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Editorial

Palearctic floras and vegetation of the Cenozoic: A tribute to Zlatko Kvaček

1. Introduction

The Cenozoic, that comprises approximately the last 66 million years of geological history, is a crucial period for understanding current patterns of the ecology and evolution of seed plants (Tiffney and Manchester, 2001; Taylor et al., 2009; Stewart and Rothwell, 2010; Gandolfo et al., 2014; Devesa and Carrión, 2017). Not in vain, regardless the Earth's region, the current floras and vegetation owe a large part of their composition, structure, and distribution characteristics to the evolutionary and geographic events that took place during the Cenozoic (Manchester, 1999; Kovar-Eder et al., 2008; Carrión and Leroy, 2010; Stevens et al., 2014; Niklas, 2016). It is during this period that the continents and climates acquire their current configuration and that the angiosperms continued the process of diversification and modernization that begun at the beginning of the Cretaceous, about 140 Ma ago (Gandolfo et al., 1998; Crepet et al., 2004; Graham, 2010; Friis et al., 2011). The period between the Eocene and the Pliocene (~56–2,58 Ma) marks the culmination of the Alpine orogeny about 7 Ma, the evolution of several tens of botanical families, and the configuration of new biomes (savannahs, steppes, and temperate grasslands, polar and subtropical deserts, tundra, and Mediterranean sclerophyllous vegetation; Axelrod, 1975; Mai, 1995; Krassilov, 2003; Postigo-Mijarra et al., 2009; Favre et al., 2015; Soltis et al., 2018, Palazzesi et al., 2021). The pronounced climatic changes in this period, particularly evident in the Palaearctic Domain, make the Cenozoic diachrony a kind of minimum time for evolutionary experimentation in terms of allopatric speciation and genetic drift (Herrera and Pellmyr, 2002; Carrión, 2003; Bennett, 2009; Soltis et al., 2018).

It is worth emphasizing that phylogenetic diversity reflects both community assembly and evolutionary diversification processes. Thus, integrating phylogenetic diversity into paleobotanical studies may help reconstruct temporal shifts in plant assemblages in the past (Verdú et al., 2020). It is also, without a doubt, relevant that the geochronological and palaeoecological resolution of the Cenozoic is progressively greater as we approach the end of the Neogene (Bruch et al., 2007; Kovar-Eder and Kvaček, 2007; Barrón et al., 2010; Postigo-Mijarra et al., 2010), during which hominization took place (Carrión et al., 2019).

From another perspective, the Cenozoic represents the most recent episode of biodiversity recovery and floristic turnover after a massive, extrinsically induced catastrophe. About 66 Ma ago, the impact of one or several massive asteroids (at least one at the Yucatán Peninsula), would end up producing an 80% reduction in marine invertebrates, the extinction of the dinosaurs and a drastic reduction in the number of mammal species (Alvarez et al., 1980). There is also well-founded evidence of taxonomic decline in many pelagic vertebrates, foraminifera, and mollusks (Jablonski and Chaloner, 1994). The impact probably produced devastating fires, initially intense cold, prolonged darkness and later global warming and nitric acid rain. There is also evidence of an imbalance between herbivory by insects and the impact on vegetation dominated by angiosperms (Labandeira, 2021). Unlike what happens in the animal record, the scale of the paleoecological trauma during the K-T event among vascular plants is far from global (Willis and McElwain, 2014). In general, the response of Palearctic floras to the climatic changes that have occurred has nothing to do with an abrupt event of mass extinction, but with processes of local and regional extinction, colonization, and ecological succession with recovery, sometimes of the original ecological structure, occassionaly replacement of niche and, finally, a modification in the geographic distribution pattern of vegetation zones (Strömberg, 2005; Nichols and Johnson, 2008; Carrión and Fernández, 2009; Stiles et al., 2020; Carvalho et al., 2021; Korasidis et al., 2022). This, in principle, wide regional disparity in the plant response to the K-T event and subsequent climatic changes, makes it important to record these phenomena of floristic and vegetation change in little explored regions and stages (Xing et al., 2016).

These and many others are fascinating topics for research. But in these times in which accelerated climate change, the extinction of species, and the danger of socio-ecological collapse are very vivid threats, a look at the –relatively- recent past is more than interesting, necessary (Utescher et al., 2011). Therefore, let us introduce a television literary reference pertinent to this issue, a metaphorical approach that allows us to link the main object and subject in this special volume.

In the gothic horror television series "Penny Dreadful" set in late 19th century Victorian London (John Logan, Showtime), a conversation takes place between the main protagonist Vanessa Yves and an African servant, Sembene, who had had a very eventful life:

-Vanessa Ives: *Do you believe the past can return?*

-Sembene: *More than that. It never leaves us.*

-Vanessa Ives: *Never?*

-Sembene: *It is who we are.*

This collection of papers contributes to the knowledge of the flora and vegetation of the Cenozoic on the Palearctic of the Northern Hemisphere and at the same time honors the memory of Zlatko Kvaček, a dear colleague. In a bio- and physiographical sense, the Cenozoic is the past that remains in what any naturalist observes in his field work and in another sense, more academic, we wish to believe that Zlatko Kvaček will never leave us, thanks to the profound intellectual penetration of his work in each of the researchers in this field of science.

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2. About Zlatko Kvaček

Professor Zlatko Kvaček was borne on July 28th in 1937 in Prague as the second child of MUDr Jiří Kvaček, a dentist, and his wife Marie. His interest in natural sciences was initiated by his grandfather Josef Kvaček, a school director and amateur natural scientist. It was his grandfather who taught Zlatko the names of plants and showed him how to prepare a herbarium. Zlatko assembled his first plant collections in Velká Losenice, village near Žd'ár and Sázavou, where the family owned a weekend house.

After elementary school, he attended high school in Praha-Libeň. There he met Pavel Veselý (now a medical doctor in Prague) and the two became life-long friends. Pavel was interested in herpetology and Zlatko in botany, so they did many field trips together, mostly to Slovakia. One of these expeditions, the "Expedition Latorica", led by Drs. Hanzák, Kalaš and Tříska from the National Museum at Prague, was a pioneer among the Czech-Slovak scientific expeditions. In 1958, after high school, Zlatko continued his studies at the Faculty of Sciences of Charles University in Prague. It was at the university where he met many of his later colleagues, among them František Holý and Milada Vavrdová (nee Dvořáková). He became an undergraduate student of professor František Němejc, a renowned Czech palaeobotanist. Zlatko graduated under his supervision with his honor thesis titled "Tertiary plant remains from the Julius Fučík Mine, in Želénky near Duchcov".

While still in high school, during a dance class, Zlatko met his future wife Hana, and their relationship was cemented by a wedding on July 7th, 1961. The marriage gave them two children: Jiří (also a paleobotanist) and Lucie.

From 1961 to the fall of 1962, Zlatko was employed as a geologist in the mining company Geologický průzkum n.p. Dubí. On the First of October of 1962, he started working as an assistant scientist under the guidance of Dr. Pavel Čepek in the Geological Institute of the Czechoslovak Academy of Sciences. During that time, he also began his PhD. studies in the same institute but under the supervision of Professor Němejc, on the "Evolution of brown coal swamp flora in Bohemia during the late Tertiary". He successfully defended his first Ph.D. thesis in 1966. From the summer of 1966 to the spring of 1967, he was at the Birbal Sahni Institute in Lucknow, India, on a research fellowship, together with Milada Vavrdová, a co-worker at the Geological Institute, where he studied Indian Tertiary floras (Kvaček, 1969).

Throughout those years, Zlatko took part in collaborations with Čestmír Bůžek, František Holý, and Ervín Knobloch, all students of Professor Němejc. They worked together on Bohemian and Moravian Tertiary floras. Bůžek and Holý focused mostly on carpology while Knobloch on macro-remains and Zlatko on cuticle analysis. In the late 1960s, Zlatko also collaborated with German colleagues, particularly with Harald Walther. Harald eventually became a frequent guest in Zlatko's family weekend cottage.

Another long-term friend and colleague was Mike Boulter from London, whom Zlatko met in 1968, during the International Geological Congress in Prague. Unfortunately, the congress was forced to an abrupt and unexpected end by the arrival of Russian and other occupational troops, who invaded Prague in August 1968. However, Boulter was able to subsequently visit Prague, collaborating with Zlatko on projects including their comprehensive work on the Palaeoclimate of Tertiary floras (Boulter and Kvaček, 1989).

In August 1st, 1973, Zlatko was appointed Head of the Paleontology Department of the Czech Geological Institute, in which the palaeobotany section was housed in Spálená 49, Praha 1. There, he met Antonín Hluštík and became his supervisor. Hluštík defended his thesis on Cretaceous conifers and the Family Frenelopsidaceae in 1983. Also that same year, the Geological Institute's palaeobotany laboratory was moved from Spálená to the Praha-Lysolaje, Rozvojová street, where the institute had acquired a building. The new building, although provisional, contained modern laboratory facilities, providing much more suitable conditions for research. In 1987, Zlatko successfully defended his second Ph.D. thesis titled "Cuticle analysis of Neogene trees from Central Europe" in the Czechoslovak Academy of Sciences, while still working in the Geological Institute.

Prof. Blanka Pacltová of Charles University and Prof. Němejc developed the idea to organize an international conference on angiosperm palaeobotany in Prague, but Němejc died in 1976, before the conference took place. Zlatko took over the full organization of the conference, titled "Advances in Angiosperm Palaeobotany", which took place in the Liblice castle in Central Bohemia. The conference was a rare opportunity to meet colleagues from both sides of the Iron Curtain. Many renowned palaeobotanists participated, including David Dilcher, Norman Hughes, Gerhard Kremp, Peter Crane (a young PhD. student from the UK), James Doyle, Leo Hickey, Joachim Gregor, Friedman Schaarschmidt, Harald Walther, Dieter Mai, Leszek Stuchlik, Ewa Zastavniak and Lilla Hably, and many other, in total 13 countries sent representatives.

His collaboration with Harald Walther started in the 1960s, intensified in the 1970s, and this productive collaboration persisted until Harald passed away in 2013. Besides their professional association, Harald and Zlatko were also very close personal friends. With Harald, Ervín Knobloch, and Dieter Mai, they organized regular social gatherings with their wives to celebrate birthdays, generally alternating between Germany and Prague.

In the late 1970s, he began to collaborate with Lilla Hably from Budapest. They published on numerous Hungarian floras and worked together on several projects. Lilla eventually became head of the Botany Department in the Budapest Natural History Museum (now the Hungarian Natural History Museum).

During the early 1980s, Zlatko met Johanna Kovar (later Kovar-Eder) and taught her cuticle analysis. She subsequently became one of his principal professional associates as they collaborated on various projects, primarily on Austrian floras, one of which was a revision of Ettingshausen material from Parschlug (Kovar-Eder et al., 2008). These collaborative projects continued throughout both their careers, despite Johanna's additional administrative duties beginning in 2003, when she was named director of the Staatliches Museum für Naturkunde, Stuttgart, Germany.

Together with Ervín Knobloch, Zlatko organized a palaeobotanical conference in September 1989, titled "Palaeofloristic and palaeoclimatic changes in the Cretaceous and Tertiary", in which many renowned palaeobotanists participated, including Steven Manchester from the University of Florida, USA. Steven and Zlatko had already known each other via mail correspondence, as they exchange scientific information while working on *Pteleaecarpum* (Bůžek et al., 1989). After the conference, they agreed on longer exchange visits, and Steven subsequently became his frequent collaborator and personal friend. The successful organization of 7th European Palaeobotany-Palynology Conference in 2006 was a highlight of Zlatko's administrative activity in palaeobotany.

After the Velvet Revolution in November 1989, Professor Blanka Pacltová asked Zlatko (along with other noteworthy paleontologists) to teach at Charles University. In November 11th, 1991, he became an associate professor there and in December 15th, 1998, he was promoted to full professor. As a member of the faculty, Zlatko focused on recruitment and education of students. His students were Jakub Sakala, Vasilis Teodoridis, Josef Pšenička, Milan Libertín, Helena Soukupová, and Jana Zajícová, but he mentored many others, among them Jakub Prokop and Jiřina Dašková. All of them successfully defended their theses and received their degrees under his formal or informal supervision. Zlatko retired in 2003 but remained employed in the faculty until 2018 when he was named professor emeritus.

During his tenure at the university, there were other colleagues outside the school with whom Zlatko collaborated. He conducted research and published with Dieter Hans Mai, Volker Wilde, Thomas Denk, Lutz Kunzmann, and Heinrich Winterscheid (German Tertiary floras), Evangelos Velitzelos (Tertiary floras of Greece), Svein B. Manum (Paleogene flora of Spitzbergen), William Rember (Tertiary floras of USA), Wolfram Kürschner (plant palaeoecology), Mikhail Akmetiev (volcanic floras), Josef Bogner (fossil Araceae), and Jan J. Wojcicki (Trapaceae). Beside Tertiary floras, Zlatko was involved also in investigations of Cretaceous plants, particularly leaves of angiosperms (Kvaček, 1983) and Paleozoic biota (Kenrick et al., 1999).

In 2007, the National Museum hosted a conference dedicated to Zlatko's seventieth birthday, titled "Palaeobotany – contributions to the evolution of plants and vegetation". This was an occasion for a number of "old friends" to meet again.

In the last decades of his life, Zlatko intensely collaborated with his earlier student Vasilis Teodoridis from the Pedagogic Faculty of Charles University. It was primarily Vasilis who helped Zlatko to maintain an interest in his work and recover from his difficulties with walking caused by contracting Lyme disease in 2011. Towards the end of his career at the university, Zlatko helped in the arranging of the National Museum large paleobotanical collection in the new compactors in 2011.

In the summer of 2020, Zlatko finally had to vacate his office in Charles University, and moved all his professional gear to the National Museum depository facility, planning to make use of the easier access to the museum's collections. Sadly, in the fall of 2020, he contracted Covid-19, and died within a matter of weeks.

Zlatko Kvaček was always a man dedicated to his passion "Paleobotany"; and it did so in a pioneering way at first, beyond the Iron Curtain, in social conditions not particularly favorable for basic research. Later, he did it from the humanist perspective of the classical sages: sharing his knowledge and stimulating the youngest. With a sharp sense of humor, always ready to pick up enthusiasm and adept at spotting talent, many today feel a moral debt to the old professor. Some emotional manifestations can be found in Kvaček (2021), and Hably and Erdey (2020) as well as in a tribute by Lilla Hably, Joanna Eder and Steven Manchester published in the official website of the International Organization of Paleobotany (https://palaeobotany.org/index.php/zlatko-kvacek-1937-2020/).

The saying "the apple does not falls far from the tree" is very appropriate here, the legacy of Dr. Zlatko Kvaček is being followed by his son, Jiří, also a palaeobotanist, associate professor and head of Department at the National Museum, Prague.

Professor Zlatko Kvaček was a prolific writer, authoring and co-authoring a number of monographs and nearly 300 papers. He supervised six PhD. students, and was a mentor to many others. He is a model for all of us with his tireless work in scientific and organizational activity. All honor to his memory.

3. A summary of the contributions in this issue

Uhl et al. (2022) investigate three localities with lignites from the Neuwied Basin and provide evidence for the occurrence of palaeowildfires in western Germany during the late Eocene–late Oligocene interval. A revision of the literature on palaeofires shows that, although wildfires were regular across the whole Cenozoic, this was probably a period of relatively low fire frequencies if compared with earlier periods of Earth's history. Uhl et al. (2022)´s work is of extraordinary value because it provides information about the source vegetation experiencing the wildfires. Thus, for instance, following wood anatomy, it is stated that most of the analyzed charcoal specimens from the late Eocene of Koblenz-Metternich originate from conifers comparable to *Doliostroboxylon*, connected with the genus *Doliostrobus*, which was widely distributed in the Eocene and Oligocene zonal and azonal vegetation belts of Central and Eastern Europe.

Pirnea et al. (2022) study fruits of *Sloanea eocenica* (Elaeocarpaceae) found in the Oligocene of the Dâlja-Uricani Formation of Petroşani Basin, South Carpathians in Romania. This fossil record contributes to inform about the European distribution of *Slonaea* and suggests an extensive development of the genus in the circum-Paratethys areas during the Paleogene. This new record of *Sloanea eocenica* is not only the first discovery from the Petroşani Basin in Romania but also the second occurrence of this species in Europe. In the European Cenozoic, the Elaeocarpaceae representatives are associated with humid mesic forests of tropical character, often riparian.

A detailed quantitative palaeoclimate reconstruction (Coexistence Approach, Climate Leaf Analysis Multivariate Programme, and Leaf Margin Analysis) of the early Miocene La Rinconada mine in eastern Iberia is provided by Postigo-Mijarra et al. (2022). It contains a rich megafloral assemblage with abundant leaf fossils from a single stratigraphic level of the sedimentary succession. The inferred temperature and precipitation values point to the existence of wet and warm climates with marked seasonality for rainfall and temperature while lacking the characteristic summer drought of the Mediterranean regimes. These findings agree with those from other Burdigalian and early Langhian sites from the Iberian Peninsula and Central-Southern Europe, suggesting the absence of a clear latitudinal gradient in temperature and precipitation for these times in Europe. This study partially fills a gap in the knowledge of the Miocene palaeoenvironments of the Iberian Peninsula. Indeed, this is the first detailed climatic analysis for an early Miocene site for the area.

Denk et al. (2022)´s paper deals with plant macrofossils from early Miocene deposits of West Turkey (Soma, Manisa). The authors have compiled a catalog of revised and new plant taxa, documenting 100 fossil taxa, of which several are new for Turkey (*Mahonia* aff. *pseudosimplex*, *Ziziphus paradisiaca*, *Comptonia longirostris*, *Carya denticulata*, *Viscum*, *Fatsia*, *Pungiphyllum cruciatum*). Using modern ecology and taphonomy, a palaeoenvironmental reconstruction is provided showing a picture of several vegetation units including dry open habitats (cycads, *Dracaena*, *Mahonia*, *Smilax miohavanensis*), swamp and riparian forests, lowland forest with large-leaved Lauraceae and *Fatsia*, and in altitude, humid temperate broadleaf-deciduous and conifer forests. The Climate Leaf Analysis Multivariate Program is used to infer palaeoclimates and correlate with other Miocene localities of Turkey. It is concluded that Early Miocene floras developed under warm climatic conditions with weak precipitation seasonality. A palaeobiogeographical analysis is also provided.

Kafetzidou et al. (2022) report on the pyroclastic rocks of the Lesvos Petrified Forest in the North Aegean, one of the most important megafloras of the early Miocene. In a new outcrop of Akrocheiras yielding leaf compressions, the authors identify a total of sixteen different taxa, most of them palaeotropical. These include mainly *Daphnogene polymorpha, Pungiphyllum cruciatum* and *Phoenicites*, and other Neogene taxa such as *Laurophyllum*, *Smilax weberi*, *Celtis japeti, Ilex miodipyrena* and *Apocynophyllum*. The palaeoecological interpretation shows the Akrocheiras Basin was dominated by lowland/riparian and mesophytic forests on well drained soils, under humid warm-temperate climate with seasonal alternations from wetter to drier conditions. The authors contend the floristic similarities of Akrocheiras with the early Miocene localities of Grevena in northern Greece, Myrina and Moudros in Lemnos Island, and with Bodovdol (Bulgaria).

Vieira et al. (2022) bring new data to improve the hitherto scarce fossil record of *Lythrum* with the twofold goal to shed light on the evolutionary history of this genus and place a new species into ecological and biogeographical contexts. There are not macro- or mesofossil records for this herbaceous genus. However, *Lythrum* pollen can be distinguished at generic level, and as far as it is known, pollen morphology has not changed since the Miocene. The earliest European *Lythrum* pollen records come from the late Miocene and parallel to starting crown group radiation in the Eurasian clade of *Lythrum*. In this contribution, they describe a variety of wetland habitats with trees such as *Alnus*, *Craigia*, Engelhardioideae, *Liquidambar*, *Nyssa*, Sapotaceae, *Taxodium*, and *Zanthoxylum*, in mosaic with well drained forested areas dominated by *Acer*, *Carya*, *Juglans*, Myricaceae, *Quercus*, *Trigonobalanopsis,* and *Ulmus* with abundant Ericaceae. The main protagonist of the paper, *Lythrum portugalliense* sp. nov., was an important part of the herbaceous communities within Rio Major riparian patches. They demonstrate that the lineage leading to *Lythrum* (incl. *Peplis* type pollen) was established on North America in the early Campanian to early Maastrichtian. These earliest records are followed by a large gap in the record lasting until the Neogene when *Lythrum* pollen starts to appear in European floras; evidencing that the family Lythraceae already had a North American-Russian distribution in the Late Cretaceous and suggesting a Beringian dispersal that continued into the early Cenozoic.

For western Anatolia, Kayseri-Özer and Emre (2022) describe two palynofloras, the late Burdigalian–early Langhian Başçayır and the Serravallian–Tortonian boundary Kızılcayer. The Başçayır palynoflora is dominated by subtropical taxa and taphonomically associated with fluvial-lacustrine environments with certain input of high and middle altitude areas. This involves mixed mesophytic forests with deciduous *Quercus* and *Carya*, Pinaceae forests, and riverine woodlands while the Kızılcayer palynoflora is dominated by herbaceous species such as Amaranthaceae and Poaceae, indicative of open land areas. The differences between these two floras are in part conditioned by topography, but it is clear that palaeoclimates across this period changed from warm subtropical to temperate in western Anatolia. This palynological investigation also helps for determining that the uplift in western Anatolia existed during the late Burdigalian and continued until the late Miocene.

Worobiek et al. (2022) present results of a palaeobotanical investigation of three sections in the borehole core Komorniki 97/72 from the Ruja lignite deposit of Lower Silesia, Poland. A total of 193 fossil-species (including 25 species of cryptogam spores, 33 species of gymnosperm pollen, and 135 species of angiosperm pollen) are identified. Pollen is combined with plant macroremains to show that during the mid-Miocene mires' development, a wetland vegetation (i.e., swamp and riparian forests, shrub bogs, and reed marshes) patched with mesophytic forests dominated the regional landscapes. The variation of palaeotropical taxa is used to evaluate climate changes during the study period. At the beginning of the sequence, the occurrence of Meliaceae and Sapotaceae is particularly suggestive of humid and warm, subtropical conditions. In this study, extinction phenomena of paleotropical elements are also detected at the end of the Miocene.

A new species of *Nelumbo* (*N. fujianensis*) from the Miocene Fotan flora of Fujian is reported by Dong et al. (2022). The new species is characterized by centrally peltate leaves with 20–30 actinodromous primary veins and 25–40 fruits embedded in a receptacle, together with abundant rhizomes without tubers. These are the first megafossils of tropical lotus for the middle Miocene of southern China. The authors place this finding in the context of the fossil record of *Nelumbo* since the late Eocene, and show that evergreen and deciduous forms of the genus had already radiated by the middle Miocene. They also incorporate a palaeobiogeographic analysis trying to define the ecological niche of the regional tropical lotus including the day length of the habitat. It seems that *Nelumbo* exhibited great phenotypic plasticity to climate changes, although eventually responded migrationally. The interpretive effort on Cenozoic paleoclimates based on herbaceous plants is considerably less than that developed on woody floras and Dong et al. (2005)´s work thus covers a certain knowledge gap, with results worthy of attention for ecologists and biogeographers. While exhibiting a fossil record dating back to the Cretaceous, *Nelumbo* is a relict taxon of the Quaternary glaciations which left restricted to tropical and temperate regions (Gandolfo and Cuneo, 2005).

The late Miocene flora from La Bisbal d'Empordà, northeastern Iberia, is here studied by Tosal et al. (2022), bringing outstanding information to understand the vegetation of coastal areas for the period ca. 9.6–9.7 Ma (early Tortonian). The fossil-bearing beds were deposited in the floodplain of a meandering river system. The authors are able to distinguish three palaeoecological assemblages: a local wetland (helophytic plant stems), riparian forests (*Fraxinus, Ulmus, Zelkova*, *Cedrelospermum*, *Populus balsamoides, Alnus gaudinii, Carpinus, Platanus, Acer tricuspidatum*, *Daphnogene*, *Laurophyllum*), and more arid, distant biotopes (*Paliurus* seeds). Data provided by the associated small mammal fauna are consistent with this palaeoenvironmental interpretation, especially the scarcity of small arboreal mammal taxa and insectivores. The detail of this study allows to demonstrate that these ecosystems may have been considerably heterogeneous physiographically.

Due to the lack of lignification of the xylem, seagrass fossils are an oddity, and they are generally associated with exceptional preservation. In addition, the depositional environments, shallow hábitats, generally experience high turbulence and, consequently, oxygenation, which does not facilitate fossilization. Braga et al. (2021) provide the first European record of Miocene seagrass fossils, in this case impressions of rhizomes found in sediments of the Guadalquivir Basin, that experienced important tectonic activity during the late Neogene. During the late Miocene, the basin was a large embayment of the Atlantic Ocean. The unique plant preservation in this site could be consequence of an unusual deposition of marl lenses in small low-energy areas among submarine dunes that probably sheltered the plants.

Based on fossil pollen records from 21 localities in western Georgia, Mahler et al. (2022) reconstruct the climate during the Miocene–Pliocene of the Colchic refugium, a great Caucasus biodiversity hotspot during the Tertiary. This biomization has unraveled major shifts in vegetation matching the late Neogene global climatic trends as well as the increased Pleistocene cooling. Interestingly, the decrease in regional temperature was not associated with increase in seasonality or decrease in precipitation during the Miocene and Pliocene. The buffering effect of the Paratethys, and its remainder, the Black Sea, is the most likely cause for this regulation of temperature amplitude and an overall climate stability in the mountains. Since the Early Pleistocene, the uplift of the Caucasus combine with favorable climatic conditions support the development of the Colchic biodiversity stronghold.

Palynological investigations in the Orce Archeological Zone (OAZ) (Guadix-Baza Basin, Granada, Spain), Venta Micena 1 (VM1), Barranco León (BL) and Fuente Nueva 3 (FN3) are presented in this issue by Ochando et al. (2022). OAZ is connected with the first *Homo* populations in Western Eurasia during the Early Pleistocene. The three studied pollen records shows similarities and differences, but overall, they show more arboreal component than today, the prevalence of open Mediterranean woodlands, and the permanence, probably in altitude, of relic Tertiary taxa such as *Carya, Pterocarya, Eucommia, Zelkova*, and *Juglans*. It is interesting that open grasslands, essential to Early Pleistocene human expansions in other regions (Dennell and Roebroeks, 2005; Zhu et al., 2018) have had a limited presence in the region during the study period.

Totmaj et al. (2021) have performed a fine-resolution multi-proxy study including pollen, spores, non-pollen palynomorphs, charcoal, loss of ignition, geochemistry and radiocarbon dating at the Annal Lake in northern Iran. The sequence is the first palaeoecological record for the Hyrcanian forest, with outstanding implications for Late Quaternary ecology and biogeography of the western and central Palearctic. The record is long and we invite the readers to explore the vegetation dynamics, but it is perhaps worth to emphasize here that even during the coldest and driest phase (LIA: 600–100 cal yr BP), the forest composition was not affected by climatic change, demonstrating the resilience of a high-phytodiversity vegetation belt. This forested ecosystem only crossed its vulnerability threshold after human disturbances since 65 cal yr BP, which principally involved selective logging of *Carpinus* and *Alnus*. This implies a dramatic lost of natural vegetation in parallel with the spread of heliophytic grasslands and agricultural areas.

Undoubtedly, for the Cenozoic as a whole, we are still in a very precarious phase of palaeobotanical and palaeoecological research, in which data remain fragmentary in time and space, with a clear prevalence of data for the Northern Hemisphere and a certain Eurocentrism in the interpretations and concentration of data, studies and resources, both human and academic. The latest conferences on palaeobotany and palynology and the record of publications itself suggests a rebound in enthusiasm for fossil plants among the new generations. The great palaeobotanists who, like Zlatko Kvaček, are leaving us, or those who are gradually retiring, leave a very valuable legacy on which multiple and stimulating research avenues have been opened. From this forum, we encourage young scientists to delve into them. The knowledge of Cenozoic floras is vital for understanding the plant world as we see it today.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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