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THE DETERMINATION AND TAXONOMIC PROBLEMS OF PALAEOGENE FOSSIL MACROFLORA FROM SLOVENIA AND CROATIA

ENIO JUNGWIRTH

Institute for Research and Development of Defence Systems,
Ilica 256 b, 10000, Zagreb, Croatia

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This paper discusses the complexity of the determination and taxonomy of Palaeogene fossil floras from Slovenia (village of Socka, north of Celje; Sava folds in Central Slovenia) and Croatia (Central Dalmatia – Mt Promina). One of the most important problems presented by the determination of individual species of fossil leaves is connected with the complex classification (species, genus and family) of traditional determinations of architecture and leaf morphology and also of cuticular studies. In this case, the problems are related to the determination of some fossil leaves and the morphological similarities inside some families, genera or species and among some families. This is related to conifers (Cupressaceae, Taxodiaceae, Araucariaceae), laurels (similarities among themselves and between some families), the families Myricaceae, Moraceae, Rhamnaceae, Proteaceae, Sapotaceae and »Leguminosae« type of leaves. In spite of these problems general palaeobotanical conclusions are very close to composition of classic Palaeogene palaeo-phytoassociations.

Key words: determination, taxonomy, palaeogene, macroflora, Slovenia, Croatia

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Članak ističe složenost determiniranja i taksonomsku problematiku uzoraka fosilne makroflore iz Socke i Posavskih bora (Slovenija) i šire okoline planine Promine (Hrvatska). Posebice je izražena problematika određivanja pojedinačnih uzoraka i njihovo pravilno svrstavanje (vrsta, rod, porodica), no unatoč svemu ne remeti se zaključak o ukupnom sastavu i karakteru fosilnih biljnih zajednica toga doba. Ovdje se ističe problematika određivanja pojedinih vrsta i njihove međusobne morfološke sličnosti, kako unutar samih porodica, rodova i vrsta, tako i između pojedinih vrsta. To se odnosi na fosilne četinjače (Cupressaceae, Taxodiaceae, Araucariaceae), lovore (međusobne sličnosti i sličnosti pojedinim drugim porodicama), porodice Myricaceae, Moraceae, Rhamnaceae, Proteaceae, Sapotaceae i lišće tzv. »leguminoznoga tipa«.

Ključne riječi: determinacija, taksonomija, palaeogen, makroflora, Slovenija, Hrvatska

INTRODUCTION

In Slovenia (Socka, Sava folds) Palaeogene flora was found in the so-called Socka Beds. The term Socka Beds (Socka-Schichten) was introduced into the literature by ROLLE (1858). CIMERMAN & PLENIČAR (1985) claim that these sediments from the Sava folds ought to be renamed or put in quotation marks. JELEN *et al*. (1992) use the term Pseudo Socka Beds, and finally for PLACER (1999) the most compatible term to be found is the Trbovlje (see Tab. 1). Because of the mining works in the Sava Folds (e. g. at the localities of Zagorje, Trbovlje, Hrastnik, Laško), numerous remains of fossil molluscs, fish, turtles, mammals and plants have been found, determined and described (e. g. ETTINGSHAUSEN, 1885; HÖRNES, 1876, 1892; GORJANOVIĆ-KRAMBERGER, 1895; ANĐELKOVIĆ, 1989 etc.). In Croatia rich Palaeogene fossil flora and fauna (e. g. ETTINGSHAUSEN, 1855; MEYER, 1853; VISIANI, 1858; DAINELLI, 1901; PAVLOVEC, 1959 etc.) have been found in the Promina formation (Mt. Promina). The term Promina Beds (Promina-Schichten) was introduced into the literature by FOETTERLE (1851).

The abundant palaeoflora found in the vicinity of the village of Socka (UNGER, 1850) represents a palaeotropic, xerophilous flora with some arctotertiary floristic elements. Collected fossil flora at localities in the Sava folds (Zagorje, Trbovlje, Hrastnik and Laško) with similar elements originate from different part of the Trbovlje Formation (ex Socka Beds). Palaeoflora from overlying marls characterized by the domination of palaeotropic over arctotertiary elements, which are more numerous than at the locality of Socka or the lower horizons at Zagorje. On the basis of the composition of fossil plant elements, two different fossil floras existed. The oldest flora is from Socka and the footwall sediments of coal seams in Zagorje. Younger flora originated from the overlying marls at Zagorje and Trbovlje. MIHAJLOVIĆ & JUNGWIRTH (1988) described fossil flora from Novi Dol near Hrastnik. The determined flora shows different ecologic features. The subtropical character of the palaeo-phytoassociation is marked by the complete absence of arctotertiary elements, so it is much closer to the fossil flora from Socka than that of Trbovlje.

DETERMINATION AND TAXONOMIC PROBLEMATIC

One of the most important problems presented by the determination of individual species of fossil leaves is connected with the complex classification (species, genus, family) of traditional determinations of architecture and leaf morphology. On the basis of numerous fossil plants remains and taxa revisions (JUNGWIRTH, 2001), at Socka locality to date 134 species of palaeotropic plants have been discovered (46 families, 79 genera), in the Sava folds 386 species (80 families, 175 genera) and at Mt Promina 96 species (37 families, 65 genera). Some characteristic samples are shown here.

Coniferae – It is very hard to differentiate the shoots of conifers from the adult parts. For this reason suspicion of some determinations and taxonomic positions is justified. ETTINGSHAUSEN (1885) determined two species from Zagorje as *Libocedrus*

Tab. 1 (JUNGWIRTH, 2002 – Unpublished) Historical review of the terms and chronological position of Socka Beds in Slovenia

TERMINOLOGY	LOCALITIES	AUTHOR (S)	AGE
Marine clay	Sava folds (Orlek)	Pleničar & Rijavec (1975)	Egerien
	Sava folds	Papp (1954)	Lower Egerien
	Sava folds (Zagorje)	Cimerman (1979)	Rupelian/Egerian
	Sava folds	Cimerman (1967)	Middle Oligocene
Trbovlje Formation ♣	Sava folds	Placer (1999)	Middle Oligocene
Pseudo Socka Beds ♣	Socka	Jelen et al. (1992)	Rupelian
»Socka Beds« ♣	Sava folds (Zagorje)	Cimerman (1979)	Rupelian
	Zagorje synclinorium	Cimerman & Pleničar (1985)	Oligocene
Socka Beds s. sl. ♣	Sava folds (Zagorje)	Pilar (1883)	Aquitanien
	Sava folds (Trbovlje)	Morlot (1850)	Miocene
	Senovo	Munda (1939)	Chatian
	Sava folds	Petrascheck (1926/29)	Chatian
	Zagorje	Kuščer (1967)	Lower Rupelian
	Sava folds	Mojzon (1958)	Lower Rupelian
	Sava folds	Anđelković (1989)	Rupelian
	Sava folds	Mai (1995)	Middle Oligocene
	Sava folds (Novi Dol)	Mihajlović & Jungwirth (1988)	Upper Stampien
	Sava folds	Bittner (1884)	Oligocene
	Sava folds	Ettingshausen (1855)	Eocene Formation
Socka Beds s. str. ♣	Socka	Mioč (1976)	Helvetian
	Socka	Rolle (1858)	Miocene
	Socka	Jelen et al. (2000)	Upper Eocene
	Socka	Jelen et al. (1992)	Biarritz-Bartonian
	Socka	Pilar (1883)	Lower Oligocene = Tongrien
	Socka	Ettingshausen (1855)	Eocene Formation
	Socka	Unger (1850)	Eocene Formation

Tab. 2 (JUNGWIRTH, 2001) Tabular review of Common Species

Number of species	Locality	Sava folds	Village of Socka	Mt Promina
386	Sava folds	–	69	39
134	Village Socka	69	–	41
96	Promina Mt.	39	41	–

salicornioides (UNGER) HEER and *Callitris brongniartii* (ENDLICHER) HEER. KVAČEK (1986), on the basis of cuticle analyses, describes the first species as *Tetraclinis salicornioides* and the second as *Tetraclinis brachyodon*. Speaking about the fossil remains of needle leaves, we must point out that they were determined as species of different sequoias. The sample of the species *Sequoia sternbergii* (GÖPPERT) HEER, well known from Socka, the Sava folds and Mt Promina, today known as *Doliostrobus taxiformis* (STERNBERG) KVAČEK, was described as species of different genera (*Doliostrobus*, *Cryptomeria*, *Araucarites*), which indicates the morphological polymorphism of the species. The species *Athrotaxis couttsiae* (HEER) GARTNER from Zagorje is better known as *Sequoia couttsiae* HEER, while the species *S. abietina* (BRONGNIART) KNOBLOCH, also from Zagorje, was earlier determined as *S. langsdorfii* BRONGNIART. The sample from Socka described (UNGER, 1850) as *Ephedrites sotzkianus* (Ephedraceae) could be considered the synonymous species *Casuarina sotzkiana* UNGER sp. of the family Casuariaceae (ETTINGSHAUSEN, 1855; 1872) from the Sava folds and Mt Promina. Fossil remains are similar to recent Mediterranean species *Ephedra fragilis* DESFONTAINES (= *E. campylopoda* MEY).

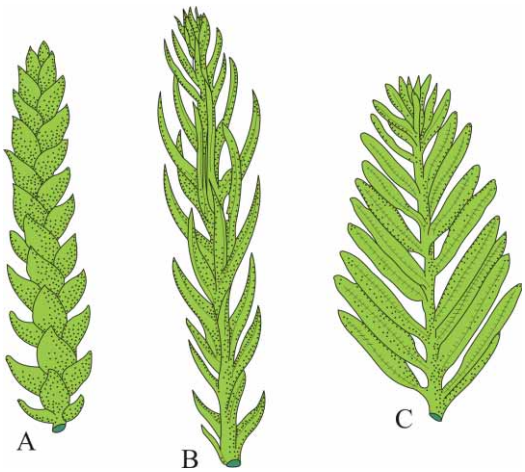

Fig. 1. Three types of young shoots of the genus *Glyptostrobus* from the Tertiary (redrawn from STEWART, 1990)

A – Cupressoid type; **B** – Cryptomeroid type; **C** – Taxodiodid type

Lauraceae – This family is very interesting for the reason that its species have leaves morphologically close to one another (»lauoroid« type of leaves). Another significant property is the great similarity with species of different families, e. g. the genus *Ficus* (Moraceae). Previous determinations actually are known as »*Laurus*« or »*Laurophyllum*«. We also vary three morphological genera *Laurophyllum*, *Daphnogene* (= *Cinnamomophyllum*) and *Laurophyllites* where »lauroid leaves« could be included. Cuticular analysis (KVAČEK, 1988) indicates however that the family Lauraceae is composed of several genera with such a type of leaves, *Daphnogene*, *Cinnamomop-*

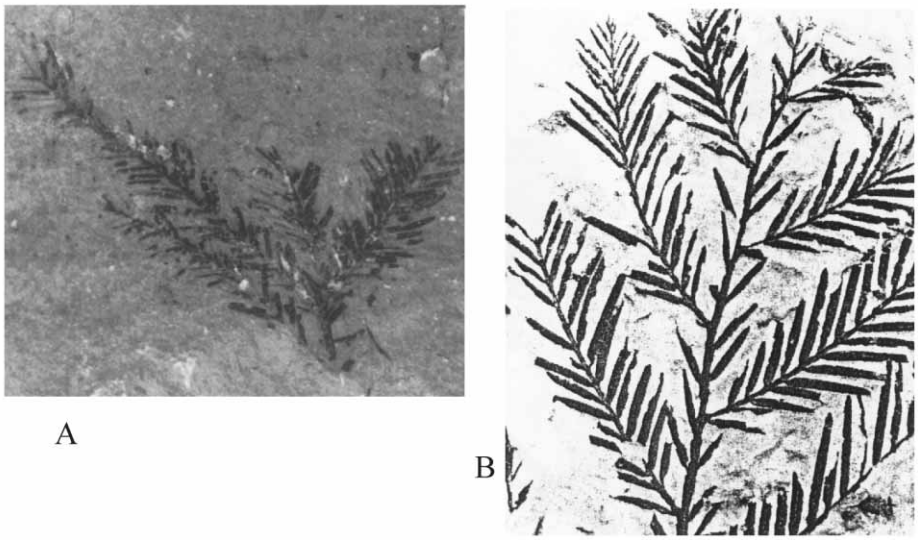

Fig. 2. Similarity between (A) *Sequoia abietina* (Sava folds – Lower Oligocene) and (B) *Metasequoia occidentalis* (Canada – Upper Cretaceous)

hyllum (*Cinnamimphyllum*), *Laurus*, *Lindera*, *Litsea*, *Ocotea*, *Cryptocarya* and some further genera. At the localities of Socka, the Sava folds and Mt Promina, numerous »lauroid« types of leaves have been found. Those which belong to the family Lauraceae are ?*Cinnamomum spectabile* HEER, *Daphnogene cinnamomofolia* (BRONGNIART) UNGER forma »*cinamomofolia*« (= *Cinnamomum scheuchzeri* HEER), *D. cinnamomofolia* (BRONGNIART) forma »*lanceolata*« (= *C. lanceolatum* UNGER sp., *C. polymorphum* AL. BRAUN, *C. rössmassleri* HEER, *Daphnogene melastomacea* UNGER), *Daphnogene bilinica* (UNGER) KNOBLOCH, *D. polymorpha* (AL. BRAUN) ETTINGSHAUSEN, *Laurophyllum* cf. *acutimontanum* MAI (= *Laurus ocoteaefolia* ETTINGSHAUSEN), *L. neomarchicum* RÜFFLE, MÜLLER-STOLL et LITKE (= *Laurus stenophylla* ETTINGSHAUSEN), *L. princeps* (HEER) KRÄUSEL et WEYLAND (= *Laurus princeps* HEER), *L.* cf. *pseudoprinceps* WEYLAND et KILPER (= *Laurus lalages* UNGER, *L. primigenia* UNGER), »*Persea*« *heeri* ETTINGSHAUSEN, »*P.*« *speciosa* HEER etc.

Fagaceae – An exceptionally great number of evergreen oaks has been described from only Socka (UNGER, 1850) and the Sava folds (ETTINGSHAUSEN, 1885), e. g. »*Quercus*« *cuspidata* ROSSMÄSSLER, »*Q.*« *cyri* UNGER, »*Q.*« *drymea* UNGER, »*Q.*« *lonchitis* UNGER, »*Q.*« *pseudo-lonchitis* UNGER, »*Q.*« *mediterranea* UNGER, »*Q.*« *tephrodes* UNGER, »*Q.*« *urophylla* UNGER. According to cuticular analysis (JÄHNISCHEN, 1956) some representatives belong to starting species of oaks (or chestnuts) *Castanopsis furcinervis* (ROSSMÄSSLER) KRÄUSEL et WEYLAND i. e. *Dryophyllum furcinerve* (ROSSMÄSSLER) SCHMALHAUSEN or *Eotrigonobalanus furcinerve* (ROSSMÄSSLER) KVAČEK et WALTHER. The abundance of these elements is very significant because they are representatives of xerophyte flora in a mesophyte forest. The determination of the arctotertiary species *Castanea atavia* UNGER from Socka is also questionable.

Moraceae – Some leaf imprints from the Sava folds and especially from the village of Socka are ascribed to *Ficus* (e. g. *Ficus tiliaefolia* AL. BRAUN sp.,*»Ficus« aglajae* UNGER, *»F.« apollinis* ETTINGSHAUSEN, *»F.« arcinervis*, HEER, *»F.« bumeliaefolia* ETTINGSHAUSEN, *»F.« degener* UNGER, *»F.« jynx* UNGER, *»F.« lanceolata* HEER, *»F.« morloti* UNGER, *»F.« pseudo-jynx* ETTINGSHAUSEN, *»F.« sagoriana* ETTINGSHAUSEN, *»F.« weteravica* ETTINGSHAUSEN etc.). Because of the unknown taxonomic position, it is customary to assign *»Ficus«* or *»Ficophyllum«* as the genus. Similar leaves can be found inside the family Lauraceae.

Myricaceae – In spite of the fact that remains of fossil Myricaceae are frequently found in the Palaeogene sediments, the genera *Myrica* and *Comptonia* are not distinctly divided. Polymorphic imprints are ascribed to different families, especially to representatives of the family Proteaceae (*Bankisia, Dryandroides, Hakea*) or the family Araliaceae (ETTINGSHAUSEN, 1872; MIHAJLOVIĆ, 1985). At the same time some species of the family Proteaceae have by mistake been assigned to the genera *Myrica* or *Comptonia*. Some determinations of *Myrica* today are ascribed to *Englehardtia* (Juglandaceae). The prominent polymorphism is the reason why the »myricoid« type of leaf was proposed to have been used by one sum species, i. e. the xerothermal species *Myrica lignitum* (UNGER) SAPORTA (MIHAJLOVIĆ, 1985). From the Sava folds, Socka and Mt Promina there are *Comtonia dryandroides* UNGER (= *Myrica dryandroides* UNGER, *Dryandra ungeri* ETTINGSHAUSEN), *Comptonia schrankii* (STERNBERG) BERRY (= *C. dryandrifolia* BRONGNIART, *Dryandra brongniartii* ETTINGSHAUSEN), *Myrica banksiaefolia* UNGER (= *Banksia ungeri* ETTINGSHAUSEN, *B. haringiana* ETTINGSHAUSEN, *Dryandroides angustifolia* UNGER, *Myrica haeringiana* UNGER), *Sotzkia longifolia* ZHILIN (= *Myrica longifolia* UNGER, *»Banksia longifolia«* ETTINGSHAUSEN).

Juglandaceae – Fossil remains today counted as *Engelhardtia macroptera* (BRONGNIART) UNGER were earlier determined as *Carpinus macroptera* BRONGNIART (Betulaceae), *Engelhardtia brongniarti* SAPORTA or *Palaeocarya brongniarti* SAPORTA. The species *E. orsbergensis* (WESSEL et WEBER) JÄHNISCHEN, MAI et WALTHER is equivalent to *E. detecta* (SAPORTA) KVAČEK or *Myrica lignitum* (UNGER) SAPORTA. JÄNISCHEN *et al.* (1977) considered that fossil remains of genus *Engelhardtia* are ascribed to the Anacardiaceae (*Rhus*), Rutaceae (*Zantoxylum*), Proteaceae (*Dryandroides, Hakea, Banksia*), Sapindaceae (*Sapindus*) even Myricaceae (*Myrica*). Some determinations of the genus *Carya* [*Carya bilinica* UNGER = *Prunus juglandiformis* UNGER; *C. elaenoides* UNGER sp. = *Juglans elaenoides* UNGER; *C. heerii* ETTINGSHAUSEN = *J. hydrophila* UNGER = *Rhus hydrophila* UNGER; *C. serrifolia* (GÖPPERT) KRÄUSEL =? *Pterocarya denticulata* WEBER] from Socka and the Sava folds are also a great problem. The species determined as *»Juglans acuminata«* (AL. BRAUN) HEINKE from Zagorje may be compared with the recent species *J. regia* LINNÉ.

Cunoniaceae – Some representatives of this family are present in the composition of fossil flora in Socka and the Sava folds (Zagorje = Zavine). The number of species described of the genus *Ceratopelatum* has been reduced over time, and some of them have been interpolated into the species *Platanus neptuni* BŮŽEK, HOLY et KVAČEK (BŮŽEK *et al.*, 1967). In this family, ETTINGSHAUSEN (1877) has included the species, *Zantoxylum sotzkiana* GREGOR (GREGOR, 1989), *Weinmania sotzkiana* ETTINGHAUSEN (= *Celastrus andromedae* UNGER and *C. dubius* UNGER).

Myrtaceae – Nine different species are found at the localities Socka (4), the Sava folds (7) and Mt Promina (4), i. e. »*Callistemophyllum*« *acuminatum* ETTINGSHAUSEN, »*C.*« *diosmoides* ETTINGSHAUSEN, »*C.*« *malaleucaeforme* ETTINGSHAUSEN, »*Eugenia*« *aizoon* UNGER, »*E.*« *apollinis* UNGER, *Eucalyptus grandifolia* ETTINGSHAUSEN, *E. haeringiana* ETTINGSHAUSEN, *E. oceanica* UNGER and *Metrosideros europaea* ETTINGSHAUSEN. In spite of their position inside the family Myricaceae, the genera »*Eugenia*« and »*Calystemophyllum*« have no strictly defined taxonomic position. ENGELHARDT (1910) suggested the sum genera *Myrtophyllum*.

Rhamnaceae – The questionable Eocene species »*Rhamnus*« *gaudinii* HEER from Socka is very similar to recent species of some families that inhabit different places, e. g. Juglandaceae, Rhamnaceae, Rosaceae, Cornaceae, Styracaceae from North America; to the families Betulaceae, Caprifoliaceae, Euphorelaceae, Dipterocarpaceae from East India and the Himalayas, or to the family Rhamnaceae from Europe, North Africa or West Asia. The species »*Rhamnus*« *eridani* UNGER has no clear systematic position, and it is most often described as *Dycotylophyllum* (»*Rhamnus*«) *eridani* (UNGER) KOCH. The three veined leaves of the genus *Zizyphus* are predominantly nanophyle, with elongate or lance shape and dentated edge, and they are very close to the genus *Daphnogene* (Lauraceae), in cases in which the leaf imprints are not complete (the edges are not visible). The species *Zizyphus paradisiacus* (UNGER) HEER from Zavine and Trbovlje (the Sava folds), earlier at Socka, has been determined as *Daphnogene paradisiaca* UNGER (UNGER, 1850; ETTINGSHAUSEN, 1885). The xerophytic species *Z. zizyphoides* (UNGER) WEYLAND (= *Ceanothus zizyphoides* UNGER) is known from Socka and Mt Promina only.

Proteaceae – Certain members of this family (e. g. »*Banksia*«, »*Dryandra*«, »*Dryandroides*«, *Lomatia*) for reasons of morphologic similarity are often changed with the genera *Myrica* or *Comptonia*. Perhaps their role in the composition of Palaeogene flora has been overrated.

Sterculiaceae – Fossil imprints of the genus *Sterculia* are present from the Eocene (Middle Europe) to the Oligocene (South Europe). Findings from Socka, the Sava folds (Zagorje) and Mt Promina have been determined as (like the maple leaf) as *Sterculia labrusca* UNGER. We could compare them with a recent sample today present in the Australian flora *S. diversifolia* G. DON (= *Brachychyton diversifolia* (G. DON) R. BROWN or with the Mexican species *S. acerifolia* HEMSLEY. Samples from Socka was initially determined as *S. labrusca* (UNGER, 1850), and after that some fragmental leaves were determined as *Daphnogene*, *Laurus*, *Ficus* (»*Ficus caricoides*« UNGER), *Platanus* (»*Platanus sirii*« UNGER), *Liquidambar* or *Acer* (*Acer sotzkianum*).

Sapotaceae – In earlier works »*Bumelia*« *minor* UNGER and *Sapotacites minor* (UNGER) HEER are the same species, i. e. *Sapotacites* represents the sum genus (e. g. KNOBLOCH, 1969). Petty-leave samples of such shape have no certain systematic place, especially when they are similar to plants with the »Leguminosae«, so called, type of leaf (the frequent »*Dalbergia*«, »*Caesalpinia*« etc.). The same problems occur with samples determined as »*Bumelia*«, e. g. »*Bumelia*« *oreadum* UNGER, and those from Socka, the Sava folds and Mt Promina were compared by ETTINGSHAUSEN (1885) with the recent *B. nervosa* SPENGL from Jamaica.

CONCLUSION

The purpose of this paper is to address the complex problem of the determination and taxonomy of Palaeogene fossil flora from localities at Socka and the Sava folds (Slovenia) and Mt Promina (Croatia). In addition, the authors have endeavoured to address the terminological and age problematics of Palaeogene sediments containing plant imprints.

Analysis of Palaeogene floras from Socka, Sava folds and Mt Promina particularly indicates the problem of the determination of certain species and their taxonomy, as well as the morphologic similarities between different families. Within the conifers this refers to the families Cupressaceae, Taxodiaceae and Araucariaceae. Then the family Lauraceae with representative leaves possess marked morphological similarities within itself as well as with several other families. The family Myricaceae has not been studied enough, so some samples have been ascribed to the family Proteaceae. The fossil Rhamnaceae has great similarities with recent species from geographically different places and they are ascribed to species of Betulaceae, Caprifoliaceae, Corneaceae, Juglandaceae, Rosaceae and Styracaceae. A certain number of representatives of Proteaceae have been mistaken for genera of Myricacea. A problem of determination is also evident inside the family Sapotaceae. Finally, problems are particularly evident when we try to determine the different plant species that have been said to have the »Leguminosae« type of leaves (e. g. Anacardiaceae, Fabaceae, Proteaceae etc.).

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SAŽETAK

Determinacijska i taksonomska problematika fosilne paleogenske makroflore iz Slovenije i Hrvatske

E. Jungwirth

U članku je naglašena složena problematika određivanja i taksonomske pripadnosti paleogenske fosilne flore utvrđene na lokalitetima Socke i Posavskih bora (Slovenija) i šire okoline planine Promine (središnja Dalmacija, Hrvatska). Tome valja pridodati problematiku naziva i starosti paleogenskih naslaga (promjene uvriježenih naziva poput Socka ili soteške naslage s obzirom na starost i genezu) u kojima se biljni ostaci nalaze.

Analize fosilnih flora iz Socke, Posavskih bora i Promine posebice ističu problematiku odredaba pojedinih vrsta i njihovu taksonomsku pripadnost (unutar istoga roda ili porodice), podjednako kao i problematiku morfološke sličnosti između pojedinih porodica. Kod četinjača to se odnosi na porodice Cupressaceae, Taxodiaceae i Araucariaceae, a kod ostalih na porodicu Lauraceae s predstavnicima listova koji posjeduju znakovitu međusobnu morfološku sličnost, ali i s nekim drugim porodicama. Porodica Myricaceae još uvijek nije dobro proučena, pa su poradi toga pojedini uzorci pripisani npr. porodici Proteaceae. Fosilni pripadnici proteacea posjeduju veliku sličnost s recentnim vrstama iz različitih zemljopisnih mjesta, te su pripisani porodicama Betulaceae, Caprifoliaceae, Corneaceae, Juglandaceae, Rosaceae i Styricaceae. Izvjestan broj predstavnika porodice Proteaceae pogrešno je zamijenjen s porodicom Myricaceae. Problem odredaba je također razvidan unutar porodice Sapotaceae. Konačno, posebno je uočena problematika kod odredaba različitih listova koje nazivamo listovi »leguminoznoga tipa« (npr. Anacardiaceae, Fabaceae, Proteaceae itd.).