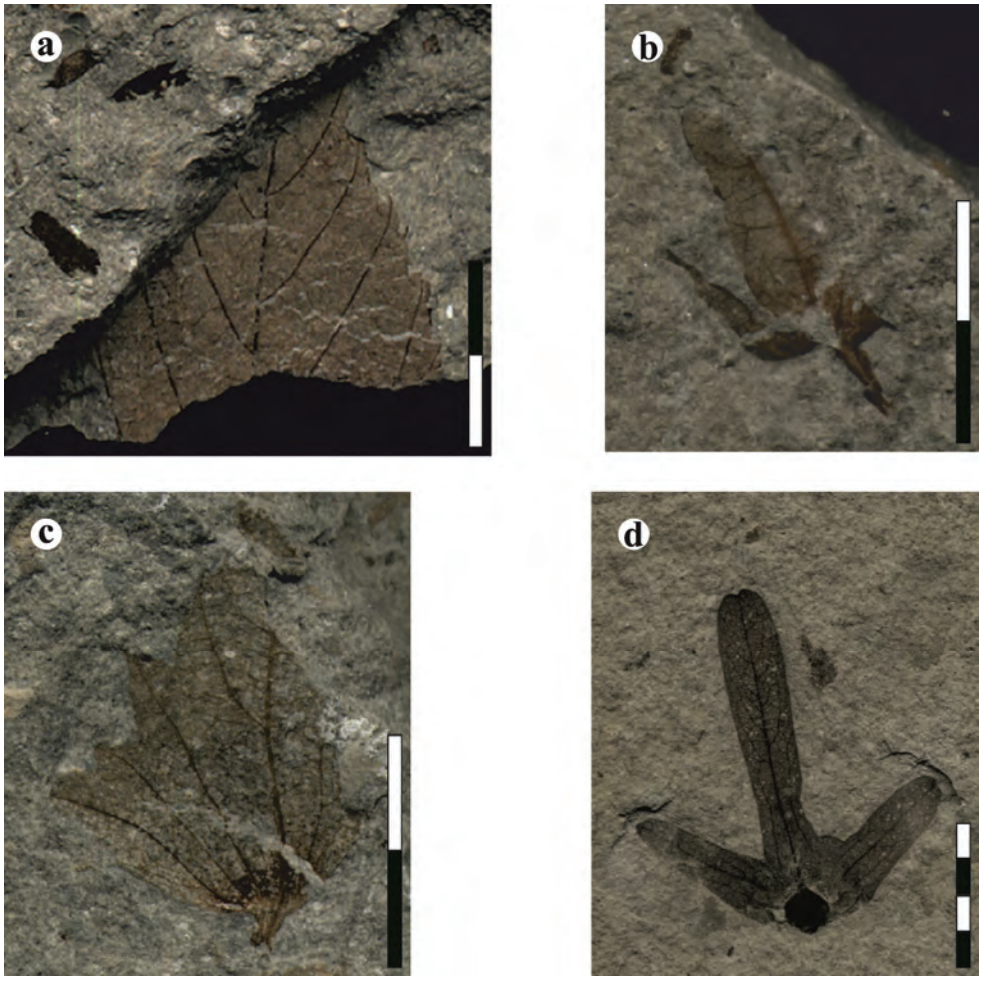

Figure 1. Leaf and winged fruits of Betulaceae and Juglandaceae.
a - *Carpinus grandis* Unger sensu Heer. Scale bar, 10 mm; b - *Carpinus betulus* Linnaeus *fossilis* Engelhardt & Kinkelin. Scale bar, 10 mm; c - *Carpinus neilreichii* Kováts. Scale bar, 10 mm; d - *Engelhardia macroptera* (Brongniart) Unger. Scale bar, 20 mm.

Material. Incomplete simple lamina: BCI.0498.

Description. Leaf simple, without base or apex preserved, lamina possibly ovate ?20 mm long and ?20 mm wide, slightly asymmetrical, margin finely double serrate (unequal teeth, small to moderate size), irregularly toothed, apical sides of teeth deeply concave to flexuous, sinuses rounded (Urticoid-Hamamelid Tooth Type, KVAČEK et al., 2011) to angular, basal sides of teeth flexuous to straight, and acute-spinose apices (with bristle tip reaching up to 0.1 cm long), teeth often slightly hook-shaped; vein spacing uniform, venation simple craspedodromous, with midrib medium thick, straight, which gradually narrows to the apex, and is gently sinuate in the upper part of the lamina; secondaries thin, pinnate, slightly bent distally (arciform) and curving towards the apex, varying steepness (alternate), only 4 pairs preserved, simple, distributed regularly at intervals of 6-8 mm, ending in tooth tips or forked near the margin, sending abmedial branches (veinlets) into the secondary teeth, the angle of secondaries with the primary vein is about 30˚; tertiaries alternate percurrent, curved, rarely forked, perpendicular or oblique to the secondary veins; higher order venation random to orthogonal; areoles perfect, quadrangular to polygonal.

Remarks and discussions. The figured specimen apparently preserves characters that can certainly be referred to this taxon. It may belong to less natural species, due to the similar gross morphological and leaf anatomical characters among species in *Carpinus* (KVAČEK & WALTHER, 1998). The double serrate leaf margin, number and arrangement of secondary veins, mostly orthogonal reticulate higher-order venation and development of veinlets (simple, exceptionally branched), but also the presence of areoles (mostly regularly orthogonal) are characteristics of the genus *Carpinus* L. and differ from leaves of other genera of Betulaceae (WOROBIEC & SZYNKIEWICZ, 2007).

Only the carpological records allow to recognize several natural species in *Carpinus*. Common tree member of the Arcto-Tertiary geoflora (and characteristic species of the late Tertiary Period, from Early Oligocene to the Late Pliocene), *Carpinus grandis* survived in the mesic vegetation within the deciduous hard-wood riparian forests

(WALTHER & KVAČEK, 2007) of temperate and subtropical zones, and historically grew throughout Eurasia, but it was also recorded in North America and Greenland. Its ecotype may be suitable also for streambanks and riverbanks, bottomland forests, lower slopes, or maritime forests. *Carpinus betulus* L. is usually considered as the nearest living relative. There are some authors that compared leaf remains of *C. grandis* with today living *C. caucasica* Grossheim and *C. orientalis* Miller from section *Eucarpinus* (see WOROBIEC & SZYNKIEWICZ, 2007). *C. betulus* grows in a wide area of Europe and in southwestern Asia, *C. caucasica* occurs in Caucasus, the Crimea, in the northern part of Asia Minor and in North Iran, and *C. orientalis* is found in south-eastern Europe and Asia Minor.

Today, *Carpinus* is a genus of about 35 species, trees and shrubs, distributed in the northern temperate regions of Europe, extending southward to SE Asia and Central America.

Two different species of *Carpinus* grow naturally in Romania, *C. betulus* and *C. orientalis* (SĂVULESCU et al., 1952). *C. betulus* is a shade tolerant species, frost resistant, widely distributed on temperate broadleaf or mixed deciduous oak forest (dominating, with a close, fairly low canopy, or admixted with *Quercus robur* Linnaeus, *Tilia tomentosa* Moench, *Acer campestre* Linnaeus) and riparian forest as flood-plain vegetation, but also in the low mountain area of mixed deciduous forests (with *Quercus petraea* (Mattuschka) Liebling, *Fagus sylvatica* Linnaeus, *Acer pseudoplatanus* Linnaeus). *C. orientalis* (an east Mediterranean, Euxino-Hyrcanian element) requires open, sunny habitats, where it grows in pure or mixed xero-thermophytic communities (plains, low hillocks vegetation), with tree cover consisting of *Fraxinus ornus* Linnaeus, *Cotinus coggygria* Scopoli, *Quercus pubescens* Willdenow.

Occurrence of *C. grandis* leaves in the fossil floras of Romania: Oligocene-Valea Jiului (Zsil-Tales, Petroșani), Hunedoara County (GIVULESCU, 1964a); Oligocene (Late Rupelian-Early Chattian)-Cornești-Aghireș, Cluj County (PETRESCU et al., 1997); Late Oligocene-Surduc, Sălaj County (PETRESCU, 1967); Late Egerian-Coruș II, Cluj District (ȚICLEANU & GIVULESCU, 1978); Sarmatian-Lapoș, Bacău County (BARBU, 1934); Sarmatian-Șoldănești (Baia), Suceava County (BARBU 1934); Sarmatian-Rădășeni-Oprișeni, Suceava County (BARBU, 1934); Sarmatian-Comănești, Bacău County (CIOCÂRDEL, 1943); Sarmatian-Borod, Bihor County (GIVULESCU, 1944); Pannonian-Băile Homorod, Harghita County (ȚICLEANU et al., 1977); Maeotian-Bunești (Fălciu), Vaslui County (BARBU 1934); Maeotian-Hârșova, Vaslui County (BARBU, 1934); Maeotian-Valea Rebricea, Vaslui County (BARBU 1934); Middle Pontian (Portaferrian)-Valea Nochi Mică (Bazinul Lugojului), Timiș County (described as *Carpinus betulus* Linnaeus, ȚICLEANU & PARASCHIV, 2001); Middle Pontian (Portaferrian)-Visag, Timiș County (ȚICLEANU et al., 1975); Pontian-Borsec, Harghita County (POP, 1936); Pontian-Băița, Maramureș County (GIVULESCU & RÜFFLE, 1971); Late Pontian (= Pannonian s.l. G/H)-Chiuzbaia, Maramureș County (GIVULESCU, 1990); Late Dacian (Early Pliocene)-Dedovița, Mehedinți County (ȚICLEANU et al., 1982).

Carpinus betulus Linnaeus 1753 *fossilis* Engelhardt & Kinkelin 1908
Fig. 1b

1991 *Carpinus betulus* Linnaeus; Roiron, p. 177, Figs. 2-14, Pl. II, Figs. 3-6, 8-9.
1997 *Carpinus betulus* Linnaeus 1753 *fossilis* Engelhardt & Kinkelin 1908; Hably & Kvaček, p. 30-31, Pl. XIII, Figs. 62, 64, 67.
2000 *Carpinus betulus* Linnaeus 1753 *fossilis* Engelhardt & Kinkelin 1908; Mai & Wähnert, p. 174, Pl. II, Figs. 1-2.

Material. Quasi-complete detached winged fruit (samara): BCI.0293.

Description. Detached leafy involucres (seed scales), asymmetric, rounded base or truncate, elongate trigonal to ovate, up to 15 mm long and ?5 mm wide, with three lobes, but one lateral missing (the outer lobe), the central lobe is much longer than the lateral lobes (inner and outer lobes, BORATYŃSKI et al., 2007); the lateral lobes are asymmetric and inserted at angles of 30˚-40˚ to the median one; apices of all lobes attenuate-acute to rounded; entire-margined to irregularly waved; venation actinodromous, one thick primary vein obvious in the central lobe, sinuate; there are present also two lateral primaries running from the base to the marginal teeth of lateral lobes; few of the secondaries seen forked, craspedodromous, irregularly spaced, moderate, relation to the midvein ca. 60 degrees on the middle portion, mostly parallel to one other, course curved, ending in tertiaries and forming large loops; tertiary veins moderate to thin, intercostal tertiaries thin, predominantly alternate percurrent, generally perpendicular to the midvein; quaternaries thin, orthogonal, forming well developed areolations; a single nut present, possibly ovoid, small, at the basis of the winged fruit; strong peduncle preserved (up to 4 mm long).

Remarks and discussions. The shape of the fruits is an important diagnostic feature for distinguishing different types of fossil hornbeam. *C. betulus fossilis* is common in the Cainozoic floras of Europe, with maximum development during the Late Miocene - the Late Pliocene. During the Pliocene *C. betulus fossilis* dominated the deciduous broad-leaved forest-floras of the Central Paratethys areas, together with species of *Fagus*, *Quercus* and *Castanea*. Connection of leaves with fruits together on the same twig has never been preserved, although some authors (e.g. BERGER, 1953) attribute similar involucres to *Carpinus grandis* Unger sensu Heer. Such fruits are seen in section *Carpinus* and the nearest extant species seems to be *C. betulus* Linnaeus (also known as *common hornbeam*, *European hornbeam*), which in a wild state grows in Europe from Gothland southward, and extends also into West Asia.

Occurrence of *C. betulus fossilis* fruits in the fossil floras of Romania: Early Sarmatian (Volhynian)-Daia (Daia Săsească, Thalheim), Sibiu County (assumed as *Carpinus vera* Andrae by ANDRAE, 1855); Early Sarmatian-Morilor Valley, Mehedinți County (PARASCHIV, 2004); Middle Sarmatian (Basarabian)-Corni, Neamț County (assumed as *Carpinus pyramidalis* Gaudin, ȚICLEANU & MICU, 1979); Sarmatian (Basarabian-Chersonian)-Râmești (Tănășești-Râmești), Vâlcea County (assumed as *Carpinus* ex gr. *grandis* Unger, ȚICLEANU, 1970); Middle Pontian (Portaferrian)-Valea Nochi Mică (Bazinul Lugojului), Timiș County (ȚICLEANU & PARASCHIV, 2001); Middle Pontian (Portaferrian)-Visag, Timiș County (assumed as *Carpinus pyramidalis* Gaudin, ȚICLEANU et al., 1975); Pontian-Borsec, Harghita County (designated as *C. grandis* Unger aff. *C. betulus* Linnaeus, POP, 1936); Late Pontian (= Pannonian s.l. G/H) Chiuzbaia, Maramureș County (GIVULESCU, 1963, 1990); Pliocene-Stoenești, Vâlcea County (assumed as *Carpinus* sp. (aff. *C. orientalis* Miller) by BARBU, 1954); Late Dacian (Early Pliocene) - Dedovița, Mehedinți County (described as *Carpinus pyramidalis* Gaudin, ȚICLEANU et al., 1982); Late Pliocene-Baraolt, Covasna County (described as *C. pyramidalis* Gaudin, PETRESCU, 1969).

Carpinus neilreichii Kováts 1856
Fig. 1c

1958 *Carpinus orientalis* Miller; Grangeon 1958, p. 63-67, Pl. V, Figs. 14, 15, 16; Pl. VI, Fig. 15.
1997 *Carpinus neilreichii* Kováts 1856; Hably & Kvaček, p. 31, Pl. XIII, Figs. 65-66; Pl. XIV, Figs. 73, 75.
1998 *Carpinus mediomontana* Mai 1978; Kvaček & Walther, p. 10-11, Pl. IV, Fig. 15.

Material. Quasi-complete detached winged fruits (samaras): BCI.0333, BCI.0669.

Description. Fruit involucres, simple, with triangular asymmetric (or inequilateral rhomboid) membranous lamina ?16-?31 mm long and ?10-?14 mm wide, base rounded, slightly cordate, extended with a short stalk, apex acuminate; actinodromous venation, with 3-5 primary veins diverging radially, straight or sinuous (sigmoidal), from a single point at the base of the involucres (however it seems that veins start from peduncle, or underneath seeds) and running toward the margin, reaching it; the primary veins have one or more subsidiary radiations above the primary one; secondaries numerous, thin, arranged parallel to one another, diverge from the primary at wide angles, some almost perpendicular to the primary; tertiaries are alternate percurrent with regular polygonal reticulate venation; areolation is well developed; margins serrate, coarsely toothed (irregularly developed marginal crenations), cuspidate or lobed; basal sides of teeth concave to flexuous, the shape of the sinus of the teeth is angular and apical sides concave; a single nut (ovoidal 3 mm long and 2 mm wide), or a visible scar in the place of its detachment at the base of the involucres is present; very strong peduncle preserved (4-6 mm long), straight or bent sideways; leathery texture or parchment-like at the base and membranous near the tip.

Remarks and discussions. Closely resembling fruits of this hornbeam species are known from the European Early Oligocene-Late Pleistocene floras (BARRÓN, 1996) erroneously described as *C. kisseri* or *C. tschonoskii* (Hably & Kvaček 1997). *C. neilreichii* is an accessory element in mesophytic forests dominated by *Quercus kubinyii*, *Zelkova zelkovifolia* and *Podocarpium podocarpum*. They are similar to those of modern *Carpinus orientalis* Miller (*C. duinensis* Scopoli, the Oriental Hornbeam) whose distribution extends from southern and central Europe (northeast Italy and Sicily to the Balkans), Turkey (Asia Minor), Crimea, Caucasus and south of the Caspian Sea (northern Iran). *C. orientalis* is a small deciduous tree or shrub, slow-growing, drought tolerant, which can dominate, as zonal element, the submontane thermophilous deciduous forests of the sub-Mediterranean area. Also, it can be an important representative of mixed deciduous forests (*Fagus sylvatica*, *Carpinus orientalis*, *C. betula*, *Quercus* spp.) that grow on mountain slopes of the Rhodope Massifs in the central Balkan Peninsula (FUND, 2012). On dry southern slopes of the Greater Caucasus Mountains, *C. orientalis* and *Quercus* spp. dominate the tree population (SCHMIDT, 2009). In the temperate broadleaf and mixed Hyrcanian forests (N Iran, especially in north of Khorassan province and disjunctly in Semnan province), natural populations of *C. orientalis* (shrublands) occur particularly on the high and middle altitude mountain slopes (up to ca. 2400 m elevation) as rock cliff communities (RAZAZ, 2013).

Occurrence of *C. neilreichii* samaras in the fossil floras of Romania: Miocene-Slătioara, Vâlcea County (designated to *Carpinus* sp. (aff. *C. orientalis* Miller) by BARBU, 1942); Middle Sarmatian (Basarabian)-Corni, Neamț County (assumed as *Carpinus* sp.? *C. kisseri* Berger, ȚICLEANU & MICU, 1979); Sarmatian-Porceni, Gorj County (assumed as *Carpinus* sp. (aff. *C. orientalis* Miller) by BARBU 1954); Sarmatian-Săcel, Gorj County (assumed as *Carpinus* sp. (aff. *C. orientalis* Miller) by BARBU, 1954); Early Pontian-Corniţel, Bihor County (attributed with confer, GIVULESCU, 1957b); Pontian-Borsec, Harghita County (POP 1936); Late Pontian (= Pannonian s.l. G/H) Chiuzbaia, Maramureș County (designated as *C.* sp. ex gr. *C. orientalis* Miller, GIVULESCU, 1964b, 1990); Pliocene-Prisaca, Olt County (described as *Carpinus* sp., MARION & LAURENT, 1898); Late Pliocene-Baraolt, Covasna County (described as *C. kisseri* Berger and *C. orientalis* Miller, PETRESCU, 1969).

Order **Juglandales** Dumortier 1829
Family **Juglandaceae** A. Richard 1818 ex Kunth 1824
Genus *Engelhardia* Leschenault 1825 ex Blume 1829

Engelhardia orsbergensis (Wessel & Weber 1856) Jähnichen, Mai & Walther 1977
Fig. 2a-d

1995 *Engelhardia orsbergensis* (Wessel & Weber 1856) Jähnichen, Mai & Walther 1977, Kovar-Eder, Hably & Derek, p. 328, Pl. III, Fig. 12; Pl. VI, Fig. 7.

2004 *Engelhardia orsbergensis* (Wessel & Weber 1856) Jähnichen, Mai & Walther 1977; Jechorek & Kovar-Eder, p. 331-332; Pl. I, Figs. 11-12.

2015 *Engelhardia orsbergensis* (Wessel & Weber 1856) Jähnichen, Mai & Walther 1977; Mantzouka, Kvaček, Teodoridis, Utescher, Tsaparas & Karakitsios, p. 61-62, Figs. 5.12-5.13.

Material. Complete or incomplete leaflets: BCI.0151, BCI.0152a, BCI.0229, BCI.0304, BCI.0576.

Description. Isolated leaflets, lanceolate to narrow elliptic, falciform, asymmetric, variable size ?17 (?23, ?24, ?70) mm long and 7.5-13 mm wide, with base asymmetrical, slightly rounded, acute or cuneate, apex acute when present, margin toothed, serrate, teeth are small, variable (sometimes coarse), usually widely spaced, irregular, with apical sides straight, concave to flexuous, teeth sinus angular, and basal sides of teeth straight to concave, their apical side is shorter than their basal side; sharp (thorn-like) or blunt apices, directed obliquely upwards; in the lower part of leaflet the margin is entire; venation semicraspedodromous, dense, midvein obvious, strong, sinuate, becoming gradually narrowed to the apex; secondaries numerous, originating at an angle of 50-80˚, thin, alternate, regularly pinnately disposed, more or less parallel, course curved, looping distally or run towards the margin and end in teeth apices; intersecondaries rare to common, parallel, thinner, arising at nearly the same or higher angles than contiguous secondaries; tertiary veins percurrent; venation of higher orders regular polygonal reticulate, areolation well developed; sessile or with rare petiolule (2 mm long) attached; texture coriaceous.

Remarks and discussions. *Engelhardia* remains (leaflets or fruits) are quite frequent and it is one of the most characteristic elements of the Ciocadia paleoflora, but no complete composite leaf has been found until present. The apex is fragmented in most of the specimens. *E. orsbergensis* is one of the most widespread species in the Tertiary floras of Europe (HABLY 1994); it appears since the middle Eocene, is very frequent in the middle Miocene (SE and Central Europe) and rare in the Pliocene when becomes extinct (KOVAR-EDER et al., 1995). In the Late Pontian deposits from Chiuzbaia it appears for the last time in Romania, revealed by pollen analysis (GIVULESCU, 1990). It seems to be a thermophilous and mesophytic element, although this palaeotropical relict species displays features more similar to xerophytic or to sclerophyllous plants (HABLY 1986). It was mostly found associated with different species of Lauraceae in broadleaf forests (subtropical laurisilvae). It prefers warm climate, disappearing gradually from European areas during climate deterioration. The leaf records of this extinct representative of the Juglandaceae have been assigned to different taxonomic units: *Protamyris* Unger, *Palaeocarya* Saporta emend. Manchester, *Ilex* Linnaeus, *Banksia* Linnaeus, *Myrica* Linnaeus, *Rhus* Linnaeus, *Sapindus* Linnaeus or *Hakea* Schrader & J. C. Wendland (GIVULESCU, 1982, 1986). The fossil species apparently resemble with the species *Engelhardia roxburghiana* Lindley ex Wallich (section *Psilocarpeae* Nagel emend. Leroy) from China and Sumatra. A close relationship exists also with the Central American *Oreomunnea mexicana* Standley revealed by cuticular studies (MANCHESTER 1987, GIVULESCU, 1994). Nowadays the endemic genus *Engelhardia* with 5 species of deciduous and evergreen trees, is distributed in subtropical and tropical regions of south-eastern Asia (northern and eastern India to eastern China, eastern Himalaya, Vietnam, Malaysia, Sumatra and Philippines). *Engelhardia roxburghiana* Lindley ex Wallich is a shade-tolerant species of tropical monsoon lowland rainforest, which appears only in the broadleaved forest zones (JUNYAN et al., 2014).

Occurrence of *E. orsbergensis* leaves in the fossil floras of Romania: Middle Oligocene-Suslănești, Argeș County (described as *Palaeocarya orsbergensis* (Weber et Wessel) Jähnichen, Friedrich et Takács, GIVULESCU, 1989); Oligocene (Late Rupelian-Early Chattian)-Cornești-Aghireș, Cluj County (PETRESCU et al., 1997); Late Oligocene-Early Miocene Muereasca de Sus, Vâlcea County (designated as *Juglans eloenoides* Unger, BARBU 1936); Late Egerian-Coruș II, Cluj District (described as *Engelhardtia detecta* Saporta, ȚICLEANU & GIVULESCU, 1978); Miocene-Slătioara, Vâlcea County (designated to *Sapindus pythii* Unger by BARBU, 1954, ȚICLEANU & PARASCHIV, 2000); Early Sarmatian (Volhynian-Early Basarabian)-Daia (Thalheim), Sibiu County (assumed as *Engelhardtia detecta* Saporta em. Kvaček, GIVULESCU, 1975); Early Sarmatian-Morilor Valley, Mehedinți County (PARASCHIV 2004); Sarmatian (Basarabian-Chersonian)-Râmești (Tănășești-Râmești), Vâlcea County (assumed as *Sapindus pythii* Unger by BARBU 1954); Late Badenian-Pârlagele, Mehedinți County (described as *Myrica lignitum* (Unger) Saporta (Fig. 2i) and *Myrica longifolia* (Unger) Saporta (Fig. 2e), STANCU & ȚICLEANU, 1975); Pannonian B-C-Valea Neagră de Criș (Valea Crișului I & II), Bihor County (described as *Rhus prisca* Ettingshausen, GIVULESCU, 1962); Early Pontian-Cornițel, Bihor County (attributed to *Rhus juglandogene* Ettingshausen, GIVULESCU, 1957b).

Engelhardia macroptera (Brongniart 1828) Unger 1851
Fig. 1d

1866 *Engelhardia macroptera* (Brongniart 1828) Unger 1851; Unger, p. 52-53, Pl. XVI, Figs. 9-11.

1996 *Engelhardia macroptera* (Brongniart 1828) Unger 1851; Bůžek, Holý & Kvaček, p. 18-19, Pl. VII, Figs. 6-9.

2004 *Engelhardia macroptera* (Brongniart 1828) Unger 1851; Kovar-Eder, Kvaček & Ströbitzer-Hermann, p. 65, Pl. VI, Figs. 8-9.

Material. Detached winged fruit: BCI.0132.

Description. Impression of an intact trialate fruit (deeply incised 3-lobed bract), large, with bracteoles fused in a basal valve called 'prophyllum', lobes widely spread (43 mm wide between the extremities), with the angle between the median and lateral wings being 50˚ to 60˚, sinuses correspondingly open, with depth of maximum 85% of the fruit, acute at the angle, which is 6 mm from the extreme base of the specimen; central lobe much longer (49 mm long) than laterals (28-29 mm long), thicker, almost equilateral, oblong-oblanceolate (spatulate) in outline, expanding gradually from a basal width of 5.5 mm to a maximum width of 8.5 mm; lateral wings inequilateral, wide at the base and gradually tapers to the apex (5-8 mm wide); apex rounded or retuse; our specimen excellently preserves the fine details of the simple pinnate (weak brochidodromous) venation and three primary veins are visible, one median primary being present in each wings; the primaries are relatively stout, sinuate, and with a slight attenuation to the tips of the wings, the strong primary vein (midrib) is flanked by a pair of weaker ascending laterals connected with midrib by a series of branching secondaries (obvious just in the first half of the lobes); secondaries numerous, thin, alternate, more or less parallel, and branch from the midvein at a wide angle, curved upward and looping along the margin; tertiary very fine, forming small arches and rectangular meshes (reticulate) within the spaces bounded by the secondaries; 'prophyllum' (the fourth lobe) rounded (as a distinct auriculae), up to 12 mm high with no detectable venation, that overlaps the other three membranous lobes; margins entire throughout, slightly undulate; nutlet is median in respect to the wing and is located at the base of the winged fruit (involucre base narrows around it); nutlet carbonified, spherical to subrhomboidal, 6 mm diameter, equipped proximally with a rostrum; the inner structure of the seed is poorly discernible due to advanced carbonization.

Remarks and discussions. Such kind of leafy bracts with well-developed prophyllum, in modern members of these groups (section Engelhardieae Manning, modern Juglandaceae) and extrapolate for the past, serves to disseminate the seeds by wind. *E. macroptera* was a warm-loving tree (thermophilous taxon), probably evergreen element. The stratigraphic range for Europe begins with the middle Eocene and ends in the Pliocene. It was present in several types of fossil vegetations, namely: mesophytic forest and deciduous forest of warm climate, subtropical-paratropical rain forest, lauraceous forest. The tissue venation and nut morphology is similar to the extant genera *Engelhardia* Leschenault ex Blume, *Alfaropsis* Iljinskaya and *Oreomunnea* Oersted, which are widely distributed in tropical and subtropical regions of the Southern and Northern Hemispheres (MANCHESTER, 1987).

Occurrence of *E. macroptera* fruits in the fossil floras of Romania: Oligocene (Late Rupelian-Early Chattian)-Cornești-Aghireș, Cluj County (PETRESCU et al., 1997); Late Oligocene-Early Miocene Muereasca de Sus, Vâlcea County (assumed as *Engelhardtia brongniarti* Saporta and *Engelhardtia producta* Unger by BARBU, 1936); Late Egerian-Coruș II, Cluj District (ȚICLEANU & GIVULESCU, 1978); Late Badenian-Early Sarmatian – Bobaița, Mehedinți County (attributed to *Engelhardtia brongniarti* Saporta, GIVULESCU, 1957a); Early Sarmatian (Volhynian-Early Basarabian) - Daia (Thalheim), Sibiu County (GIVULESCU, 1975); Early Sarmatian-Morilor Valley, Mehedinți County (PARASCHIV, 2004); Early Sarmatian-Oaș (Racșa), Satu-Mare County (attributed to *Engelhardtia brongniarti* Saporta, SAGATOVICI & ȚICLEANU, 1973); Sarmatian-Porceni, Gorj County (assumed as *Engelhardtia schlickumi* Weyland by BARBU, 1954); Sarmatian-Pietrari (Pietrarii de Sus), Vâlcea County (described as *Engelhardtia schlickumi* Weyland by BARBU, 1954); Early Pontian-Cornițel, Bihor County (attributed to *Engelhardtia brongniarti* Saporta, GIVULESCU, 1957b).

Order Fabales Bromhead 1838
Family Fabaceae Lindley 1836 (= Family Leguminosae A. L. de Jussieu 1789 nom. cons.)
Genus *Podocarpium* Al. Braun 1836 ex Stizenberger 1851

Podocarpium podocarpum (Al. Braun in Buckland 1836) Herendeen 1992
Fig. 2f

1992 *Podogonium knorrii* (Braun 1845) Heer 1859; Herendeen, p. 3-18, Figs. 12-20.
1996 *Podocarpium podocarpum* (Al. Braun 1836) Herendeen 1992; Bůžek, Holý & Z. Kvaček, p. 30, Pl. XX, Figs. 9-15.
2010 *Podocarpium podocarpum* (Al. Braun) Herendeen; Hably, Schweitzer & Szeberényi, p. 13-14, Photo 10.

Material. Complete leaflet: BCI.0287.

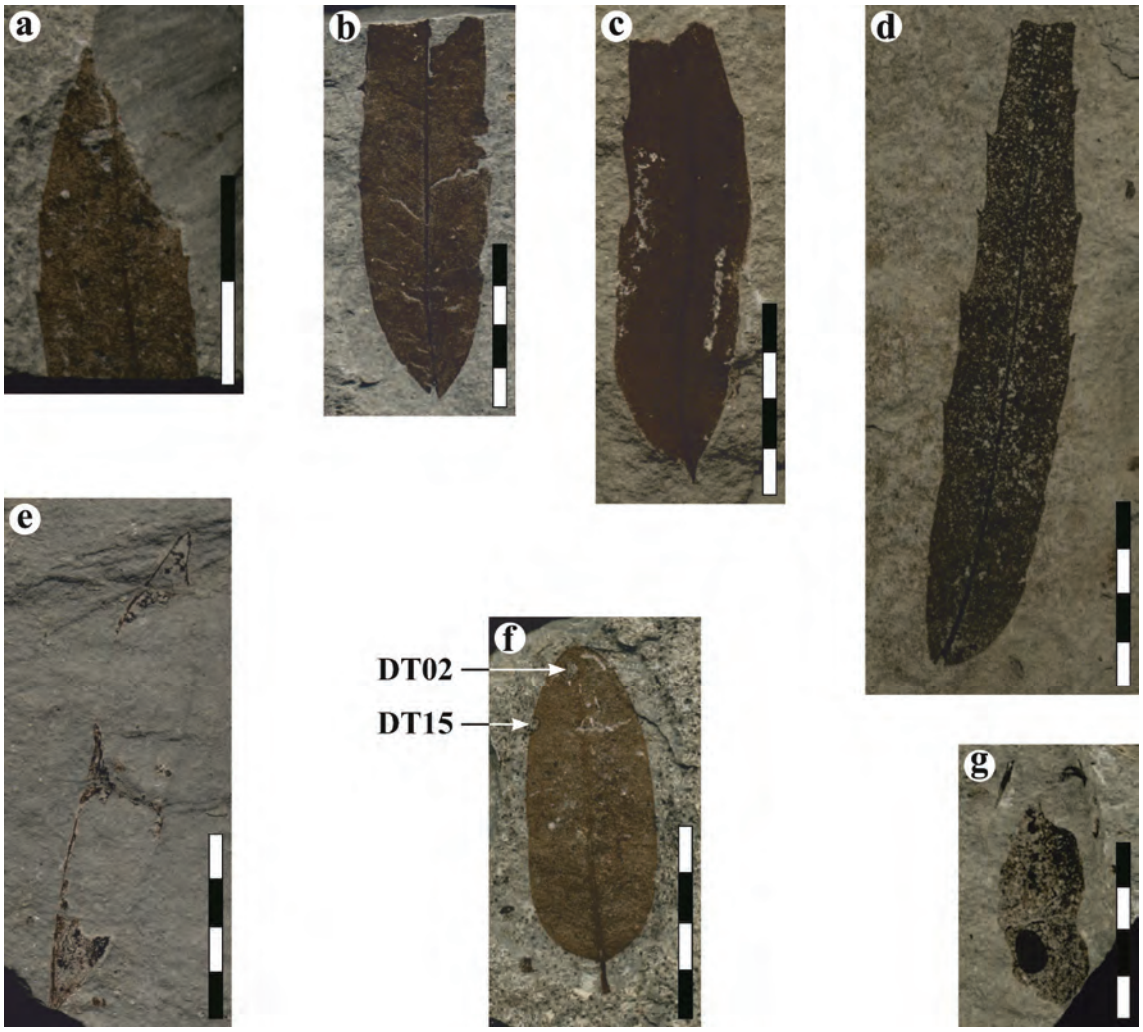

Figure 2. Leaflets and fruits of Juglandaceae and Fabaceae.
a-d - *Engelhardia orsbergensis* (Wessel & Weber) Jähnichen, Mai & Walther. Scale bars, 10 mm (a) or 20 mm (b-d); e, g - *Leguminocarpum regeli* (Heer) Dotzler. Scale bars, 20 mm; f - *Podocarpium podocarpum* (Al. Braun in Buckland) Herendeen. Scale bar, 20 mm.

Description. Impressions of detached leaflets, complete and fragments, medium to relatively large, up to 36 mm long and 13.5 mm wide (microphyll 1 to microphyll 2, WING et al., 1999), almost oblong, the widest a bit below the middle, with margins entire, subparallel, slightly undulate in some specimens, approximately equilateral throughout, about equally rounded at the apex and base (but also base can be convex), apical and basal angle obtuse; midvein invariably stout and prominent in one-half of the lamina, straight, rarely curved distally and becomes gradually thinner towards the top, secondaries and tertiaries very thin, dense, run nearly parallel, camptodrome, consisting of a series of looped and anastomosed veins, rather inconspicuous, areolation of thin veinlets forming isodiametric polygonal meshes; petiolule short and stout, 3.3 mm long and 1 mm wide, inflated at the base, slightly bent sideways; texture coriaceous.

The leaflet suffered damages caused by insects as a result of direct feeding on above-ground. Two insect damage types (DTs) are obvious (see Fig. 2f) on the upper part of the lamina, hole feeding damage (DT02, LABANDEIRA et al., 2007) as one irregular to circular perforation, 1-2 mm in diameter, which represent standard bite mark, occurring on primary and secondary veins, and margin feeding type (DT15, LABANDEIRA et al., 2007) certified by an incipient semicircular excision (about 1 mm in diameter), produced by chewing insects (possibly orthopterans or weevils).

Remarks and discussions. Typical leguminous foliage, however its generic affinity is uncertain. *Podocarpium* is a form genus with the natural affinities still dubious. Anyway the taxon is considered to represent deciduous woody plants as an Arcto-Tertiary element. Leguminosae (including *Podocarpium*) is one of the most diversified groups, mostly arboreal, of broad-leaved elements (KOVAR-EDER et al., 2006). In Europe, the maximal distribution of *P. podocarpum* falls into the early-middle Miocene (KOVAR-EDER et al., 2004). This legume mostly inhabited gallery forests under subtropical and warm-temperate climates or the plant was adapted to life in an almost dry (subxerophyte) or physiologically dry habitat, e.g. moors, fens, sunny (southern) hill-sides (BŮŽEK et al., 1996). Accessory element of

the rich Miocene floras, *P. podocarpum* frequently accompanied dominant species, as *Fagus silesiaca, Quercus kubinyii, Engelhardia orsbergensis, Zelkova zelkovifolia* in the Badenian and Sarmatian.

It is worth to mention that *Podocarpium* reacts to the feeding distress provoked by insects generating a necrotic ring spot. Because the plant response to damage is dependent on the type of insect harming it, the first measure was to repair damaged tissue sealing off the attacked area. In this manner, insects can cause damage resulting in tissue necrosis (death of cell or tissues). Necrosis is rather a symptom of disease, because insects can serve as vectors of infections, introducing disease to a plant after feeding on an infected plant.

Occurrence of *P. podocarpum* leaflets in the fossil floras of Romania: Middle Eocene-Gârbou, Cluj County (assigned to *Sophora* cf. *secundiflora* DC., PETRESCU et al., 1976); Oligocene (Late Rupelian-Early Chattian)-Cornești-Aghireș, Cluj County (described as *Cassiophyllum berenices* (Unger) Kräusel, PETRESCU et al., 1997); Late Oligocene-Early Miocene Muereasca de Sus, Vâlcea County (assumed as *Leguminosites* sp., BARBU 1936); Sarmatian-Porceni, Gorj County (assumed as *Robinia affinis* Marion & Laurent, MARION & LAURENT, 1898); Early Sarmatian (Early Volhynian)-Deva, Hunedoara County (assumed as *Gleditschia suevica* Rüffle and *Podogonium lyellianum* Heer, ȚICLEANU & ARTIN, 1982); Early Sarmatian-Tâmpa, Hunedoara County (described as *Leguminosites* sp., BARBU 1932); Pannonian B-C-Valea Neagră de Criș (Valea Crișului I & II), Bihor County (described as Leguminosen-Blatt, GIVULESCU, 1962); Early Pontian-Corniţel, Bihor County (attributed to cf. *Sophora bilinica* Ettingshausen, GIVULESCU 1957b); Pontian-Borsec, Harghita County (assigned to *Leguminosites* sp., POP, 1936); Late Pontian (= Pannonian s.l. G/H)-Chiuzbaia, Maramureș County (GIVULESCU, 1990).

Genus *Leguminocarpum* Dotzler 1937

Leguminocarpum regeli (Heer 1859) Dotzler 1937
Fig. 2e, g

1859 *Robinia regeli* Heer; Heer, p. 99-100, Pl. 132, Figs. 34-41.
1937 *Leguminocarpum regeli* (Heer 1859) Dotzler; Dotzler, p. 42-43, Pl. V, Figs. 6-7.
2004 *Leguminosites parschlugianus* (Unger 1850) Kovar-Eder & Z. Kvaček 2004; Kovar-Eder, Kvaček & Ströbitzer-Hermann, p. 74, Pl. IX, Figs. 6-7.

Material. Fragments or complete large pods: BCI.0541, BCI.0563.

Description. Compressed pods (fruits), lanceolate, curved (falcate) or quasi-linear in outline, ?23 to 54 mm long and 9 to 10 mm wide, with two valves, glabrous, inflated; there are several seeds in a fruit, which is slightly arched over the cavity and contained at least two seeds widely spaced, moniliformly disposed, and apparently transversely elongate elliptical (ovoid or reniform) in outline, slightly crinkled, 5 mm long axis and 3.5 mm short axis; seeds eccentrically arranged against pod walls, stand along the axis of the fruit (possibly because the seed was disturbed from its loculus) and not greatly flattened during fossilization (carbonization) being much smaller than the seed cavity; the outline of the pod is rounded to flattened where neighbouring seeds meet; the margins are thickened, with strong obvious replum (but all the sutures are broad and strong), constricted medianly to 8.5 mm wide (diameter slightly greater on the both sides of the middle of the pod, see Fig. 2e); the pods are rather gradually narrowed at both ends, with bluntly pointed apex (beak-like structure) and almost complete base; the surface is finely cross (or intricately reticulate) veined; the veins seems to start oblique from the sutures diverging rapidly in Y form; texture coriaceous, and no peduncle preserved.

Remarks and discussions. There is no certainty regarding the true generic affinity of these pods, although the shape, thickness, length or curve can be diagnostic for some taxa. They are named for their resemblance to the pods of Legumes, fruits which are distinctive and the most ready resource by which to identify members of the Leguminosae family. Leguminous fruits (pulses) of this kind were identified in Europe from the Late Oligocene until the Pliocene. *Leguminocarpum* is a thermophilic element that was probably associated with subxeric woodland. The leguminosae fruit, however, resemble modern pods produced by the representatives of the family of Fabaceae Mimosoideae (e.g. *Albizia, Acacia*) or Papilionoideae (e.g. *Robinia*). The pods of Ciocadia flora were tardily or not at all dehiscent because they still preserved seeds inside. In order to document the gross features of the fossil pods, the presence of thickened pod walls can be explained as temporary reservoir of assimilates and other nutrients, protection measures for the seeds during development, and source-sink pathway that delivers nutrients to the seed coat (WANG & GRUSAK, 2005).

Occurrence of *Leguminocarpum regeli* pods in the fossil floras of Romania: Oligocene (Late Rupelian-Early Chattian)-Cornești-Aghireș, Cluj County (described as *Leguminocarpum* sp. aff. *Caesalpinia* sp., PETRESCU et al., 1997); Late Egerian-Coruș II, Cluj District (described as *Leguminocarpon* sp., ȚICLEANU & GIVULESCU, 1978); Early Miocene-Coruș, Cluj County (attributed to *Leguminocarpon* sp., GIVULESCU, 1969); Miocene-Slătioara, Vâlcea County (designated *Leguminosites trispermus* Marion & Laurent, MARION & LAURENT, 1898); Badenian-Valea Glâmboaca, Vâlcea County (assumed as pod of *Cassia* sp. by BARBU, 1954); Early Sarmatian-Morilor Valley, Mehedinți County (PARASCHIV, 2004); Pannonian B-C - Valea Neagră de Criș (Valea Crișului I & II), Bihor County (described as *Leguminosites* sp., GIVULESCU, 1962); Early Pontian-Corniţel, Bihor County (attributed to *Podogonium knorrii* (Al. Braun) Heer, GIVULESCU, 1957b); Pontian-Borsec, Harghita County (assigned to *Leguminosites* sp. or *Podogonium knorrii* (Al. Braun) Heer, POP, 1936).

CONCLUSIONS

The fossil flora from the Ciocadia Valley is well comparable to other middle Miocene assemblages from Romania and Europe, thanks to the diversified local flora, species richness and considerable numbers of genera. Two fossil-genera representing disarticulated fossil legume organs, *Podocarpium* and *Leguminocarpum*, are described for the first time from this site. Multiple taxonomic relations are considered with emphasis on *Carpinus*, *Engelhardia* and Leguminosae. The zonal- or intrazonal appearance of the vegetation shares miscellaneous characters, both in physiognomy and composition, of mesic vegetation within the deciduous hard-wood riparian forests and subhumid (subxeric woodland) thermophilic gallery forests, under subtropical and warm-temperate climates.

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