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Investigation of climate and vegetation change in Göbekli Tepe (Türkiye) region using pollen data

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Abstract

Today, it is known that there is a change in the world's climate system and the living things that cause the deterioration of the natural balance are human beings. Human beings have always made changes in the environment they live in to meet their nutritional and shelter needs. These changes have affected the habitat in the region over time, causing both flora and fauna to change and have affected the level of biodiversity. In order to understand this change, pollen records from past periods are valuable archives of vegetation dynamics and provide important information about vegetation. In this study, pollen belonging to the ancient period was investigated from the wells drilled in near Göbekli Tepe, which is described as the "zero point of history". Wells were dug from 3 different localities and samples were taken from different depths. Pollen was found in the 1st and 3st wells, but no pollen was found in the 2st well. The pollen analyzes obtained from the samples in the 1st well between 6 meters and 7-7.5 meters were approximately B.C. It covers the years 11126 and 13354. The pollen analyzes made at 6, 10, 12 meters in the samples in the 3rd well were B.C. It reflects the changes in vegetation and climate between 10634-12418. Although individuals belonging to *Quercus, Salix, Juglans, Abies, Pinus* and *Juniperus* species of forest vegetation were encountered in Ancient Göbekli Tepe, no individuals belonging to these tree species were encountered today. In this study, data were obtained supporting that the region was forest-steppe in the past, and the presence of forest-forming taxa *Juglans, Abies, Pinus*, and *Juniperus* was determined for the first time and the vegetation of the past period was made more evident. The information obtained in this study shows that there is a significant change in the region and will be a source for detailed studies to be done in the future.

Key words: Göbekli Tepe, human impact, oak steppe-forest, pollen

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Göbekli Tepe (Türkiye) bölgesinin iklim ve bitki örtüsü değişiminin polen verileri kullanılarak araştırılması

Özet

Günümüzde dünya iklim sisteminde bir değişim olduğu ve doğal dengenin bozulmasına neden olan canlıların insanoğlu olduğu bilinmektedir. İnsanlar, beslenme ve barınma ihtiyaçlarını karşılamak için yaşadıkları çevrede her zaman değişikler yapmışlardır. Bu değişiklikler zaman içerisinde bölgedeki habitatı etkileyerek hem floranın hem de faunanın değişmesine neden olmuş ve biyoçeşitlilik düzeyini etkilemiştir. Bu değişimin anlaşılması için geçmiş dönemlere ait polen kayıtları, bitki örtüsü dinamiklerinin değerli arşivleridir ve bitki örtüsünün hakkında önemli bilgiler sağlamaktadır. Bu çalışmada "tarihin sıfır noktası" olarak nitelendirilen Göbekli Tepe bölgesinde açılan kuyulardan eski döneme ait polenler araştırılmıştır. 3 farklı lokaliteden kuyular kazılmış ve farklı derinliklerden örnekler alınmıştır. 1. ve 3. kuyularda polenlere rastlanmış olup, 2. kuyuda polen bulunmamıştır. 1. kuyudaki örneklerinden 6 m ve 7-7.5 m'ler arasında elde edilen polen analizleri yaklaşık G.Ö. 11126 ve 13354 yıllarını kapsamaktadır. 3. kuyudaki örneklerinde 6, 10, 12 m'lerde yapılan polen analizleri G.Ö. 10634-12418 yılları arasındaki vejetasyon ve iklimdeki değişimleri yansıtmaktadır. Orman bitki örtüsüne ait ağaçlardan *Quercus, Salix, Juglans, Abies, Pinus* ve *Juniperus* türlerine ait bireylere Eski Dönem Göbekli Tepe'de rastlanmış olmasına rağmen günümüzde bu ağaç cinslerine ait hiç bir bireye rastlanmamıştır. Bu çalışmada bölgenin geçmiş dönemde orman-

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bozkır olduğunu destekler şekilde veriler elde edilmiş ve orman oluşturan *Juglans*, *Abies*, *Pinus*, ve *Juniperus* taksonlarının varlığı ilk defa belirlenerek geçmiş döneme ait bitki örtüsü daha da belirgin bir hale getirilmiştir. Bu çalışmada elde edilen bilgiler bölgede önemli bir değişimin olduğunu göstermekte olup, ileride yapılacak detaylı çalışmalar için bir kaynak teşkil edecektir.

Anahtar kelimeler: Göbekli Tepe, insan etkisi, meşe bozkır-ormanı, polen,

1. Introduction

The formation of today's climatic conditions started from the last glacial period, that is, 20-22 thousand years ago. During this period, the temperatures in the world decreased, the pattern and amount of precipitation changed, changes-growth-shrinkage-displacements were experienced in the pressure and wind systems. During this period, all vegetation migrated and cold-resistant species became dominant. Not only the climatic variables have changed, but also the soil formation processes and plant species have changed with the climate [1].

Plant species migrated from the poles to the equator and from high to low, and took shelter in places where they could find an environment to survive. Today's biodiversity features have emerged as a result of these warming-cooling periods [2]. Climate changes have a huge impact on all ecosystems, especially temperature increases, leading to habitat changes, reduction or extinction of local species, and biodiversity losses. In addition to climate change, anthropogenic pressures significantly affect the composition of vegetation, and a better understanding of past vegetation dynamics is required to resolve the impact of these forcing factors and to assess future vegetation change [3].

In order to understand how both the climate and the vegetation of people change over time, it is important to investigate the regions where people settled down. In this context, it is known that Göbekli Tepe, near Örencik village, 18 km northeast of Şanlıurfa, in the Southeastern Anatolia Region of Turkey, is a Neolithic archaeological site and is the oldest known historical structure in the world so far and located within the borders of the Fertile Crescent, is also at the intersection of domestication areas of sheep, cattle, goats and pigs, and this confirms that Göbekli Tepe is the region where animal domestication first started [4]. Thus, human beings have started to make choices by changing the environment in which they live by domesticating both plants and animals for their needs such as nutrition and shelter. Domestication is to enable animals or plants to be used for the benefit of humans and to adapt them to live in a close relationship with humans [5]. Similarly, in the domestication of animals, it is likely that some changes were made in this region both for the feeding of these animals and for the needs of people. Therefore, climate was not the only factor affecting ecosystem dynamics in Göbekli Tepe; It is estimated that vegetation cover is also greatly affected by anthropogenic pressures. There is evidence that humans have altered the landscape and vegetation for thousands of years [6,7,8]. Anthropogenic pressures not only change tree position, but also change the composition of vegetation, increasing fire frequency and grazing activities, leading to a decrease in stress-sensitive species [9]. Pollen analysis makes an important contribution to our understanding of how plant populations around the world change over time, the distribution and abundance of pollen taxa reflect spatial changes in the composition of plant communities and biomes at a regional scale [10].

In this study, the change of climate and vegetation from that period to the present has been investigated by digging wells in areas close to Göbekli Tepe and taking plant pollen from the old period. The pollen-based scientific approach was made for the first time for the Göbekli Tepe Region and a basis was established for the evaluation of the results.

2.Materials and methods

2.1.Study site

The research area is Göbekli Tepe Basin, in which Örencik Village is located in Haliliye district of Şanlıurfa (Figure 1,2,3). The establishment of this settlement here thousands of years ago was not accidental. Due to the natural conditions of the environment, security, water-food supply and the vital and social functions that follow, this place has been chosen as a settlement. The samples taken from the three wells by drilling from the sandy sedimentation area detected during the fieldwork were sent to the laboratory in order to provide information about the presence of pollen depending on the examination of the flora fossils in it.

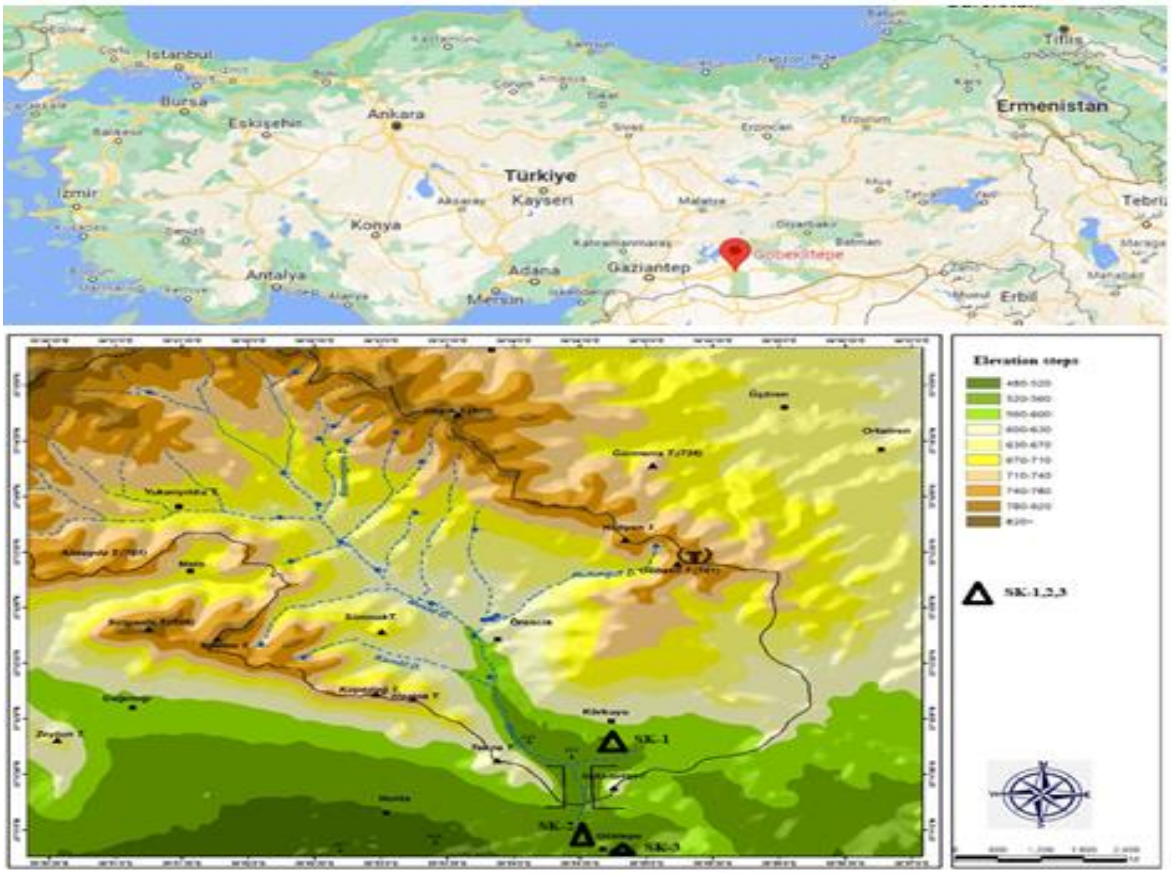

Figure 1. Map showing the location of Göbekli Tepe in Türkiye and the distribution of drilling points in the basin

Figure 2. Satellite photo of Göbekli Tepe basin

Figure 3. General view of the Göbekli Tepe region

Depending on the field investigations, the areas where the alluviums flowing over the Göbekli Tepe basin are filled were especially preferred. Because these alluviums, together with plant seeds and living remains, are dragged by external forces and stacked in a layered manner on pits or flat areas where the slope decreases. These areas are also very important in terms of paleoenvironmental research from past to present, from a hoarding organization. The patterns taken from the mentioned field were numbered according to their depth and placed in protective sampling bags. These patterns were sent to TUBITAK Marmara Research Center. The submitted samples were first subjected to age determination. Based on the period we examined from these samples, then the samples were subjected to pollen analysis at the Institute of Geosciences of Istanbul Technical University and information about the vegetation of the period was obtained.

2.2. Pollen Analysis

Pollen analyzes were carried out on 8 samples. Since there is not enough pollen in SK-2 in the samples, it is not shown in the diagram. Fossil pollen and spore analysis consists of two stages: "Sampling and preparation of pollen sections" and "Identification and counting of pollen and spore grains".

2.3. Sampling and preparation of pollen sections

Approximately 20 g samples were taken from the samples. The samples taken were prepared with the standard pollen preparation method [11]. Firstly, 35% HCl acid to eliminate carbonate content and 47% HF acid to eliminate silica content were added to the samples, respectively. Then, ZnCl2 (density>2.0) solution was added to the samples to separate the palynomorphs. Microscope slides were prepared by passing the remaining sediment sample through 200 µm and 10 µm nylon sieves and placing some glycerin on glass coverslips. Pollen identifications were analyzed using a Leica transmitted light microscope at Istanbul Technical University Eurasia Institute of Earth Sciences, using immersion oil in different lenses (x40 and x100).

2.4. Identification and counting of Pollen and spore grains

Within the scope of the research, classification of fossil spores and pollen was made depending on the degree of differentiation of morphological characteristics between genera. Pollen atlases [12] and pollen photographs were used for counting and pollen identification. The results obtained are shown in detailed pollen diagrams and pollen diagrams were created using the TiliaIT program [13]. The photographs of the obtained some pollen are shown in Figure 4.

Figure 4. Some pollen photographs used for the identification of taxa

3. Results

The pollen analyzes obtained from the SK-1 samples between 6 m and 7-7.5 m. It covers the years B.C. 11126 and 13354 and gives information about vegetation-climatic changes (Figure 5). The SK-1, 6 meter specimen covers the Younger Dryas period. According to pollen analysis, plant communities seen in this period are mainly *Artemisia* steppes and herbaceous plants of Asteraceae-Cichorioideae, Asteraceae-Asteriodeae and Poaceae are numerous. While *Artemisia* steppes were around 14%, Asteraceae Cichorioideae from herbaceous plants was determined as 45.5%. While the pollen belonging to the Poaceae family reached 13%, the pollen belonging to the Asteraceae-Asteriodeae family was observed as 5.9%. The increase in herbaceous and steppe plants in this period indicates that the study area was cold and dry in 11126 before today (B.C.). In the forest community, there are *Quercus*, *Salix*, *Juglans*, *Pinus*, *Abies* and *Juniperus* species, albeit few. Similarly, the density of herbaceous and steppe plants in the SK-1 7-7.5 meters sample shows that the region was under the influence of a cold and arid climate in 13354 before today (B.C.). The non-pollinated palynomorph (NNP) assemblage includes Pseudoschizaea Phytolith, Glomus, Anabea, Trilet spore.

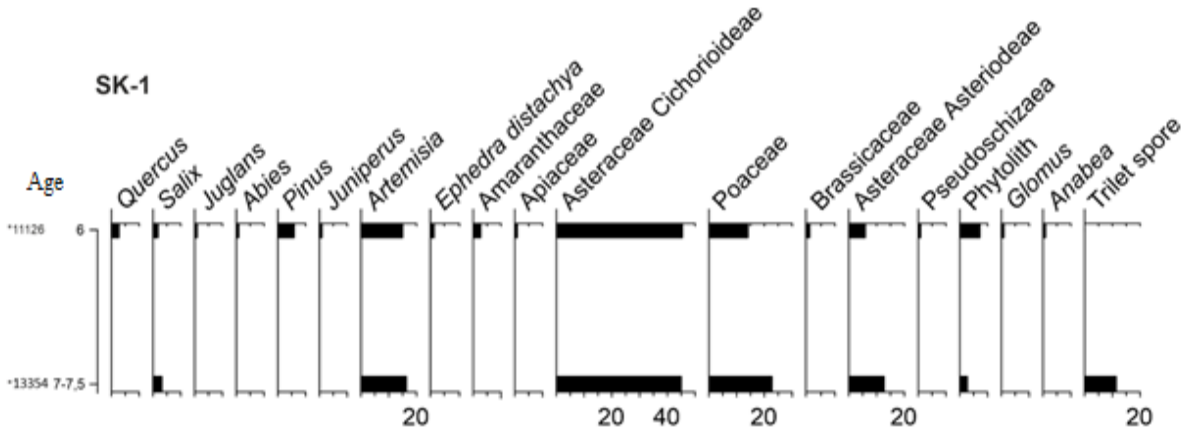

Figure 5. Detailed pollen diagram of SK-1 samples

Pollen analyzes of SK-3 samples at 6, 10, 12 meters reflect the changes in vegetation and climate between the years 10634-12418 before the present day (Figure 6). Among the plant communities, *Artemisia* steppes, Asteraceae-Cichorioideae, Asteraceae-Asteroideae and Poaceae herbaceous plants are numerous. While Artemisia steppes reached 44% at 12 m in samples, Asteraceae-Cichorioideae from herbaceous plants were recorded between 38-41%. While the pollens belonging to the Poaceae family reached 16.1%, the pollens belonging to the Asteraceae-Asteriodeae family were found to be between 7-12.9%. The increase in herbaceous and steppe plants in this period indicates that the study area was cold and arid between the years 10634-12418 before the present day. In the forest community, there are Quercus and Salix species, albeit few. Phytolith, Glomus and Botryococcus algae were detected in the non-pollen palynomorph (NNP) assemblage.

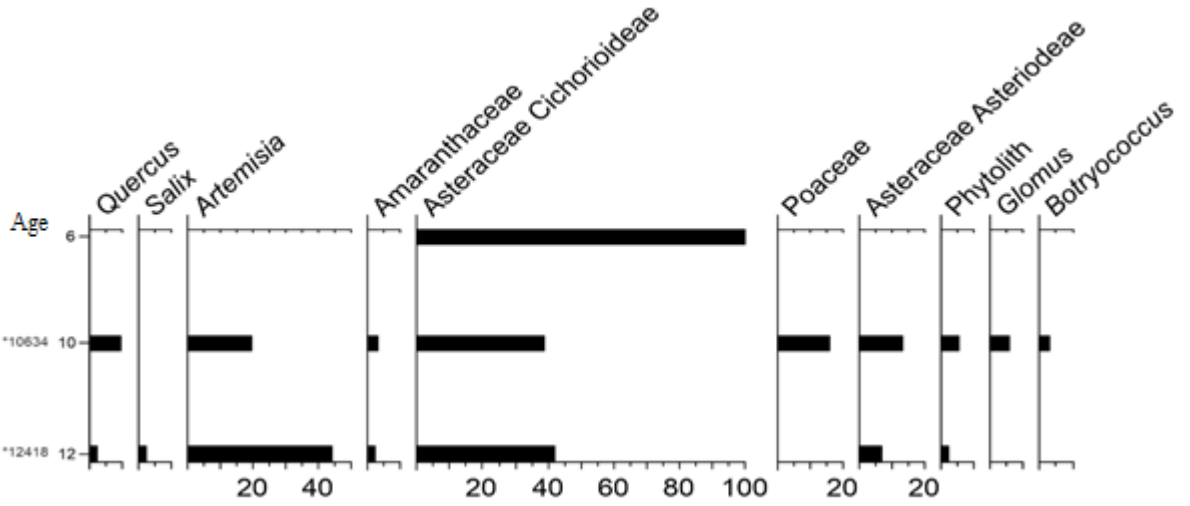

Figure 6. Detailed pollen diagram of SK-3 samples.

Fossil pollen records are well-established indicators of past vegetation changes, the prevalence of pollen in environmental environments has made palynology one of the most common and valuable tools for studying past environmental and climatic changes globally for decades [14]. In this study, the characteristics of the obtained fossil pollen were investigated using current techniques and revealed the data on the vegetation that lived in the Göbekli Tepe region in the past. In addition, the plants living in this region today were determined both by literature review and as a result of individual observations and compared in Table 1. In addition, the plant species that are naturally distributed in this region today were determined by both literature review and individual observations, and the taxa determined as a result of pollen analyzes were compared in Table 1.

Table 1. The status of the taxa of Göbekli Tepe region in the past-present and present-day Şanlıurfa

Taxon names	Ancient Göbekli Tepe	Nowadays Göbekli Tepe	Today's Şanlıurfa Spread
Quercus	+	-	+
Salix	+	-	+
Juglans	+	-	-
Abies	+	-	-
Pinus	+	-	-
Juniperus	+	-	-
Artemisia	+	-	+
Ephedra distachya	+	-	-
Amaranthaceae	+	+	+
Apiaceae	+	+	+
Asteraceae	+	+	+
Poaceae	+	+	+
Brassicaceae	+	+	+

In Table 1, although individuals belonging to *Quercus*, *Salix*, *Juglans*, *Abies*, *Pinus*, and *Juniperus* species belonging to forest vegetation were encountered in Ancient Period Göbekli Tepe, no individuals belonging to these trees have been observed today. However, it was determined that only *Quercus* [15] and *Salix* [16] individuals were distributed in Şanlıurfa. Thus, trees belonging to the forest were found in a few communities in the old period, and these have completely disappeared from the region due to the changes that have occurred until today. Both climatic and anthropogenic influences have caused them. Because anthropogenic pressures cause a decrease in pressure sensitive species such as *Abies* [9].

The genus *Artemisia* is a genus of the Asteraceae family and is a hardy herbaceous or shrubby plant group that grows in dry or semi-arid habitats. Plants belonging to this group were found in the Göbekli Tepe region in the past but not seen today, and their distribution continues in Şanlıurfa [16]. *Ephedra distachya* is a shrub that protects the soil against erosion with its strong roots, and although it was found in the past, it is not even found in Şanlıurfa today.

Species belonging to Amaranthaceae, Apiaceae, Asteraceae, Poaceae and Brassicaceae families are encountered both in the past and today. In addition, the detection of Phytolith, *Glomus* and *Botryococcus* algae in the non-pollen palynomorph (NNP) assemblage in the samples obtained is an indication that there are also water resources in the Göbekli Tepe region. As a result of these determinations, it also shows that the people around Göbekli Tepe benefit from these resources and may engage in some economic activities depending on these resources. Recent research has highlighted that the region between the upper reaches of the Euphrates and Tigris was a region where the transition to food-producing subsistence took place in the early Epipalaeolithic and Pottery Neolithic Period [17].

In the study of Neef (2003), it was stated that since taxa such as *Pistacia*, *Prunus*, *Quercus* and Poaceae were identified in Göbekli Tepe, it indicates the existence of a forest-steppe dominated by pistachio-almond oaks around Göbekli Tepe in the Early Neolithic Age [18]. This forest-steppe is typical of arid areas bordering a steppe with a slightly continental character. It is relatively open with widely spaced trees, also supported by results from zoological remains that indicate relatively open landscapes near the site [19].

4. Conclusions and discussion

In this study, we have obtained data supporting that it is a forest-steppe and the existence of forest-forming *Juglans*, *Abies*, *Pinus* and *Juniperus* has been determined for the first time and the vegetation of the past period has been made more evident. Comparable steppe forest types have disappeared in the Göbekli Tepe region today, because human intervention has often led to irreversible degradation of vegetation, especially in these areas where tree growth is limited by water stress [18]. Human beings are trying to survive and benefit from the ecological texture they live in, and accordingly exhibit various practices. This situation continues from the past to the present. It is certain that there is deterioration in the world climate system and if the human being, who is the main source of this deterioration, continues his various activities such as production and consumption habits without taking the necessary precautions, this deterioration in the climate will continue to increase [20]. Destruction or change of habitats can cause populations to shrink and disappear over time [21].

In this study, important information was obtained by performing fossil pollen analyzes of the past vegetation of Göbekli Tepe region. The change of climate and vegetation was examined and the data obtained, especially some taxa belonging to forest vegetation, were determined for the first time based on pollen analysis. This study will help to better determine the vegetation of that period by scanning more regions and investigating pollen from more wells in future studies. In addition, it has been revealed that there are deep differences between the natural vegetation of the past and the natural vegetation of today.

References

[1] Atalay, I. (1996). Palaeosols as indicators of the climatic changes during Quaternary period in S. Anatolia. *Journal of Arid Environments*, 32(1), 23–35. https://doi.org/10.1006/jare.1996.0003

[2] Brauer, A., Haug, G. H., Dulski, P., Sigman, D. M., & Negendank, J. F. W. (2008). An abrupt wind shift in western Europe at the onset of the Younger Dryas cold period. *Nature Geoscience*, 1(8), 520–523. https://doi.org/10.1038/ngeo263

[3] Van Vugt, L., Garcés-Pastor, S., Gobet, E., Brechbühl, S., Knetge, A., Lammers, Y., & Schwörer, C. (2022). Pollen, macrofossils and sedaDNA reveal climate and land use impacts on Holocene mountain vegetation of the Lepontine Alps, Italy. *Quaternary Science Reviews*, 296, 107749.

[4] Demirci, S., Koban Baştanlar, E., Dağtaş, N.D., Pişkin, E., Engin, A., Özer, F., & Togan, I. (2013). Mitochondrial DNA diversity of modern, ancient and wild sheep (*Ovis gmelinii anatolica*) from Turkey: new insights on the evolutionary history of sheep. *PloS one*, 8(12), e81952. https://doi.org/10.1371/journal.pone.0081952

[5] Parmaksiz, A., Oymak, S., Yuncu, E., Demirci, S., Bastanlar, E., Unal, E., & Ozer, F. (2018). Y-Chromosome Polymorphisms in 12 Native, Karagul, Karacabey Merino Breeds from Turkey and Anatolian Mouflon (*Ovis gmelinii anatolica*). *Kafkas Universitesi Veteriner Fakultesi Dergisi*, 24 (6): 821-828.

[6] Rey, F., Schworer, C., Gobet, E., Colombaroli, D., van Leeuwen, J.F.N., Schleiss, S., & Tinner, W. (2013). Climatic and human impacts on mountain vegetation at Lauenensee (Bernese Alps, Switzerland) during the last 14,000 years. *Holocene*, 23(10), 1415e1427. https://doi.org/10.1177/0959683613489585

[7] Schworer, C., Colombaroli, D., Kaltenrieder, P., Rey, F., & Tinner, W. (2015). Early human impact (5000-3000 BC) affects mountain forest dynamics in the Alps. *Journal of Ecology*, 103(2), 281e295. https://doi.org/10.1111/1365-2745.12354

[8] Vescovi, E., Tinner, W., Beer, R., van Leeuwen, J.F.N., Steinhauser, U., Ziegler, S., Gilli, A., Wirth, S.B., Samartin, S., Jacquat, C., & Carraro, G. (2018). Vegetation history of the upper Leventina valley from neolithic to Roman times, recorded by pollen, spores, plant macrofossils, and charcoal. In: Della Casa, P. (Ed.), The Leventina Prehistoric Landscape (Alpine Ticino Valley, Switzerland). *Chronos Zürich*, 207e225.

[9] Conedera, M., Tinner, W., Neff, C., Meurer, M., Dickens, A.F., & Krebs, P. (2009). Reconstructing past fire regimes: methods, applications, and relevance to fire management and conservation. *Quaternary Science Reviews*, 28 (5e6), 555e576. https://doi.org/10.1016/j.quascirev.2008.11.005

[10] Connor, S. E., & Kvavadze, E. V. (2008). Modelling late Quaternary changes in plant distribution, vegetation and climate using pollen data from Georgia, Caucasus. *Journal of Biogeography*, 36(3), 529-545.

[11] Cour, P. (1974). Nouvelles techniques de détection des flux et des retombées polliniques: étude de la sédimentation des pollens et des spores à la surface du sol. *Pollen et Spores*, 16, 103-141.

[12] Reille, M. (1992). Pollen et spores d'Europe et d'Afrique du Nord. Laboratoire de botanique historique et de palynologie, Marseille, France.

[13] Grimm, E.C. 1991-2015. TiliaIT. https://www.tiliait.com.

[14] Chevalier, M., Davis, B. A., Heiri, O., Seppä, H., Chase, B. M., Gajewski, K., & Kupriyanov, D. (2020). Pollen-based climate reconstruction techniques for late Quaternary studies. *Earth-Science Reviews*, 210, 103384.

[15] Akan, H., Kaya, Ö.F., Eker, İ. & Cevheri, C. (2005). The flora of Kaşmer Dağı (Şanlıurfa). *Turkish Journal of Botany*, 29 (4), 291-310.

[16] Atamov, V., Aslan, M., Cevheri, C., & Çetin, E. (2007). Contribution to the flora of Fatik mountain (Sanliurfa-Turkey). *Asian Journal of Plant Science*, 6(1), 1-11.

[17] Dietrich, L., Meister, J., Dietrich, O., Notroff, J., Kiep, J., Heeb, J., & Schütt, B. (2019). Cereal processing at Early Neolithic Göbekli Tepe, southeastern Turkey. *PLoS One*, 14(5), e0215214.

[18] Neef, R. (2003). Overlooking the Steppe-Forest: A Preliminary Report on the Botanical Remains from Early Neolithic Göbekli Tepe (Southeastern Turkey) The Newsletter of Southwest Asian Neolithic Research. *NeoLithics* 2/03, 13-16.

[19] Driesch, A., & Peters, J. (1999). Vorläufiger Bericht über die archäozoologischen Untersuchungen am Göbekli Tepe und am Gürcütepe bei Urfa, Türkei. *Istanbuler Mitteilungen*, 49, 23-39.

[20] Demir, A. (2009). The effects of global climate change on biodiversity and ecosystems resources. *Environmental Sciences of Ankara University*, 1, 037-054.

[21] Parmaksız, A., Yiğin, A., & Bozkaya, F. (2023). Determination of genetic structure of Bald ibis population living in Birecik (Türkiye) using mtDNA COI sequences. *Biological Diversity and Conservation*, 16(1), 31-37.