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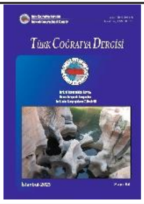

The vegetation history of Lake Gâvur and surrounding areas during the last 4400 years BP (Kahramanmaraş, Türkiye)[1]

Gâvur Gölü ve çevresinin son 4400 yıllık vejetasyon tarihi (Kahramanmaraş, Türkiye)[2]

Muhammet Topuz [a *] Nurgül Karlıoğlu Kılıç [b] Rüya Yılmaz Dağdeviren [b] Murat Karabulut [c]

[a] *Department of Geography, Hatay Mustafa Kemal University, Hatay, Türkiye.*
[b] *Department of Forest Botany, Istanbul University-Cerrahpaşa, Istanbul, Türkiye.*
[c] *Department of Geography, Kahramanmaraş Sütçü Imam University Kahramanmaraş, Türkiye.*

ORCID: M.T. 0000-0001-5526-3797; N.K.K. 0000-0002-6255-6819; R.Y.D. 0000-0003-1209-5257; M.K. 0000-0002-1456-6908

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***Sorumlu yazar/Corresponding author:**
(M. Topuz) mtopuz@mku.edu.tr

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ABSTRACT / ÖZ

In the context of interpreting and planning today's environment, it is crucial to be aware of the characteristics of past periods. Lake sediments and the fossilized pollen they contain provide us with valuable information about past vegetation. This study discusses the paleovegetation records of sediment core of Lake Gâvur (Kahramanmaraş, Türkiye), which was dried in the 1970s. The area determined as the study site, Gâvur Lake and its vicinity, is of great importance for paleogeographic studies. In the region, there are ancient settlements dated back to the Neolithic period. Furthermore, excavations in the region are bringing to light well-preserved elephant fossils. A 5 m-long sediment core was obtained with an Eijkelkamp core sampler and palynological samples were taken at 10 cm intervals. The prepared samples were analyzed according to the standard method. The sediments were dated by AMS radiocarbon dating of bulk at two levels. Among arboreal pollen (AP) from approximately 4400 cal yr BP, the dominant arboreal taxa were *Pinus*, *Cedrus*, *Quercus* and *Fraxinus*. Initially, AP dominated NAP (non-arboreal pollen) along with the pollen diagram, and AP gradually decreased up to the present. The evaluation of the fossil pollen percentage indicates that in that period arboreal taxa were more widely distributed around the lake than they are in the present. Inferred major causes for the increase of pollen percentage of Poaceae and Asteraceae in the LG-3 (upper) zone of the pollen diagram are anthropogenic impacts.

Günümüz çevresinin yorumlanması ve planlanması bağlamında geçmiş dönem ortam özelliklerinin bilinmesi oldukça önemlidir. Göl çökelleri ve içerdiği fosil polenler, geçmiş dönem vejetasyonu hakkında bize önemli bilgiler sunmaktadır. Bu çalışma, 1970'lerde kurutulmuş olan Gâvur Gölü'nden (Kahramanmaraş, Türkiye) alınan sediman karotundaki sığ çökellerin tuttuğu paleovejetasyon kayıtlarını tartışmaktadır. Çalışma sahası olarak belirlenen Gâvur Gölü ve yakın çevresi, paleocoğrafya çalışmaları açısından oldukça önemlidir. Bölgede neolitik döneme tarihlendirilmiş eski yerleşimler bulunmaktadır. Ayrıca bölgede büyük fil fosilleri korunmuş olarak yapılan kazılarla gün yüzüne çıkarılmaktadır. Eijkelkamp karot örnekleyici ile 5 m uzunluğunda bir karot elde edilmiş ve 10 cm aralıklarla bu karottan palinolojik örnekler alınmıştır. Hazırlanan örnekler standart yönteme göre analiz edilmiştir. Alınan karotun iki seviyesinde AMS radyokarbon tarihlendirmesi yapılmıştır. Yaklaşık olarak GÖ 4400 yıllarına ait arboreal polenler (AP) arasında baskın ağaç taksonları Pinus, Cedrus, Quercus ve Fraxinus'tur. Polen diyagramı boyunca odunsu taksonlara ait polenler (AP), otsu bitki taksonlarına ait polenlere (NAP) göre daha baskın olmakla birlikte günümüze doğru dereceli olarak azalmıştır. Fosil polen yüzdesi verileri değerlendirildiğinde, odunsu taksonların o dönemde göl çevresinde günümüze göre daha geniş bir yayılış yaptığı görülmektedir. Polen diyagramının LG-3 (üst) zonunda; Poaceae ve Asteraceae'nin polen yüzdesindeki artışı antropojenik etkilerdir.

[1] This study is a part of PhD thesis on "in An investigation late quaternary paleogeography of Gâvur Lake (Kahramanmaraş)" which prepared by Muhammet Topuz under the supervision of Prof. Dr. Murat Karabulut and Assoc. Prof. Dr. Nurgül Karlıoğlu Kılıç.

[2] *Bu çalışma, Prof. Dr. Murat Karabulut ve Doç. Dr. Nurgül Karlıoğlu Kılıç danışmanlığında Muhammet Topuz tarafından hazırlanan"Gavur Gölü (Kahramanmaraş) Geç Kuvaterner Paleocoğrafyası'nın İncelenmesi" başlıklı doktora tezinden üretilmiştir.*

1. Introduction

Investigation of the aquatic environmental conditions of the past climate in terms of the oscillation cycle characteristics and comparison of past and current climate gives a clearer understanding of the causes of the changes (Şekeryapan et al., 2020). Especially, climate change during the Holocene is very important and it can be followed by using the multi-proxy-based paleolimnological analysis of lacustrine sediments. Because the lake sediments comprise natural archives that keep records of ecological conditions and climate changes during the deposition periods (Eastwood et al., 1999; Şenkul & Doğan, 2013; Davies et al. 2015; Karlıoğlu Kılıç et al., 2018; Kükrer et al., 2019; Erginal et al., 2022).

Considering the settlement date of Anatolia, the lakes have also been exposed to increasing anthropogenic pressure, especially in the last 10 thousand years. This pressure resulted from the establishment of settlements on the edges of lakes and wetlands, which have been important water resources for thousands of years (Akkermans & Glenn, 2003; Niknami et al., 2009; Kashima, 2011; Erdem, 2013; Becks, 2013; Xie et al., 2017). District of Southwest Anatolia is the one of the most known land among the prehistoric island and lake-shore settlements. In the partial distribution map of historical settlements in Anatolia, it is seen that settlements are concentrated in the lakes region, where the number of lakes is high (Massa & Palmisano, 2018). Duru (2011) reports an abundance of settlements dating back to the Neolithic and Chalcolithic periods within the Lakes Region, home to approximately 65 lakes of varying sizes. Notable settlements along the shores of Lake Beyşehir include Çukurkent, Yeniköy Höyük, Yılan Höyük, Alan Höyük, Beyşehir Höyük, Erbaba, Çem Çem, and Kaşaklı. On the other hand, Pınarbaşı (Konya), is a lakeshore settlement where excavation has just started (Harmankaya et al., 1997). Contrary to the Southwest Anatolia Region, in the Southeastern Mediterranean Region where Lake Gâvur is located, there are relatively few studies around the study area. Nevertheless, in the early Bronze Age, there are 4 known major settlements (Sirkeli, Kinet and Tahtalı mounds, Domuztepe) in the region (Atakuman, 2004; Massa & Palmisano, 2018). Lake Gâvur was amongst the most preferred lakes in the Anatolian peninsula for the establishment of residential areas in the last 10 ka, as revealed by the existence of many mounds around the lake, including particularly the Domuztepe Mound dated to 9,000 years BP (Gearey et al., 2011).

Some of the important studies on Lake Gâvur and its immediate surroundings revealed the physical and geographical characteristics of the lake (Gürbüz et al., 2003); some interpreted the archaeological findings (Tekin, 2017); others have studied the wetland ecosystem (Korkmaz, 2008; Gürbüz et al., 2008). Korkmaz (2001) studied the geomorphological evolution of the lake and Gürbüz et al. (2003) investigated the hydrographic features, cultural ecology and rehabilitation of the studied area. Ceylan (2016) searched the temporal changes in the Lake Gâvur by remote sensing methods. Also, Miller (1986) and Alaura (2016) studied the features of Elephas maxima asurus, which is an important proxy for understanding regional ecology and its live conditions. This lake is located in a tectonically (Barka & Kadinsky-Cade, 1988; Şaroğlu et al., 1992; Chorowicz et al., 1994; Pekcan, 1997; Yılmaz et al., 2006; Herece, 2008; Duman & Emre, 2013) and archaeologically (Miller, 1986; Tadmor and Yamada 2011; Hawkins, 2000; Alaura, 2016) controversial region. Detailed fossil pollen studies have not been conducted around the lake and its surrounding areas until the recent years. Therefore, we aim to investigate the paleovegetation history of Lake Gâvur for the last 4400 years BP by using palynological analysis in this study.

2. Material and method

2.1. Study Area

The wetland of Lake Gâvur is located in Kahramanmaraş of the Mediterranean Region (Fig. 1), between 37°14ˈ-37°24ˈ north parallels and 36°46ˈ-36°56ˈ east meridians. The studied lake is situated in a special region because three fault zone are close to each other (Fig. 2). The study area is located in the Mediterranean and Iran-Turanian phytogeographic transition zone where the Anatolian diagonal is divided into two branches in the south (Davis, 1965-1985). The dominant taxa of vegetation belong to the Mediterranean Phytogeographical region. According to the ecologic region of Atalay (2014), the study area takes place in the Mediterranean subregion (*Pinus brutia*) and Mediterranean Mountain Region (*Cedrus*, *Pinus nigra, Abies*). The vegetation characteristics of the study area have been examined in 3 parts and, these vegetation types are forest, shrub, and Alpin grass formation. Forest extends from 800 m to 2100 m. *Pinus* predominates, but other arboreal species such as *Quercus*, *Cedrus*, *Abies,* and *Fraxinus* also occur in the study area. Belonging to the shrub formation are *Styrax, Pistacia, Rhamnus, Phillyrea, Olea, Cistus, Cercis, Paliurus, Pyracantha,* and *Arbutus* located at between the 500-1200 m. The species belonging to the Alpin grass formation are located above 1800 m. *Astragalus*, *Acanthalimon, Trifolium, Vicia, Coronilla, Campanula, Viola,* and *Papaver* are the most known (Korkmaz, 2001).

Kahramanmaraş meteorological station is the nearest station around the study area, with an average annual rainfall of 709 mm. This value differs from south to north for topographic, orographic, and atmospheric reasons (Karabulut & Cosun, 2009). The Mediterranean climate (Erlat, 2014), which is also considered as the displacement of the conditions that lead to the formation of tropical desert and steppe climate with the humid climate of marine western coasts, is seen in a narrow area that can correspond to 15% of the continents. It is thought that the Mediterranean climate and its elements are mostly controlled by remote connections and surface temperature changes. The inter-annual variability in the Mediterranean climate is high and increasing due to the effects of global warming. It is emphasized that the Mediterranean climate zone is in a sensitive position where many environmental, economic, and hydrological balances can deteriorate rapidly with the effect of global warming (Türkeş, 1996; Xoplaki et al., 2000; Giorgi & Lionello, 2008; Erlat, 2014).

2.2. Research Methodology

A 500 cm-long core (GC1) was collected in the deepest part of Lake Gâvur by using an Eijkelkamp semi-disturbed core sampler in the fieldwork (Fig. 1). The core was brought to the Palynology Laboratory of the Forest Botany Department of Faculty of Forestry, Istanbul University-Cerrahpaşa for fossil pollen analysis. Fossil pollen sub-samples were taken at 10 cm resolution along with the studied core. These sub-samples were analyzed for the identification of fossil pollen grains according to the standart method (Erdtman 1954; Moore et al., 1991).

Figure 1. *Location map of the study area. (*The lake boundary was determined when the lake was at its widest in aerial photographs in 1948 (Gürbüz et al., 2003; Ceylan, 2016). The lake has been dried by agricultural activities nowadays).*

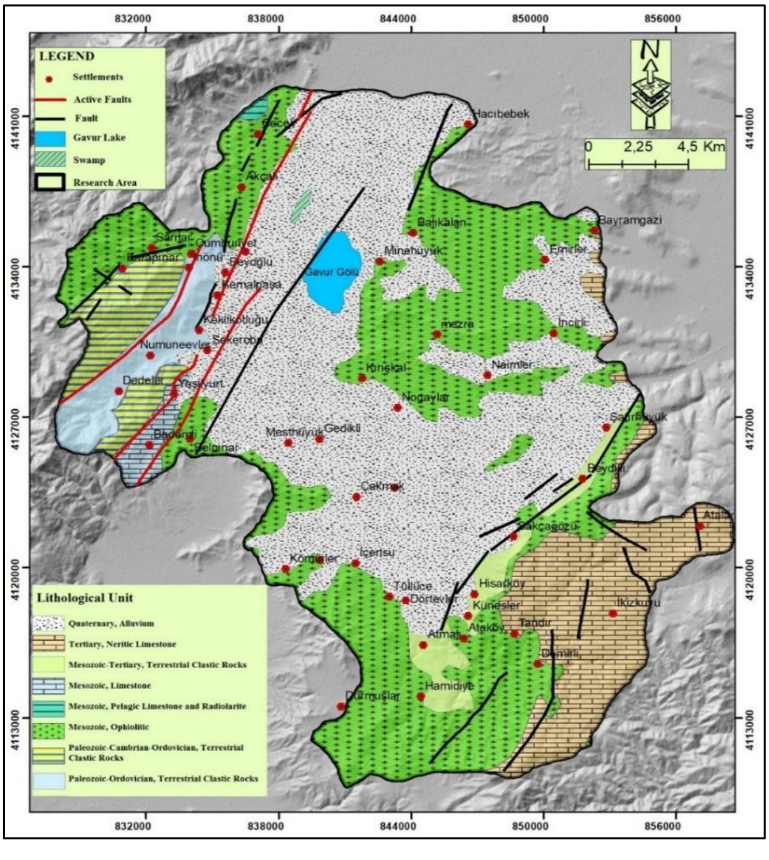

Figure 2. *Lithological units map of the study area (General Directorate of Mineral Research and Exploration, 2002).*

Counting and identification of the pollen grains were made using a computer-assisted Leica DM750 brand light microscope, x10, x40 and x100 with immersion oil, lens, and ocular. Pollen atlases were used together with reference pollen preparations in Palynology Laboratory for pollen identification (Erdtman, 1952; Erdtman 1957; Faegri & Iversen 1964; Aytuğ 1967; Aytuğ et al. 1971; Iwanami et al. 1988; Moore et al. 1991; Hesse et al. 2009). The percentage pollen diagram was drawn in the program TILIA (Grimm, 2015). Pollen diagrams are divided into a series of pollen zones, which are called "Local Pollen Assemblages Zones: LPAZ" characterized by largely similar pollen content at different stratigraphic intervals. A stratigraphically constrained cluster analysis uses a square root transformation was run by CONISS (constrained incremental sum-of-squares cluster analysis).

Two sub-samples (250 cm and 500 cm) were analyzed for AMS radiocarbon dating in the TUBITAK-MAM (Scientific and Technological Research Council of Turkey Marmara Research Center). The results were calibrated to calendar years with a two-standard deviation (2σ) error limit, using the program OxCal v4.2 (Ramsey & Lee, 2013) with the IntCal13 atmospheric curve.

3. Results and discussion

3.1. Lithology and AMS radiocarbon dating

Based on the lithology of the studied core, 0-50 cm of the core is soil organic material, 50-300 cm is clay-silt-sand, 300-500 cm is just clay (Fig. 3). Table 1 shows the radiocarbon and calibrated ages of bulk organic carbon in the dated samples.

3.2. Palynological data

The pollen diagram of Lake Gâvur, was divided into 3 local pollen assemblage zones (LG-1, LG-2, and LG-3) based on the pollen percentage data (Fig. 3).

LG-1 (500-380 cm): Among the conifers, *Pinus* has the highest pollen percentage within the group of arboreal pollen taxa (Fig. 3). While *Pinus* has 64.07% at the beginning of the zone, it reached the highest pollen percentage with 71.62% in 450 cm along with the pollen diagram. *Cedrus,* which is another conifer species, starts the zone with a value of 8.3% and has reached its peak value (20.29%) in this zone at 420 cm, after that, it starts to decrease at the end of this zone. *Abies* and *Cupressaceae* have quite low pollen percentages in this zone. Among the broadleaved trees, *Quercus* and *Fraxinus* have the highest pollen percentage in this zone. *Quercus* started with 8.3% at the beginning of this pollen assemblage zone, reached 15.42% in 410 cm, and started to decrease at the end of this zone. *Fraxinus* pollen percentage, which is very important in terms of paleovegetation characteristics of the region, started at 9.2% in this zone and it reached 11.8% at 460 cm and kept its existence along this zone. *Alnus, Fagus,* and *Juglans* represented the low pollen percentages in this zone. The AP percentage reached the highest value in this zone.

NAP (Non-arboreal pollen) taxa such as *Artemisia*, Apiaceae, Caryophyllaceae, Chenopodiaceae, and Poaceae had very low pollen percentages during this zone (Fig. 3). According to the assessment; arboreal species are more intense during this period. It was confirmed that agriculture existed in the region approximately 4400 cal yr BP.

LG-2 (379-50 cm): The beginning of LG-2 was characterized by the reduction of *Pinus* pollen. There was a proportional decrease in the percentage of *Pinus* pollen from 67% to 34% at the end of this zone. This decrease may be due to the use of many trees in mines melting in the early Bronze Age (Yalçın, 2015), and this was caused by the extensive destruction of forests. In this assemblage zone, the second dense pollen was *Quercus*, which started with a percentage of 3.9%, reached 24%, and kept its existence during this zone. *Fraxinus* was the third dense pollen in this zone, reaching its maximum value of 21.3% in the middle of this zone. It was remarkable that Poaceae and Caryophyllaceae represented the high pollen percentages in this zone (Fig. 3).

LG-3 (49-0 cm): *Pinus* started with a pollen percentage of 59.3% and decreased to 47.7% in the LG-3 zone. The pollen percentages of *Abies* and *Cedrus* decreased to the end of this zone and Cupressaceae increased during the zone. *Quercus* also showed a decreasing line and *Fraxinus* increased at the end of this zone. In non-arboreal species, Poaceae increased from 4% to 17.7% in this zone. Caryophyllaceae, which is also non-arboreal species, increased from 2% to 4.4%. Asteraceae also increased to 6% in this zone (Fig. 3).

Fraxinus, which is claimed to be a relic, had a more intense pollen percentage approximately in the 4400 cal yr BP and was accompanied by different pollen grains representing the same environmental conditions. The existence of Cupressaceae in the pollen diagram indicated that this taxon was planted in cemeteries in the region as well as in other beliefs and myths.

The study's results are compared with those of other studies, and this comparison reveals the following outcomes. It is highlighted that vegetation has not changed so much in the last 2500 years in the Gölbaşı and Bozova Lakes (van Zeist et al., 1970). The pollen analysis results of Gölbaşı Lake, which is the closest lake to the study area spatially, are compared with our findings, and significant results are obtained. van Zeist et al. (1970) associated the density of *Abies* pollen grains in the cores with long-distance transport. In the context of the density of *Pinus* pollen, our findings overlap the study of van Zeist et al. (1970). There is harmony among studies in the context of the existence of *Olea* and similar species pollen. Attention is drawn to the presence of wheat pollen in the density of herbaceous species in the region (Zeist et al., 1970). The gradual decrease in *Quercus* after 8 m is interpreted as an important indicator of deforestation in the higher areas in the region. It is thought that *Fraxinus* and *Alnus* pollen are comes from trees and shrubs in river valleys in the Lake Gölbasi (Zeist et al., 1970).

Table 1. *AMS radiocarbon ages were obtained from Lake Gâvur sediments.*

Laboratory code	Depth (cm)	d13C (‰)	Conventional age BP	2 sigma calibration (cal BP)
TUBİTAK-0391	250	—26,8±1,0	4752±33	3638-3507
TUBİTAK-0392	500	—27,9±1,0	5470±35	4368-4246

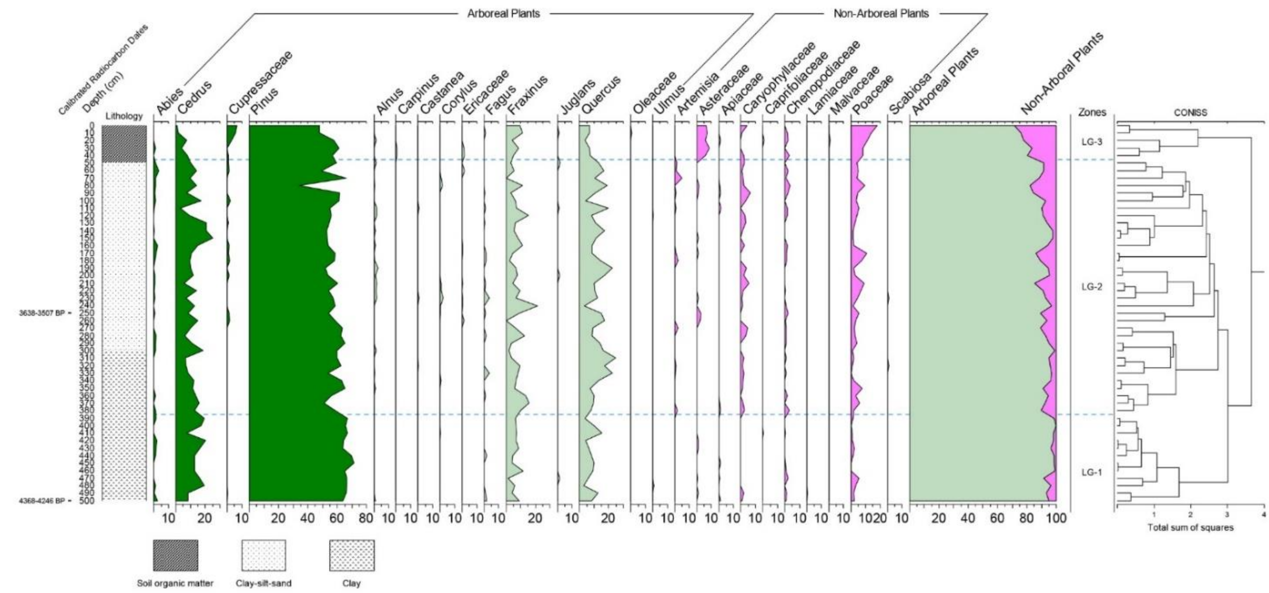

Figure 3. *Percentage pollen diagram of GC1 core.*

According to van Zeist et al. (1970), the presence of *Fagus* pollen in Gölbaşı Lake sediment should be attributed to long-distance transport. In herbaceous species, the pollen type has been more detailed. Natural or cultivation accumulation of Cerealia-type pollen was discussed in the study of van Zeist et al. (1970). The presence of intensive agricultural activity, especially in the period between 2.5 m and 9 m, was revealed by the decreasing woody pollen density. For the level between 13.20 and 13.45 m, a radiocarbon date was calculated as 3080 ± 115 BP. The period when human activities are more intense was calculated by van Zeist et al. (1970) as about 2850 to 1750 BP for the core level between 12.50 and 9.00 m. *Asteraceae* pollen density is associated with agriculture in the valleys around the lake towards the present day. Although the herbaceous community's pollen density has increased towards the present, its presence in the past is interpreted as a sign of agriculture in the region. Changes occurring in the region are attributed not only to climatological changes, but also to geomorphological processes. The idea that the pollen curves in the Gölbaşı diagram are the result of human activity is especially confirmed by the fact that the climatic changes in the last 3000 years did not cause a change in the vegetation in the high areas (van Zeist et al., 1970).

Van Zeist & Bottema (1977) mentioned that the human impact has increased in Söğüt and Beyşehir Lakes in the last 2.000 years. *Juglans*, *Castanea*, *Olea,* and *Vitis* are cultivated extensively. All species except *Vitis* were found in the pollen diagram of Lake Gâvur. In the study of Aytuğ & Görecelioğlu (1993) indicated that the destruction of forest and woodland cover started 4000 years ago in Anatolia. It is reported that in the last 2000 years, there have been significant interventions by humans in nature and serious disruptions in the environment.

Human impact in the pollen diagrams belongs to different study sites was investigated during the Holocene in Anatolia by using the OJCV (*Olea*, *Juglans*, *Castanea,* and *Vitis*) and Anthropogenic Pollen Index (API) (Woodbridge et al., 2019).

4. Conclusion

As a result, it is possible to say that the pollen percentage of non-arboreal species increases towards the present day, and this shows the increased human impact around the Lake Gâvur. Also, the presence of *Fagus*, *Castanea*, *Ulmus*, *Corylus*, and *Carpinus* pollen grains can be interpreted as a sign of the presence of a different vegetation cover around the lake than today. The existence of dense *Pinus* pollen in almost every zone should be associated with the richness of the region of *Pinus* as it is today.

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Declaration of interest

The authors declare no conflict of interest.

Author contribution

M.T. and M.K., contributed to taken the core; N.K.K., R.Y.D. contributed to data analysis and drawing of some maps and figures; M.K. contributed to the management of the project, N.K.K., R.Y.D., and M.T. contributed to introduction, application of the method, literature review, interpretation of results and production of figures.

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