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Tel: +90 (212) 244 7521 Fax: +90 (212) 244 3209
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Tasarım / Design
Adnan Elmasoğlu

Uygulama / Layout Design
Hülya Tokmak

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İçindekiler / Contents

Framing Research into the Neolithic Bone Flute from Aşıklı Höyük, Turkey

Rozalia Christidou[a]

Abstract

A worked shaft of a vulture ulna, classified as a flute from the Preceramic Neolithic settlement mound of Aşıklı Höyük in Central Anatolia, Turkey, is examined with regard to its morphological and shaping characteristics. Acoustic and high-power microwear analyses are pending. Generically, the term "flute" refers to an aerophone that produces one or more pitches. The Aşıklı Höyük specimen has a notched mouth hole and a side hole. It is unique among the bone artifacts collected from the site. The complex pattern incised on its surface and the arrangement of the elements of the pattern following flute anatomy underly the unusual character of the find. This flute probably represents a part of an originally longer, more complex device. The incised pattern appears to be truncated by a transverse break which followed grooving at one end of the artifact. The rough broken edge contrasts with the carefully worked opposite end and suggests recycling.

Keywords: Aşıklı Höyük, Central Anatolia, Neolithic aerophone, bone flute, vulture ulna

Özet

Orta Anadolu, Akeramik Neolitik Dönem yerleşmesi Aşıklı Höyük'te ortaya çıkarılan ve flüt ya da kaval olarak sınıflandırılan işlenmiş akbaba dirsek kemiği, bu çalışmada biçimsel özellikleri ve biçimlendirme süreci bağlamlarında incelenmiştir. Akustiğe ve yüksek ölçekli mikro iz analizine dayalı araştırmalar devam etmektedir. Genel anlamda "flüt" terimi, bir veya birden fazla perdeden oluşan üflemeli çalgıya karşılık gelir. Aşıklı Höyük örneğinin ağızlığı çentiklidir ve bir adet yan deliği vardır. Yerleşmenin diğer kemik buluntuları arasında tekildir. Onu farklı ve özgün kılan başlıca özellikler ise yüzeyine kazınmış karmaşık desenler ve bu desenlerin flütün anatomisini takip eden düzenidir. Söz konusu buluntu, olasılıkla daha uzun ve de karmaşık bir enstrümanın bir bölümünü temsil etmektedir. Bir uçtaki çizi bezeme, oluk açma yöntemiyle enine bölünmesinin bir sonucu olarak kesintiye uğramış olmalıdır. Buluntunun pürüzlü kırık ucu, özenle biçimlendirilmiş diğer uç ile tezat oluşturur ve ikincil kullanımı işaret eder.

Anahtar Kelimeler: Aşıklı Höyük, Orta Anadolu, Neolitik üflemeli çalgı, kemik flüt, akbaba dirsek kemiği

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a Rozalia Christidou, Dr., UMR 5133-Archéorient, France.
rozalia.christidou@gmail.com ; https://orcid.org/0000-0002-0829-5793

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Introduction

The use of shafts–or portions thereof–of avian long bones as vertical, end-blown flutes is traced back to the Early Upper Paleolithic period (e.g., Buisson 1990; Conard and Malina 2008; Ibáñez et al. 2015). Archaeological and ethnological studies include numerous examples of aerophones made from long bones of birds and mammals, ivory, reeds, wood, and eventually also metal (e.g., Renaud 1926; Brade 1975; Lund 1981, 1985; Payne 1991; Zhang et al. 1999; Conard et al. 2004; Moreno-García et al. 2005; Hagel 2008; Küchelmann 2010). Clay flutes have existed since the Neolithic period (e.g., Clodoré-Tissot 2009, 26; Healy et al. 2010; Pomberger et al. 2018).

In the archaeological literature, "flute" is a term for any tube or vessel with one or more holes, used as a wind instrument (cf. Le Gonidec 2009, 18-19). Whistles and pan pipes belong to this class of artifact. An assemblage of seven long bone shafts, possibly from birds, with incised patterns on their surfaces, found in a 6th millennium cal. BCE burial of the Mariupol cemetery in Ukraine was classified as a syrinx, or pan pipes (Makarenko 1933, 43). Several single and double-piece specimens, mainly from large birds, from a 3rd millennium cal. BCE grave of the Ajvide cemetery on the island of Gotland, Sweden, could also be musical instruments (Mannermaa and Rainio 2013).

Typically, the manufacture of flutes from long bones involved the removal of one or both articular ends using grooving or a combination of grooving and snapping (see also Olsen 1979, 357-359, 1980, 43-44, 1984, 316-317, 342-344; Conard et al. 2009; García Benito et al. 2016). Rough, broken edges and natural protrusions on the outer surface of the bone shafts, for example, the ulnar papillae, or quill knobs, in the birds, were scraped and abraded until smooth. The wall of the medullary cavity was also abraded to remove natural internal relief like the ridges and struts in avian wing bones. Conical finger holes were perforated, and rough hole rims were abraded smooth. Other actions included the beveling and notching of the mouth hole, the opening of a window near this hole and surface decorations. In some cases, the natural form of the bone shaft was also modified to flatten the surface bearing the finger holes.

The identification of bone cylinders as sound-producers and musical instruments is not without problems since such fragments served various functions. For example, they were used as handles, containers or personal ornaments (e.g., Averbouh 1993; Barge-Mahieu et al. 1993; Genz 2003; Saliari and Draganits 2013; Ayalon 2018, 522-523). In addition, fragmentation and ambiguities surrounding the origins of bone modifications can constrain functional inferences (e.g., Chase and Nowell 1998; d'Errico et al. 1998; Turk et al. 2020). Overall, biases and limitations addressed in standard taphonomic and experimental artifact analyses also pertain to the study of possible music devices (cf. Lawson 1999). Since the late 1960s (see in particular Megaw 1968), there is also awareness of the cross- and interdisciplinary character of the research into these objects, which includes mathematics, musicology and organology.

The methodological considerations being outlined above are crucial to identifying ancient sounds and music playing instruments. A series of publications focus on early examples of these objects and provide criteria for modern human behavior and innovation (e.g., Brown et al. 2000; d'Errico et al. 2009; Morley 2006, 2013). Moreover, in recent years sound and music perception, production, and use have been integrated into a research of a wider scope, the archaeology of sound (see, e.g., Dauvois and Boutillon 1994; Scarre and Lawson 2006; Blake and Cross 2015).

Here we report the discovery of a locally unique bone tube classified as a flute in Level 4 of the Preceramic Neolithic mound site of Aşıklı Höyük in Central Anatolia (Figure 1). Such finds are extremely rare in Anatolia. Another flute, dated to the 7th millennium cal. BCE, has been reported from the Neolithic site of Bahçelievler, Bilecik Province, in Northwest Turkey[1]. Level 4 of Aşıklı Höyük is older. It covers the years 8350-8050 cal. BCE (Quade et al. 2018) and represents a formative stage in the local subsistence system, early caprine management in particular (Stiner et al. 2014; Buitenhuis et al. 2018; Peters et al. 2018). Material culture evidence also highlights the early character of the archaeological assemblage of Level 4 (Astruc 2018; Yelözer and Christidou 2020). The bone tube comes from a midden deposit of the upper part of the level, excavated within the area of an earlier, abandoned structure, Building 6. The midden also contained a variety of unworked animal bones and obsidian and ground stone artifacts.

The tube displays a side hole midway between its ends, which are both open, and a notch at one end. It thus bears a strong resemblance to confirmed bone flutes. Its raw material is also consistent with these artifacts. The Aşıklı Höyük specimen was cut off the shaft of an ulna of a vulture, possibly a common griffon, or Eurasian griffon (*Gyps fulvus*), identification by M. C. Stiner (09.10.2010). In Level 4, the taphonomy of large bird bones varies with species. Some of these birds occur rarely, suggesting use of raw materials such as bones and feathers rather than food consumption (Stiner et al. 2014, 8405). The cylinder from the vulture ulna is an isolated occurrence. It was probably chosen as raw material for its straight, naturally hollow form. Bone density–high in the birds–could also have influenced its selection for a flute since this property of the bone is related to the quality of the tone of the sound produced. A study of the acoustic behavior and design of the Aşıklı Höyük bone tube would allow us to ascertain its use as a flute. The present paper provides a description of the morphological and shaping characteristics of the specimen, which are essential to the understanding of its structure. Use modifications observed in the field with a stereoscopic microscope at 20-40 diameters are also described. At the time of writing, it has not been possible to photograph the shaping and use marks on the object, which is kept, since its discovery in 2010, at the archaeological museum of Aksaray, Turkey.

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1 https://arkeofili.com/bilecikte-8-500-yillik-bir-muzik-aleti-bulundu/

Description

To indicate the positions of the morphological and technological traits of the Aşıklı Höyük tubular flute, we use conventions and directional terms published in Le Gonidec (2009, 18-19, Table 1). The side of the flute that bears one or more finger holes is called the face. It corresponds to the anterior side of the Aşıklı Höyük specimen. On the longitudinally blown flutes, the notching of the edge of the mouth hole facilitates sound production. This edge is called the proximal end of the flute. The opposite edge is its distal end. It is uncertain whether the functional orientation of the Aşıklı Höyük find coincides with its anatomical position.

Table 1. Metrical data on the flute from Aşıklı Höyük (measurements in millimetres). Hole diameters vary; the values reported here are indicative.

Flute		
Total length		71.4
Outer diameter	Proximal	12.7[a] / 12.8[b]
	Central	12.4[a] / 13.1[b]
	Distal	12.5[a] / 12.8[b]
Inner diameter	Proximal	9[a] / 9.5[b]
	Distal	9.6[a] / 10.2[b]
Side hole		
Internal diameter		5.6[c] / 5.1[d]
External diameter		6.5[c] / 5.6[d]
Proximal notch		
Length		3
Width		3.2[e] / 5.4[f]

[a] length from the face to the rear side of the flute; [b] length from the left to the right side of the flute; [c] along the length of the flute; [d] along the width of the flute; [e] outer edge of the notch; [f] inner edge of the notch

The cylinder from which this artifact is made comes from the central part of the ulna. It is 71.4 mm long and its outer and inner diameters are nearly uniform (Table 1). The thickness of the bone wall, which has been worked and thinned, is 1.7 mm. This wall is perforated by a conical hole, which is located at nearly equal distances from the ends of the artifact: the length measured between the proximal external edge of the cone and the proximal edge of the flute is 32.3 mm; it is 30.4 mm between the cone's distal external edge and the flute's distal edge. The external and internal diameters of the cone show that the hole is slightly oval, with the major axis running in a proximal-distal direction. The notch in the proximal end represents about half of a similar hole which was truncated later, when the artifact was cut transversely by annular grooving and snapping. The groove, relatively shallow (depth: ≤1mm), was incised using a stone edge with a back-and-forth motion. Then, the bone was cracked along the groove. At the distal end, it was incised down to the medullary cavity. The cut surface, even and regular at this end, was not modified further. Sharp projections on the snapped proximal edge were removed with a grinding stone.

The perforation was made using a hand-held sharp stone tool and semi-circular strokes. It is oval and lopsided. Its wall and parts of its edge show overlapping striated facets indicative of shifts in the angles and lengths cut with the perforating tool (cf. Poulmarc'h et al. 2016, 963 with references). Similar facets are present within the notched area of the proximal edge of the flute. Despite the relatively short distance and the technical similarities between the hole and the notch, their midlines do not coincide.

The outer surface of the bone cylinder was scraped smooth. The natural prominences, or papillae, for feather attachment on the ulna were probably removed during this work. The medullary cavity was abraded longitudinally to eliminate natural relief, possibly using sand and a strap made from a flexible material such as leather or plant fibers. The abrasion striations have a dulled appearance.

A pattern composed of longitudinal, transverse, and oblique incisions was engraved on the scraped outer surface of the flute's body. To cut these marks, a stone edge was moved along the bone surface in the same way that it was employed on the ends of the artifact. Two longitudinal grooves were first created on its rear side (Figure 2). The distance between the two marks is about 8 mm. Then, a transverse groove was made on the flute's rear and left sides. Its distance from the proximal edge of the object is 3.1-3.8 mm. Sets of six, seven and eight parallel and subparallel oblique incisions were also shaped. They occur in a herringbone arrangement around the flute's circumference. In most of the cases, the ends of the incisions of adjacent sets intersect. Each set covers about one-quarter of the circumference of the object. The distances between the marks of a set vary between 3.7 and 8 mm. Overall, there has been little care to avoid asymmetries within a set. More importance was paid to the creation of rows of zigzags that run around the circumference of the tube. External incisions, that is, shallow, isolated, or grouped cut-marks indicating deviations of movements from the main incision path, are also visible. Lastly, the sets of oblique incisions were framed by a pair of annular grooves cut about 3 mm above the distal edge of the flute.

The central perforation, which is preserved intact on the face of the flute, interrupts an intersection of oblique incisions. It was made after these marks were shaped. The proximal annular grooving, which appears expedient when it is compared to the distal grooving, also followed the shaping of an oblique incision. It is likely that the shaping of the intact side hole and the proximal grooving and snapping represent reworking of an initially longer flute. The creation of the proximal notch exploited the existence of another, initially intact, side hole.

Differences observed in the amount of use polish and smoothing on the flute's surface may also be related to reworking. The scraping striations appear obliterated or severely worn down and polished over. The edges of the incisions on the corpus of the flute are also highly polished and rounded. The polish is associated with fine striations of varying directions and often microscopic pits, suggesting extended manipulation and use. The distal extremity of the flute and the proximal notch display macroscopic rounding of their ridges and angles and bright, macroscopic polish. By contrast, the relief created during the perforation of the central side hole and the proximal grooving and snapping is well preserved, although rounding and polish are developed on it.

Discussion

Severe wear in the form of macroscopic polish, rounding, and smoothing of surface features helps recognize intense and extended use of ancient artifacts including musical instruments. Such use wear as well as reworking traces are often observed on the personal items made of bone at Aşıklı Höyük (Yelözer and Christidou 2020; Christidou forthcoming). It is not unreasonable to assume that an exceptional object such as the worked ulna of a vulture was considered as a personal belonging and that its use-life was prolonged through reshaping (cf. Choyke 2009 with references). The expedient character of the proximal grooving and snapping may also indicate ownership and personal decision and experience. It is not possible to reconstruct the initial object, which would be longer, with more than one side holes, but the shaping of a conical hole suitable to function as a finger hole and the truncation of another, similar opening for the creation of the proximal notch reinforce the idea that the last modifications of the artifact were made by an experienced individual, aware of the function of the notch and the intact side hole and the functional properties of the bird bone.

The stratigraphic context of the flute, which was recovered from a midden (cf. Introduction), reflects a common practice related to the treatment of personal items from Aşıklı Höyük. These objects were regularly deposited in dump areas, together with waste generated by daily activities, for example, animal bones and ordinary tools. This attitude is very characteristic of the oldest occupations, which include Level 4. Independently of the functions performed by the various manufactured objects and the meanings ascribed to them, at the end of their use-lives, they were treated in the same way as the debris usually associated with the habitation and the organization of the space by the local community. The deposition of personal possessions and more precisely ornaments made of bone and stone changed in Level 2, when these artifacts were taken out from circulation and the community sphere and buried with the dead.

With regard to typology, the existence of a single side hole and the notched proximal edge suggest a whistle (Clodoré-Tissot 2009, 28-34, Fig. 2). The conical shape and the diameter of the side hole resemble to the finger holes perforated on Stone Age flutes (cf. Clodoré-Tissot 2009; García Benito et al. 2016, 214). It is larger than that of the Basque specimen, which has a diameter of about 3 mm (Ibáñez et al. 2015, 282).

The shaping of dot and line patterns on bone tools, including flutes, appears to have been an intermittent practice from the Palaeolithic period through historical times (e.g., Fages and Mourer-Chauviré 1983; Buisson 1990; Moreno-García et al. 2005). Incised patterns occur on bone tools and personal items in prehistoric sites in Anatolia and adjacent regions (e.g., Özkan 2002, 522; Badalyan et al. 2007, Fig. 6e; French 2010, Fig. 59.2, 5 and 6; Mărgărit et al. 2016, Fig. 20.1; Paul and Erdoğu 2017, Fig. 3). The history of choice of intersecting incisions forming zigzags and chevrons in Anatolia remains little documented (Azeri et al. forthcoming). The specimen from Level 4 of Aşıklı Höyük represents an early example. The arrangement of the marks observed on this specimen indicates a relatively elaborate composition, which also accords with flute anatomy. Specifically, the positions of the longitudinal and distal annular incisions indicate the proper orientation for shaping and using such an instrument. There is little doubt that the pattern was constructed specifically for this object.

The choice of the vulture bone must be discussed. Apart from the functional properties of the bone, mentioned above, the bird, the common griffon, could also have been invested with a symbolic value. It is known to have played later a role in the figurative representations of Çatalhöyük in Central Anatolia and, earlier, in various Eastern Anatolian and Middle Eastern sites (e.g., Helmer et al. 2004; Peters and Schmidt 2004; Gifford-Gonzalez 2007; Stordeur 2010). On the other hand, flutes are made from bone and other organic materials in the same cultural context (e.g., Hassan 1976, 56). At Aşıklı Höyük, the use and processing of plant materials in architecture and crafts is well documented (Astruc 2018; Tsartsidou 2018; Christidou forthcoming), while large birds occur rarely, and it is possible that the worked ulna bone here discussed was obtained by scavenging from a dead vulture. Therefore, one may wonder whether flutes were not rare at the site but made more often from reeds and wood. Since responses to sounds and music are culturally determined, the acoustic analysis of the Aşıklı Höyük find should include sonority comparisons between flutes made from bone and plant materials.

High-power microwear analysis can allow assessment of the handling wear and the manufacturing marks and, more specifically, the incisions made during the production and reworking of the flute. Thus, it would enhance our understanding of the perception and use of singular products and personal items at the site during the occupation of Level 4. Whether future research suggests that other organic flutes could have been used for the same purpose at the site, the behaviors so far recognized and associated with the production and maintenance of the bone specimen place it among the personal items from the site.

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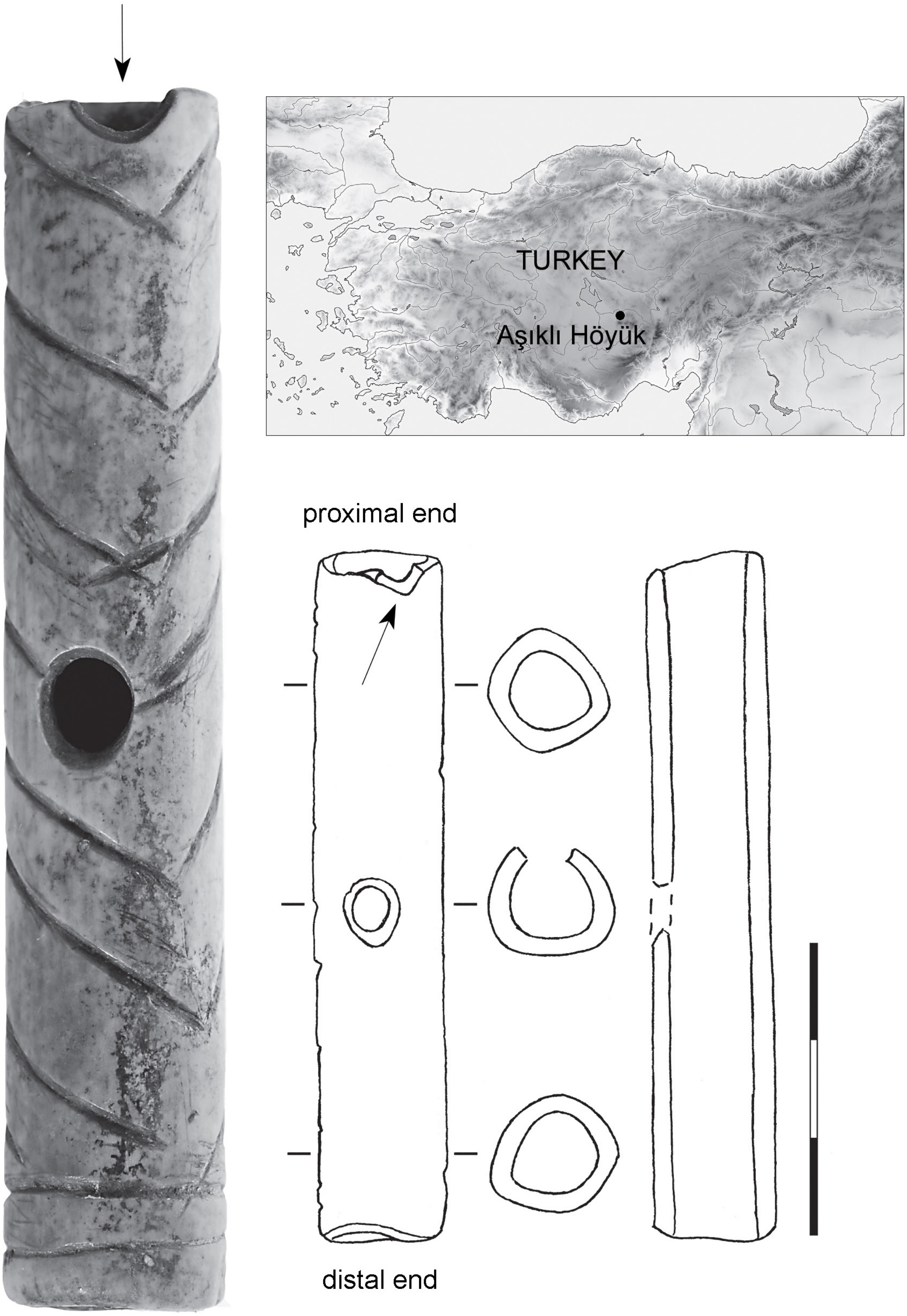

Figure 1. (a) The location of Aşıklı Höyük in Turkey; (b) contour drawings of the bone flute, face and right views (scale: 3 mm); (c) flute slightly turned toward the right side to show the proximal notch (Aşıklı Höyük Excavations Archive). The arrows indicate the notch.

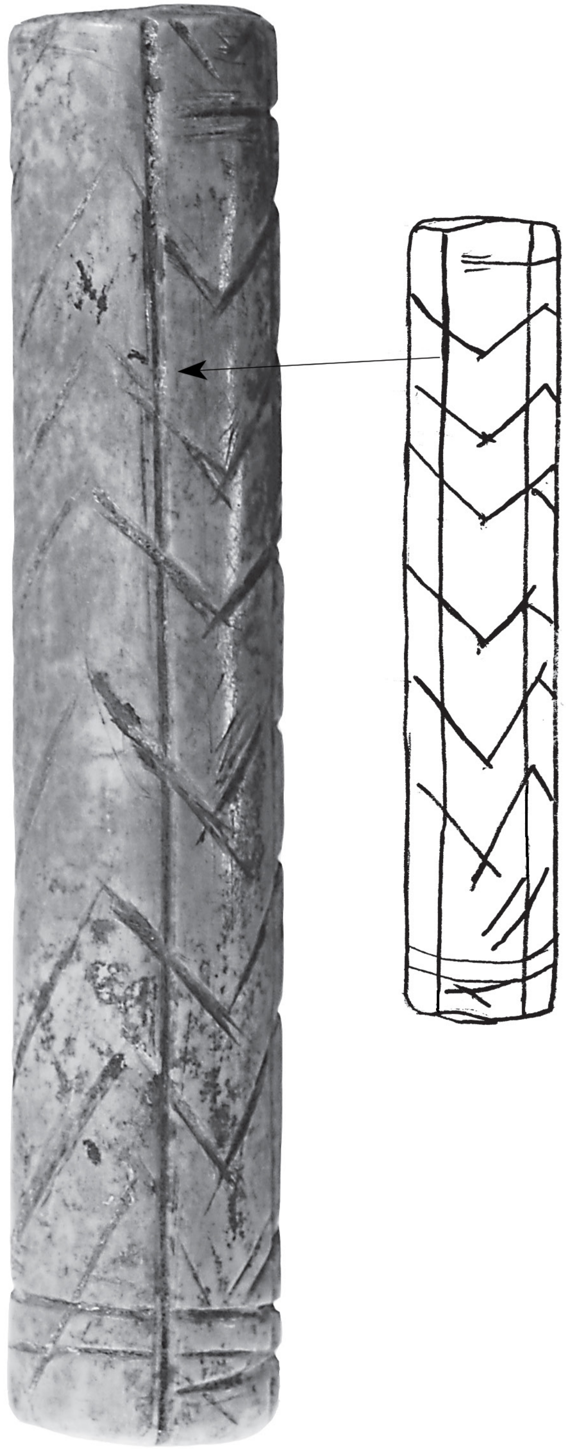

Figure 2. The rear side of flute sketched (right), not presented to scale. The photograph (Aşıklı Höyük Excavations Archive) shows the longitudinal groove near the right side of the artifact.

Agricultural Practices at Mentesh Tepe (Kura Valley, Azerbaijan) during the Neolithic, Chalcolithic and Bronze Age: An Overview from Sickle Elements and Botanical Remains

Laurence Astruc[a], Alexia Decaix[b], Denis Guilbeau[c], Bertille Lyonnet[d], Farhad Guliyev[e]

Abstract

The Neolithic process took place in the South Caucasus between the very end of the 7th and the early 6th millennium BCE, at least two millennia after it had already taken place in neighboring Anatolia and Iran. Agriculture appeared at that time, and was the main basis of the economy, together with herding. Cereals, mainly barley and different kinds of wheats, were the dominant cultivar. Mentesh Tepe, one of the rare multi-period settlements of the region, allows us to witness the development of ancient agricultural practices, since Neolithic, Chalcolithic and Bronze Age occupations have been identified there. The site is located in Azerbaijan in the vicinity of the Zeyem Cay, a tributary of the Kura River, some 10 km from the foothills of the Lesser Caucasus. We present here data originating from the analyses of botanical remains and techno-functional lithic tools studies. We have thus been able to identify trends and changes through time affecting cultivation and harvesting techniques. These are the result of economic

a Laurence Astruc, Dr., MSH Mondes, ArScan, UMR 7041, Du village à l'état au Proche et Moyen-Orient (VEPMO), 21 allée de l'université, 92023 Nanterre cedex. laurence.astruc@gmail.com ; https://orcid.org/0000-0003-1618-0617

b Alexia Decaix, Dr., AASPE, UMR 7209, Muséum National d'Histoire Naturelle, 55 rue Buffon, 75005 Paris. alexiadecaix@yahoo.fr ; https://orcid.org/0000-0002-0637-165X

c Denis Guilbeau, Dr., Ministère de la Culture, Préhistoire et Technologie, UMR 7055, 21 allée de l'Université, 92000 Nanterre. denisguilbeau@hotmail.com ; https://orcid.org/0000-0002-0058-0805

d Bertille Lyonnet, Dr., CNRS, UMR 7192, 52 rue du Cardinal Lemoine, 75005 Paris. blyonnet@wanadoo.fr ; https://orcid.org/0000-0001-8135-0675

e Farhad Guliyev, Dr., Institute of Archaeology and Ethnology, Academy of Sciences, Baku, Azerbaijan. farguliyev@gmail.com ; https://orcid.org/0000-0003-1994-4776

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and socio-cultural changes and reflect both the organization of communities and the technical skills of local inhabitants.

Keywords: Caucasus, Neolithic, Chalcolithic, Bronze Age, agriculture

Özet

Güney Kafkasya'da Neolitik Dönem, Anadolu ve İran gibi komşu coğrafyalardan en az iki binyıl daha geç, MÖ 7. binyılın sonu ve 6. binyılın başlangıcında başlamıştır. Bölgede aynı dönemde ortaya çıkan tarım, hayvancılıkla birlikte ekonominin temelini oluşturur. Arpa ve farklı buğday türleri başta olmak üzere tahıllar ekimi en yoğun yapılan türlerdir. Bölgedeki ender çok dönemli yerleşmelerden biri olan Menteş Tepe Neolitik'ten Tunç Çağı'na dek tarımsal faaliyetlerin gelişiminin takip edilebilmesini sağlamaktadır. Yerleşme Azerbaycan'da, Kura Nehri'nin kollarından biri olan Zeyem Çayı'nın yakınında, Küçük Kafkas Dağlarının eteklerine 10 km mesafede yer almaktadır. Bu çalışmada, yerleşmede bulunan botanik kalıntıların analizleri ile taş aletlerin teknolojik ve kullanım izi analizlerine dayanan veriler sunulmaktadır. Bu veriler, yerleşmede zaman içerisinde tahılların kültüre alınması ve hasadındaki değişimleri tanımlayabilmemizi sağlamaktadır. Bu değişimler, ekonomik ve sosyo-kültürel değişimlerin sonucudur ve hem toplulukların sosyal organizasyonunu hem de yerleşme sakinlerinin teknolojik becerilerini yansıtmaktadır.

Anahtar Kelimeler: Kafkasya, Neolitik, Kalkolitik, Tunç Çağı, tarım

Introduction

The process of Neolithic transformations in the South Caucasus took place between the very end of the 7th and the early 6th millennium BCE, at least two millennia after it had already occurred in neighboring Anatolia and Iran. Clusters of settlements belonging to the Shomu-Shulaveri culture appear along the Middle Kura River valley, and related or other cultural groups along the Araxes River valley and in the Ararat plain (Badalyan et al. 2004, 2007, 2010; Martirosyan-Olshansky et al. 2013; Chataigner et al. 2014; Nishiaki et al. 2015a; Nishiaki and Guliyev 2020; Palumbi et al. 2021). They are a testimony to increasing sedentism and bear witness to the rise of an economy predominantly relying on domesticated species, as shown by botanical and faunal analyses. The Near Eastern origin of this fully developed Neolithic is still debated, as the possible input of local Mesolithic groups (Nishiaki et al. 2019).

In this agricultural context, cereals were the most important cultivar. These plants are of paramount importance in the models of food production, marking not only the Neolithic but also the entire Chalcolithic period (5th and first half of the 4th millennium BCE) and Bronze Age (3500-2500 BCE). Profound modifications in settlement patterns, architecture, acquisition of raw materials, technical preferences and skills, the appearance and development of metallurgy, changes in relations with groups from other regions and in the cultural and socio-economic background, undoubtedly occurred through time. A cereal-based economy was supplemented by the cultivation of pulses. Species of cereals were not necessarily the same but sowing and harvesting them were important moments of the year for the inhabitants of most settlements. Apart from botanical remains (identifiable chaff and seeds), the ancient inhabitants of the Caucasus left behind tools, testimonies of their agricultural practices, for instance stone lithic blanks used as sickle elements. These were fixed to wooden, bone or antler hafts, and were used to cut crops. Complete sickles are sometimes found at archaeological sites. The lithic elements of these sickles vary in their raw material, shape, and size; moreover, their evolution through time can be illustrated, the changes revealing the farmers' technical know-how and permitting reconstructions of the harvesting techniques.

Botanical remains and sickle elements are key to reconstructing ancient agricultural practices. The goal of this paper is to follow the evolution of these practices at Mentesh Tepe (Figure 1) over a long-time span, one of the rare multi-period sites in this region. Three major occupations have been identified for the Neolithic (Mentesh I), Chalcolithic (Mentesh II and III) and Early Bronze Age (Mentesh IV), and these were each separated by hiatuses.

Presentation of the Site

The site of Mentesh Tepe is located in the vicinity of the Zeyem Cay, a tributary of the Kura River, at a distance of about 10 km from the foothills of the Lesser Caucasus. The site is surrounded by houses and gardens. This region is now deeply transformed by human settlement and activity, notably by cereal and potato farms. Better-preserved natural landscapes still exist on the alluvial plain and the slopes of the Lesser Caucasus, which is marked by various kinds of vegetation: (1) riparian forests along the rivers on the alluvial plain, where the main species of trees belong to the *Salicaceae* family, followed by tamarix (*Tamarix* sp.), alder (*Alnus glutinosa*) and elm (*Ulmus laevis, U. minor*); (2) the *shibliak,* an open shrub land developing at lower altitudes on dry slopes and dominated by Christ's thorn (*Paliurus spina-christi*); (3) a mixed forest with several species of oaks (*Quercus iberica*, *Q. robur, Q. macranthera*) (Bohn et al. 2003; Gabrielian and Fragman-Sapir 2008). Anthracological analyses undertaken in the Middle Kura Valley have shown that, from the Neolithic to the Early Bronze Age, the inhabitants collected wood mainly in the riparian forest, and secondarily in the open woodlands where heliophilous trees were growing (Decaix 2016; Decaix et al. 2016). A more densely forested landscape has been identified through the presence of yew (*Taxus baccata*). The continuous development of maple trees (*Acer* sp.), of others from the *Rosaceae* family and of Christ's thorn (*Paliurus* sp.) may be an indication of a decrease in the forested cover and of a more open environment, with the creation of drier *shibliak* landscape formations, perhaps caused by an increase in the anthropogenic impact at the beginning of the Bronze Age (Decaix 2016; Decaix et al. 2016).

Neolithic occupation at Mentesh Tepe was not of long duration (between ca. 5880-5536 cal. BCE). The geographical location of the site makes it the easternmost known settlement of the Shomu-Shulaveri culture (henceforth SSC). Two main phases have been identified, separated by a thick layer of burnt ashes, but the upper one is very poorly preserved (Lyonnet et al. 2016, 2017). The architecture, with round constructions of plano-convex mudbricks and cob that are either above-ground or semi-subterranean, is typical of the SSC. Most of the finds (lithics, pottery, botanical and zoological remains) come from the first phase, and almost all were discovered in a large man-made pit used as for the deposition of refuse, while the buildings themselves were almost totally void of any implements. Pottery is not very abundant and, during phase 1, is exclusively tempered with vegetal seeds of Poaceae, a rather rare temper occurrence in the Shomu-Shulaveri culture that may be due either to not yet well understood regional differences or to chronology. Relations in shapes with the more easterly region of the Karabagh and Mil Plain have been identified. The scarce sherds from phase 2 are closer to SSC standard pottery (Lyonnet 2017).

After a hiatus of ca. 800 years, very short and ephemeral occupation is attested in the Early Chalcolithic period (Mentesh II, ca. 4800-4500 cal. BCE), consisting of post-holes and pits containing specific pottery types that share similarities with those known in the Alazani valley (Lyonnet et al. 2012; Lyonnet 2017). This period was followed by a short gap in occupation, until the site was settled during the Middle/Late Chalcolithic 1 period (Mentesh III, ca. 4300-4050 cal. BCE). This time was marked by well-planned architecture made of flat mudbricks (with possibly the remains of a tripartite building), and by the testimonies of many different activities (several pottery kilns, metallurgy) (Lyonnet et al. 2012, 2017). One finds several indications of relations with northern Mesopotamia at that time, that further increasingly developed slightly later, during the Late Chalcolithic period, the time of the Leilatepe culture, which, however, is absent from Mentesh Tepe itself.

This was followed by a long period of abandonment, until the site, becoming a shapeless small mound, was re-used in the Early Bronze Age as the location of two funerary chambers dug into previous layers, each caped with a kurgan of river pebbles. The first funerary construction pertains to the Early Kura-Araxes period I, ca. 3500-2900 cal. BCE, and contained 39 individuals (Lyonnet 2014; Pecqueur in Poulmarc'h et al. 2014). The second one dates to the Early Kurgan/Martkopi period, ca. 2500-2400 cal. BCE, and was rather lavish since it contained 3 individuals and a wagon with four wheels (Pecqueur et al. 2017). Several pits, especially found around the second kurgan, are associated either with its construction or with ephemeral occupation from a time a little earlier. They yielded some archaeological material, unfortunately often mixed with that of earlier layers.

Archaeobotanical Remains

Method

More than 2000 liters of sediment, sampled from various contexts such as pits, floor layers, or hearths, were sieved in the excavation house: a flotation device with a 0,5mm mesh sieve was used. After drying, the samples were studied using a binocular microscope for seeds and fruits and an optical reflecting-light microscope for charcoal fragments. Macrobotanical remains were mainly preserved in charred form, and some of them were biomineralized (Boraginaceae, *Celtis* sp.). Modern reference collections of seeds and fruits and atlases were used for comparisons (Berggren 1981; Jacomet 2006; Nesbitt and Goddard 2006; Cappers et al. 2009, 2011; Neef et al. 2012; Cappers and Bekker 2013). Fragments of charcoal were identified by using a collection of modern wood, as well as wood anatomy atlases (Schweingruber 1990; Parsa Pajouh et al. 2001; Benkova and Schweingruber 2004; Schweingruber et al. 2011).

Results

Analysis of seeds and fruits from Mentesh Tepe was based on more than 40,000 items, belonging to 88 stratigraphic units, and covering the various phases of the site's occupation; Mentesh III, belonging to the last third of the 5th millennium BCE, gave most of the samples. Only those with secure chronological attribution will be discussed in this paper (71 samples).

Cereal remains were predominant since the Neolithic (Figure 2). Their morphology shows that they were already fully domesticated cereals. Three cereal species have been identified: barley, emmer, and free-threshing wheat. Although barley was the main crop identified in all periods, free-threshing wheat became more important during the Chalcolithic, while emmer less so. Pulses, as lentil, grasspea and pea/vetch type, were identified in the entire chronological sequence, which was not the case for flax found only in Mentesh III. Most of the samples are made up of cereals, pulses, with some remains of certain fruit trees and wild plants, which tend to show that we are dealing with detrital assemblages, where the remains might be of various origins, scattered in small quantities in the stratigraphic units. 47 taxa of wild plants have been identified, some probably arable weeds (Willcox 2012).

The vague identification of wild plants, mostly at the genus level, does not allow for a very thorough analysis of this category, which would for instance make use of the FIBS method (*Functional Interpretation of Botanical Surveys*). Indeed, in order to apply this method, it would be necessary to identify the taxa as precisely as possible—i.e., at the species level—because elements considered by the analysis are specific to each species (biological type, germination period, flowering period, leaf height, average leaf area). This type of analysis can address important issues like crop intensity, sowing seasonality, use of irrigation systems or manuring systems (Charles and Jones 1997; Bogaard et al. 1999; Jones et al. 2000; Charles 2002). However, despite the unfeasibility of this type of analysis as a result of the current state of taxa identification, a first approach can look at sowing seasonality by studying the beginning and duration of the flowering period of wild herbaceous plants. This would provide an estimation of the sowing seasonality of the cultivated plants with which they are associated. Table 1 indicates, for each taxa of wild plants, their possible 'function' (arable as weeds, ruderal plants, fodder or even as medicine or food), as well as their possible environment of growth.

Table 1. Taxa of wild plants identified at Mentesh Tepe, with possible uses and environments of growth.

	Adonis	*Aegilops*	*Ajuga*	*Anchusa*	*Artemisia*	*Astragalus*	*Bromus*	*Buglossoides arvensis*	*Capparis*	*Chenopodium album*	*Chenopodium*	*Cuscuta*	*Erodium*	*Euphorbia*	*Fumaria*	*Galium*	*Glaucium aleppicum*	*Glaucium corniculatum*	*Glaucium*	*Heliotropium*	*Hordeum spontaneum*	*Hordeum*	*Lithospermum officinale*	*Malva*	*Medicago astroides*	*Medicago*	*Polygonum*	*Rochelia*	*Scirpus*	*Scleranthus annuus*	*Setaria*	*Thymelaea*	*Trigonella*	*Vaccaria*
Ruderal			■	■	■		■		■	■	■			■	■	■		■		■				■		■	■			■			■	
Arable weeds	■	■	■	■	■	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		■	■	■	■	■
Fodder							■														■					■			■				■	
Medicinal uses, Edible plants	■					■			■	■	■		■		■	■			■	■	■			■		■	■					■	■	
Steppes	■	■	■	■	■	■	■	■			■			■		■	■			■				■	■	■	■							
Semi-desert		■					■		■	■			■		■					■	■			■		■		■					■	
Dry slopes			■	■	■	■	■	■		■	■	■	■	■		■		■	■	■	■	■	■	■	■	■	■	■		■	■	■	■	■
Wetlands			■	■	■	■	■				■	■		■		■						■				■	■		■		■			
Meadows			■	■	■	■	■						■	■		■						■				■	■	■				■		
Forests			■		■	■	■				■	■		■		■																		
Neolithic	■					■	■	■				■		■		■				■	■	■				■							■	
Early Chalcolithic	■	■				■	■	■								■			■	■	■								■		■		■	
Late Chalcolithic	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Early Bronze Age	■	■		■	■	■	■	■						■		■				■	■					■			■		■		■	

Thus, in the case of cereals sown in the autumn and harvested in the spring/early summer, early germinating and flowering weeds would have had a survival advantage over later germinating or flowering weeds. On the other hand, if cereals were sown in spring and harvested in summer, the autumn wild species would have been eliminated during pre-sowing tillage, and the spring germinating weeds would have had the best chance of survival (Bogaard et al. 2001; Bogaard 2004).

For each genus identified in the botanical assemblage, the flowering period (as well as its duration in months) of the various species potentially growing in the Southern Caucasus has been recorded thanks to the use of flora inventories (Bobrov et al. 1934; Davis et al. 1965; Gabrielian and Fragman-Sapir 2008).

Neolithic Period (Mentesh I)

Cereals were the main plants represented among the crops (97%) during the Neolithic (Figure 2). It should be emphasized here that a majority of cereal remains were not determined beyond the family level (68%), due mainly to their state of preservation. Among identified remains, barley was dominant (Figure 3, 16%), followed by emmer (7%) and naked wheat (5%). Unidentified wheat remains were also present (4%). Caryopses (96%) dominated in relation to chaff remains (4%), regardless of the cereal concerned.

Pulses were also attested (2%, mainly lentils, and only one seed of an undetermined pulse was found). While no plant remains used for manufacturing items (such as flax) were identified, fruit trees from woodlands and wild plants each accounted for 7% of seed and fruit remains. Fruit trees from woods were represented by hackberry (*Celtis* sp.) and grapevine (*Vitis vinifera*). There were twenty taxa of wild plants, mainly 'harvest' or ruderal species (*Adonis* sp., *Astragalus* sp., *Bromus* sp., *Cuscuta* sp., *Euphorbia* sp., *Galium* sp., *Heliotropium* sp., *Hordeum* sp., *Medicago* sp., *Trigonella* sp.). Spontaneous barley, a plant belonging to semi-desert environments or dry mountain slopes, as well as corn gromwell (*Buglossoides arvensis*), were also present. 91% of the wild plants discovered have a beginning of their flowering period between January and June (Figure 4), and 63% a flowering period from March to June. 82% have a short flowering time-span extending from one to three months.

Early Chalcolithic Period (Mentesh II)

Due to the smaller number of samples from this period, the data presented should be considered from a qualitative more than from a quantitative viewpoint.

At the beginning of the Chalcolithic, cereals still largely represent the main excavated plant remains (Figure 2). Once more, a majority of cereal remains were not identified beyond the family level (70%) due to their poor state of preservation. Among the more precisely determined remains (Figure 3), barley dominates (17%), followed by naked wheat (7%) and emmer (3%). 3% of the cereal remains were identified only at the level of one genus: wheat. The proportion of chaff (7%) is slightly higher than in the Neolithic, but in the cases of the three cereals identified, caryopses still remain dominant (93%). Pulses (3%) are in greater proportions than during the previous period. Once again, lentils were the main legume identified (one seed from the pea/vetch type and one from an undetermined pulse were also found).

Also, during this period, no plants used in manufacturing items were recognized. Fruit trees from woodlands are represented only by a grapevine seed (*Vitis vinifera*). 21 wild plant taxa were identified. These are mainly messicolous and ruderal plants (*Adonis* sp., *Aegilops* sp., *Artemisia* sp., *Astragalus* sp., *Bromus* sp., *Galium* sp., *Glaucium* sp., *Heliotropium* sp., *Setaria* sp., *Trigonella* sp.). Two taxa representative of semi-desert environments or dry sloping areas are also present (*Buglossoides arvensis* and *Hordeum spontaneum*), while taxa more closely related to wetlands were identified (*Scirpus* sp.). During this phase, 89% of the wild plants were flowering between January and June (Figure 4), and 65% from March to June. For 82% of those plants, the flowering duration would have been short, between one to three months.

Middle/Late Chalcolithic (Mentesh III)

In the last third of the 5th millennium BCE, wild plants were apparently more important than in the previous period. However, this is probably an artifact of a single sample, which has biased the picture. Indeed, a sample from the filling of jar 14 (FLOT 052) yielded numerous euphorbia (*Euphorbia* sp.) remains, and although some of them could have been subjected to the action of fire, this does not seem to have been the case of a large majority. They could, therefore, be modern seeds, or at least more recent than the site's occupation phases. Keeping this sample, wild plants represent 55% of the identified assemblage, and the crops 45%. By removing this specific sample, the situation is reversed: cultivated plants were the main remains identified (53%), followed by wild ones (47%) (Figure 2). Among the cereals (Figure 3), barley constituted the greater part, with 27% of the remains, followed by free-threshing wheat at 6%, while emmer represented only 1%. It should be noted, however, that while remains of undetermined wheat represented only 2% of the total of cereal remains, undetermined cereals only made up 64% of the total. Caryopses constituted most of the cereal remains (93%).

Among pulses, lentils were dominant, but grass pea (*Lathyrus sativus*) was also present, as were the remains of peas or vetch (*Pisum/Vicia*) and those of undetermined cultivated pulses. Flax was identified for the first time at the site during this period.

Among the fruit trees from woodlands, hackberry (*Celtis* sp.) and grapevine (*Vitis vinifera*) were attested. For the latter, it should be noted that two of the four pips identified were mineralized. Their age was therefore difficult to assess. Finally, 47 taxa of wild plants were identified, mainly messicolous or ruderal plants, as well as a few taxa from dry environments and wetlands, for instance the bulrush (*Scirpus* sp.). 84% of the potential weed species would have a beginning of the flowering period before June and 57% a flowering period from March to June. 80% of these plants had a short flowering period lasting between one and three months (Figure 4).

Early Bronze Age (Mentesh IV)

Cereals were the main crops identified in the Early Bronze Age samples (Figure 2). These mainly originated from contents of jars excavated in kurgan 54 but were also found in pits and hearths. The results should thus be taken with caution since the latter contexts are not perfectly secure as explained earlier. Barley, free-threshing wheat and emmer were present in proportions of 19%, 15% and 3% respectively (Figure 3). Barley and naked wheat mainly appeared as chaff (respectively 14% and 13% of chaffs against 5% and 2% of caryopsis), while emmer, which was present in minute quantities, was identified by almost as many caryopses as chaff (2% of each). Cultivated pulses represented less than 1% of the recognized remains: apart from a few remains of unidentified ones, only lentils were identified.

Flax was absent from samples attributed to this period. Among fruit trees, only one grapevine seed was identified. There were twenty-two taxa of wild plants, mainly messicolous or ruderal. Some taxa are more suited to dry or semi-desert environments (*Hordeum spontaneum, Buglossoides arvensis*), while others are more likely to be found in humid areas (*Scirpus sp.* for example). 61% of the wild plants would have flowered between March and June, with a flowering period starting before June for 86%. 82% of those plants would have had a short flowering duration (Figure 4).

To conclude, based on the analysis of seeds and fruits, crops, particularly cereals, formed a substantial component of the diet from the Neolithic to the Early Bronze Age. In each period, wild plants identified in the botanical samples were most probably arable weeds, growing jointly with crops in the fields. Most of them would have had a flowering period between March and June and would have grown between January and June. Most of them also had a short flowering season, between one and three months. Those weeds would have therefore been associated with autumn sowing (Bogaard et al. 2001) and were probably harvested in late June/early July. As already mentioned, it is not possible to go deeper in the analysis of weeds to reconstruct agrarian practices. A preliminary isotopic analysis on charred grains nevertheless allows further insight into the farming practices (Herrscher et al. 2018). Considering all periods, these analyses show that manure was probably used in wheat and barley fields, whereas pulses were presumably watered. One should now investigate the biochemical composition of cereals and pulses in a diachronic perspective, to identify possible changes over time in agrarian practices. As for cereal processing, the analysis of phytoliths (Decaix et al. 2016) from several of the site's structures has shown their presence during all periods, a result of inflorescence. This indicates that the de-husking phase took place on site, a fact consistent with the identification of chaff remains in macrobotanical samples. Chaff remains may have been used as fuel or mudbrick temper and for pottery during the Chalcolithic period. This analysis also shows that during the Neolithic and Chalcolithic periods cereal grains were brought in the houses directly without straw. These two components of the plant may have been separated outside the dwellings, whereas de-husking of cereals could have been done either inside or outside the houses. The analysis of macrolithic tools demonstrated the presence of many querns; some of these were probably related to cereal processing (C. Hamon, personal communication, October 2021).

Sickle Elements

Method

The expression 'sickle elements' traditionally refers to a typological group within the lithic industry. A macroscopic gloss is visible on these blanks by the naked eye. Use-wear experiments have demonstrated that such a gloss is often the result of a contact with cereals, but that it can also be the result of contact with other materials, for instance other siliceous plants such as reeds, or pottery, stone and hide worked in relatively humid conditions or/and with additives. This gloss is visible on most raw materials (chert, flint, chalcedony, silicified marls, etc.), except on obsidian since this volcanic glass naturally reflects light. In the case of obsidian tools, a matte surface can be seen by the naked eye when the blanks have been damaged by post-depositional action; sickles, however, cannot be detected unless a complete use-wear determination is carried out. The 89 elements with a gloss presented in this article, after analysis of a sample of blanks at low and high magnification (stereomicroscope and reflection microscopes with a magnification of up to 200x), were clearly used to harvest cereals. The method does not allow identifying the cereal species. Their dimensions and morphology lead to the thought that they were part of composite instruments whose hafts were of wood or bone/antler (Arazova and Skakun 2017; Arai 2020), into which several lithic blanks were inserted. There is a single mention of a handle made of slate in Neolithic levels at Chokh in Daghestan (Korobkova 1996, 69).

Results

Mentesh Tepe provides an opportunity to follow the way these tools were selected (technology and typology) and used (use-wear-analysis) over time, during the Neolithic, the Chalcolithic and the Bronze Age. Some differences can be seen over the long time-lapse.

Neolithic Period

38 sickle elements are known from the Neolithic contexts (Figure 5, 6), 22 of them made of chalcedony (Figure 5.1-2), four of flint and 12 of obsidian (Figure 5.3-7). All the tools of chalcedony are flakes knapped by direct hard percussion. The quality of the rock is variable: it can be either fine and homogeneous or rough and heterogeneous. The used edge is unique, opposed to cortical surfaces or abrupt edges that are either natural, knapped or retouched. The blank can be cortical (one with a lateral, natural surface, one with a cortical back and two with residual cortex). 16 tools are complete and two are residual, as they were re-used as wedges (‘*pièces esquillées*’). The lengths of the complete tools vary between 26mm and 60mm. Six blanks have a convex back, which was fully or partially retouched. The gloss in most cases largely extends over both the ventral and dorsal surfaces. In three cases, however, it is marginal. The blanks are inserted obliquely into the hafts. Five of them show remains of bitumen. The polish is well developed on the flakes made of chalcedony used to harvest cereals (Figure 6), and appears on the cutting edge, extending over the ventral and dorsal surfaces. It is compact, bright, and bears a tiny dotted striation.

Four flint sickle elements are also flakes. The complete ones measure 26, 33 and 45mm in length. Two fragments have revealed traces of bitumen. Wear is similar to that appearing on chalcedony (see the descriptions on Chalcolithic material).

Ten obsidian sickle elements are unipolar blades knapped by the standing pressure technique, while two are flakes. Eight blades were analyzed chemically, and they all come from the Sarıkamış area (Astruc et al. in press). As is often the case for obsidian blades, seven of them are multiple tools; sickle elements transformed into burins (n=2), lateral retouch (n=1), a denticulate (n=1), a *pièce esquillée* (n=1), a lateral retouch/burin (n=1), and a lateral retouch/*pièce esquillée* (n=1). One flake is a burin and the other is a denticulate. This typological diversity is proof that sickle elements could be made from what were previously other tools or transformed in different ones after their use as sickles. It is worth noticing, however, that in our sample no blank has revealed traces of secondary use. Four complete sickle elements have lengths between 22 and 37mm, but three fragments are 42mm long. The obsidian pieces show no bitumen, and the wear is clearly parallel to the edge on four specimens, indicating longitudinal hafting (Figure 5.3-7). The use-wear seen on these tools is described below.

Chalcolithic Period

Regarding the Chalcolithic period, 49 sickle elements were recognized in our sample. Nine are made of chalcedony (Figures 7, 8, 9), four of obsidian (Figure 10), 35 of flint (Figure 11.2-4, Figure 12), one of jasper (Figures 11.1, 13). The sickle elements in chalcedony are all flakes knapped by hard direct percussion. The quality of the rock is variable, either fine and homogeneous or rough and heterogeneous. The complete items are between 26 and 46mm long, but one fragment is 51mm. Four tools show a residual cortex. In five instances, the wear reflecting cereal harvesting is visible on one side, while the opposite edge is retouched: backed pieces (n=4; direct, inverse or crossed retouch, partial or total), partial lateral semi-abrupt retouch (n=1). The wear is oblique to the edge, indicating diagonal hafting. Six tools show traces of bitumen. On the Neolithic sickle elements made of chalcedony, the wear is similar to the one observed here. The general distribution of the traces depends on the more or less rough nature of the raw material: they are in any case more developed on the top of the micro-topography, and the difference is clear when the material is rough (Figure 8.1, Figure 9.1, 9.2B) or fine (Figure 8.2). The photograph (Figure 9.2A) shows a zone where a polish is highly developed (compact thread, flat micro-topography), scratched by a tiny scar produced during use (the interior of the scar is not polished).

The three obsidian blades were chemically analysed (Astruc et al. in press), and come from Tsakhkunjats 1 (North Armenia), Gegham (West of the Sevan Lake) and Sjunik 3 (South of the Sevan Lake). A laminar flake with lateral retouch is complete and measures 50mm in length. Blades are all knapped by using the pressure flaking technique: one has lateral retouches and the other, a lateral retouch and a back. Fragments are 44 to 60mm long. Hafting is parallel to the edge. The illustrated tool in Figure 10.1 is most probably to be attributed to the Chalcolithic period, as shown by its typological characteristics, although it comes from a mixed context. This tool's two lateral cutting edges were used to harvest cereals. The wear on the obsidian is totally different from the one appearing on chalcedony, flint or jasper. For this raw material, the rock itself reflects light, as does the polished area. Microscope with a magnification of 100x-200x is necessary to identify and locate the polish. In some cases, the tool is damaged by post-depositional processes (Figure 10.A-B), and the surface of the used area is matte, as are the abrasive features (abrasion and striation are highlighted). The cutting edges are always smoothed. After its use as a sickle, the illustrated blade was re-shaped on both edges by pressure retouch: the wear is thus no longer present in the retouched zones of the dorsal surface. Part of the left edge has been secondarily used to scrape a relatively hard vegetal material: a tiny continuous polish along the very edge is visible on the dorsal surface (Figure 10.C). The Chalcolithic blade illustrated Figure 10.2 was used as a sickle element and the edge was rejuvenated by direct coarse denticulation. Its use as a sickle continued after this sequence of retouch.

A blade made of high-quality red jasper was knapped by pressure flaking, probably by means of a lever (Figure 11.1). The active edge was retouched by a careful pressure flaking and the opposite edge was transformed by marginal direct retouch. Wear is highly influenced by the nature of the raw material: a fine texture with tiny fossils. Polish is very much apparent, compact and bright. Striation is absent. The cutting edge is slightly smoothed and polished.

During the Chalcolithic period, sickle elements were most often made of flint (n=34). Complete blades are between 65 and 88mm long. Most, if not all, were detached by pressure flaking in a standing position. The typology is diverse: a scraper (n=1), a scraper/lateral retouched back (n=1), pointed (n=1), pointed/lateral retouch (n=4), lateral retouch (n=17), truncation (n=1), and lateral retouch/truncation/burin (n=1). The use of pressure retouch is predominant in this sample. In nine cases, the gloss is visible on both edges. 28 blades bear traces of a longitudinal hafting, and three of oblique hafting. 10 tools show traces of bitumen. Figure 12.1 shows a tiny tool (this module is rare in the sickle assemblage) made on a bladelet. The left edge was used as a sickle and the wear is clearly visible on the ventral surface, but not in the dorsal one since the blank has been retouched by a micro-denticulation. Figure 12.2 shows a large blade used on both sides. The polish is very extensive and has a compact and flat aspect (Figure 12.2A). The cutting edge is smoothed and highly polished. No striation is visible. On the left edge, a direct partial retouch was made by pressure flaking. The tool was used for harvesting, after a sequence of retouch, as shown by the partial polishing of retouch scars (Figure 12.2B).

Bronze Age

Among the 41 sickle inserts found in mixed or possibly disturbed contexts, only two could be confidently attributed to the Bronze Age based on technological and typological comparisons with other sites (Figures 14, 15, 16). They are the only artifacts found at Mentesh Tepe made on siliceous marl. The tools are complete: one flake is about 62 x 31 x 10 mm, the other is 60 x 26 x 5.5 mm. Both were shaped with a bifacial retouch made by percussion and pressure flaking. They both have a denticulated edge. They are hafted longitudinally. One of them bears traces of bitumen. The wear is once again highly influenced by the raw material. The large sickle element shown in Figure 15 is made on marl with a low content of silica. The wear is mainly due to abrasive phenomena (Figure 15A) with a small and dull polish component. Higher magnification reveals spots of highly polished silica (Figure 15B). By contrast, the second insert contains a higher degree of silica, and the wear is more like that of flint tools. The polish is highly developed and extensive, and the edge is smoothed and polished (Figure 16A, B). The thread is compact, the micro-topography is slightly domed and a striation parallel to the edge is visible. The polish is bright, but in some areas is a little duller.

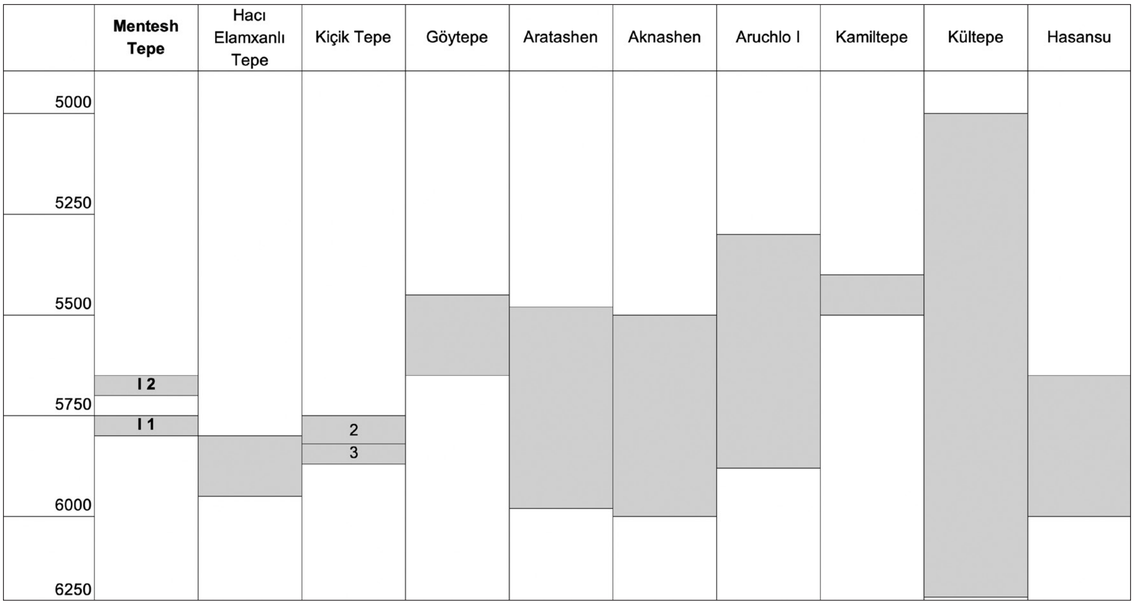
Discussion

The sickle elements of Mentesh are testimonies of the agricultural practices at the site, in a context where cereals were the main cultivar. As at neighboring sites in the Kura valley like Kiçik Tepe and Göytepe (Table 2), and frequently observed at archaeological sites of the Southern Caucasus, barley is the most frequently encountered cereal, regardless of the period, followed by wheat varieties. This is also the case, for instance at the Neolithic sites of Aratashen and Aknashen in Armenia, where barley grains are the most numerous, followed by free-threshing and hulled wheat (Hovsepyan and Willcox 2008; Badalyan et al. 2010). It is by looking at this last genus that we can see an evolution through time, with a shift from hulled wheat (mainly emmer) to free-threshing wheats. This change seems to have taken place during the first half of the 6th millennium BCE (Decaix 2016; Akashi et al. 2018; Palumbi et al. 2021). This evolution in the cultivated wheats might also be visible at Mentesh Tepe, but our periodization of the samples is not yet refined enough. During the following periods—the Chalcolithic and Early Bronze Age—free-threshing wheat remained predominant among cultivated wheats (Hovsepyan 2008, 2010; Berthon et al. 2013; Decaix et al. 2020a, 2020b). During the Early Bronze Age, the gap between the proportions of barley and naked wheat at Mentesh Tepe is narrowing even more (Figure 3). The cultivation of pulses (lentils, peas, grasspeas, *vicia*, bitter vetch) and flax was also common in the region (Hovsepyan 2008; Badalyan et al. 2010; Berthon et al. 2013; Decaix 2016; Neef et al. 2017), with the exception of the Early Bronze Age, when proportions of pulses decreased (less than 1% at Mentesh Tepe) and flax seems to have disappeared from the botanical corpus (Decaix 2016; Decaix et al. 2020a).

Few remains of fruit trees were found in the seeds and fruit samples of Neolithic Mentesh Tepe, as was for example the case at the nearby Middle Kura Valley sites like Kiçik and Goytepe

(Akashi and Tanno 2020; Palumbi et al. 2021). Indeed, for instance at Kiçik Tepe, one can see a shift between phases 3 and 2, with an increase in the proportion of free-threshing wheat in phase 3, at the expense of hulled wheats (Palumbi et al. 2021). Then from the Chalcolithic onwards, more fruit trees are present, identified mainly by means of anthracological analysis, since hackberry and grape remain the only species recognized by looking at seeds and fruits. This stands in contrast with what can be seen in the Araxes valley, where there is a higher diversity in fruit trees as from the Neolithic (Decaix 2016). It is noteworthy that not so many Chalcolithic sites have been investigated from an archaeobotanical perspective, so diachronic occupation at Mentesh Tepe is essential to better grasp agricultural practices and their evolution. Our study demonstrates that sickles at Mentesh Tepe were composite tools made with a wooden or bone haft, with lithics inserted either obliquely or parallel. Experiments with long lithic inserts have demonstrated that a slightly curved haft and oblique hafting were more efficient for harvesting than a straight haft and parallel hafting (Astruc et al. 2012). Botanical analysis shows that the harvest took place in the spring/early summer. It was most probably a collective activity conducted by members from different households.

Table 2. Chronology of the Neolithic sites mentioned in the text (Badalyan et al. 2007, 2010; Nishiaki et al. 2013; Lyonnet et al. 2016; Hansen et al. 2017 Museibli 2017; Helwing and Aliyev 2018; Marro et al. 2019; Nishiaki and Guliyev 2020; Palumbi et al. 2021). No precise dates for Shomutepe, Ilanlytepe, Toyretepe, Chalagantepe, Alilemektepe, Polutepe, Gagalartepe (6th millennium BCE). For the Chalcolithic and Bronze Age periods, Mentesh Tepe is the only well-dated site.



The way the inhabitants of the village manufactured the sickles reflect the acquisition routes of lithic raw materials and the community's technical know-how in the production of the tools.

Obsidian, flint, jasper and siliceous marls were chosen for sickle elements. The origins of some of the raw materials are known, and they reveal how villagers were exploiting a large territory through direct acquisition or exchanges with other communities. Bitumen could also be sourced (see below). In Neolithic levels, the raw materials are 85% obsidian, 12.5% chalcedony, 1.5% flint, and 1.2% other rocks, and in the Chalcolithic levels, 97% are obsidian, 1,7% flint, 0.8% chalcedony, and 0.5% other rocks. During the Bronze Age, obsidian (from Chikiani) and siliceous marls are present. The sources of most of the lithic raw materials (chalcedony, flint, jasper, Ostaptchouk 2017; the marl is of unknown origin) are 30-50 km distant from Mentesh Tepe. Obsidian sources are distributed across Georgia, Armenia and North-Eastern Anatolia, and lie at a distance between 100 and 270 km from the site (for sources and pathways see Astruc et al. in press). The main source during the Neolithic was Şarıkamış (other sources were Tsaghkunyats, Chikiani, Gegham, Arteni, Yaglica, Gutansar, Hatis), and Gegham for the Chalcolithic (other sources: Şarıkamış, Tsaghkunyats, Chikiani, Gutansar, Syunik, Arteni, Khorapor, Hatis). It seems that the inhabitants of Mentesh Tepe did not care about the geographical origin of obsidian glass. Technological and typological analysis have shown that it is considered in the same way, regardless of its provenance (Astruc et al. in press). It is therefore unlikely that, during the Neolithic, they would have selected obsidian exclusively from Şarıkamış to harvest cereals: although the eight blades come from this same source, this is due only to its predominance at this period.

Deposits of chalcedony are known in the region of the lower Agstafachaj/Aghstev valley on the Azeri (Ostaptchouk 2017) and the Armenian side near the village of Sarigyugh (Chataigner et al. 2020). The amount of chalcedony found in the assemblages markedly decreases from 12.5 to 0.5% between the Neolithic and Chalcolithic. One must bear in mind that artifacts made of chalcedony were preferentially used as sickle elements: the use-wear analysis conducted for items from Chalcolithic levels did not reveal any other function. Likewise, flint tools were mainly used as sickle elements during the Chalcolithic period. To complete this inventory of materials involved in sickle manufacture, one should mention the bitumen visible on some of the sickle elements made of chalcedony and flint. It is worth noting that the composition analysis of a lump of bitumen, most probably used for decorating the Chalcolithic ceramic tableware, indicates its probable origin in the Shirvan region (Abbasova 2012). Arazova and Skakun (2017) mention the use of plant gum to fix lithic elements into the groove of the haft, but no analysis was conducted.

Sickle elements at Mentesh reveal the main trends of lithic assemblages during the Neolithic and the Chalcolithic, namely flakes in chalcedony knapped by direct percussion and blades of flint, jasper and obsidian knapped applying the pressure technique. Blades were selected within the main production at the site, pressure flaking was carried out in a standing position. Smaller nodules were rarely chosen (a single example in our sample, Figure 12.1) and larger nodules—pressure flaked by means of a lever—were on the contrary not selected to make sickles—with the possible exception of red jasper blades (Figure 11.1). Sickle elements were used mainly with unretouched edges. Micro-denticulation, denticulation or lateral retouch by pressure flaking were done to rejuvenate the edge after initial use to cut cereals. Most sickle elements show traces of use on a single edge, while the opposite one is not used (often a natural or retouched edge was prepared to facilitate hafting). Some were used on both sides: the lithic element was turned around and fixed once more in the haft's groove. Multiple tools are frequent in sickle typology, being also burins, scrapers, truncations, lateral retouched tools or pointed edges. In our sample, however, only one lithic element (a lateral pressure-flaked retouched tool) was reused for another activity, i.e., for the scraping of a vegetal material. Typical sickle elements of the Bronze Age were made of flakes that were all shaped by percussion and pressure retouch: the techno-typology is radically different from that of older specimens of the Neolithic and Chalcolithic periods.

Secure data is now available on harvesting techniques, but subsequent treatment of crops is not well documented. Since self-propagating plants (weeds) were collected together with cereals, careful sorting probably took place after the harvest to separate the wild plants fulfilling functions different from that of cereals. The use of threshing-sledges to produce chaff and grain is not attested at Mentesh Tepe during the Neolithic and Chalcolithic periods. Evidence for this technique is nevertheless well-known in Near Eastern contexts as from the beginning of the Neolithic (Anderson 2006; Anderson et al. 2006) and later in the South Caucasus (*infra*). Macro-tools such as querns were discovered at the site and a fraction of these are related to cereal treatment (Hamon 2012; C. Hamon, personal communication, October 2021). Grain processing and storage are unknown, as no concentrations of grains were seen in the excavation area. A large number of jars and silos were found in the Chalcolithic period, but there were no traces of their original contents, and the samples studied are the result of secondary fillings (Lyonnet et al. 2011, 2017; Decaix 2016).

In the Lesser Caucasus, sickle elements are identifiable when one follows typological approaches. A few use-wear studies were carried out (Arazova 1986; Badalyan et al. 2007, 2010; Chabot et al. 2009, in press; Esakia 2017; Arazova and Skakun 2017, 2019). In their review of "the oldest harvesting tools of Azerbaijan", Arazova and Skakun (2017) examined material from sites "located in the middle reaches of the Kura River on the Ganja-Qazakh plain (Shomu Tepe, Gargalartepe, Toyretepe, Göytepe, Hasansu, etc.), on the Karabakh plain (Ilanlytepe, Chalagantepe), on the Mugan plain (Polutepe, Alikemektepe), and in the middle reaches of the Araxes River, particularly on the territory of Nakhchivan Autonomous Republic (Kültepe I)." They claim that "flint and obsidian inserts from sickles are numerous and account for 20 to 40% of the whole stone industry of the site." We were not able to evaluate the percentage of sickle elements at Mentesh Tepe, because we only characterized a sample of tools, but it is clearly far less. In the same study, Arazova and Skakun (2017) identified several types of sickles: straight handles with parallel inserts, slightly curved handles with slightly curved oblique inserts, slightly curved handles with parallel inserts, and a single element within a slightly curved haft (Arazova and Skakun 2017, figure 4). At Shomu Tepe (Arazova 1986; Narimanov 1987), sickles with antler and mandible hafts were identified, as well at Göytepe. At Mentesh Tepe, there were no indications of the degree of haft curvature. We only know that parallel and oblique inserts coexisted during the Neolithic and Chalcolithic periods, and that parallel hafting is attested during the Bronze Age. This suggests a picture different from the one expressed by these authors who say that “it could be supposed that the transition from sickles with an oblique cutting edge to those with a straight one can be traced throughout the early stages of agricultural communities in Azerbaijan.” Arazova and Skakun (2017) make an interesting comment on the Bronze Age sickles: “The latter were widespread in the Caucasus during the Bronze Age. However, their cutting edge was made of bifacial flint blades with denticulated working edge. It was during this period that metallic sickles appeared (Kushnareva and Chubinishvili, 1970: 126-7; Munchaev, 1975: 380).” Following a use-wear analysis, Esakia (2017) mentioned the presence of sickles at Aruchlo I during the Neolithic, one of them being on the lateral edge of a scraper used with its front-edge to scrape wood.

At the neighboring Neolithic site of Göytepe (Arai 2020; Nishiaki and Guliyev 2020), sickles made with bone hafts and oblique obsidian or flint inserts are well documented. They are made of antler or of cattle mandible. Several examples are complete, made with oblique inserts. Studies on the lithic industry (Nishiaki 2020) have made it obvious that flakes and blades have a matte surface or gloss, and in some cases traces of bitumen were detected. Blanks are between 17 and 58mm in length and 12 to 28mm in width. The working edge is retouched, denticulated or unmodified, and the tools can be associated with burins, backs or ‘Aknashen tools’. Takase (2020) confirmed through use-wear analysis that those blanks were used for cutting/sawing grass plant material. One can note that chalcedony was not exploited by the inhabitants of Göytepe and Haci Elamxanli Tepe.

Use-wear analysis of obsidian tools was conducted at two Armenian sites, Aratashen (Badalyan et al. 2007; Chabot et al. 2009) and Aknashen (Badalyan et al. 2010; Chabot et al. in press). At Aratashen, use-wear analysis has shown that “a large proportion of the segments of retouched blades as well as those used in the raw form have a function related to agricultural work” (Badalyan et al. 2007, 46). The detailed use-wear analysis is not published, but the articles mention the presence of sickle elements and tribulum inserts. Illustrations show an example of each item made of obsidian. At Aknashen (Horizons VII-II, Neolithic; Horizon I, Chalcolithic), the importance of agricultural work is also clear (Badalyan et al. 2010; Chabot et al. in press).

Three activities in which obsidian tools were involved are mentioned: harvesting with sickle elements, stripping (harvesting with a simple blade in one's hand, a motion where the harvester firmly wedges the seed head between their thumb and the blade then pulls it toward pulls it toward him/herself; this technique may have been used to harvest emmer wheat and hulled barley present at the site, Hovsepyan and Willcox 2008), and threshing. These two activities are not documented at Mentesh Tepe. Sickle elements were identified in all horizons at Aknashen, except in the Chalcolithic one (but study is still in progress). Blanks can be knapped by pressure with a crutch or a lever, or by indirect percussion. The typology is diverse: unretouched, with fine teeth, with a notch or retouched. Some of the blanks show use on both their lateral edges. The tools used to strip were identified in horizons I, V, VII. Tools are unretouched, with a notch or with partial retouch. Threshing elements are present in horizons I, V and VII. They were knapped by pressure with a crutch or a lever or using another undefined technique. Typologically, they are retouched segments, notches, with fine teeth or unretouched. Two burins were identified, the burin being struck after the use in threshing. Double use was noticed in the case of some elements: harvesting and threshing or stripping and threshing. They were knapped by several techniques: standing-up pressure with a crutch, pressure with a lever and another unknown technique; they were either retouched blades or a denticulate.

The sickle inserts found in other Neolithic sites in the South Caucasus are rarely well-described. As far as one can notice, most consist of fragments of blades, and sometimes flakes inserted obliquely into the haft (see for an overview Korobkova 1996; for Hacı Elamxanlı Tepe, Nishiaki et al. 2013, 2015a/b; Kadowaki et al. 2016; for Shomu Tepe, Arazova 1986). At Kiçik Tepe as well, obliquely hafted flint sickle elements were identified. In the Mil Steppe, at Kamiltepe, one sickle insert with a denticulate edge was found, at MPS5 an obsidian blade was probably used as a sickle insert with longitudinal hafting with both edges used (Guilbeau et al. 2017, 396).

As for the Chalcolithic period (5th millennium-early 4th millennium BCE), sickle inserts are not documented elsewhere in the South Caucasus, but there is a lack of data on Chalcolithic sites, and an even more acute paucity of publications on chipped stone industries associated with this period. Narimanov (1987) did mention "clay sickles" at Leilatepe and compared them with those found in Ubaid contexts in Mesopotamia (Lyonnet and Guliyev 2010, 222). Akhundov (2007) has also indicated the presence of sickles at the sites of Leilatepe and Böyük Kesik but has not provided further information. Based on the drawings, one could say that elements with parallel wear appear to have been identified at Böyük Kesik.

As for the Bronze Age, large flakes with a bifacial shaping were documented elsewhere in the South Caucasus at sites attributed to the Kura-Araxes culture, and even very much later (see for instance the Mil Steppe Iron Age, Guilbeau et al. 2017, 396). Jayez et al. (2017) published the industry of Kohne Tepesi (East Azerbaijan, Iran) in which the authors underline, like in

Mentesh, a clear dichotomy in the nature of the lithic assemblage: specialized, highly skilled production with flint bifacial sickle elements versus obsidian opportunistic production. Similar types of sickle inserts (with variations of size and shape) were more widely used in this period, even far beyond the Caucasus (Kourtessi-Philippakis and Astruc 2002; Kourtessi-Philippakis 2010; Gatsov 2012).

Conclusion

At Mentesh Tepe in the middle Kura Valley, during the Neolithic and Chalcolithic periods and the Bronze Age, the local economy was based on herding and agriculture. During all these times, cereals were the main cultivar, predominantly barley and various kinds of wheat. Sowing took place in the autumn and harvesting in the spring/early summer. During each period, farmers manufactured their sickles in a specific fashion. No complete sickle has ever been found during excavations, but their reconstruction is possible through the study of lithic artifacts. Sickles were always composite instruments made of a haft (in wood, antler or bone) in which stone elements were inserted. During the Neolithic, the latter were predominantly flakes made of chalcedony, but sometimes of obsidian blade fragments. The inserts, often unretouched, were hafted either in oblique to form a jagged cutting-edge in the case of chalcedony, or in parallel to form a continuous cutting-edge in the case of obsidian. Local or imported rocks—sometimes brought from nearly 270 km away—were therefore selected, and the level of skill required to produce blanks varied from the implementation of a simple *chaîne opératoire* and direct percussion in the case of chalcedony, to a complex reduction sequence and pressure technique for obsidian. To sum up, chalcedony inserts could be produced by everyone, but obsidian ones were manufactured by specialists. During the Chalcolithic, chalcedony inserts with oblique gloss declined in favor of flint and, exceptionally, jasper elements. However, obsidian was still in use. Parallel hafting was predominant. Inserts were mainly blades made by pressure flaking and were probably produced by skilled craftsmen. Edges were often retouched by pressure flaking. During the Bronze Age, lithic inserts were completely different. The morphology of flakes, made of silicified marls, was entirely the result of percussion and pressure retouch, and the edge was denticulated. For these elements, skills were no longer geared towards knapping, but towards retouching. They were specialized tools, while everyday industry was simple and opportunistic and made of obsidian. Throughout the sequence, players involved in the production of sickles probably did not have the same skills and status within communities. Mentesh Tepe is a good example of the hidden complexity of some of the agricultural practices of these ancient societies. Other techniques of harvesting and post-harvesting, such as stripping and threshing, were not identified at the site, no matter the period. Such techniques were identified, nonetheless, in the Ararat plain as early as the Neolithic. Our knowledge of agricultural practices in the South Caucasus is merely incipient. The development of multi-disciplinary approaches is now imperative. Botanical studies, including work on self-propagating plants and weeds, phytoliths, and isotope analyses, as well as techno-typological and use-wear observations on lithic tools (both chipped stone and macro-tools) and the study of storage facilities will no doubt reveal new aspects of these ancient communities' daily lives in the near future.

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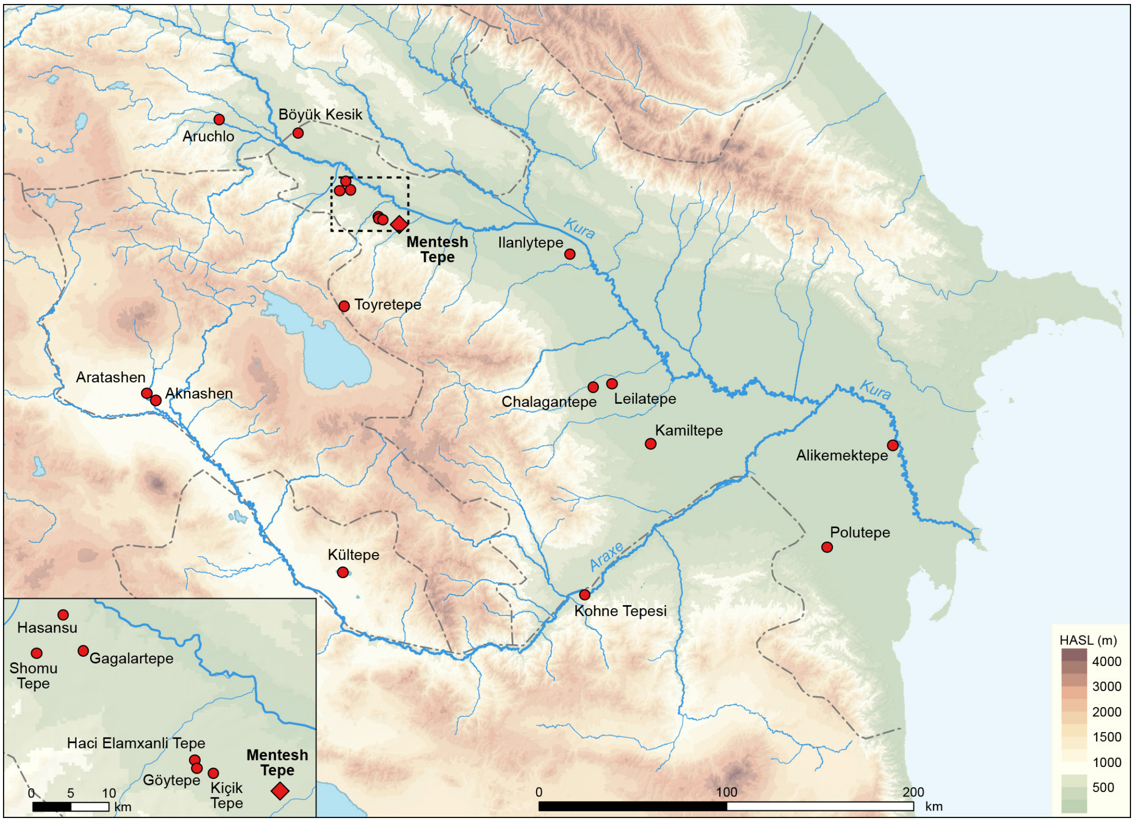


Figure 1.
Location of Mentesh Tepe and other sites mentioned in the text.

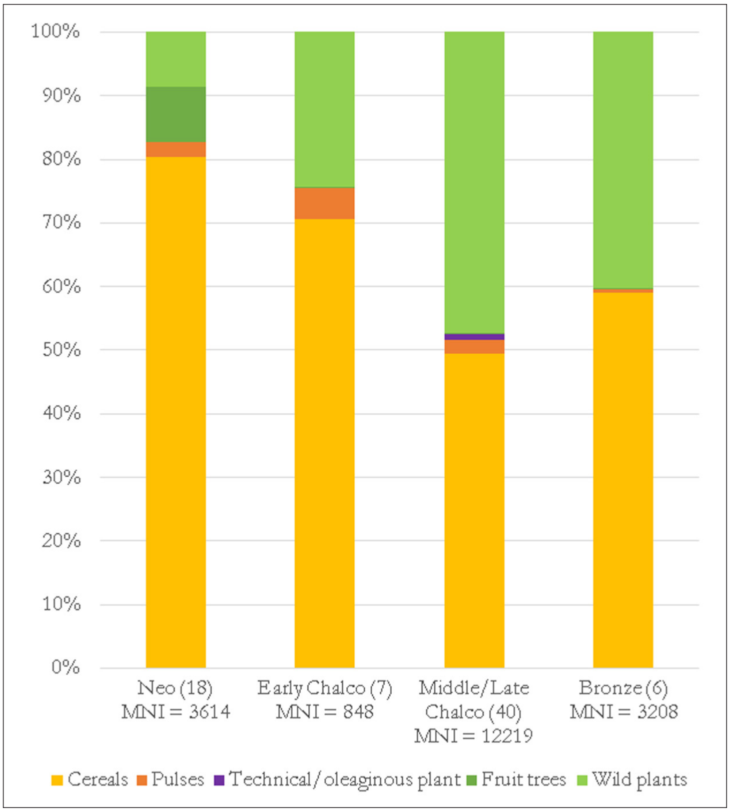


Figure 2.
Proportions of each plant category identified at Mentesh Tepe (Number of contexts indicated inside parentheses next to the period/phase; MNI=Minimum Number of Individuals).

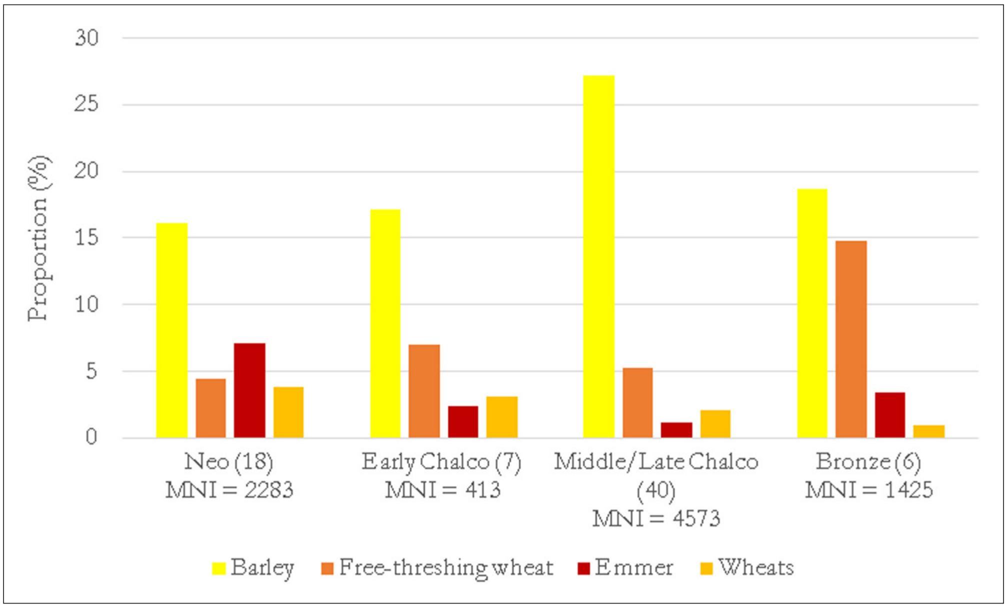


Figure 3. Cereal proportions during the site's various occupation phases (Number of contexts indicated inside parentheses next to the period/phase; MNI=Minimum Number of Individuals).

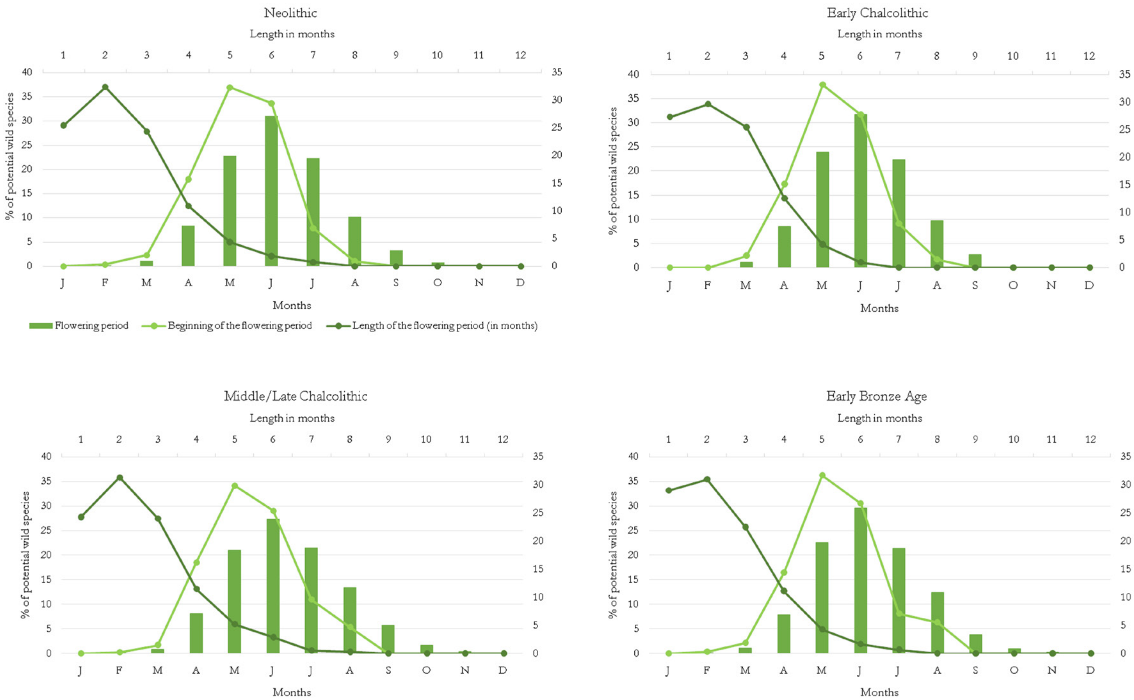


Figure 4. Synthetic diagrams specifying flowering periods and their lengths (in months) of potential weed species identified in samples from Mentesh Tepe.

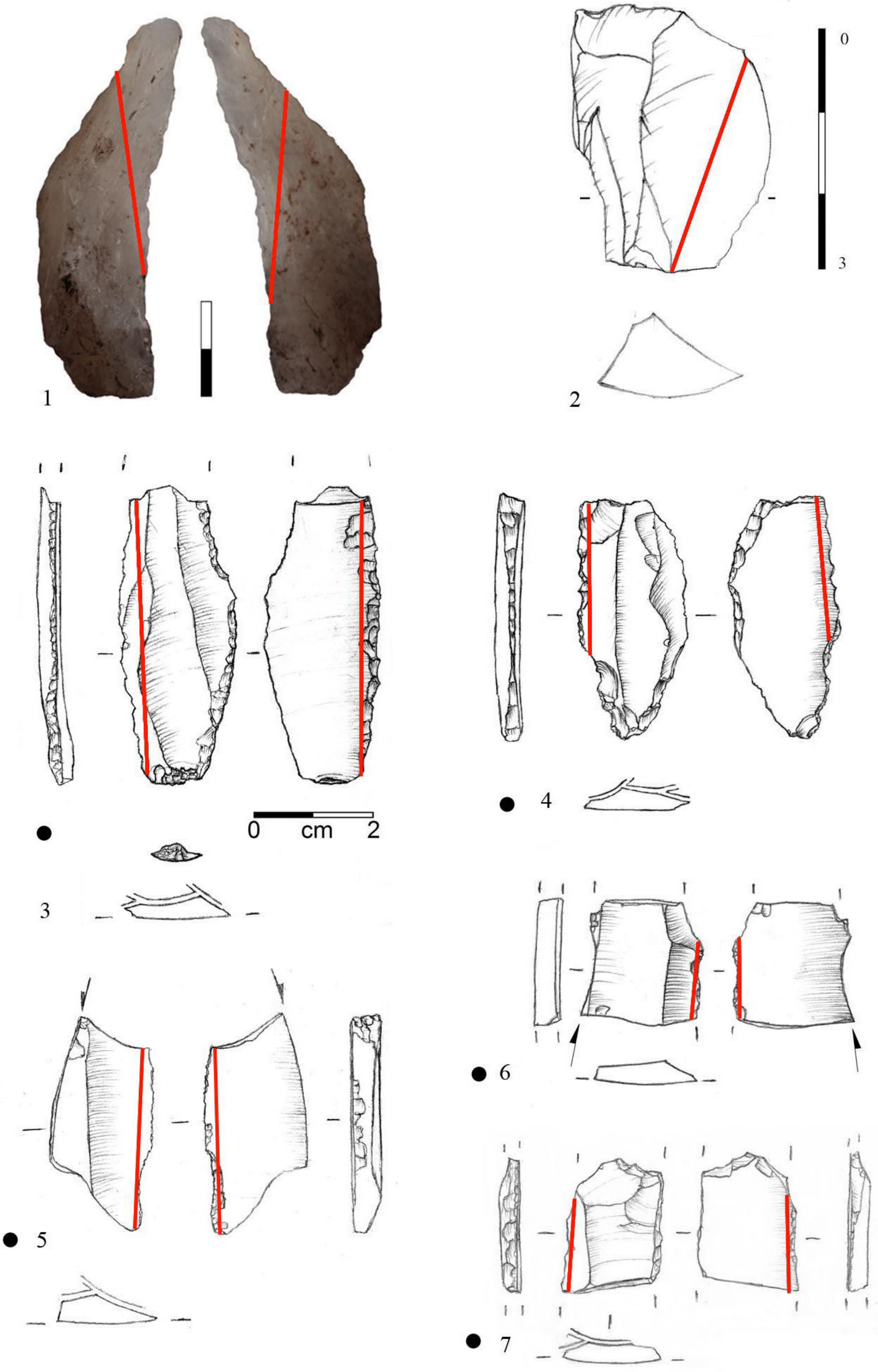


Figure 5. Neolithic. Sickle elements made of chalcedony (1-2) and obsidian (3-7). They are, respectively, flakes and blades. The distribution of the gloss is oblique in the case of chalcedony, and parallel to the edge in the case of obsidian. The red line indicates this polished zone's interior edge.

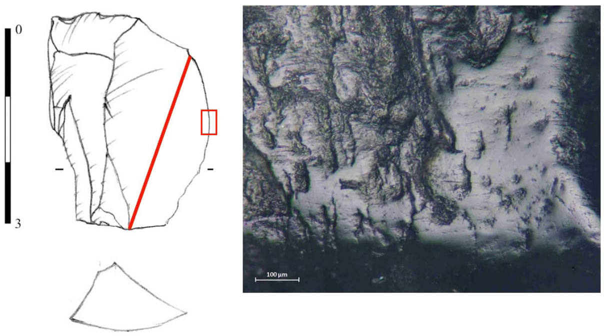


Figure 6.
Neolithic. Flake made of chalcedony with oblique gloss (magnification 100x). The raw material is slightly rough, and the development of polish follows the micro-topography (it is particularly visible here, since one can notice at the ventral surface, where hackles can be seen: the lower part of the micro-topography is not polished). The edge is rounded and fully polished. The polish is compact and bright. Fine striations run parallel to the edge.

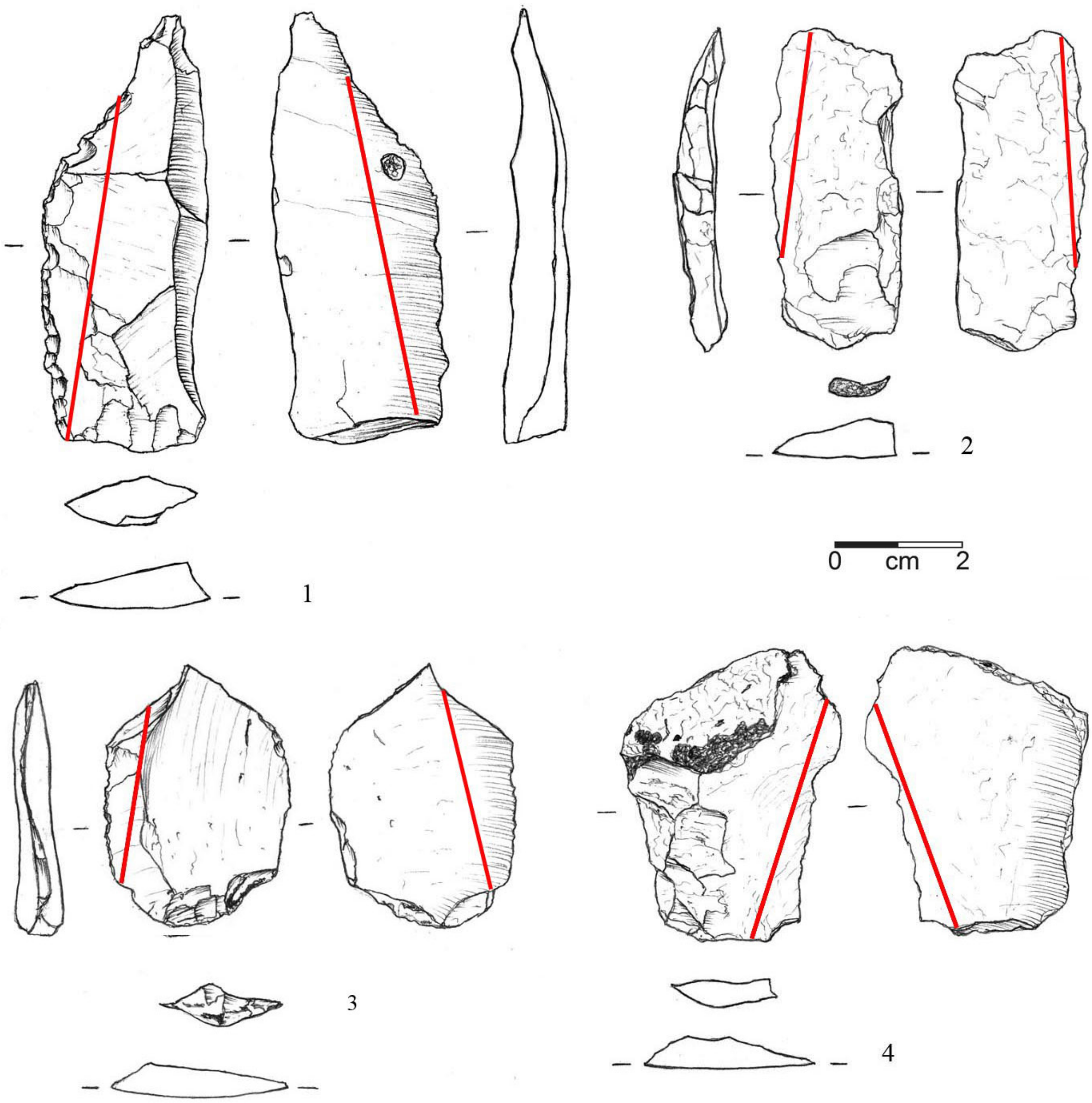
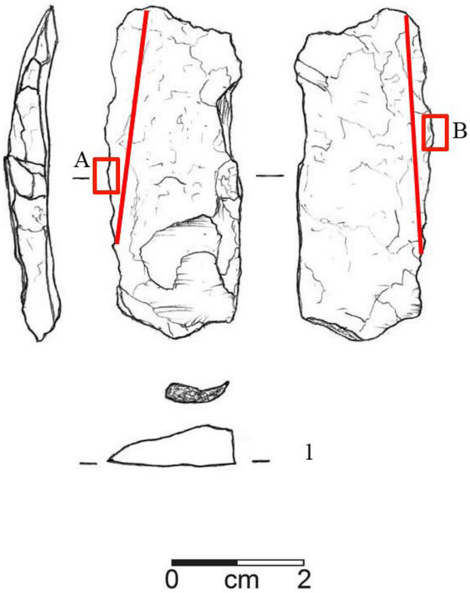
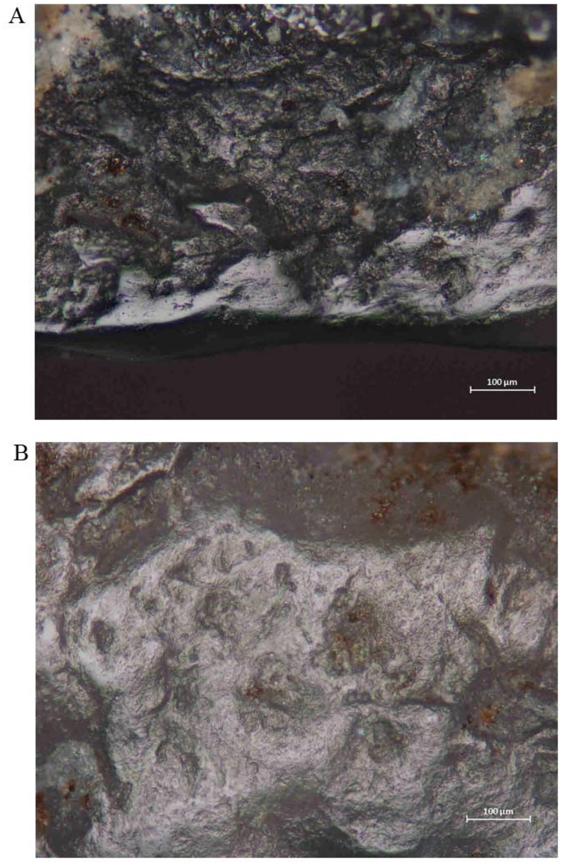
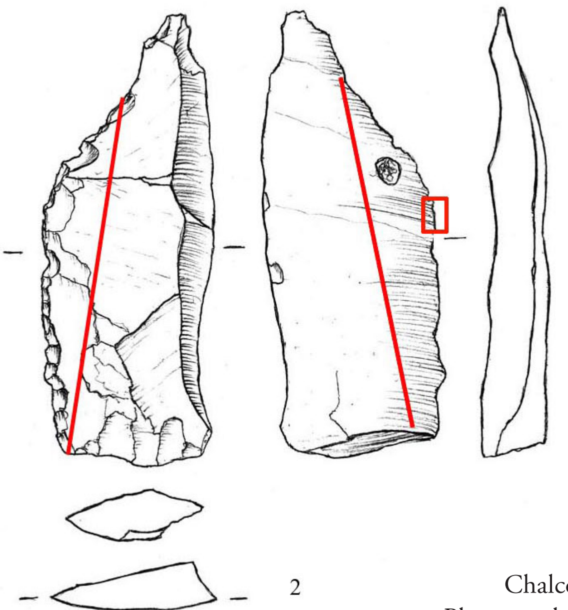


Figure 7. Chalcolithic. Irregular flakes used as sickle elements made of chalcedony with oblique gloss. Remains of bitumen are clearly observed on pieces 2, 3, 4.







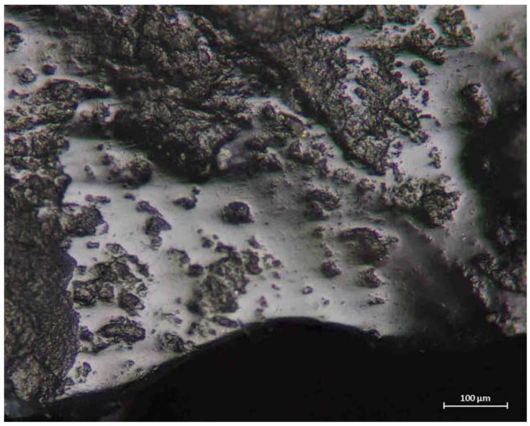


Figure 8.
Chalcolithic. Flakes made of chalcedony with oblique gloss. Photographs magnified 100x. 1.A. Rounded and polished cutting edge and well-developed polish on the dorsal side. 1.B. Compact polish seen on the ventral surface in the cutting edge's immediate vicinity. 2. Rounded and polished cutting edge and polish extending on the ventral surface with parallel and fine striations.

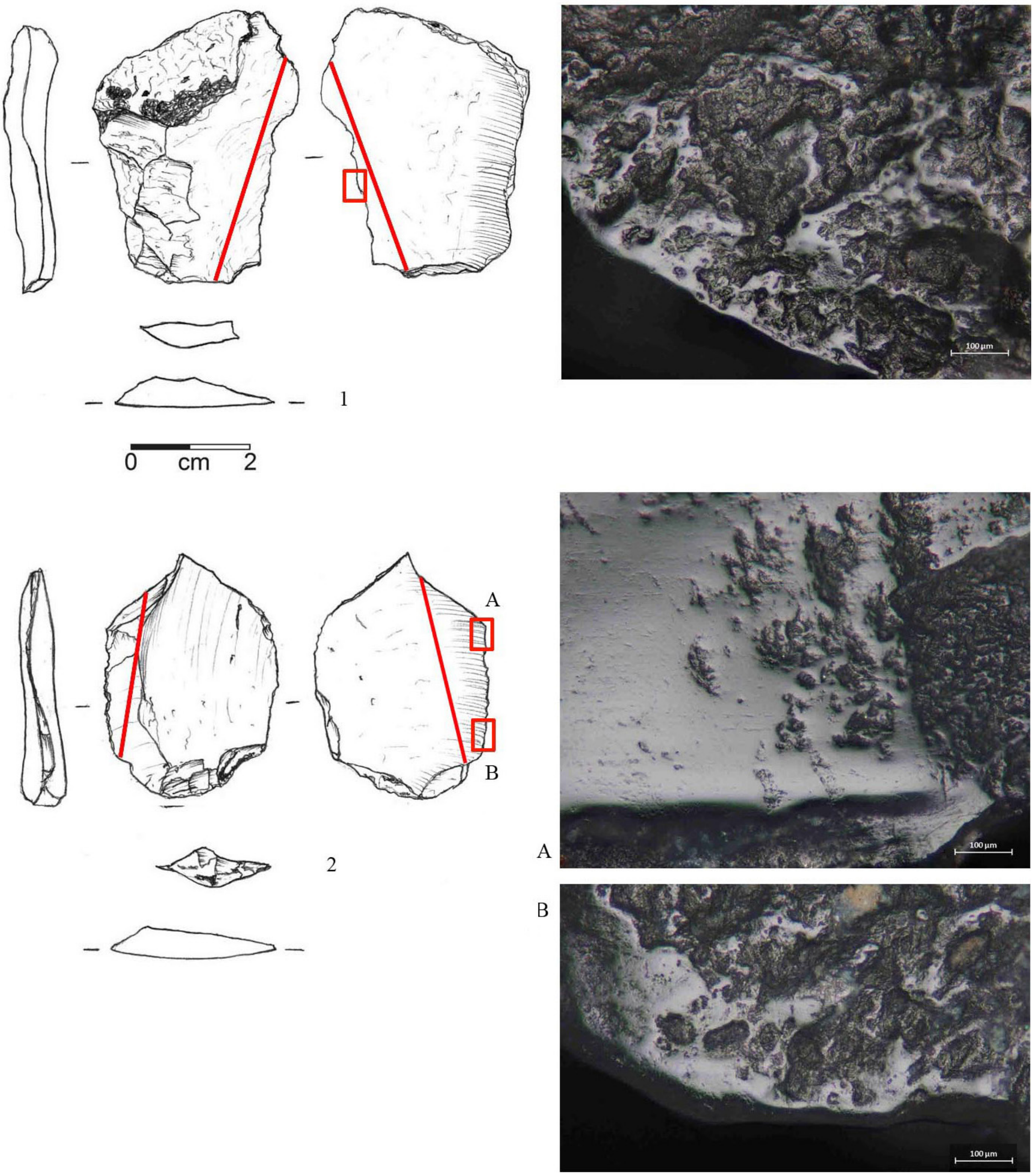


Figure 9. Chalcolithic. Irregular flakes made of chalcedony with oblique gloss. Photographs magnified 100x. 1. Rough micro-topography. Rounded and polished cutting edge. Compact polish on the ventral surface more apparent on the topography's upper part. 2.A. Fully polished area with a flat and compact surface and dotted fine parallel striation. The area is bordered by two scars with incipient polish (scaling probably created during time of use). 2.B. Rounded cutting edge and compact polish, especially in the immediate vicinity of the edge and on the upper part of the topography.

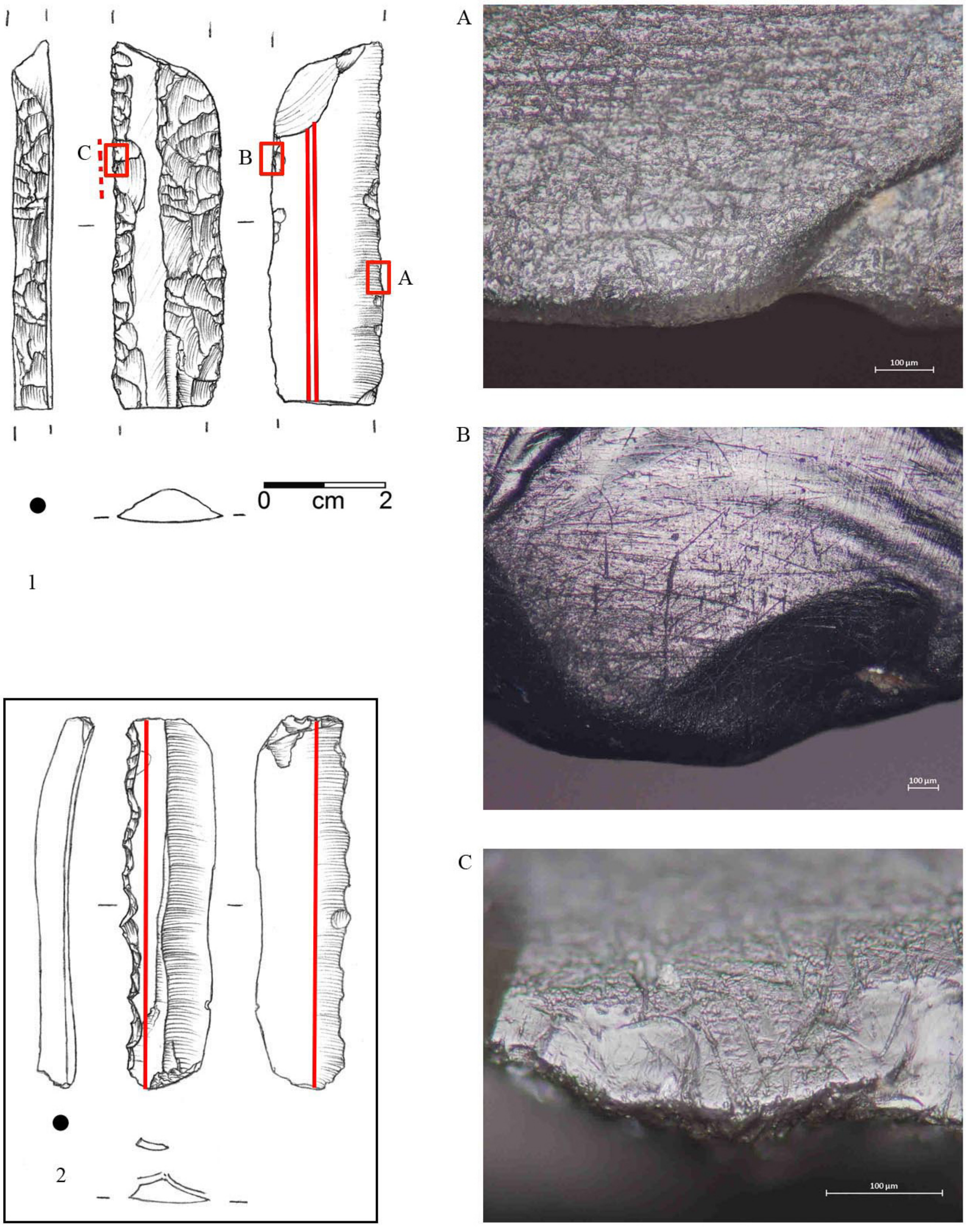


Figure 10. 'Multi-period' (1) and Chalcolithic (2) blades made of obsidian, used as sickle elements with hafting parallel to the edge. 1. Blade with semi-abrupt retouch made by pressure flaking, with three areas of use: both edges were used to harvest cereals (A, B, magnification 100x); a third zone on the left edge (C, magnification 200x) was used to scrape vegetal material. Note that the natural surface of obsidian reflects the light (see photo B at the top). 1.A. Rounding of the cutting edge and the edges of scars. Matte surface defined by longitudinal striation. 1.B. Matte rounding of the edge and matte surface in its immediate vicinity, due to abrasion and longitudinal striation. 1.C. Direct tiny scaling. A small continuous polish extends on the very edge.

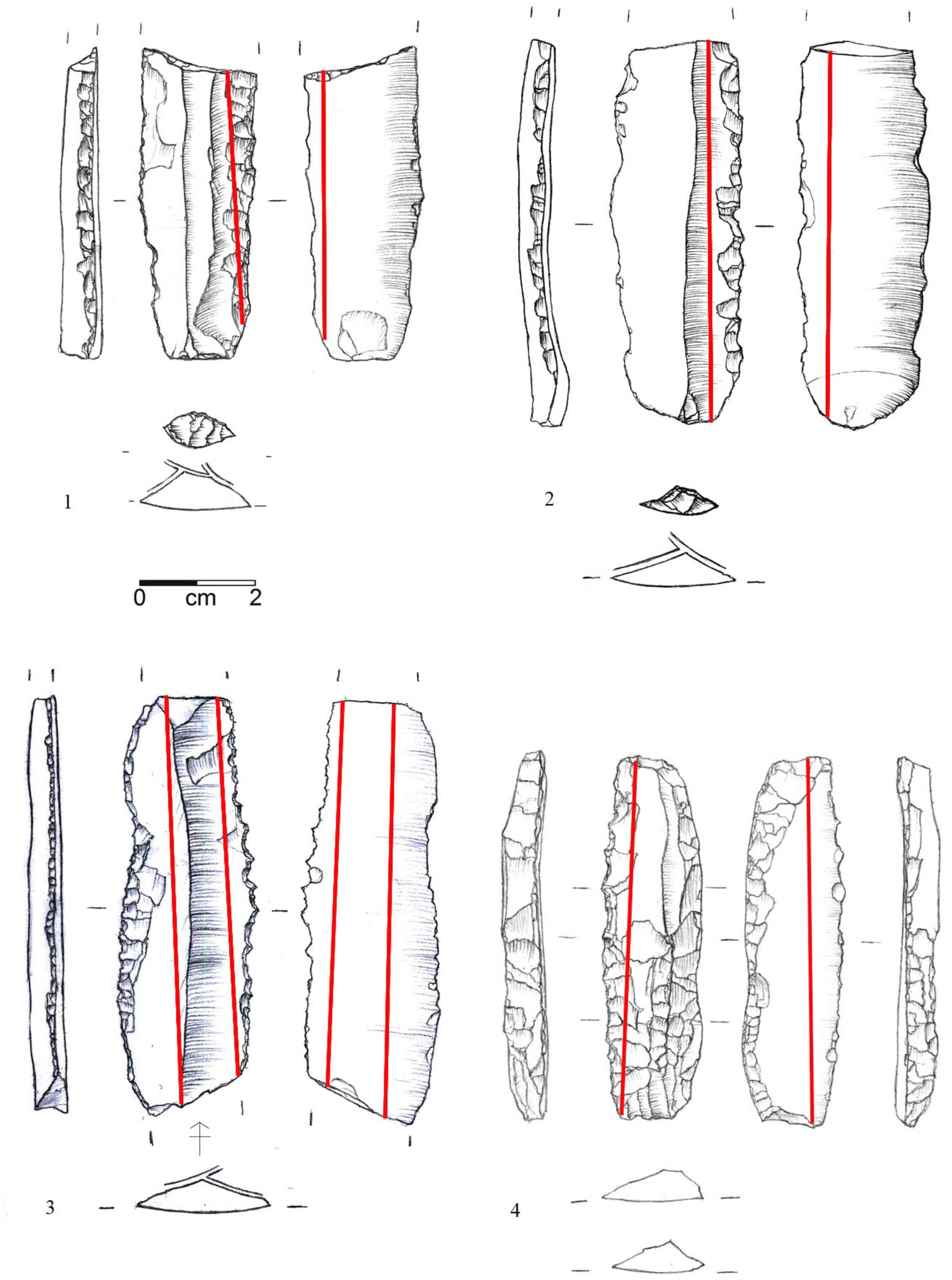


Figure 11. Chalcolithic. Blade sickle elements made of jasper (1) and flint (2-4).
They all show pressure flaking retouch and are worn on one (1, 4) or two edges (2, 3).
Gloss largely extends on the ventral and dorsal surfaces. Its distribution is parallel to the cutting edge.

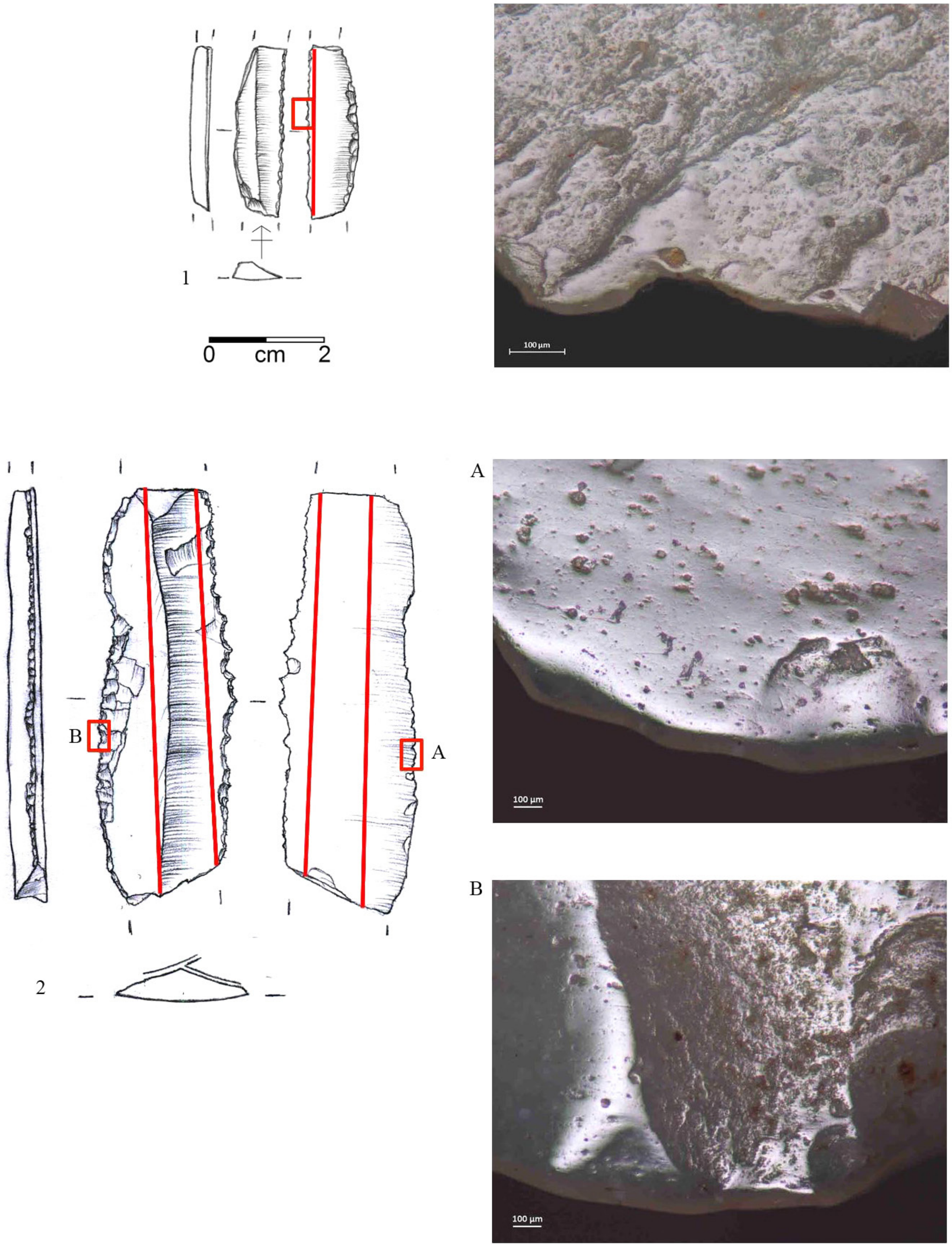


Figure 12. Chalcolithic. Bladelet (1) and blade sickle elements made of flint, with pressure retouch applied to make tools for harvesting cereals. 1. The direct micro-denticulation is later than the use. Polished and rounded cutting edge (magnification 100x). Extended compact polish on both faces. 2.A. Highly developed polish with compact thread, high brightness and a fine dotted striation parallel to the edge. 2.B. Same polish on the dorsal surface (on the left) cut by rejuvenating retouch (direct pressure flaking). The retouch is partly polished, showing that use as a sickle element continued after rejuvenation.

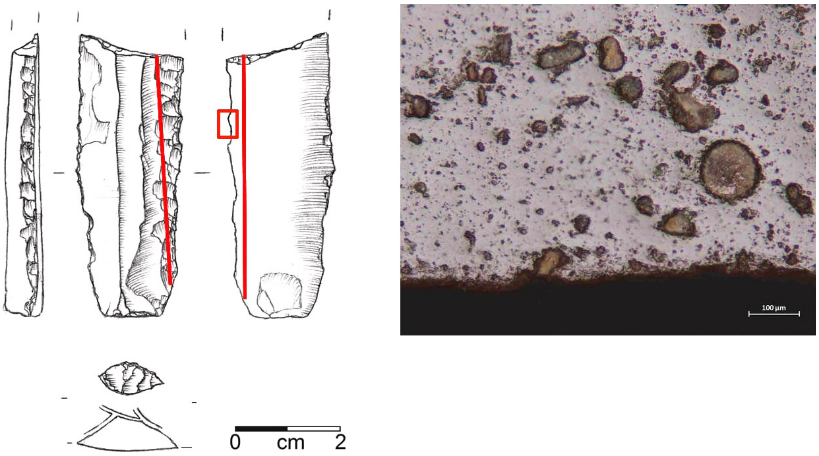
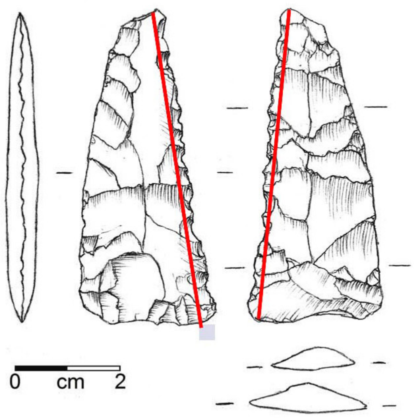


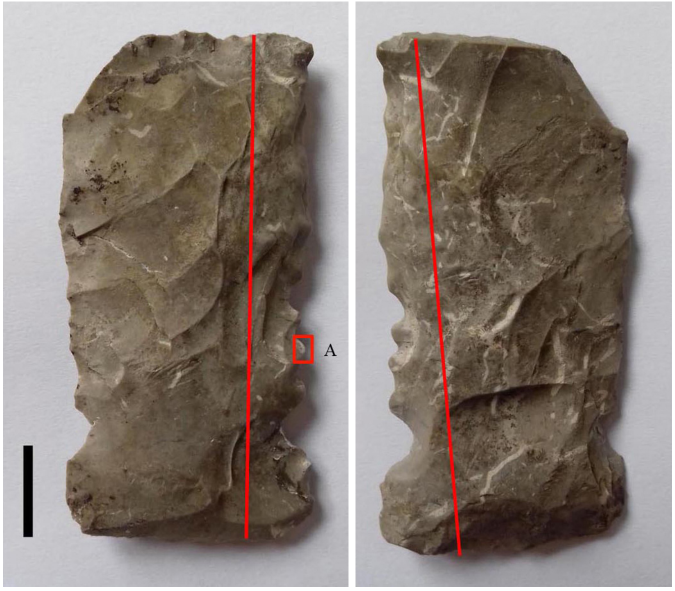
Figure 13.
Chalcolithic. Proximal fragment of a pressure blade made of jasper with pressure flaking lateral retouch. This edge was used to harvest cereals. The inserts were fixed in the haft, parallel to each other. Well-developed compact and bright polish with no striation (magnification 100x).

1



2

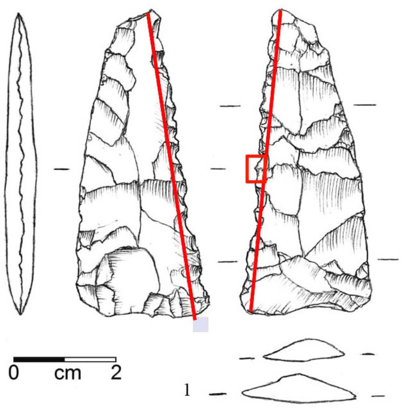
Figure 14.
Bronze Age. Two bifacially retouched elements, shaped by complete invasive retouch made by percussion and pressure flaking. Used edges on each blank are denticulated. The edge and the adjacent surfaces shaped by use are rounded and smoothed.



A


Detail

Figure 15.
Bronze Age. The raw material of the first tool is a fine marl. The main use-wear is abrasion. The cutting edge is completely rounded. A dull polish is also present and is hardly developed. Detail shows a highly polished circular patch of silica (magnification 50x and 100x).



A

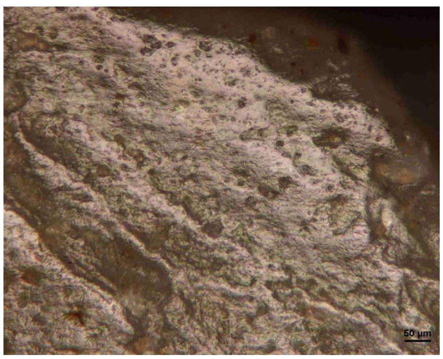

B


Figure 16.
Bronze Age. The second element is made of siliceous marl. Wear is different, as polish is highly developed. A. The cutting edge is completely rounded and polished (magnification 50x). B. The polish is compact, bright and extends all over the surface. Parallel fine dotted striations are visible (magnification 100x).

Investigating a Subsistence Model of Staple Finance for the Late 4th to Early 2nd Millennium BCE of the Greater Near East

Benjamin Irvine[a]

Abstract

Previous research into the dietary habits and subsistence practices of Early Bronze Age (3rd millennium BCE) Anatolian populations utilising stable isotope analyses ($\delta^{13}C$ and $\delta^{15}N$) demonstrated that there was a general homogeneity in isotopic values at both an intra- and inter-population level. This was also shown to be the case in relatively contemporary populations in the regions neighbouring the Anatolian Peninsula; Greece/the Aegean, and northern Mesopotamia. This isotopic homogeneity suggested that there was a dietary and subsistence strategy uniformity for the time period. In this study, adult human $\delta^{13}C$ and $\delta^{15}N$ values from the Early Neolithic to the Late Byzantine periods of the Greater Near East were collated and examined to further investigate dietary habits and subsistence strategies supra-regionally, as well as diachronically. This synthesis of the isotopic data is examined in conjunction with archaeobotanical and archaeozoological data to test the hypothesis of a distinctive model of staple finance. This holistic and big data approach demonstrates that, plausibly, there is a comparatively characteristic model of staple finance for the late 4th – early 2nd millennium BCE. However, the results also demonstrate that the isotopic homogeneity observed for Early Bronze Age Anatolia is not as ubiquitous across the larger region, although there are distinctive diachronic patterns.

Keywords: Palaeodiet, bioarchaeology, stable isotopes, agriculture, pastoralism

Öz

Geçmiş yıllarda yapılan araştırmalar Anadolu'da Erken Tunç Çağı'nda (MÖ 3. binyıl) $\delta^{13}C$ ve $\delta^{15}N$ sabit izotop analizi değerleri arasında genel bir homojenlik olduğunu göstermiştir. Söz konusu homojenlik beslenme alışkanlıklarının ve geçim uygulamalarının gerek topluluk içerisinde gerekse farklı topluluklar arasında benzerlik olduğuna işaret etmekte, bu benzerliğin

a Benjamin Irvine, Dr., Koç University Research Center for Anatolian Civilizations, RCAC, İstanbul; British Institute at Ankara, BIAA, Ankara. ibenjamin20@ku.edu.tr ; https://orcid.org/0000-0002-2060-7198

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Anadolu Yarımadası'na komşu bölgelerdeki topluluklarda da -Yunanistan/Ege kıyıları ve Kuzey Mezopotamya- görüldüğünü ortaya koymaktadır. İzotopik homojenlik aynı zamanda beslenme ve geçim stratejisinin zamansal bağlamda standart olduğunu önermektedir. Bu çalışma kapsamında Erken Neolitik Dönem'den Geç Bizans Dönemi'ne kadar Doğu Akdeniz coğrafyasındaki yetişkinlere ait $\delta^{13}C$ ve $\delta^{15}N$ izotop değerleri bir araya getirilmiş, toplulukların beslenme alışkanlıkları ve geçim stratejileri zamansal bağlamda incelenmiştir. İzotopik veriler arkeobotanik ve arkeozoolojik verilerin ışığında söz konusu dönem için önerilen ve *staple finance* olarak bilinen mahsule dayalı örgütlenme modelini test etmek için kullanılmıştır. Bu bütüncül yaklaşım MÖ 4. binyılın sonundan 2. binyılın başına kadar devam eden uzun soluklu ve *staple finance* sistemine dayalı olan bir örgütlenme modeline işaret etmekle birlikte Anadolu'nun Erken Tunç Çağı'nda gözlemlenen izotopik homojenliğin bölgeler arasında farklılıklar sergilediğini de ortaya koymaktadır.

Anahtar Kelimeler: Paleodiyet, biyoarkeoloji, sabit izotop, tarım, otlatıcılık

Introduction

Background to the Research

This study has developed from initial research into the dietary habits of Early Bronze Age (EBA) populations of Anatolia (Irvine 2017; Irvine et al. 2019). It was noted that the stable isotopic values ($\delta^{13}C$ and $\delta^{15}N$) in bulk bone collagen from human adults of these EBA Anatolian populations were, overall, very similar and there appeared to exist a general degree of homogeneity at both an intra- and inter-population scale. The $\delta^{13}C$ and $\delta^{15}N$ values of these sites were also compared with $\delta^{13}C$ and $\delta^{15}N$ values from relatively contemporary populations in geographical neighbouring regions (from Early Helladic sites in Greece and EBA sites in northern Mesopotamia) to examine if this was solely an Anatolian phenomenon. The initial comparisons revealed that there was also a homogeneity in $\delta^{13}C$ and $\delta^{15}N$ values beyond Anatolia, and, furthermore, that the $\delta^{13}C$ and $\delta^{15}N$ values in neighbouring regions' populations were similar to those of the EBA Anatolian populations – i.e., that a general degree of isotopic homogeneity was found at both an intra- and inter-regional scale (Irvine 2017; Irvine et al. 2019). Following these initial examinations, and further investigations into archaeobotanical and archaeozoological data from the same time period and region, the homogeneity in $\delta^{13}C$ and $\delta^{15}N$ values, and also dietary habits, exploited and consumed food resources, and subsistence and agricultural strategies resulted in this phenomenon being termed as an 'EBA package' (Irvine et al. 2019). This current study builds upon those initial observations and provides a large-scale holistic approach to examining dietary habits and subsistence and agricultural strategies of the Greater Near East. Stable isotopic ($\delta^{13}C$ and $\delta^{15}N$) values from populations across the Greater Near East, dated from the Early Neolithic to Late Byzantine periods are examined in conjunction with archaeobotanical and archaeozoological data from the late 4th to early 2nd millennium BCE.

Using stable isotopes to reconstruct and examine palaeodiet can reveal differences in dietary habits and access to food resources between individuals, populations, and diachronically (Quinn and Beck 2016; Pokutta 2017). Stable isotope ratios of carbon (C) and nitrogen (N) are the most commonly utilised for examining dietary habits and associated subsistence strategies (Walker and DeNiro 1986; Faure and Mensing 2005; Pollard et al. 2007; Lee-Thorp 2008; Schwarz and Schoeninger 2011; Fernandes et al. 2012). The theories, methodologies, and application of stable isotope ratio analysis of C and N, from human and faunal bone collagen, in order to reconstruct palaeodiets has been well established and previously described (see, amongst others, Schoeninger and DeNiro 1984; Walker and DeNiro 1986; Ambrose 1993; Ambrose and Norr 1993; Richards and Hedges 1999; Katzenberg 2000; Faure and Mensing 2005; Pollard et al. 2007; Lee-Thorp 2008; Schwarz and Schoeninger 2011; Richards 2020). Stable isotopic signals (and meta-data of them) are now becoming a common way to examine large-scale, diachronic and pan-regional, patterns in dietary habits and subsistence strategies, and changes in them (Papathanasiou 2015; Papathanasiou and Richards 2015; Pokutta 2017; Gamarra et al. 2018; Jovanović et al. 2019; Arena et al. 2020; Liu et al. 2021; Irvine forthcoming; Irvine et al. forthcoming).

As this study takes a large-scale, holistic approach it examines 'the woods, rather than the trees'. This is not to dismiss or ignore finer scale (i.e., at the intra-population and intra-temporal period scale) subtleties and differences, but this large-scale approach allows us to better examine an overview of possible diachronic and pan-regional patterns and changes. These are important not just for understanding past subsistence strategies, but also for gaining a better understanding of factors such as long-term political and social developments.

Outlining the 'Greater Near East'

This paper uses the Anatolian Peninsula as a focal point, and gathers its (immediate) neighbouring regions (the Aegean and Greece, the eastern/southeastern Balkans, North Mesopotamia, Cyprus, the South Caucasus, and north-western Iran/Zagros) to form a large geographical region termed the 'Greater Near East' from which the stable isotope data, archaeobotanical, and archaeozoological data examined in this study comes. Whilst this is not entirely un-problematic, due to varying cultural, chronological, political, climatic, and environmental entities across this large area in prehistoric and pre-modern times, it is deemed acceptable for the purpose of this study, and there are precedents and rationales for examining this large area as a whole. Basri and Lawrence (2020) and Gaastra et al. (2021) collated large datasets from across the Near East for their studies. Basri and Lawrence (2020) have even argued that "Despite its large size, it can be argued that the region was broadly coherent from the Neolithic onwards, when we can see the long-range circulation of raw materials, such as obsidian, and ideas, such as painted pottery. By the Iron Age, massive political entities such as the Neo-Assyrian Empire held sway over almost the entire region". Furthermore, Mesopotamian, Aegean, and Anatolian regions were increasingly connected, at least through trade and the circulation of raw materials and objects from the 4th millennium BCE onwards (Massa 2016; Şahoğlu 2016; Ünlüsoy 2016; Massa and Palmisano 2018; Yılmaz 2019; McMahon 2020).

Defining the 'EBA package'

What was initially termed as an "EBA package" (Irvine et al. 2019) was a brief and abbreviated, albeit notional and ineloquent, way of referring to a model of staple finance that was inferred by the homogeneity observed in the stable isotope data. This definition, and its elaboration in this study, focuses only on key domestic crops and animals that would have contributed the bulk of nutrition and food resources to human diet. Therefore, viticulture, olives, nuts, and fruits are not examined in any depth in this paper. The same is true for non-cereal crops and wild animals which were also likely to have been inconsequential food resources. This 'package' is economic in terms of being a model of staple finance, but in this paper, it is largely referred to with regards to human dietary habits. There are, of course wealth finance economic aspects and implications, in particular animals as commodities, but this in itself can also be related to the dietary aspect that some animals/species of animals were not always being principally reared for primary consumption.

Wild fauna (including marine and freshwater resources) recovered from excavations were not examined in this study as in the Late Chalcolithic (LCh) to Middle Bronze Age (MBA) periods it appears as though hunting played a very minor role in both the subsistence strategies, and dietary habits of the populations (Vermeersch et al. 2021a). Crops such as vines or olives were also excluded from analysis in this study as they should be considered as cash crops, and related to wealth finance rather than staple finance (Barjamovic 2020). There is no doubt that they were important parts of the prehistoric E-MBA agricultural economy, and were indeed consumed by people, but they would not necessarily have contributed in a significant and/or daily manner to their dietary habits. Additionally, whilst legumes are present at almost all sites during this time (E-MBA), their quantity varies considerably from site-to-site, and they are almost consistently a minor crop relative to cereals, and, consequently, unlikely to be as major a part of the hypothesised staple finance 'package'.

Materials and Methods

The stable isotope data ($\delta^{13}C$ and $\delta^{15}N$ values) utilised in this study comes from 69 sites in total across the Greater Near East region, as previously defined for this study, with populations ranging in date from the Younger Dryas through to the Late Byzantine and Islamic periods (see Table 1, and Fig. 1). The raw isotope data was collated from previously (by the end of

2021) conducted and (principally) published research studies. Only the $\delta^{13}C$ and $\delta^{15}N$ values obtained from the bulk bone collagen of adult human individuals was collated to enable comparability. Studies that reported only population means of $\delta^{13}C$ and $\delta^{15}N$ from sites (n=11 out of 69) were excluded from the statistical analyses and Figures 6 and 7, but have been included in Table 1 and Fig. 1 (where these sites/populations are identified as having only population means), and their means and standard deviations are also plotted in Figs. 8-10. Some $\delta^{13}C$ and $\delta^{15}N$ data from the publications was also excluded from examination in this study if the collagen quality criteria of the C/N ratio, %C, and %N were outside the commonly accepted ranges (DeNiro 1985; Guiry and Szpak 2021) or if they were from individuals that could not be firmly identified as adults in age. Data from a wide range of time periods was chosen so that diachronic patterns could be examined, particularly how the data from individuals and populations of the late 4th-early 2nd millennium BCE compared to others, and to further assess the preliminary observations about their apparent homogeneity.

Statistical analyses were also applied to the collated stable isotope data using Excel with the XLSTAT add-on. The data were first tested for normality using a Shapiro-Wilk test, with $p \leq 0.05$ as the level of statistical significance. None of the datasets displayed a normal distribution; the closest was the $\delta^{13}C$ data for the Neolithic (p=0.08). Therefore, to analyse differences between the groups of data ($\delta^{13}C$ and $\delta^{15}N$ from each time period) a non-parametric Kruskal-Wallis ANOVA test with a post-hoc Dunn's Procedure/two-tailed test were used.

As well as the adult human isotopic data, published archaeobotanical and archaeozoological data was compiled from 127 sites dated to within the range of the late 4th to early 2nd millennium BCE of the Greater Near East (see Table 2 for an overview and Fig. 2 for site locations). Whilst efforts were made to bring together as comprehensive an amount of data as possible, author error resulting in accidental omission of research, deliberate discriminatory exclusion of exceptionally small sample sizes, and the inability to access data (e.g., unpublished) mean that this compilation of archaeobotanical and archaeozoological data is not exhaustive. Furthermore, it is beyond the scope of this study to examine all the botanical and faunal data in the same expansive diachronic range as for the isotopic data. Therefore, as this study focuses on exploring staple finance of the late 4th to early 2nd millennium BCE, only botanical and faunal assemblages from sites dating to around this time range were included. As well as enabling this study to be more refined in its focus, only collating botanical and faunal data from this time range enables us to more clearly examine the possible subsistence, agricultural, and pastoral aetiologies for any patterns in the isotopic data. Additionally, as previously discussed, only key domestic crops and animals were examined in this study; namely cereals (wheat [*Triticum*] and barley [*Hordeum vulgare*]), sheep/goat (*Ovis/Capra*), cattle (*Bos taurus*), and pigs (*Sus scrofa*).

Table 1. Summary overview, in chronological order, of sites with stable isotope data ($\delta^{13}C$ and $\delta^{15}N$) used in this study. N.B. Sites that only have population means reported are marked with an *. Time periods refer to local regional chronologies used by the researchers, where possible absolute dates have been included. PPN = Pre-Pottery Neolithic; EN = Early Neolithic; LN = Late Neolithic; ECh = Early Chalcolithic; Ch = Chalcolithic; LCh = Late Chalcolithic; KA = Kura-Araxes; EBA = Early Bronze Age; EH = Early Helladic; MBA = Middle Bronze Age; MH = Middle Helladic; MM = Middle Minoan; LBA = Late Bronze Age; LM = Late Minoan

Site Name	Location	Time Periods with $\delta^{13}C$ and $\delta^{15}N$ data	Reference
Körtik Tepe*	South-east Turkey	Younger Dryas and Early Holocene (10400-9200 cal. BCE)	Benz et al. 2016
Hasankeyf Höyük	South-east Turkey	PPN (ca. late 10th millennium cal. BCE)	Itahashi et al. 2017
Nevalı Çori	South-east Turkey	PPN (ca. 8720-7470 cal. BCE)	Lösch et al. 2006
Aşıklı Höyük	Central Anatolia	PPN/EN (ca. 8350-7300 cal. BC)	Itahashi et al. 2021
Barcın Höyük	North-west Anatolian Peninsula	LN (6600-6200 cal. BCE)	Budd et al. 2020
Tell el-Kerkh	North-west Syria	LN (ca. 6400-6070 cal. BCE)	Itahashi et al. 2018
Çatalhöyük	South Central Turkey	LN (ca. 8000-7000 BP)	Richards et al. 2003
Hakemi Use	South-east Turkey	LN (6100-5950 cal. BCE)	Itahashi et al. 2019
Aktopraklık	North-west Anatolian Peninsula	LN to ECh (6400-5635 cal. BCE)	Budd et al. 2013 and 2018
Halai	South-east Greece	EN-LN (ca. 6000-5300 BCE)	Vaiglova et al. 2021
Durankulak*	Eastern Bulgaria	LN to Early/Mid. Copper Age (ca. early to mid. 6th millennium BCE)	Honch et al. 2013
Mentesh Tepe	North-west Azerbaijan	Neolithic (5933-5485 cal. BCE), Kura-Axe (2834-2471 cal. BCE), Martkopi (2480-2133 cal. BCE), LBA (911-804 cal. BCE)	Herrscher et al. 2018
Uğurlu	Gökçeada Island, North-east Aegean	Ch (5500-4900 cal. BC)	Pilaar Birch et al. 2021
Makriyalos	North Greece	LN (5500-4500 cal. BCE)	Vaiglova et al. 2018
Alepotrypa Cave	Southern Greece	LN (ca. 5000-3200 BC)	Papathanasiou et al. 2000
Tharrounia	Euboea, South-east Greece	LN (5300-3200 BCE)	Kontopoulos and Sampson 2015
Varna*	Eastern Bulgaria	Mid. to Late Copper Age (ca. 4660-4415 BCE)	Honch et al. 2013
Arslantepe	East Turkey	LCh (Period VII – 3800-3400 BCE)	Iacumin et al. 2020

Site Name	Location	Time Periods with $\delta^{13}C$ and $\delta^{15}N$ data	Reference
Çamlıbel Tarlası	North Central Turkey	LCh (3650-3375 cal. BCE)	Pickard et al. 2016
İkiztepe	North Turkey	LCh-EBA I (ca. late 4th millennium BCE)	Irvine et al. 2019; Irvine and Erdal 2020a
Tell Brak	North-east Syria	LCh to EBA (4200-2000 cal. BCE)	Styring et al. 2017
Gegharot	West Armenia	KA [EBA] (ca. 3500/3350-2900 BCE)	Herrscher et al. 2021
Chobareti	South Georgia	EBA (ca. 3300-2900 cal. BCE)	Messager et al. 2015
Souskiou-Laona Settlement	South-west Cyprus	Chalcolithic (ca. 3000 cal. BCE)	Goude et al. 2018
Tell Bakr Awa	North-east Iraq	EBA (3100-2200 BCE), MBA (2200-1600 BCE), Iron Age (1200-330), Islamic period (636-1500 CE)	Fetner 2016
Titriş Höyük	South-east Turkey	EBA I-III (3000-2100 BCE)	Irvine et al. 2019
Kvatskhelebi	North Central Georgia	KA [EBA] (ca. 2900-2800 cal. BCE)	Herrscher et al. 2021
Kalavan-1	North-east Armenia	KA [EBA] (2850-2490 cal. BCE)	Herrscher et al. 2021
Manika	Euboea, South-east Greece	EBA/EH (ca. 2900-2300 BCE)	Kontopoulos and Sampson 2015
Bakla Tepe	South-west Turkey	EBA I and II/III (ca. 3000-2800 and 2500-2300 BCE), Late Roman/ Early Byzantine	Irvine et al. 2019; Irvine and Erdal 2020b; Irvine unpublished data
Bademağacı	South Turkey	EBA II (ca. 2500 cal. BCE)	Irvine et al. 2019
Psematismenos-Trelloukkas	South Cyprus	EBA (3rd millennium BCE)	Goude et al. 2018
Tell Leilan	North-east Syria	EBA (2700-2200 cal. BCE)	Styring et al. 2017
Tell Barri	North-east Syria	EBA (2800-2000 BCE), MBA (2000-1500 BCE), LBA (1500-1200 BCE), Neo-Assyrian period (900-800 BCE), Achaemenian period (500-300 BCE), Parthian period (100-300 CE)	Sołtysiak and Schutkowski 2015
Thebes	South/South-east Greece	EH to MH (ca. 3000-2000 BCE), Classical (ca. 510-323 BCE), Hellenistic (ca. 323-31 BCE), Mid. Byzantine (13th-14th centuries CE)	Dotsika et al. 2018; Vika 2011 and 2015
Marki-Alonia	Central Cyprus	Middle Cypriot Bronze Age (ca. 2400-1850 BCE)	Scirè-Calabrisotto et al. 2020
Archontiko	North Central-East Greece	EBA III (ca. 2130-2087 BCE)	Nitsch et al. 2017

Site Name	Location	Time Periods with $\delta^{13}C$ and $\delta^{15}N$ data	Reference
Tell Ashara	East Syria	EBA-MBA (ca. 2300-1900 BCE), Old Babylonian period (ca. 1900-1700 BCE), Neo-Assyrian period (ca. 900-600 BCE)	Sołtysiak and Schutkowski 2018
Aspis	South Greece	MH (ca. 2100-1700 BCE)	Triantaphyllou et al. 2006 and 2008
Lerna	South Greece	MH (ca. 2100-1700 BCE)	Triantaphyllou et al. 2006 and 2008
Mycenae*	South Greece	MH (ca. 2100-1700 BCE)	Triantaphyllou et al. 2006 and 2008
Kouphovouno*	South Greece	MH (ca. 2100-1700 BCE)	Lagia et al. 2007
Asine	South Greece	MH (ca. 2100-1700 BCE)	Ingvarsson-Sundström et al. 2009
Kültepe-Kanesh	Central Turkey	MBA (ca. 1930-1720 BCE)	Yazıcıoğlu Santamaria 2015
Knossos (Ailias chamber tombs and Lower Gypsades tomb and ossuary)	North Crete	MM Ib-LM I (ca. 1900-1500 BCE)	Nafplioti 2016
Tell Masaikh	East Syria	Old Babylonian period (ca. 1900-1700 BCE), Neo-Assyrian period (ca. 900-600 BCE), Classical period (ca. 600 BCE-600 CE), Early Islamic period (ca. 600-1200 CE)	Sołtysiak and Schutkowski 2018
Thessaloniki Toumba	North Central-East Greece	LBA (ca. 1700-1050 BCE)	Nitsch et al. 2017
Boğazköy/Hattuşa	North Central Turkey	Iron Age (ca. 10th-9th centuries BCE), Hellenistic period (3rd century BCE), Roman period (ca. 2nd century CE)	Pickard et al. 2017
Gebel Mashtale	East Syria	Classical period (ca. 600 BCE-600 CE)	Sołtysiak and Schutkowski 2018
Kerameikos, Athens	South/South-east Greece	Late Archaic period (ca. 500 BCE), Classical period (475-336 BCE), Hellenistic period (ca. 320-100 BCE), Imperial Roman period (1st-3rd century CE)	Lagia 2015
Plateia Kotzia, Athens	South/South-east Greece	Late Archaic period (ca. 500 BCE), Classical period (475-336 BCE), Hellenistic period (ca. 320-100 BCE), Imperial Roman period (1st-3rd century CE)	Lagia 2015

Site Name	Location	Time Periods with $\delta^{13}C$ and $\delta^{15}N$ data	Reference
Mesebria	East Bulgaria	Classical (5th-4th centuries BCE), Hellenistic 4th-2nd centuries BCE), Early-Mid. Byzantine (5th-7th centuries CE), Mid. Byzantine (8th-14th centuries CE)	Moles 2012
Laurion, Athens	South/South-east Greece	Classical period (475-336 BCE)	Lagia 2015
Helike	South Greece	Hellenistic (4th-2nd centuries BCE), Roman period (ca. 1st-8th centuries CE), Late Byzantine period (14th-15th centuries CE)	Borstad et al. 2018
Sagalassos*	South/South-west Turkey	Classical-Hellenistic (400-200 BCE), Late Imperial Roman period (300-450 CE), Mid. Byzantine (800-1200 CE)	Fuller et al. 2012
Ephesus	West Turkey	Roman (2nd and 3rd centuries CE)	Lösch et al. 2014
Edessa	North Greece	Roman (2nd-4th centuries CE)	Dotsika and Michael 2018
Hierapolis	West/West Central Turkey	Roman-Early/Mid. Byzantine (1st-7th centuries CE), Mid. Byzantine (9th-13th centuries CE)	Wong et al. 2017
Sourtara*	Central Greece	Mid. Byzantine (6th-7th centuries CE)	Bourbou et al. 2011
Messene*	South Greece	Mid. Byzantine (6th-7th centuries CE)	Bourbou et al. 2011
Eleutherna*	Central Crete	Mid. Byzantine (6th-7th centuries CE)	Bourbou et al. 2011
Abdera	North-east Greece	Mid. Byzantine (6th-13th centuries CE)	Bourbou and Garvie-Lok 2015
Kovuklukaya	North Turkey	Mid. Byzantine (ca. 770-970 cal. CE)	Özdemir 2018
Kastella	North Central Crete	Mid. Byzantine (11th century CE)	Bourbou and Richards 2007; Bourbou and Garvie-Lok 2015
Stylos*	North-west Crete	Mid. Byzantine (11th-12th centuries CE)	Bourbou et al. 2011
Petras	North-east Crete	Mid. Byzantine (12th-13th centuries CE)	Bourbou and Richards 2007; Bourbou and Garvie-Lok 2015
Servia	North Central-East Greece	Mid.-Late Byzantine (11th-15th centuries CE)	Bourbou and Richards 2007; Bourbou and Garvie-Lok 2015
Nemea	South Greece	Mid.-Late Byzantine (12th-15th centuries CE)	Bourbou and Richards 2007; Bourbou and Garvie-Lok 2015
Mitilini*	Lesbos, East Aegean	Late Byzantine (14th-15th centuries CE)	Bourbou and Richards 2007; Bourbou and Garvie-Lok 2015

Table 2. Dominant (by NISP and MNI) domestic faunal and botanical species at sites of the 4th-2nd millennium BCE in the GNE – time periods have been simplified and refer to regional chronologies. MCh = Middle Chalcolithic; LCh = Late Chalcolithic; EBA = Early Bronze Age; MBA = Middle Bronze Age.

Site	Location	Time Period	Dominant Domestic Faunal Species	Dominant Domestic Cereal Species	Reference
Kythrea-*Ayios Dhimitrianos*	North Cyprus	MCh	Sheep/Goat	-	D. Reese personal communication 2020
Orman Fidanlığı	West Central Turkey	MCh-LCh	Sheep/Goat	-	Gündem 2012
Yumuktepe	South/South-east Turkey	Mid./LCh - LCh	-	Wheat	Fiorentino et al. 2014
Megalo Nisi Galanis	North/North-west Greece	MCh-EBA I	Sheep/Goat	-	Greenfield and Fowler 2005
Kuruçay Höyük	South-west Turkey	LCh	-	Wheat and Barley	Nesbitt 1996; Nesbitt and Samuel 1996
Çamlıbel Tarlası	North Central Turkey	LCh	Cattle	Wheat	Bartosiewicz and Gillis 2011; Bartosiewicz et al. 2013; Papadopoulou and Bogaard 2012
Çadır Höyük	North Central Turkey	LCh	Sheep/Goat	Barley	Arbuckle 2014a; von Baeyer 2018
Tepecik	East Turkey	LCh	-	Wheat and Barley	van Zeist and Bakker-Heeres 1975
Hacınebi	South-east Turkey	LCh	Sheep/Goat	Barley	Miller 1997a; Miller 2013; Stein et al. 1996
Lemba-*Lakkous*	South-west Cyprus	LCh	Pig	Barley	Croft 1991; Riehl et al. 2014a
Çayboyu	East Turkey	LCh	-	Wheat and Barley	Nesbitt 1996; Nesbitt et al. 2017
Mokhra Blur	South Central Armenia	LCh-EBA	Sheep/Goat	-	Piro 2009
Köhneh Shahar	North-west Iran	LCh - EBA	Sheep/Goat	-	Samei et al. 2013
Kumtepe	West Turkey	LCh - EBA I	Sheep/Goat	Wheat	Oybak Dönmez 2006; Sperling 1976; D. Reese pers. comm. 2020; Riehl 1999; Riehl et al. 2014a
İkiztepe	North Turkey	LCh-EBA I	Sheep/Goat	Wheat	Ioannidou 2011; Nesbitt and Samuel 1996; van Zeist 2003a
Areni-1 Cave	South-west Armenia	LCh-EBA I	Sheep/Goat	-	Wilkinson et al. 2012

Site	Location	Time Period	Dominant Domestic Faunal Species	Dominant Domestic Cereal Species	Reference
Sotk 2	East Armenia	LCh - EBA I-II	-	Barley	Hovsepyan 2013
Gegharot	North-west Armenia	LCh – EBA I/II	Sheep/Goat	Barley	Badalyan et al. 2008; Hovsepyan 2015
Natsargora	Central Georgia	LCh-EBA I/II	Cattle	-	Rova et al. 2010
Tell Hadidi	North Syria	LCh/EBA I-III	Sheep/Goat	Barley	Clason and Buitenhuis 1978; van Zeist and Bakker-Heeres 1988
Sos Höyük	North-east Turkey	LCh-EBA II/ III	Sheep/Goat	LCh: Wheat MBA: Barley	Howell-Meurs 2001; Longford et al. 2009; Marro 2011; Palumbi 2010; Piro 2009
Kul Tepe	North-west Iran	LCh-EBA II/ III	Sheep/Goat	-	Davoudi et al. 2018
Küllüoba	West Central Turkey	LCh-EBA III	Sheep/Goat	Wheat	Çizer 2015; Gündem 2012
Arslantepe	East Turkey	LCh-EBA III	Sheep/Goat	Barley	Balossi Restelli et al. 2010; Bartosiewicz 1998; Crisarà 2013; Marro 2011; Palumbi 2010; Persiani 2008; Sadori et al. 2006 Siracusano and Bartosiewicz 2012;
Kohneh Pasgah Tepesi	North-west Iran	LCh-EBA (III?)	Sheep/Goat	Wheat and Barley	Davoudi et al. 2018; Decaix et al. 2019
Yarım Höyük	South-east Turkey	EBA I	-	Wheat and Barley	Rothman et al. 1998
Zeytinli Bahçe	South-east Turkey	EBA I(b)	Pig	-	Siracusano in Frangipane et al. 2002
Bakla Tepe	West/South-west Turkey	EBA I and EBA II/III	Sheep/Goat	Wheat	Oybak and Doğan 2008; T. Maltas pers. comm. 2019; D. Reese personal communication 2020
Yenibademli	Gökçeada (West Turkey)	EBA I-II	Cattle	-	Çakırlar 2016
Beşiktepe	West Turkey	EBA I-II	Cattle	-	Çakırlar 2016

Site	Location	Time Period	Dominant Domestic Faunal Species	Dominant Domestic Cereal Species	Reference
Liman Tepe	West Turkey	EBA I-II	Sheep/Goat	Wheat	T. Maltas personal communication 2019; D. Reese personal communication 2020
Hassek Höyük	South-east Turkey	EBA I-II	Pig	Barley	Boessneck 1992; Boessneck and von den Driesch 1981; Miller 1997a
Tatıka	South-east Turkey	EBA I-II	Sheep/Goat	-	Silibolatlaz Baykara 2019a
Tell Hajji Ibrahim	North Syria	EBA I-II	Sheep/Goat	Barley	Miller 1997b; Weber 2006
Tell el-'Abd	North Syria	EBA I-II	-	Barley	Riehl 2019
Habuba Kabira	North Syria	EBA I-II	Sheep/Goat	-	von den Driesch 1993
Tell Shiukh Fawqani	North Syria	EBA I-II	Sheep/Goat	-	Vila 2005
Tell Beydar	North-east Syria	EBA I-II	Sheep/Goat	-	van Neer and De Cupere 2000
Tell Karrana 3	North Iraq	EBA I-II	Sheep/Goat	-	Boessneck et al. 1993
Troy (I-II)	West Turkey	EBA I-II/III	Cattle	Wheat	Blum and Riehl 2015; Çakırlar 2016; Riehl 1999; Riehl et al. 2014a; Riehl and Marinova 2016
Tell Ziyadeh	North-east Syria	EBA I/II-II	Pig	-	Rufolo 2011
Tell al-Raqa'i	North Syria	EBA I/II-II/III	Sheep/Goat	-	Rufolo 2011 and 2015
Tsoungiza	North-east Peloponnese (Greece)	EBA I/II-III	Sheep/Goat	-	Halstead 2011
Lerna	East Peloponnese (Greece)	EBA I/II-III	Sheep/Goat	-	Gejvall 1969; Reese 2013a and 2013b
Tell 'Atij	North-east Syria	EBA I/II-III	Sheep/Goat	-	Rufolo 2011
Ovçular Tepesi	Nakhchivan (Azerbaijan)	EBA I-II/III	Sheep/Goat	-	Davoudi et al. 2018
Demircihüyük	West Central Turkey	EBA I-III	Sheep/Goat	-	Gündem 2012
Mentesh Tepe	North-west Azerbaijan	EBA I-III	-	Wheat	Decaix et al. 2016

Site	Location	Time Period	Dominant Domestic Faunal Species	Dominant Domestic Cereal Species	Reference
Göltepe/Kestel	South Central Turkey	EBA I-III	Sheep/Goat	-	Okaluk et al. 2019
Titriş Höyük	South-east Turkey	EBA I-III	Sheep/Goat	Barley	Allentuck and Greenfield 2010; Greenfield 2002; Hald 2010; Trella 2010
Ziyaret Tepe	South-east Turkey	EBA I-III	Sheep/Goat	-	Greenfield-Jongsma and Greenfield 2013
Horum Höyük	South-east Turkey	EBA I-III	Sheep/Goat	-	Bartosiewicz 2005
Lidar Höyük	South-east Turkey	EBA I-III	Sheep/Goat	-	Kussinger 1988
Hayaz Höyük	South-east Turkey	EBA I-III	Sheep/Goat	-	Buitenhuis 1985
Tilbeşar	South-east Turkey	EBA I-III	Sheep/Goat	-	Berthon and Mashkour 2009
Mezraa Höyük	South-east Turkey	EBA I-III	-	Barley	Oybak Dönmez 2006
Gre Virike	South-east Turkey	EBA I-III	-	Barley	Oybak Dönmez 2006
Tell Apamea	West Syria	EBA I-III	Cattle	-	Gautier 1984
Umm el-Marra	North Syria	EBA I-III	Sheep/Goat	-	Weber 2006
Tell Brak	North Syria	EBA I-III	Sheep/Goat	Barley	Deckers and Riehl 2008; Dobney et al. 2003; Emberling and McDonald 2001; Hald and Charles 2008; Weber in Emberling et al. 1999; Weber 2001
Tell Knedig	North Syria	EBA I-III	Sheep/Goat	-	Vila 2005
Tell Chuera	North Syria	EBA I-III	Sheep/Goat	-	Vila 1995 and 2010
Kharab Sayyar	North-east Syria	EBA I-III	Sheep/Goat	-	Vila 2010
Tell Bderi	North-east Syria	EBA I-III	Sheep/Goat	Barley	Becker 1988; Omar 2017; van Zeist 2003b; Zeder 1998
Tell Khazna	North-east Syria	EBA I-III	Pig	-	Antipina 2004
Tell Arbid	North-east Syria	EBA I-III	Sheep/Goat	-	Koliński and Piątkowska-Małecka 2008; Piątkowska-Małecka and Smogorzewska 2010 and 2013

Site	Location	Time Period	Dominant Domestic Faunal Species	Dominant Domestic Cereal Species	Reference
Tepe Hasanlu	North-west Iran	EBA I-III	Sheep/Goat	-	Davoudi et al. 2018
Kohneh Tepesi	North-west Iran	EBA I-III	Sheep/Goat	-	Davoudi et al. 2018
Poliochni	Lemnos, North Aegean	EBA I-III/ MBA	Sheep/Goat	Wheat	Cultraro 2013; Sorrentino 1997
Kurban Höyük	South-east Turkey	EBA I-III/ MBA	Sheep/Goat	Barley	Miller 1986; Miller 1997a; Miller 2013; Wattenmaker 1987 and 1998
Tell es-Sweyhat	North Syria	EBA I-III - MBA	Sheep/Goat	Barley	Buitenhuis 1985; Miller 1997a; Miller 2013; van Zeist and Bakker-Heeres 1988; Weber 2006
Bademağacı	South-west Turkey	EBA II	Cattle	-	De Cupere et al. 2008
Gelinciktepe	East Turkey	EBA II	Sheep/Goat	-	Persiani 2008
Tell Mashnaqa	North-east Syria	EBA II	Sheep/Goat	-	Zeder 1998
Hamoukar	North-east Syria	EBA II/III	Pig	-	Grossman 2013
Korucutepe	East Turkey	EBA II-III	Sheep/Goat	Wheat and Barley	Boessneck and von den Driesch 1974 and 1975; van Zeist and Heeres 1974
Gritille	South-east Turkey	EBA II-III	Sheep/Goat	-	Stein, 1987 and 1988
Kazane Höyük	South-east Turkey	EBA II-III	Sheep/Goat	Wheat	Creekmore 2008; Nesbitt and Samuel 1996
Tell Halawa	North-west Syria	EBA II-III	Sheep/Goat	-	Boessneck and von den Driesch 1989
Tell Tuqan	North-west Syria	EBA II-III	Sheep/Goat	-	Minniti 2014
Ebla	North-west Syria	EBA II-III	Sheep/Goat	-	Minniti 2013
Ghanem al-Ali	North Syria	EBA II-III	Sheep/Goat	-	Omar 2010
Tell Mozan	North-east Syria	EBA II-III	Sheep/Goat	Barley	Deckers and Riehl 2008; Doll 2010
Tell Tuneinir	North-east Syria	EBA II-III	Sheep/Goat	-	Loyet 2003
Tell Taya	North Iraq	EBA II-III	Sheep/Goat	-	Bökönyi in Reade 1973
Eleusis	South Greece	EBA II-MBA	Cattle		Cosmopoulos et al. 2003

Site	Location	Time Period	Dominant Domestic Faunal Species	Dominant Domestic Cereal Species	Reference
Ulucak	West Turkey	EBA II/III	Cattle	-	Çakırlar 2016
Tell Rad Shaqrah	North Syria	EBA II/III-III	Sheep/Goat	-	Koliński and Piątkowska-Małecka 2008
Tell Leilan	North-east Syria	EBA II/III-III	Sheep/Goat	-	Rufolo 2011; Weiss et al. 1993
Marki-*Alonia*	Central Cyprus	EBA II/III-MBA	Sheep/Goat	-	Croft 2006
Haftavan Tepe	North-west Iran	EBA II/III-EBA III/MBA I	Sheep/Goat	-	Mohaseb and Mashkour 2017; Davoudi et al. 2018
Acemhöyük	South-central Turkey	EBA III	Sheep/Goat	-	Arbuckle 2013
Tilbaşar Höyük	South-east Turkey	EBA III	-	Barley	Kavak et al. 2018 and 2019
Tell Tayinat	South-east Turkey	EBA III	Sheep/Goat	-	Welton et al. 2011
İmamoğlu Höyük	East Turkey	EBA III	-	Barley	Oybak and Demirci 1997
Al-Rawda	West Syria	EBA III	Sheep/Goat	-	Vila and El Besso 2005
Tell Qarqur	West Syria	EBA III	Sheep/Goat	-	Arter 2003; Grossman personal communication in Price et al. 2017
Tall Al-Handaquq	North-west Jordan	EBA III	Sheep/Goat	-	Price et al. 2018
Selenkahiyeh	North Syria	EBA III	Sheep/Goat	Barley	Ducos 1973; Ijzereef 2001; van Zeist and Bakker-Heeres 1988
Emar/Tell Meskene	North Syria	EBA III	Sheep/Goat	-	Gündem 2010
Tell Afis	North Syria	EBA III	Sheep/Goat	-	Wilkens 2000
Ali Al-Hajj	North Syria	EBA III	Sheep/Goat and Cattle	-	Arai 2014
Tell Gudeda	North-east Syria	EBA III	Sheep/Goat	-	Rufolo 2011
Kashkashok IV	North-east Syria	EBA III	Sheep/Goat	-	Zeder 1998
Chagar Bazar	North-east Syria	EBA III(?)	-	Barley	Riehl 2018

Site	Location	Time Period	Dominant Domestic Faunal Species	Dominant Domestic Cereal Species	Reference
Asine	Northeast Peloponnese (Greece)	EBA III-MBA	Pig	-	Macheridis 2016
Politiko-*Troullia*	Central Cyprus	EBA III-MBA	Sheep/Goat	-	Metzger 2008
Zarko	Central Greece	EBA	Sheep/Goat	-	Becker 1991
Kastanas	North Greece	EBA	-	Barley	Riehl et al. 2014a
Sitagroi	North-east Greece	EBA	Sheep/Goat	-	Bökönyi 1986
Pevkakia	East Greece	EBA	Sheep/Goat	-	Amberger 1979; Hinz 1979; Jordan 1975
Kouphovouno	South Greece	EBA	Sheep/Goat	-	Gardeisen 2007
Tiryns	East Peloponnese (Greece)	EBA	Sheep/Goat	-	von den Driesch and Boessneck 1990
Emborio	Chios (Aegean)	EBA	Sheep/Goat	-	Clutton-Brock 1982
Phylakopi	Milos (Aegean)	EBA	Sheep/Goat	-	Gamble 1982
Zas	Naxos (Aegean)	EBA	Sheep/Goat	-	Halstead in Halstead 1996
Karataş-Semayük	South-west Turkey	EBA	Cattle	-	Hesse and Perkins 1974
Kaman-Kalehöyük	Central Turkey	EBA	Sheep/Goat	-	Atıcı 2005
Dilkaya	East Turkey	EBA	-	Wheat and Barley	Nesbitt and Samuel 1996
Tell Barri	North-east Syria	EBA	Sheep/Goat	Wheat and Barley	Sołtysiak and Schutkowski 2015
Shengavit	West Central Armenia	EBA	-	Wheat	Hovsepyan 2015
Aparan III	North Central Armenia	EBA	-	Barley	Hovsepyan 2010 and 2015
Tepe al-Atiqeh	Central Iraq	EBA	Sheep/Goat	-	Omar 2017
Salat Tepe	South-east Turkey	EBA-MBA	Sheep/Goat	-	Silibolatlaz Baykara 2019b
Panaztepe	West Turkey	EBA-MBA(?)	Sheep/Goat	-	D. Reese personal communication 2020
Tell el-Burak	South Lebanon	MBA I	-	Wheat	Riehl and Orendi 2019
Agia Paraskevi	Central Greece	MBA	Pig	Wheat	Gkotsinas et al. 2014

The common and standard method for recording faunal assemblages is the NISP (Number of Identified Species), and the MNI (Minimum Number of Individuals) for botanical assemblages (see Vermeersch et al. 2021a, 2021b and references within). Therefore, only this data was collated from the published research and used for creating Table 2 and Figs. 3-5 (i.e., weights were not examined in this study). To enable meaningful proportional comparisons, only faunal assemblage NISP counts with a minimum of 150 were included for creating the relative proportions of domestic fauna at sites (Fig. 5). For the botanical assemblages, only MNI counts with a minimum of 250 were utilised to examine relative proportions - unfortunately, as there was a paucity of sites in the published literature meeting this threshold for botanical assemblages, this information is not visualised in the same way. Furthermore, only the counts of specimens identifiable to species or genus (for both botanical and faunal assemblages) have been included in this study. However, due to the difficulties of identifying sheep or goat to species level, many archaeozoological reports groups them together as sheep/goat, *Ovis/Capra*, or ovicaprines, and this method was also employed for this study to provide some consistency and to increase the total comparable data (see also Vermeersch et al. 2021a, 2021b).

Results

Adult Human Isotope Data

From the collated stable isotope data there are ca. 1150 total data points from 58 sites (excluding the 11 sites that only reported population means) across all time periods, which equates to roughly the same number of individuals. For the E-MBA there are 384 data points from 28 different sites. Using a visual examination of where the majority of the E-MBA data points plot (Fig. 6), and following on from previous examinations of $\delta^{13}C$ and $\delta^{15}N$ means from Anatolia and relatively contemporary diachronic and geographic populations (see Irvine et al. 2019), an isotopic range for the E-MBA was arbitrarily suggested to provide an approximate indication. This subjective range was proposed as being from ca. -19‰ to -20.5‰ for $\delta^{13}C$, and ca. 7‰ to 10‰ for $\delta^{15}N$. However, several statistical analyses were performed for this study to better examine the dataset(s) beyond the arbitrary and visual. Although data was collated and examined for a multitude of time periods, the bulk of data can be assigned to three main periods; the Neolithic, the E-MBA, and Classical to Late Byzantine. Therefore, the statistical analyses focused on these grouped periods. The means, standard deviations, and ranges of $\delta^{13}C$ and $\delta^{15}N$ for the three main data populations are given in Table 3 and the means and standard deviations are plotted in Fig. 7. The 95% confidence of intervals for these $\delta^{13}C$ and $\delta^{15}N$ means and standard deviations are given in Table 4, and scatter plots with 95% confidence interval ellipses for each of the three main grouped datasets can be found in the Supplementary Information, Fig. 7.

Table 3. Means, standard deviations (SD), and ranges for $\delta^{13}C$ and $\delta^{15}N$ data from the Neolithic, E-MBA, and Classical-Late Byzantine periods of the Greater Near East.

Time Period	$\delta^{13}C$ mean and SD (‰)	$\delta^{13}C$ Range with Minimum and Maximum Values (‰)	$\delta^{15}N$ mean and SD (‰)	$\delta^{15}N$ Range with Minimum and Maximum Values (‰)
Neolithic (n=228)	-19.7 ± 0.8	3.9 (-22.1 to -18.2)	8.7 ± 1.8	7.8 (5.4 to 13.1)
E-MBA (n=384)	-19.6 ± 0.5	3.6 (-21.0 to -17.4)	9.2 ± 2.0	12.7 (5.3 to 18.0)
Classical-Late Byzantine (n=422)	-18.9 ± 0.7	4.9 (-20.5 to -15.6)	9.7 ± 1.2	10.5 (4.0 to 14.5)

Table 4. The 95% confidence intervals for the means and standard deviations (SD) of $\delta^{13}C$ and $\delta^{15}N$ data from the Neolithic, E-MBA, and Classical-Late Byzantine periods of the Greater Near East.

Time Period	95% Confidence Interval for $\delta^{13}C$ mean (‰)	95% Confidence Interval for $\delta^{13}C$ SD (‰)	95% Confidence Interval for $\delta^{15}N$ mean (‰)	95% Confidence Interval for $\delta^{15}N$ SD (‰)
Neolithic	-19.8 to -19.6	0.7 to 0.8	8.4 to 8.9	1.6 to 2.0
E-MBA	-19.7 to -19.6	0.5 to 0.6	9.1 to 9.2	1.9 to 2.1
Classical-Late Byzantine	-19.0 to -18.8	0.7 to 0.8	9.6 to 9.8	1.1 to 1.3

The Kruskal-Wallis test determined that, statistically, there is an overall difference between the three main sample populations (i.e., time periods – Neolithic, E-MBA, and Classical-Late Byzantine) for $\delta^{13}C$; p=< 0.0001. The post-hoc multiple pairwise comparisons using Dunn's Procedure identified statistically significant differences between all the time periods (i.e., three distinct groups), but in particular the Classical-Late Byzantine sample population was the most different (Table 5). For $\delta^{15}N$, the Kruskal-Wallis test also determined overall statistical differences between the groups; p=<0.0001. The Dunn's Procedure identified that for $\delta^{15}N$ the Classical-Late Byzantine populations were also the most different from the others (Table 6).

Table 5. p-values for pairwise comparisons for $\delta^{13}C$ between the three main time period sample populations. Statistically significant differences highlighted in bold.

	Neolithic	E-MBA	Classical-Byzantine
Neolithic	1	0.386	**< 0.0001**
E-MBA	0.386	1	**< 0.0001**
Classical-Byzantine	**< 0.0001**	**< 0.0001**	**1**

Table 6. p-values for pairwise comparisons for $\delta^{15}N$ between the three main time period sample populations. Statistically significant differences highlighted in bold.

	Neolithic	E-MBA	Classical-Byzantine
Neolithic	1	0.412	**< 0.0001**
E-MBA	0.412	1	**< 0.0001**
Classical-Byzantine	**< 0.0001**	**< 0.0001**	**1**

Overall, the stable isotope values from the region across all time periods are indicative of primarily terrestrial C_3 based mixed diets. However, in the later periods (from the LBA, but particularly from the Classical period onwards), the introduction of C_4 plants into agricultural, subsistence, and dietary systems can be witnessed in the stable isotope data (Fig. 6); some of the human values are higher than the $\delta^{13}C$ threshold of ca. -18‰ indicating an increased consumption (direct or indirect) of C_4 plants (Hedges 2003; Lee-Thorp 2008; Wang et al. 2019; Liu et al. 2021).

There are also some individuals from the E-MBA who have distinctively very high, and outlying $\delta^{15}N$ values (the E-MBA individuals with $\delta^{15}N$ values >12‰ as can be seen in Fig. 6). These individuals come almost entirely from the eastern Syrian settlements of Tell Ashara and Tell Masaikh (Sołtysiak and Schutkowski 2018), and will be discussed further below.

Botanical and Faunal Data

Of the 127 sites, collated in this study, with botanical and/or faunal data (Fig. 2), 109 have faunal data, 47 have botanical data, and 27 have information on both. Domestic faunal assemblages are generally dominated by sheep/goat with 89 (81.7%) of the sites with faunal data (n=109) having a dominance of ovicaprines in their domestic faunal assemblages, this is followed by cattle (n=10; 9.2%), and then pig (n=9; 8.3%) (Fig. 3). Regarding domestic cereals (Fig. 4), in general, barley is the most ubiquitous, with 24 (51.1%) of the sites' (n=47) botanical assemblages being dominated by this species. This is followed by wheat (n=14; 29.8%), and then settlements with an equal dominance (n=9; 19.1%). Proportional dominance of sheep/goat ranges from 35.8% to 96.7% of individual sites' domestic faunal assemblages (Fig. 5). However, the mean dominance is 72% ± 14.1 and, in general, when dominant they tend to account for >60% of a site's domestic faunal assemblage. The faunal assemblage dominance for cattle ranges from 42% to 71.8%, with a mean of 55% ± 12.6. For pigs, when they are the dominant domestic faunal species this ubiquity ranges from 35.5% to 56.8%, with a mean of 47.8% ± 8.3. In general, therefore, it can be said that sheep/goat are not only the most omnipresent domestic animals of the period, but, furthermore, they tend to dramatically dominate assemblages when they are the most ubiquitous. Only 9 of the 47 archaeobotanical studies collated during this study had a high enough Total MNI (≥250) to allow relative proportions to be examined. Ubiquity of barley in a site's archaeobotanical assemblage ranges from 56.1% to 98.8% with a mean of 74.7% ± 16, and for wheat the mean is 81.9% ± 20.7, with a range of 51.2% to 95.5% in dominance.

Whilst the data from the botanical and zoological reports can provide us with an indication as to the potential dominance of crops and animals, and thereby the importance of a particular cereal or species to a site and/or populations, in turn providing indications about their agricultural and subsistence strategies, and dietary habits, we should exercise a certain degree of caution. Archaeobotanical and/or archaeozoological assemblages rarely include the entirety of a site's botanical or faunal material, and this may be the result of sampling strategy (for example, biases from sampling storage contexts), or methodological limitations such as a lack of fine-mesh sieving or flotation (see Vermeersch et al. 2021a for an excellent summary of methodological challenges regarding botanical and faunal remains).

Discussion

Supra-regional and Diachronic Patterns in the Stable Isotope Values

The statistical analyses demonstrate that the three main periods analysed (Neolithic, E-MBA, Classical-Late Byzantine) are significantly distinct from one another; the Kruskal-Wallis and the Dunn's Procedure tests show this, as do the 95% confidence intervals and the means. The means and 95% confidence intervals also show that there was a diachronical increase in $\delta^{13}C$ and $\delta^{15}N$ values (for both points see Fig. 7 – mean $\delta^{13}C$ and $\delta^{15}N$ values of the three main time periods). For $\delta^{13}C$ this is particularly true for post-Bronze Age populations, which is likely related to the deliberate introduction and exploitation of C_4 plants in the arable agricultural systems. This dietary shift, witnessed in the move to more positive $\delta^{13}C$ values in the Classical period has previously also been noted for Mesopotamian populations (Sołtysiak and Schutkowski 2018). It has also been argued though that shifts in isotopic values over time may be related to climatic changes affecting the isotopic values of food resources at the base of food webs (i.e., plants); for example, increased $\delta^{13}C$ values from the Neolithic period onwards may be related to a general overall pattern of decreasing water availability in the GNE from the Neolithic onwards (see Ferrio et al. 2005; Araus et al. 2014; Riehl et al. 2014b; Gaastra et al. 2021). Anatolian populations show a reduction in $\delta^{15}N$ values from the (later) Neolithic to the EBA, followed by an increase in-post Bronze Age periods (see Irvine forthcoming; Irvine et al. forthcoming). This is not, however, observed in the overall data of the GNE, and instead there is an overall gradual diachronic increase in the mean $\delta^{15}N$ values. Also, according to the data examined in this study, the homogeneity of the E-MBA populations previously witnessed in the studied Anatolian (and also some of the Greek, and North Mesopotamian) populations (Irvine et al. 2019; Irvine forthcoming; Irvine et al. forthcoming) is not replicated across the GNE. The range of $\delta^{13}C$ values in the E-MBA period is lower than in the Neolithic and the Classical-Late Byzantine periods, but this is not true for $\delta^{15}N$ which actually has the greatest range.

However, when the means of individual temporally contemporaneous populations are plotted together (Figs. 8-10), it is clear that in the Neolithic (Fig. 8) there is consistent variability in the $\delta^{13}C$ and $\delta^{15}N$ values. Although not included in the collated stable isotope data or any of the figures due to being outside of the geographically defined zone examined in this paper, the $\delta^{13}C$ and $\delta^{15}N$ data from Neolithic Ganj Dareh in Iran (SW Zagros) demonstrate that the population consumed a terrestrial C_3-based diet with adult human means for $\delta^{13}C$ and $\delta^{15}N$ being ca. -20‰ and 10‰, respectively (Merrett et al. 2021). For the E-MBA (Fig. 9), the majority of the populations are within a relatively narrow range (very similar to the arbitrary range noted from initial observations, as described earlier: -19‰ to -20.5‰ and 7‰ to 10‰) with a few outlying points (populations). Interestingly, whilst one of these outlying points (Kültepe) is from Anatolia, three of the other outlying points are from the same region of eastern Syria (Tell Ashara and Tell Masaikh), five others are from the Caucasus, and the other two are from Cyprus. This may, therefore, be indicative of marginal regional conditions that result in divergent isotopic values (either by way of differing agricultural/subsistence strategies, dietary habits, or local regional baseline isoscapes), and this would certainly seem to be the case for Tell Ashara and Tell Masaikh. This, in turn, could suggest that there is a 'core area' of northern Mesopotamia, Anatolia, and Greece/the Aegean for the 'EBA package' and its associated isotopic ranges. Additionally, despite the proximity of some of the E-MBA settlements to coastal regions there is a distinct lack of evidence in the stable isotope data for marine (and even aquatic) resource consumption. This peculiarity has also been highlighted by other isotopic studies in the region (see Negari 2016; Goude et al. 2018; Irvine and Erdal 2020a). For the Classical-Late Byzantine populations, the majority also plot in a very tight cluster, but with more positive $\delta^{13}C$ and $\delta^{15}N$ values than in the Neolithic and E-MBA periods. Also, in contrast to the overall mean, most of the means of the discrete Classical-Late Byzantine populations (Fig. 10) are more negative than the -18‰ threshold which is accepted as being suggestive of increasing C_4 content in the diet, and, therefore, this actually points to a predominantly C_3-based diet for these populations. This perhaps suggests that the role of C_4 plants like sorghum and millet in these post-Bronze Age periods may not have been as important in agriculture, subsistence, and dietary habits as previously thought/expected?

So, overall, whilst the E-MBA homogeneity is not as ubiquitous as hypothesised, it still seems to exist in the main. Interestingly, after an admixture of genes in the Late Neolithic (ca. 6500 BCE), the Late Chalcolithic and EBA Anatolian gene pool is very homogeneous, much like the isotope signals and subsistence strategies (Skourtanioti et al. 2020). This may be a coincidence, but it would make sense to a certain degree as a general uniformity and homogeneity in all aspects of life is witnessed for the 4th-2nd millennium BCE of the GNE - see also later discussions in this paper. Furthermore, the different temporal periods, overall, exhibit very distinct isotopic signals which can be argued to be indicative of changes and particular patterns of subsistence and agricultural strategies. It is also possible that the isotope values and ranges may actually indicate a particular model of staple finance, for example, extensive farming based on wheat and/or barley, and mixed management strategies of sheep/goat, cattle, and pig and that it may not necessarily be temporally restricted.

Terrestrial C_3-based diets and a homogeneity in the isotopic values, (exhibited through narrow ranges in $\delta^{13}C$ and $\delta^{15}N$ values, and no significant differences between social groups), for E-MBA populations has been previously noted, not just in the GNE, but also in the wider Mediterranean region (e.g., Negari 2016; Varalli et al. 2016). However, these observations have, so far, been restricted to single populations or regions. Furthermore, not only has a homogeneity in isotopic values been noted, but the ranges in the $\delta^{13}C$ and $\delta^{15}N$ values are often similar to those observed in this study. For example, at the EBA site of Arano (Verona, Italy) the range is -19.7‰ to -20.9 for $\delta^{13}C$ and 6.9‰ to 8.9‰ for $\delta^{15}N$ (Varalli et al. 2016). This suggests that, whilst it is beyond the scope of this current paper to discuss it in more depth, a distinct and common model of staple finance may have had a wide(r) geographical range.

From visual examination of Figs. 6 and 9 it is clear that the individuals with high (>12‰) $\delta^{15}N$ values are deviations relative to the other $\delta^{15}N$ values from the same temporal dataset. The high $\delta^{15}N$ values from E-MBA Tell Ashara and Tell Masaikh make the E-MBA dataset less homogenous by producing a large range for $\delta^{15}N$ values (12.7‰). This range is higher than that of the Neolithic dataset (7.8‰) and the Classical-Late Byzantine dataset (10.5‰). At Tell Ashara and Tell Masaikh these high (>12‰) $\delta^{15}N$ values during the EBA and MBA periods (the $\delta^{15}N$ values become lower from Neo-Assyrian period onwards) are higher than expected for a terrestrial diet based on C_3 crops and domestic animals such as ovicaprids and cattle which have fed on C_3 plants (see Sołtysiak 2020). This may be to do with low water availability, being in a low rainfall area (outside of the limits for rainfed agriculture of the Upper Khabur and Jazira: see Wilkinson 1994; McMahon 2020), and with no irrigation from the Euphrates River being exploited. However, the authors suggest that it was more likely related to intensive plant cultivation and very high levels of manuring due to the increasing demands of a growing urban population (Sołtysiak and Schutkowski 2018; see also Bogaard et al. 2007 and 2013 for the effects of intensive crop cultivation and manuring on isotopic values). There are some individuals (those with lower $\delta^{15}N$ values) at Tell Ashara who, it is posited, may have consumed mostly grain imported from areas with higher precipitation (thereby requiring less intensive cultivation methods), perhaps northern Mesopotamia (Sołtysiak 2019). I would also further suggest that to achieve such high $\delta^{15}N$ values in the humans there would have also been the regular consumption of animals foddered/grazing on highly manured crop grains/

crop stubble. This agrarian strategy of intensive cereal cultivation with concentrated manuring is somewhat different to the general pattern of extensification witnessed for the time period in this region (see Araus et al. 2014, Styring et al. 2017). Therefore, not only are the Tell Ashara and Tell Masaikh populations isotopic 'outliers', but they are also subsistence and agricultural strategy outliers. Whilst most other populations in the region at this time were moving towards, or had already established, extensive agriculture, they are not. This may suggest that there were still some localised variations in subsistence and agricultural strategy that prove an 'exception to the rule'. To clarify some terminology, intensive agriculture refers to labour intensive, and labour-limited agriculture characterised by high levels of manually distributed manuring over a small area of agricultural fields, whilst extensive agriculture refers to land-limited agriculture over a larger area with lower labour intensity due to extensive methods such as an increased exploitation of animals for traction and draught labour (Wilkinson 1994 and Paul Halstead's comments in reply).

Whilst variation is undeniable on a smaller temporal or regional scale, when viewed on a larger scale there is still the suggestion of a distinctive pattern in the E-MBA of the GNE. It is, however, acknowledged that the perspective of this study may not identify subtleties that could have had an effect such as individual settlement size and structure/organisation, or more local environmental and climatic differences, and short-term changes. A study by Pokutta (2017) suggested global variability in $\delta^{13}C$ and $\delta^{15}N$ isotope values and therefore dietary patterns in the Bronze Age. The findings of this study also suggest that this is a likelihood, to a certain extent, and examining a larger geographical range provides more chance of varied subsistence, agricultural, and dietary strategies due to several factors such as local environment and climate as well as society and culture, to name a few.

It should also be emphasised here that any suggestion of an E-MBA model of staple finance in this paper, or indeed any comments on dietary habits and subsistence practices, does not refer to individual dietary habits (i.e., daily, weekly, or even monthly meals), or food preparation methods or techniques. The analysis of $\delta^{13}C$ and $\delta^{15}N$ values from bulk collagen analysis, and a broad investigation of archaeobotanical and archaeozoological assemblages does not allow for a fine enough examination of these types of aspects of dietary habits and subsistence strategies. Furthermore, the stable isotope analyses, at this scale, only allows for the examination of isotopically homogenous or heterogenous patterns in the data. In other words, for example, if two populations (separated by geography and/or time) both eat wheat grains, but one population consumes them exclusively as bread and the other population consumes them exclusively as gruel/porridge then the stable isotope values will not be able to make this distinction. A similar principle is applicable for the consumption of animal meat, the stable isotope data will not be able to determine whether an individual, or population, consumed good or poor cuts from an animal.

Crops and Arable Agriculture

In the Neolithic and Early Chalcolithic there was a greater range/diversity of exploited plants and crops, especially when compared to the later monoculture of the Mediterranean Quartet (Sarpaki 1992). For example, at Çatalhöyük, there was no fixed crop assemblage, with a diverse range of plants exploited (Fairbairn 2007; Fairbairn et al. 2007; Bogaard et al. 2017). The Neolithic and Early Chalcolithic periods were probably ones of ecological opportunism and experimentation (Liu et al. 2019). This greater range in exploited plants is also mirrored in the greater range of $\delta^{13}C$ and $\delta^{15}N$ stable isotope values for the Neolithic in Anatolia (Irvine et al. forthcoming).

As can be seen from Table 2 and Fig. 4, the two most ubiquitous crops in the late 4th to early 2nd millennium BCE (henceforth abbreviated to E-MBA to provide a simplified symmetry with the chronological grouping of the stable isotope data) are barley and wheat. It is also observed that there are some geographical differences, with wheat being the dominant crop largely in the western regions. This is likely related to rainfall and water availability, as wheat has a higher water requirement than barley, and also local climatic variability such as the length and severity of summers and winters, and therefore growing seasons. This agrees well with Riehl's (2014: Fig. 4) findings about the distribution of plants and vegetation in Anatolia, north Mesopotamia and the northern Levant, as well as modern yearly average rainfall data (Fig. 11). Vermeersch et al. (2021a) found that in the Levant, free-threshing wheat is mostly limited to sites in areas with 500-600 mm of precipitation. However, their study also indicated that most of the main domestic crop and faunal species in their study are not particularly restricted by precipitation, and furthermore, that economically important crops (e.g., free-threshing wheat) are likely to have been irrigated, and also that some settlements may have imported crops from elsewhere if their environmental conditions didn't allow for their cultivation (Vermeersch et al. 2021a; see also Sołtysiak 2019). Furthermore, although related to the previous point, is that the predominance of wheat and barley goes beyond these crops being a staple food. Their ubiquity may, hypothetically, also be related to the use of wheat and barley as capital in payments, interest on loans, and debts, as we know it was in early 2nd mil. BCE at Kültepe/Kanesh, for example (Dercksen 2008a, 2008b; Barjamovic 2020). One final interesting aspect, although perhaps related to 'environmental determinism', is that the distribution of wheat and barley in the E-MBA GNE quite closely mirrors the ranges of the initial founder crops (see Gopher et al. 2017).

The monoculture of domestic crops, and particularly wheat and barley, in the E-MBA period of the GNE is not a new revelation though, and it has been observed and stated by numerous researchers over the years. A cereal monoculture of wheat and barley was noted in the southern Jazira, with the inclusion of pulses, mostly lentils, (and vines) in the northern part of the Jazira (Wilkinson 1994). Riehl (2019) found that there is a predominance of barley at Tell el-'Abd and states that this is typical for Bronze Age sites in the Near East and in particular of the Euphrates sites. She suggests that a major reason for this may be due to the biology of barley with its short life-cycle which leads to fast ripeness of the grains, thereby reducing the risk of drought during the hot and dry summer season. Furthermore, these biological aspects of barley may also explain its extended use in economy and trade and its related socio-political importance (Riehl 2019). Nesbitt (1995) suggested that a plausible hypothesis for the shift to a dominance of wheat (particularly bread and macaroni wheat) was that the increasing demand from larger and more urban populations encouraged farmers to shift production to crops that responded better to manuring and were easier to process once harvested.

These kinds of observations are not restricted to Anatolia, Mesopotamia, and the Levant. In the South Caucasus changes in agriculture in the Early Bronze Age to a monoculture of cereals have also been noted. It has been suggested that the particular cultivation choices of particular plants by people of the Kura-Araxes culture, were related not only to climatic changes, but also to economic efficiency and the cultural choice of specific agricultural products and traditions (Hovsepyan 2015). Furthermore, it was human decisions which were the most likely cause for these changes in the agrarian economy between the Neolithic and the Bronze Age of the South Caucasus (Hovsepyan 2015). The dominance of cereals in the upper parts of the middle mountainous, and the entire high mountainous zones has been suggested to be related to the low yield and risks of crop failure in non-cereals (Hovsepyan 2015). Mountainous farming can be particularly risky and the cereals discovered at the Bronze Age centres and settlements of the South Caucasus are more resistant to severe bio-climatic conditions and require less intensive maintenance than most other field-crops, meaning that cereal cultivation required less effort and was less risky (Hovsepyan 2015). In the Erzurum region of north-east Turkey, they still today cultivate a *Triticum aestivum* landrace known locally as *Kirik* which is well adjusted to the mountain climate together with barley (Longford 2015; C. Longford personal communication July 2021). The Kura-Araxes culture is an interesting case with regards to arable agriculture and cereals. The dominant wheat in the Caucasus was free-threshing wheat and even when the Kura-Araxes people migrated to regions in northern Mesopotamia/eastern Anatolia and the Levant that had a dominance of barley and/or glume wheats they maintained a preference for free-threshing wheat (this can actually be seen to a certain extent in Fig. 4). Even if it wasn't always the dominant cereal crop at their centres, it is present, and usually in conjunction with an absence of glume wheats. There appears to be a link between the presence of free-threshing wheat and the Kura-Araxes culture (Longford 2015; C. Longford, personal communication July 2021). This kind of arable agricultural and dietary 'identity' can also be witnessed, to some extent, in Fig. 9 where the $\delta^{13}C$ and $\delta^{15}N$ means of the EBA/Kura-Araxes southern Caucasus populations form their own isotopic cluster. It seems, therefore, that free-threshing wheat was one particular part of the Kura-Araxes cultural identity and 'taste' which moved with them as they migrated, rather than the Kura-Araxes horizon being simply the diffusion of a socio-economic and ceramic tradition (C. Longford, personal communication July 2021). This last point is of particular interest to the discussions later in this paper about the mobility and transference of the 'EBA package'. It should also be noted here that this present study has not distinguished between different wheat types, but that this is something to be conscious of and an example of one of the finer details 'blurred' by this large-scale overview and holistic approach.

One slight exception to the rule of wheat/barley dominance is Cyprus, which, unlike the mainland of the GNE, was not grain-centric in terms of agriculture and archaeobotanical assemblages after the Cypro-PPNB. Instead, there is a dominance of 'cash crops', like olive, grape, and fig from the Chalcolithic onwards. Whilst the relative proportions of grain increase in the EBA, grain cereals likely only dominated (to the same levels of the Cypro-PPNB) in the LBA (Lucas and Fuller 2020). The extensification of agriculture is also noted for Cyprus from the Mid.-Late Chalcolithic and EBA, likely in parallel with the increasing importance of cereals (Lucas 2014; Lucas and Fuller 2020). This is quite similar to the period when the extensification of agriculture is also happening on the mainland, providing some weight to the idea of a pervasive and ubiquitous mode of staple finance (i.e., agricultural strategies) in the region.

Animal Management, Ante-mortem Product Exploitation, and Livestock as Wealth Finance

The findings of this study (see Table 2, Figs. 3 and 5) demonstrate that in the E-MBA period (more accurately the late 4th to early 2nd millennium BCE) the most ubiquitous domestic animal species in the GNE were sheep/goat. As with the distribution of dominant cereal crop species, there are also some geographic differences with cattle being more dominant in western Anatolia. This may be related to more humid conditions and the higher availability of rainfall (see Fig. 11), as cattle have higher water requirements than sheep or goats (Gaastra et al. 2020a). This was suggested to be the case at Kohneh Pasgah Tepesi, where the importance of cattle may have been related to the favourably moist climatic conditions in that part of Iran (Decaix et al. 2019). However, the data collected by Vermeersch et al. (2021a) in the Bronze and Iron Age Levant suggests that animal husbandry may not be as dependent on the environment as previously thought, and instead may be as a result of historical, political, social, and economic decisions. This is also supported by the work of Gaastra et al. (2021) for the entire Near East from 13.000-0 BCE who found that fluctuations in the proportion of sheep/goat, cattle, or pigs were not related to long- or short-term phases of aridity and/or Rapid Climate Change events. The dominance of cattle in western Anatolia may also not necessarily be related to environmental and climatic factors, but rather cultural ones (see Arbuckle 2014b). Gaastra et al. (2021) discovered that for the Middle Holocene period (ca. 4000-2250 BCE) proportions of domestic animals were variable between different regions of the Near East, and furthermore, between different landscape types and between urban and rural sites. Their results found that the proportions of domestic animals, and changes in them, are much more nuanced than presented here in this study. However, in general, the proportional variations that they observed are mostly of cattle and (particularly) pigs, and related to urban versus rural settlements, and that, overall, for this time period there is a consistent dominance of sheep/goat which consistently account for >60% of faunal assemblages (Gaastra et al. 2021). This agrees very well with the findings of this current study. Sites with a dominance of cattle, or relatively higher proportions of cattle, may indicate more 'urban' centres due to their role in farming (traction), movement of agricultural surplus, and trade (see Atıcı 2014; Kohler et al. 2017; Styring et al. 2017; Gaastra et al. 2020b, 2021). As with cereal crops, the animal husbandry economy on Cyprus was slightly different to that of the mainland, at least initially. Animals were not intensively exploited for their ante-mortem products on Cyprus until the LBA (Lucas and Fuller 2020). This may be to do with Cyprus being outside of, or at least not fully integrated into, the GNE market economy in the EBA as it was not fully integrated into the broader Mediterranean trade network until the LBA (Lucas and Fuller 2020). Cattle were only re-introduced to the island in the EBA, but this is likely to have stimulated a major shift in agricultural practices (milk, traction, and dung), and a reduction of pig in faunal assemblages coincides with an increase in ovicaprines from the LCh onwards (Lucas and Fuller 2020).

Previous $\delta^{13}C$ and $\delta^{15}N$ stable isotope analyses of EBA populations and their animals have demonstrated that it appears as if not all domestic animals were directly consumed (Varalli et al. 2016; Irvine et al. 2019). At LCh Tell Brak and EBA Tell Leilan the human stable isotope values suggest low animal protein consumption (Styring et al. 2017). Rearing, keeping, and managing livestock requires significant investment and organisation and, therefore, if the animals were not being reared principally for primary consumption, then the question arises, why were people keeping them? Although this will be discussed in more depth further below, to put it very simply and generally, animals were no longer reared just for their primary products (i.e., meat), or merely utilised in a secondary manner (dairy, traction, fibres). Rather, the secondary exploitation of their ante-mortem products (Vigne and Helmer 2007) had become vastly intensified, and they had now developed into having not just a practical value, but a commercial value as wool-bearers or beasts of burden and traction. For example, at Kültepe/Kanesh the textual sources reveal that "…out of 14 sheep received as payment, only 1 was slaughtered for immediate consumption, and the remaining 13 were sold for 31.16 shekels of silver; out of 11 sheep received as payment, 9 were sold for silver, while 2 were slaughtered for consumption" (Dercksen 2008b). This provides a prime example that livestock had become a commodity beyond primary consumption, and could even act as a means of direct or indirect exchange with a relatively stable value.

Furthermore, in EBA Anatolia it has been shown that domestic animals from the same site/settlement have a large range of $\delta^{13}C$ values (Irvine et al. 2019; Irvine and Erdal 2020b). Varied $\delta^{13}C$ (and $\delta^{15}N$) values indicate different sources of carbon in the animals' diets and have been suggested as evidence of differing animal management strategies, including; grazing on crop stubble and/or manured fields, the (seasonal) mobile herding of animals outside of the agricultural zone of a settlement, and stable foddering (Pearson et al. 2007; Makarewicz 2017; Middleton 2018; Irvine et al. 2019; Ventresca Miller et al. 2019; Irvine and Erdal 2020b; Sołtysiak 2020;). The implication being that there may have also been some movement of animals, not just differing management and feeding strategies. This has been supported for the EBA in Anatolia by $\delta^{34}S$ data which showed that whilst at Bakla Tepe the animals were all local but had different diets (sources of carbon in their dietary protein), at Bademağacı it was demonstrated that some of the animals were not local, with one hypothesis being that they had been imported to the site (Irvine et al. 2019; Irvine and Erdal 2020b). This may tentatively suggest a trade or supply chain of animals/animal products which may, consequently, also imply a wealth finance aspect of animal husbandry. For example, in the Ur III economy we know that wool producing herds of sheep were regulated by the state and that cattle herding and rearing were also regulated differentiating between edible and labour needs (meat, dairy, or draft animal use) (Zeder 1988). Different animal management strategies for sheep and goats are known from Tell Beydar following analysis of the texts. These revealed that grain-fed animals were rare and that large flocks were exclusively fed by grazing (Riehl 2006). However, some of the sheep and goats were kept separately and fattened by grain, and it was these animals which were later slaughtered for their meat. It is also very likely that these sheep and goats intended for slaughter were kept in stables. However, the regular flocks were so large (ca. seven thousand animals) which meant that they could not be kept in the city, or even sheared there (Riehl 2006). In some parts of northern Mesopotamia, there is a clear distinction between urban centres and their satellite towns and villages. In the Upper Euphrates region pigs were almost completely absent at Titris Höyük, but present in significant numbers at smaller settlements such as Hassek Höyük, Kurban Höyük, and Gritille Höyük. These differences in pig husbandry patterns may indicate an institutional presence within urban centres compared to the smaller settlements, whose inhabitants were rearing pigs as agricultural and pastoral resources were increasingly being redirected to support the growing cities (Price et al. 2017). Furthermore, the reduction in pig numbers at sites in the EBA would perhaps provide evidence for a shift to animals with an economical/financial value; pigs consume grain and do not provide ante-mortem products. They are also more likely to disrupt crop agriculture (if free-roaming) and, therefore, another reason for their demise may be the increased extensification of arable agriculture around settlements (Price et al. 2017).

Thus, a key aspect of the 'EBA package', as presented and elaborated on here in this study, is the intensification of the exploitation of animals' ante-mortem products from the late 4th millennium BCE. This resulted in the (re)organisation of animal husbandry, or at least parts/aspects of it, becoming part of the wealth finance economy which, in turn, had an impact on the staple finance economy including agricultural strategies, subsistence practices, and dietary habits. In many ways, it can be stated that the Near East and Eastern Mediterranean in the late 4th millennium BCE witnesses a 'Second Agricultural Revolution'.

Cattle

The lack of consumption of cattle (either primarily through meat consumption, or secondarily through milk/dairy products) may be related to cattle being mainly used for traction – especially related to grain production (i.e., ploughing), and the redistribution of grain surplus. Cattle were kept for as long as economically useful and productive, and then sold for meat. The pastoral economy was not one based around meat production and kill-off patterns also reflect this. Pathologies on some of the distal bones of cattle skeletons from Kohneh Pasgah Tepesi indicates that cattle were used as draught animals, most likely in agricultural activities (Decaix et al. 2019). At Salat Tepe cattle were kept to an old age suggesting the importance of exploiting their ante-mortem products such as milk and traction (Silibolatlaz Baykara 2019b). High prices for purchase, or rental, of cattle also reflect this importance. Cattle commanded a higher price range than sheep, and were rented as well as being bought and sold; 12 shekels of silver per animal for purchase and 0.8–3.5 shekels of silver for rental (Gökçek 2004). The textual evidence also shows that sheep, cattle, and pigs were brought to Assyrians for payment and that they were accepted in lieu of silver, which further demonstrates that the use of livestock for meat was not the primary focus (Atıcı 2014). This means that livestock should be considered as a commodity for exchange and that they "…functioned as a means of exchange with values dictated by supply and demand, which generated new economic opportunities and new markets for sale, purchase, and rent" (Atıcı 2014).

Sheep/Goats

We know from written texts that the woold trade was an important part of local and also pan-regional economies. Evidence for the importance of sheep raising and the presence of a highly developed and organised textile industry and, by implication, large-scale sheep husbandry for wool in Anatolia can be found in the Kültepe/Kanesh tablets, for example. There is frequent mentioning of various prized sheep breeds (e.g., *lakannūm*, *šallinum,* and *utharum*) that provided meat, fibre, and capital value, as well as palace functionaries such as the chief of shepherds and the shepherd of the queen (Gökçek 2004). The Kültepe/Kanesh tablets also reveal that there was a complex and selective pricing policy for sheep that involved the colour of the fleece, its place of origin, the quality of the meat, the animal's physical condition, and the breed (Gökçek 2004). For sheep, there was a price range from ca. 1.4 to 4.6 shekels of silver per sheep. (Gökçek 2004). One Assyrian cuneiform tablet from Kültepe/Kanesh describes the movement of 630 kg of wool from Kanesh to another city in Anatolia (Dercksen 2008a), and using other texts it has been estimated that over the course of 40-50 years 14.500 pieces of cloth and 100.000 textiles were shipped from Anatolia to Aššur (Larsen 1987). This shift to a highly specialised pastoral economy which focused on sheep and goat husbandry was driven by the commodification of textile production and had already commenced in the 3rd millennium BCE, if not even slightly earlier (Styring et al. 2017). Evidence for the importance of textile production from the 4th millennium BCE onwards at GNE settlements comes from changing herd composition to include more sheep, more sheep being kept to old age, and an increase in the number as well as changing dimensions and weights of spindle whorls. (Schoop 2014; McMahon 2020). In Anatolia, for example, from the LCh onwards there is a dramatic increase from earlier periods of the Anatolian Chalcolithic in the number of spindle whorls, loom weights, as well as the evidence of full looms (Schoop 2014).

Faunal isotope values from LCh Tell Brak and EBA Tell Leilan suggest the possible foddering of animals on cereal grains which not only provides another example of differing animal management strategies, but could also demonstrate the input and investment of labour and land/land management (such as water/irrigation etc.) that populations/institutions were willing to put in to sustain large sheep/goat herds due to their new economic value (Styring et al. 2017). Conversely, the widespread move to rearing wool-bearing sheep and the associated textile trade meant that large areas of land that previously could not reliably be used to support agriculture became productive, and land in more fertile areas that had formerly been used to grow flax (for textile production) was now available for the cultivation of other crops (McCorriston 1997; Lawrence and Wilkinson 2015). The production of textiles from flax required significantly more labour than that utilising animal fibres. Therefore, this transition to animal fibres allowed not only for the re-allocation of highly productive agricultural land to cereal crops, but also labour that had formerly been dedicated to flax cultivation could now be re-invested elsewhere - "Within households relying on marginal agricultural land, labour freed from producing fibre might have been diverted to producing surplus textiles for exchange. Such a strategy would have triggered specialization in textile craftsmanship" (McCorriston 1997). This also further demonstrates the impact that this (animal husbandry) aspect of the 'Second Agricultural Revolution' had on modes of both staple and wealth finance in the GNE. The intensified exploitation of animals' ante-mortem products and their 'commercialisation', although primarily economic in nature, affected participating societies in their entirety, triggering a wide range of interconnected changes from the economy and technology to social structure and ideology (Schoop

2014). In the Chalcolithic period of Anatolia (6th-4th millennium BCE), for example, there was chronological and regional diversity in pastoral strategy, but ovicaprines were always important components of herds. By the 3rd millennium BCE, though, sheep had more-or-less become the most ubiquitous species, together with a trend of increasing survivorship of adult sheep through the Chalcolithic and into the EBA (Schoop 2014).

Although there was undoubtedly a move towards a specialised animal economy based on sheep and goats and the resultant textile trade, many sites did employ a mixed strategy of animal exploitation. For example, at Salat Tepe *Ovis/Capra* demonstrated a mixed management strategy for meat and ante-mortem products such as milk and wool/hair (Silibolatlaz Baykara 2019b), and at EH Lerna, a mixed pattern of primary consumption (young culling) and ante-mortem product exploitation (older animals/older culling ages) has been noted (Reese 2013a; 2013b).

Mobility and Transference of the 'EBA package'

Following the arguments of Pauketat (2000), we may consider that an E-MBA model of staple finance and common agricultural practices of the late 4th to 2nd millennium BCE were the result of social compliance. Utilising Pauketat's (2000) proposal, it could be that smaller populations were 'coerced' into an economic food producing system, initially instigated by larger settlements with greater hierarchical systems and more prominent 'elites', that produced the greatest output whilst also allowing the greatest control over both resources and, thereby, the populations (see also, Frangipane 2018). Information about agricultural systems has the potential to be viewed within the semblance of power relations as a result of human land-use practices. It has been demonstrated that the Neo-Assyrian Empire (934-611 BCE) utilised agrarian systems, and the intensive production of surplus crops to exert political control over the landscape and its inhabitants, the subjects of this empire (Rosenzweig 2018). The expansion of the Neo-Assyrian Empire was founded on increased agricultural production and agrarian control enabled the Neo-Assyrians to exert political control over its subjects. For example, at Tuˇshan, the agrarian system which was imposed by the Neo-Assyrian empire "…bound subjects to the polity through a demanding program of intensive, surplus crop production that curtailed, but did not extinguish, agricultural diversity and independence." (Rosenzweig 2018). It is known that in the EBA of Anatolia, Greater Mesopotamia, and the Levant there was an emergence of settlement hierarchy and that the larger 'city-states' may have exerted an influence on their local regional environment, and also possibly, in some cases, some smaller cities, towns, and villages (Zeder 1988; Wilkinson 1994; Baird 1999; Matney 2012; Price et al. 2017; Gaastra et al. 2020b; Massa et al. 2020; Umurtak 2020). Some have also suggested that these peripheral satellite settlements may have been under the direct influence of larger centres to the extent of producing and providing crops and animals for them (Zeder 1988; Wilkinson 1994; Price et al. 2017; Gaastra et al. 2020b, 2021). It should be argued here that providing extra food resources for a larger settlement, does not always mean that these smaller, 'rural' settlements were necessarily coerced into this provisioning, although this may have been the case. Instead, it may have been a mutually beneficial arrangement based upon the principals of trade, barter, exchange, and a market economy. If one, tentatively, expands this theory it may provide one possible explanation as to why, to some extent, a monoculture of crops and domestic animals exists in the archaeological record, and thus also a relative homogeneity in the stable isotope values. In effect, the vast majority of EBA settlements were growing the same crops, and rearing the same species of domestic animals, and this may have been the result of regional political or economic control. Once this style of economic food producing system had been established and other smaller contemporary settlements had been "constrained by the spaces and practices" of these new systems, the ability to "objectively resist domination…would have been inhibited" resulting in those settlements at a certain point having no choice but to switch to, and become locked into, those economic agricultural systems (Pauketat 2000).

In the EBA the sites were often very close together; during the mid-EBA of Anatolia it has been estimated that the average distance between mounded settlements in the main valleys was 3-6 km (Massa 2016). A similar pattern has been noted for the Jazira, with sites ca. 5-20 km apart during the EBA (Wilkinson 1994). Settlements of the period, therefore, should not be viewed in isolation as they were (in the majority) far from isolated. The short distance between settlements suggests intensive interaction with their neighbours, with the transfer of technological knowledge and cultural behaviours mostly from one individual to another and one village/town/city to another (Matney 2012; Massa 2016; Ünlü 2016). Therefore, it is not so hard to imagine common patterns of agricultural subsistence as a local exchange of ideas, practices, and methods becoming regional and then pan-regional. Additionally, there were many common and shared cultural aspects of EBA settlements. Indeed, the material culture of the Anatolian EBA, for example, demonstrates a trend towards homogenisation (Bachhuber 2015). It has been shown that more culturally similar interacting groups are more likely to accept a particular innovation (Massa 2016). At Karataş (southwest Anatolia), for example, which shares many of the same cultural features of other EBA Anatolian settlements it is likely that wheel-made pottery and metallurgy was imported to the settlement (Massa 2016). In addition, the presence of 'colonies' at some EBA sites such as Kanlıgeçit, Kastri, Ayia, Photia, and Manika has been suggested (Heyd et al. 2016; Massa 2016). It is feasible to argue that the members of these colonies would have brought cultural and technological practices of their home with them to their new locations, possibly including agricultural practices. In the latter part of the 3rd millennium BCE especially, many basic commodities (copper, stone artefacts, some vessel types) start circulating in large(r) quantities and across larger distances reaching even relatively isolated locations/settlements demonstrating a wide range and permeability of material culture, goods, and technologies across EBA Anatolia (and further afield) (Massa 2016; Şahoğlu 2016; Massa and Palmisano 2018; Yılmaz 2019). Evidence for long distance trade, through the presence of exotic raw materials and objects, is also found in northern Mesopotamia from the 4th millennium BCE onwards (McMahon 2020). As with the exchange of material culture and technology (e.g., finished objects, wheel-made pottery, metals etc.) agricultural practices can potentially be considered to be as much a part of the (EBA) trade networks as those other goods and technologies. It has been attested archaeologically that this '[EBA] economic package' (wheat, barley, cattle, sheep, and goats) had begun to spread from the Near East through Central Asia and into northern China around 5000 BP and was established there by the 4th millennium BP (Li and Dong 2018; Liu et al. 2019; Zhou et al. 2020); therefore, its ubiquitous movement on a much smaller regional scale across Anatolia and the Greater Near East should be anticipated (see also Liu et al. 2019; Skourtanioti et al. 2020). Furthermore, the movement of economic/subsistence packages has already been confirmed in the region for the Neolithic (Brami 2019; Lucas and Fuller 2020).

It has been suggested that there would have been a movement of specialists (traders, builders, potters, weavers, and metal workers) in the EBA, although not necessarily over large distances (Massa 2016). This may also include the movement of farmers, pastoralists, or agricultural specialists. In the latter half of the 3rd millennium BCE western Anatolian sites such as Troy and Bakla Tepe intensified their contacts with communities to the east, from Mesopotamia and (likely via) Central Anatolia (Şahoğlu 2016; Ünlüsoy 2016; Massa and Palmisano 2018; Yılmaz 2019). Ünlüsoy (2016) has proposed that evidence for direct contacts with the Mesopotamian elite culture via inner-western Anatolian communities at Troy can be observed through the presence of tin bronzes, wheel-made pottery, and prestige goods produced with non-local materials. At Troy this change in focus affected all aspects of daily life and the social, economic, and political organisation were drastically transformed (Ünlüsoy 2016). It is therefore feasible to suggest that material culture (metals, ceramics etc.) were not the only things to be transported along this south east-north west vector. It is also very possible that agricultural and subsistence practices such as a narrow range of key (cereal) crops and an increased emphasis on herds composed of *Ovis/Capra* all controlled by a centralised authority, which are currently more commonly associated with Mesopotamia (see Paulette 2013, 2016), would have also been 'conveyed' westwards and adopted by the communities of Anatolia, and then subsequently, by those of the Aegean and Greece.

Finally, when considering mobility and the potential for mobility, from the EBA I-II to EBA III periods in Anatolia, a reduction in the number of settlements is observed, and one of the key unanswered questions remains; what happened to the people from those abandoned settlements? Bachhuber (2015) suggests four possibilities; they were killed or starved to death, they were absorbed by larger settlements, they became more mobile pastoralists, they migrated (for example, to Cyprus where many Anatolian characteristics are witnessed in the Philia culture of the late 3rd millennium BCE). Apart from the scenario where they all die, the other three involve the movement of groups of people, either on a small spatial scale (to the nearest large settlement), across an area (mobile pastoralism), or larger distances (to another region). See also the emptying, and changing settlement dynamics, of areas of the surrounding rural hinterlands that accompanied the growths of Tell Brak, Tell Leilan, and Tell Beydar in the late 4th millennium BCE (McMahon 2020). It is logical to assume that these people would have taken their practices and traditions (including agricultural practices and dietary habits, amongst others) with them where they went, and this may have also played a role in the dissemination of particular agricultural practices resulting in a general homogenisation. One such example to think about at this juncture would be the movement of the Kura-Araxes people and their preference for free-threshing wheat. Another example to consider is the argument that cultural, architectural, technological, and agricultural production changes of the EBA Philia culture on Cyprus have been attributed to increased external contact (Kouka 2009; Lucas and Fuller 2020). Furthermore, the indications are that, following external contact and influences, the agricultural system of the 3rd millennium BCE on Cyprus more intensively integrated arable (cereal) agriculture, cash crops, and ante-mortem product exploitation of domestic animals (Lucas and Fuller 2020; Scirè-Calabrisotto et al. 2020). Ultimately, the 'EBA package' superseded the Cypriot agricultural system which had existed for millennia, demonstrating its pervasiveness. Whilst there are currently no stable isotope data from the Cyclades for the 4th to early 2nd millennium BCE, and very little from (late) 3rd millennium BCE Cyprus (see Goude et al. 2018; Lucas and Fuller 2020 – has a summary of stable isotope research on Cyprus; Scirè-Calabrisotto et al. 2020) it would be very surprising if their isotopic signals were not very similar to those of EBA Anatolia and EH and MH Greece. This hypothesis can only be confirmed with certainty once more stable isotope work to examine dietary habits has been conducted on further populations in the areas from the Balkans to Mesopotamia. Furthermore, more information should be gathered to test and further examine the diachronical extent of this hypothesis. Whilst this economic package was initially termed an 'EBA package', it likely also extended into the MBA, and possibly even parts of the LBA and Iron Age, only really being drastically altered (particularly with regards to human isotopic values) with the introduction of C_4 plants such as millet and sorghum into the intentionally cultivated and exploited botanical assemblage, entering into human dietary habits either through direct consumption, or indirectly as fodder for animals.

Conclusions

This study has demonstrated that there is a relatively distinct subsistence model of staple finance for the late 4th to early 2nd millennium BCE, visible in the adult human $\delta^{13}C$ and $\delta^{15}N$ values, as well as the archaeobotanical and archaeozoological records (see also Vermeersch et al. 2021a for the distinct nature of Levantine E-MBA botanical and faunal assemblages compared to the LBA and Iron Age). However, this model is not as homogeneous and ubiquitous as previously hypothesised, with evidence of variability on a pan-regional scale. In its simplest form (at least in terms of socio-economic driving forces) the EBA is a time of agriculture, metal, and wool. The Ebla texts reveal an economy based on agriculture, viticulture, animal husbandry, and textile, and metallurgical activities (Pettinato 1976, 1981, 1991; Bachhuber 2015). The stable isotope data, in conjunction with the data and information from other specialist researchers examined in this study would certainly appear to also support this being a time of agriculture and wool. Therefore, the idea of an E-MBA model of staple finance, encompassing extensive agricultural methods and intensive exploitation of ante-mortem animal products, is one that is both rational and appealing to researchers of the prehistoric GNE. Whilst it becomes most apparent from the late 4th millennium BCE onwards in northern Mesopotamia and Anatolia, it is doubtful that this phenomenon has a single point of origin (either spatially or temporally) but instead was something that developed progressively before being adopted and adapted by others. Furthermore, it likely developed both in conjunction with, and as a result and progeny of other societal and cultural developments such as the development of central control, urbanisation, long-distance trade and exchange networks, surplus production, wealth finance (particularly involving animal products), and intensified production from extensive agriculture with many of these factors in effect having a virtually reciprocal and indeed in some cases, a trajectorially linear relationship with each other. It follows on from, and develops, the idea of an intensification of the ante-mortem products revolution in the Chalcolithic of the Near East, and goes hand-in-hand with the increased control in the EBA of populations (organisation of labour, specialists, agricultural surplus and distribution) by emerging elites, intensified trade and exchange networks, urban planning and construction, and more intensive interactions with the environment, including arable and pastoral agriculture. In general, it can be said that the EBA is a time of increase, and also of development, towards what one might argue to be increased standardisation and regulation of architecture, funerary habits, genes, metallurgy, textile and ceramic production and craft specialisation, and in these respects the subsistence strategies and dietary habits of the populations are no different.

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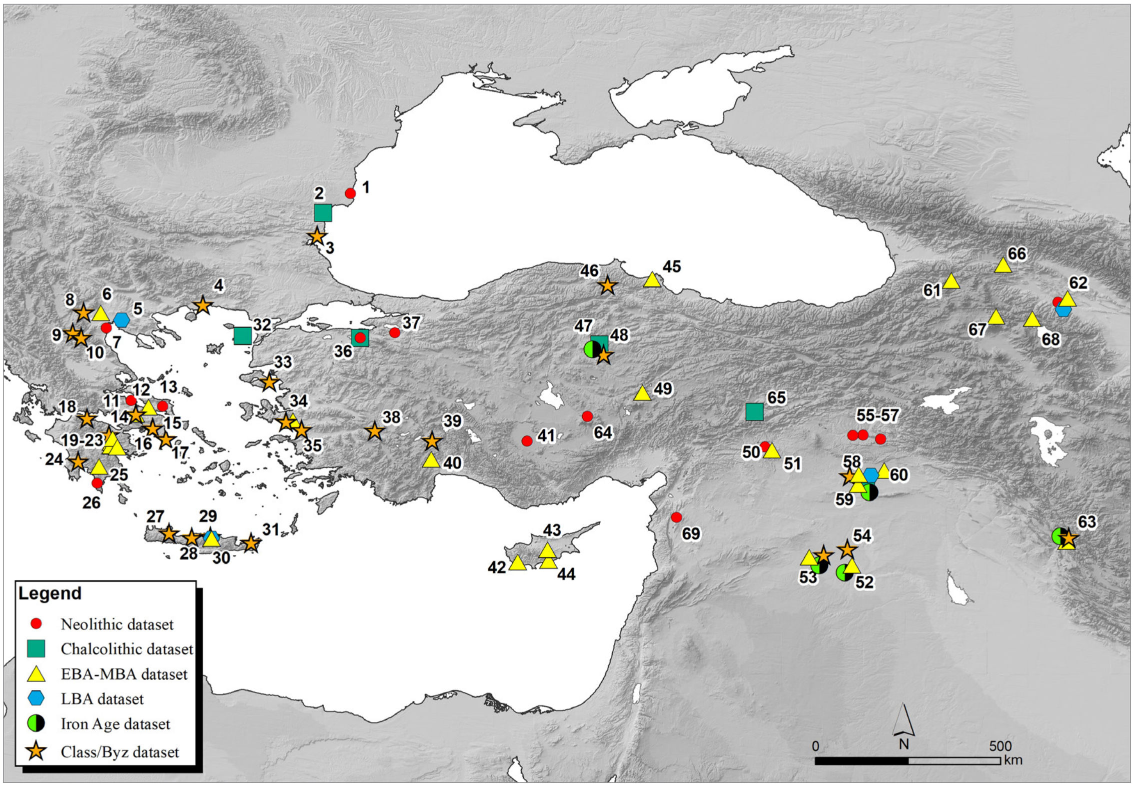


Figure 1. Map showing sites in the Greater Near East with stable isotope ($\delta^{13}C$ and $\delta^{15}N$) data used in this study. N.B. Sites that only have population means reported are marked with an *. 1. Durankulak*, 2. Varna*, 3. Mesebria, 4. Abdera, 5. Thessaloniki Toumba, 6. Archontiko, 7. Makriyalos, 8. Edessa, 9. Sourtara*, 10. Servia, 11. Halai, 12. Tharrounia, 13. Manika, 14. Thebes, 15. Kerameikos, Athens, 16. Plateia Kotzia, Athens, 17. Laurion, Athens, 18. Nemea, 19. Helike, 20. Mycenae*, 21. Aspis, 22. Lerna, 23. Asine, 24. Messene*, 25. Kouphovouno*, 26. Alepotrypa Cave, 27. Stylos*, 28. Eleutherna*, 29. Kastella, 30. Knossos, 31. Petras, 32. Uğurlu Höyük, 33. Mitilini*, 34. Bakla Tepe, 35. Ephesus, 36. Aktopraklık, 37. Barcın Höyük, 38. Hierapolis, 39. Sagalassos*, 40. Bademağacı, 41. Çatalhöyük, 42. Souskiou-Laona Settlement, 43. Marki-Alonia, 44. Psematismenos-Trelloukkas, 45. İkiztepe, 46. Kovuklukaya, 47. Çamlıbel Tarlası, 48. Boğazköy/Hattuşa, 49. Kültepe, 50. Nevalı Çori, 51. Titriş Höyük, 52. Tell Masaikh, 53. Tell Ashara, 54. Gebel Mashtale, 55. Hakemi Use, 56. Körtik Tepe*, 57. Hasankeyf Höyük, 58. Tell Brak, 59. Tell Barri, 60. Tell Leilan, 61. Chobareti, 62. Mentesh Tepe, 63. Tell Bakr Awa, 64. Aşıklı Höyük, 65. Arslantepe, 66. Kvatskhelebi, 67. Gegharot, 68. Kalavan-1, 69. Tell el-Kerkh.

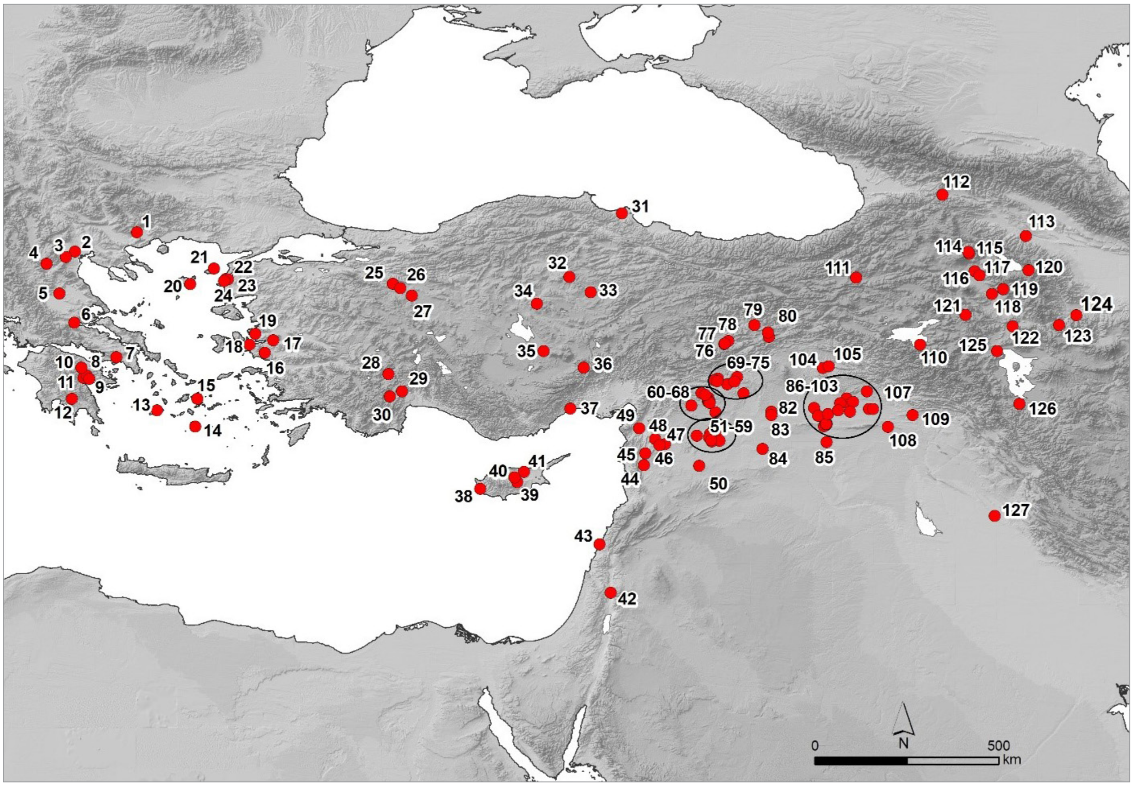


Figure 2. Map showing Greater Near East sites with archaeozoological and/or archaeobotanical data examined in this study. 1. Sitagroi, 2. Kastanas, 3. Pevkakia, 4. Megalo Nisi Galanis, 5. Zarko, 6. Agia Paraskevi, 7. Eleusis, 8. Tsoungiza, 9. Lerna, 10. Tiryns, 11. Asine, 12. Kouphovouno, 13. Phylakopi, 14. Emborio, 15. Zas, 16. Bakla Tepe, 17. Ulucak, 18. Liman Tepe, 19. Panaztepe, 20. Poliochni, 21. Yenibademli, 22. Beşiktepe, 23. Kumtepe, 24. Troy, 25. Demircihüyük, 26. Orman Fidanlığı, 27. Küllüoba, 28. Kuruçay Höyük, 29. Karataş-Semayük, 30. Bademağacı, 31. İkiztepe, 32. Çamlıbel Tarlası, 33. Çadır Höyük, 34. Kaman-Kalehöyük, 35. Acemhöyük, 36. Göltepe/Kestel, 37. Yumuktepe, 38. Lembas-Lakkous, 39. Politiko-Troullia, 40. Marki-Alonia, 41. Kythrea-Ayios Dhimitrianos, 42. Tall Al-Handaquq, 43. Tell el-Burak, 44. Tell Apamea, 45. Tell Qarqur, 46. Ebla, 47. Tell Tuqan, 48. Tell Afis, 49. Tell Tayinat, 50. Al-Rawda, 51. Umm el-Marra, 52. Tell Halawa, 53. Habuba Kabira, 54. Emar/Tell Meskene, 55. Selenkahiyeh, 56. Ali Al-Hajj, 57. Tell Hajji Ibrahim, 58. Tell es-Sweyhat, 59. Tell Hadidi, 60. Tell Shiukh Fawqani, 61. Tilbaşar Höyük, 62. Gre Virike, 63. Mezraa Höyük, 64. Yarım Höyük, 65. Zeytinli Bahçe, 66. Hacınebi, 67. Tilbeşar, 68. Horum Höyük, 69. Kurban Höyük, 70. Hayaz Höyük, 71. Gritille, 72. Titriş Höyük, 73. Hassek Höyük, 74. Lidar Höyük, 75. Kazane Höyük, 76. Arslantepe, 77. Gelinciktepe, 78. İmamoğlu Höyük, 79. Çayboyu, 80. Tepecik, 81. Korucutepe, 82. Tell Chuera, 83. Kharab Sayyar, 84. Ghanem al-Ali, 85. Tell Mashnaqa, 86. Tell Knedig, 87. Tell Bderi, 88. Tell Gudeda, 89. Tell Tuneinir, 90. Tell 'Atij, 91. Tell Ziyadeh, 92. Tell Rad Shaqrah, 93. Tell al-Raqa'I, 94. Kashkashok IV, 95. Tell Beydar, 96. Tell Khazna, 97. Tell Barri, 98. Chagar Bazar, 99. Tell Mozan, 100. Tell Leilan, 101. Tell Arbid, 102. Tell Brak, 103. Tatıka, 104. Ziyaret Tepe, 105. Salat Tepe, 106. Hamoukar, 107. Tell el'Abd, 108. Tell Taya, 109. Tell Karrana 3, 110. Dilkaya, 111. Sos Höyük, 112. Natsargora, 113. Mentesh Tepe, 114. Gegharot, 115. Aparan III, 116. Shengavit, 117. Mokhra Blur, 118. Ovçular Tepesi, 119. Areni-1 Cave, 120. Sotk 2, 121. Köhneh Shahar, 122. Kul Tepe, 123. Kohneh Pasgah Tepesi, 124. Kohneh Tepesi, 125. Haftavan Tepe, 126. Tepe Hasanlu, 127. Tepe al-Atiqeh

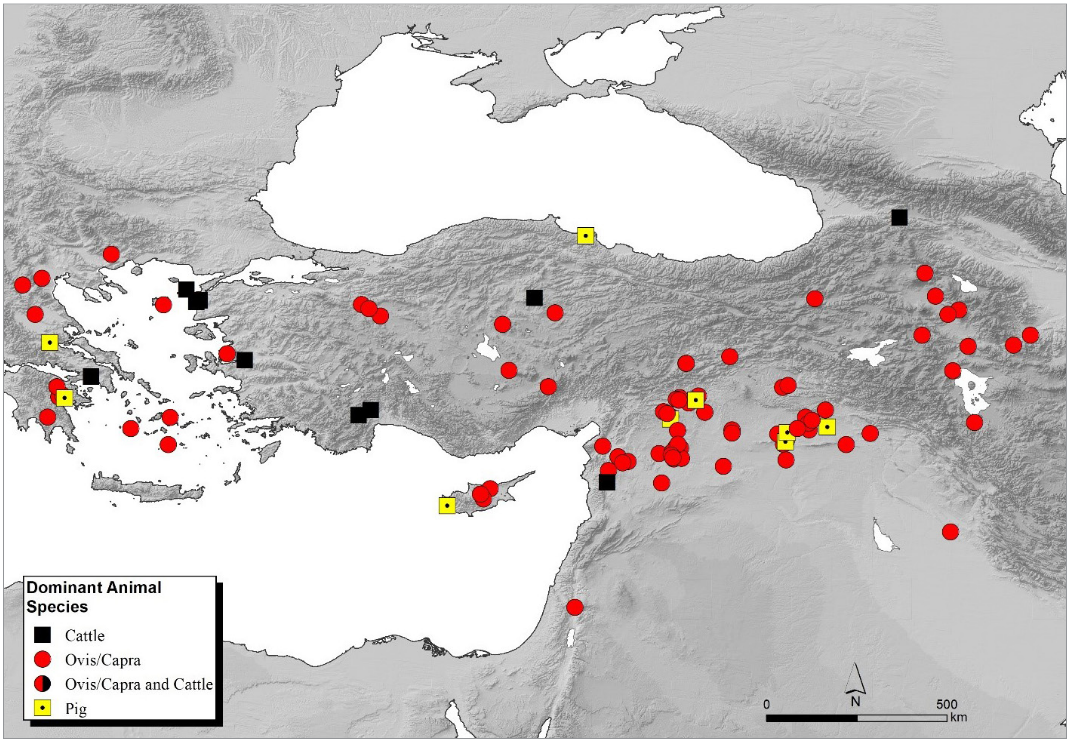


Figure 3. Map showing the dominant (by NISP) domestic faunal species at the 4th-2nd millennium BCE sites of the GNE examined in this study. Refer to Fig. 2 for site names.

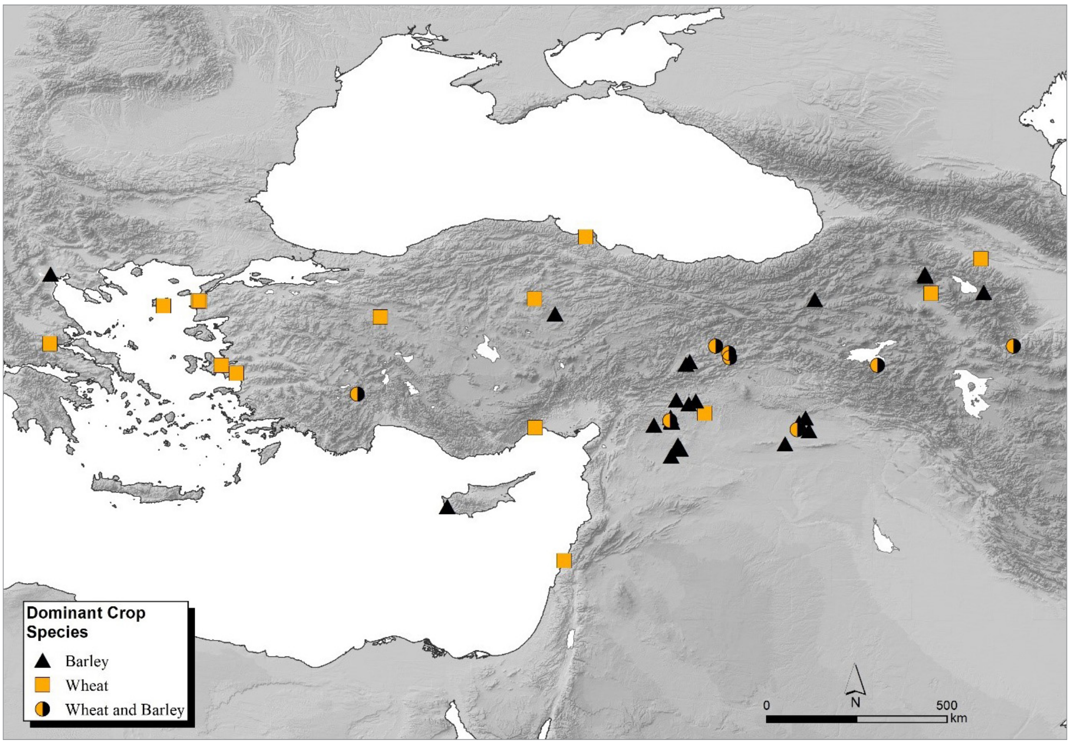


Figure 4. Map showing the dominant (by MNI) domestic crop species at the 4th-2nd millennium BCE sites of the GNE examined in this study. Refer to Fig. 2 for site names.

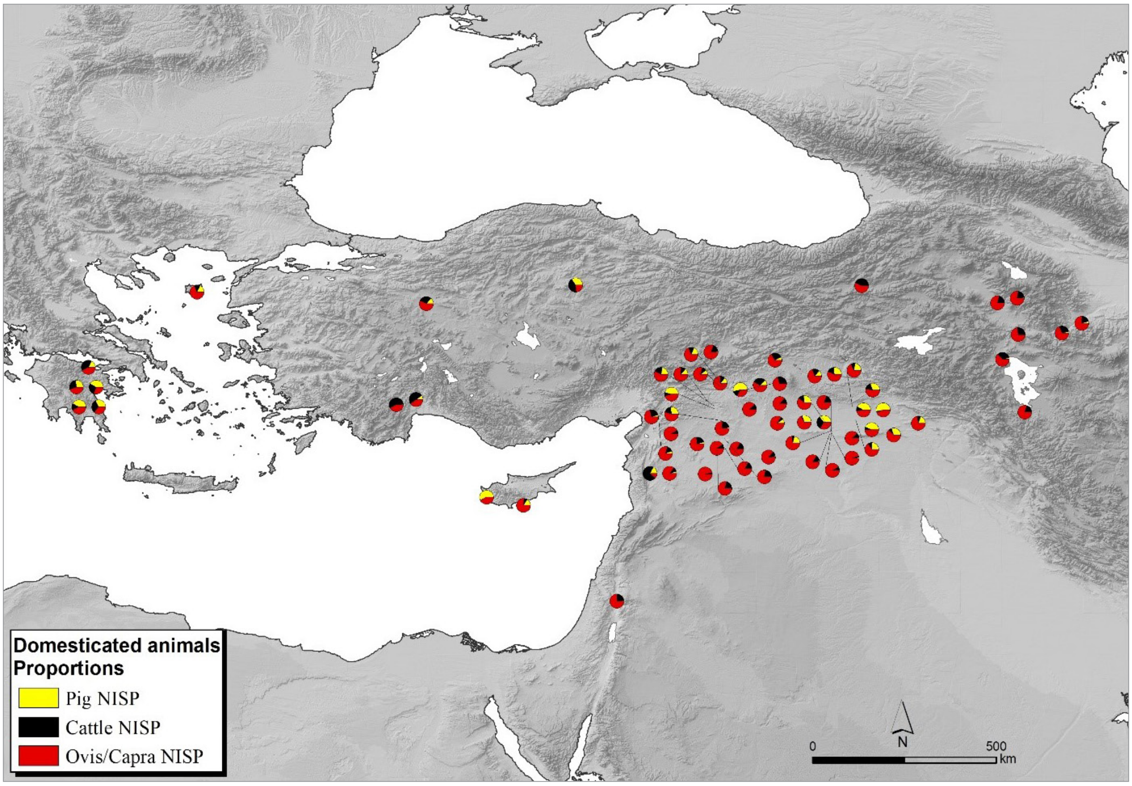


Figure 5. Map showing the proportional dominance (by NISP) of domestic faunal species at 4^{th}-2^{nd} millennium BCE sites of the GNE examined in this study. Refer to Fig. 2 for site names.

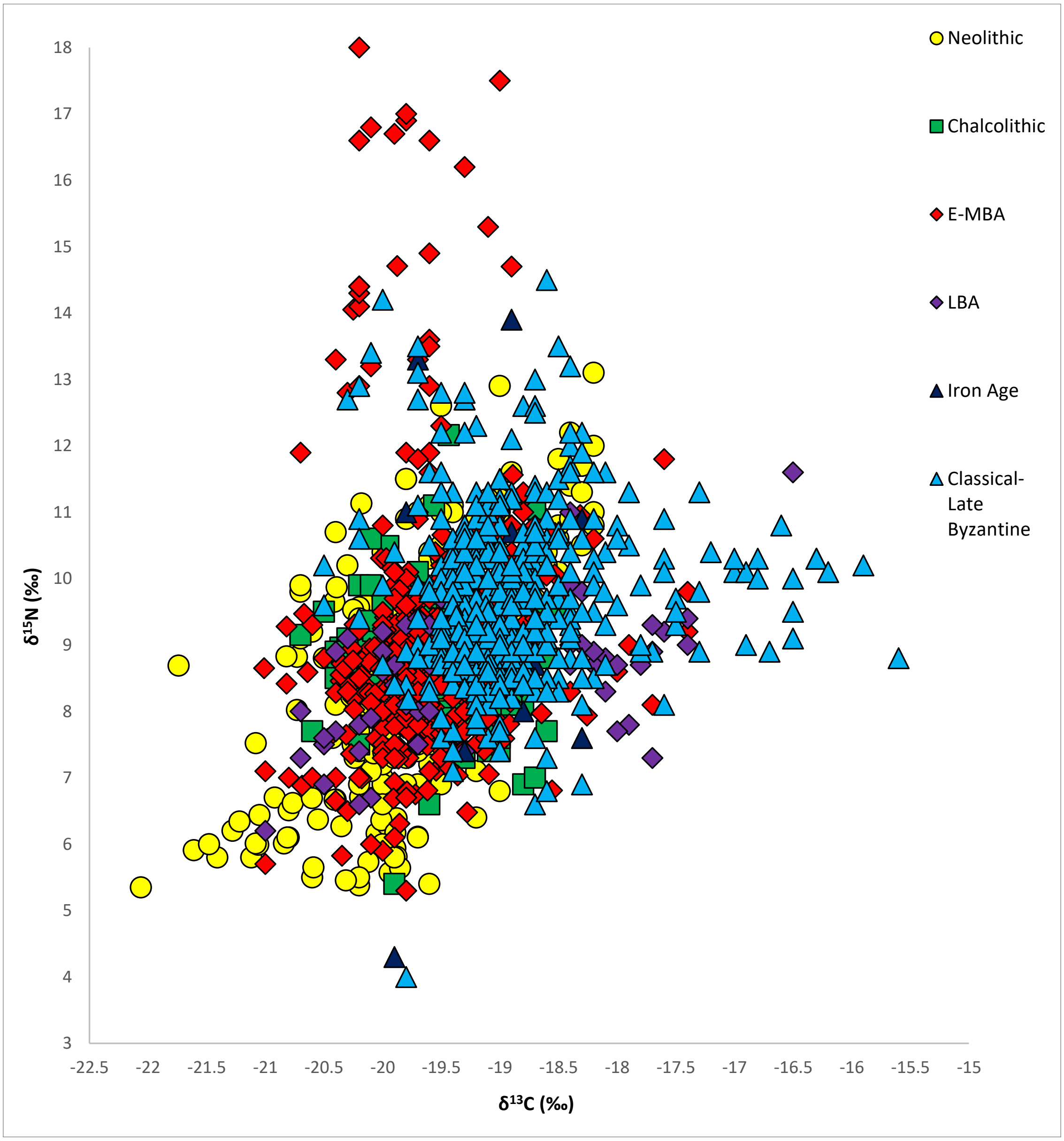


Figure 6. All human bulk bone collagen $\delta^{13}C$ and $\delta^{15}N$ values from the sites (Neolithic to Late Byzantine periods) examined in this study.

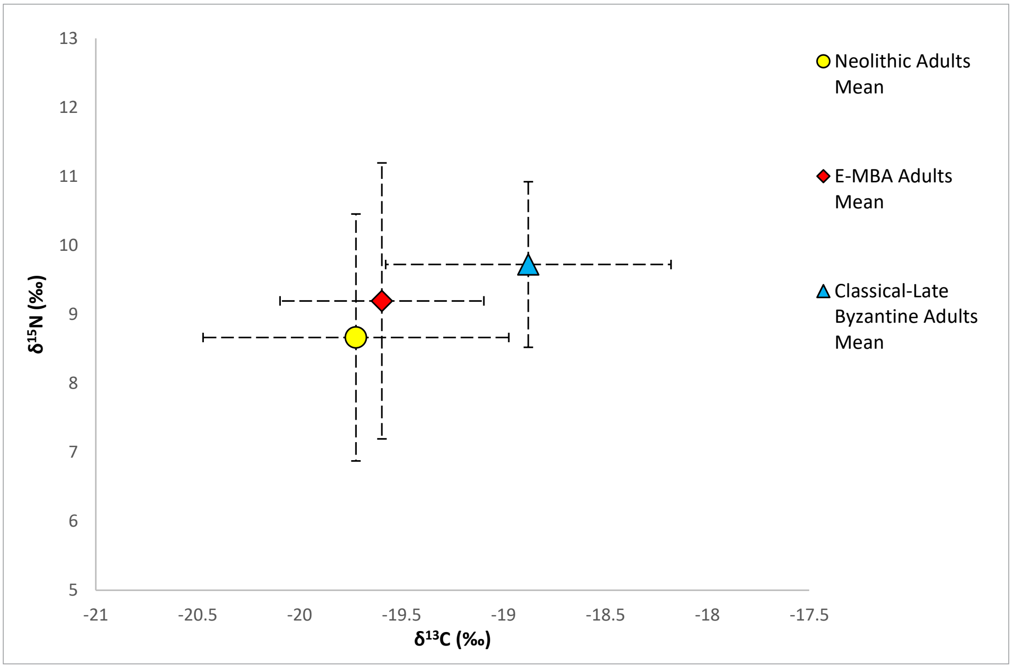


Figure 7. Mean adult human bulk bone collagen δ^{13}C and δ^{15}N values and standard deviations from the sites (Neolithic to Late Byzantine periods) examined in this study.

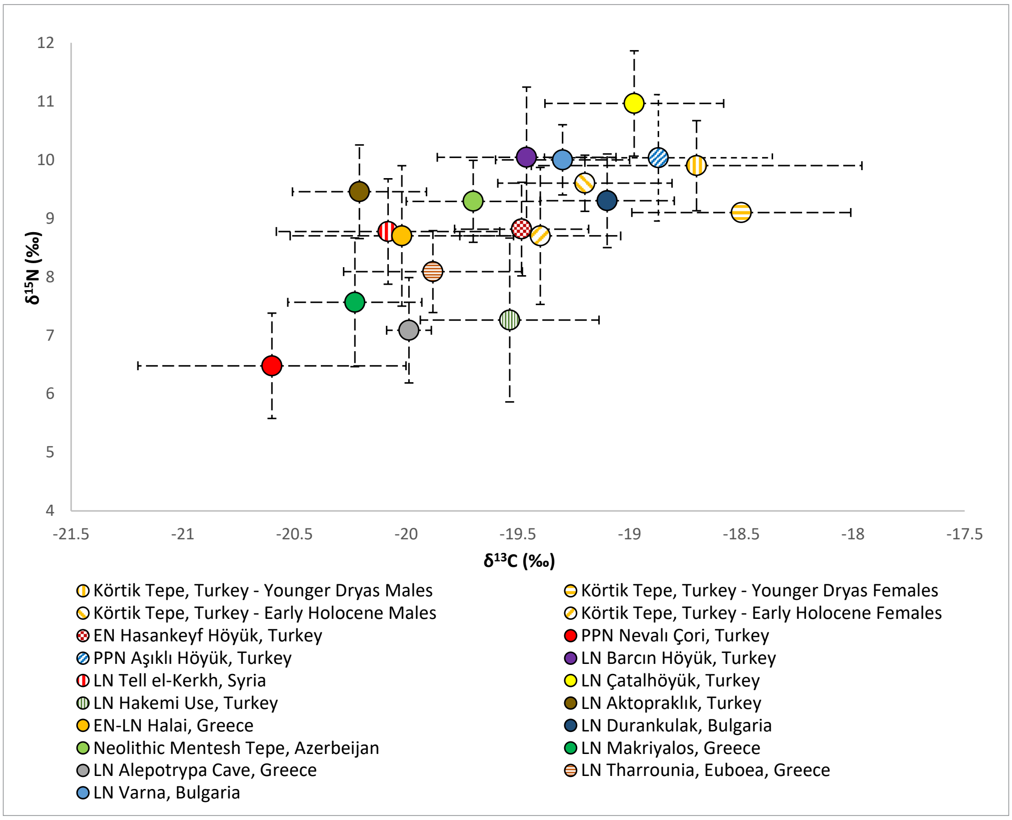


Figure 8. Mean adult human bulk bone collagen δ^{13}C and δ^{15}N values and standard deviations for the Neolithic sites examined in this study.

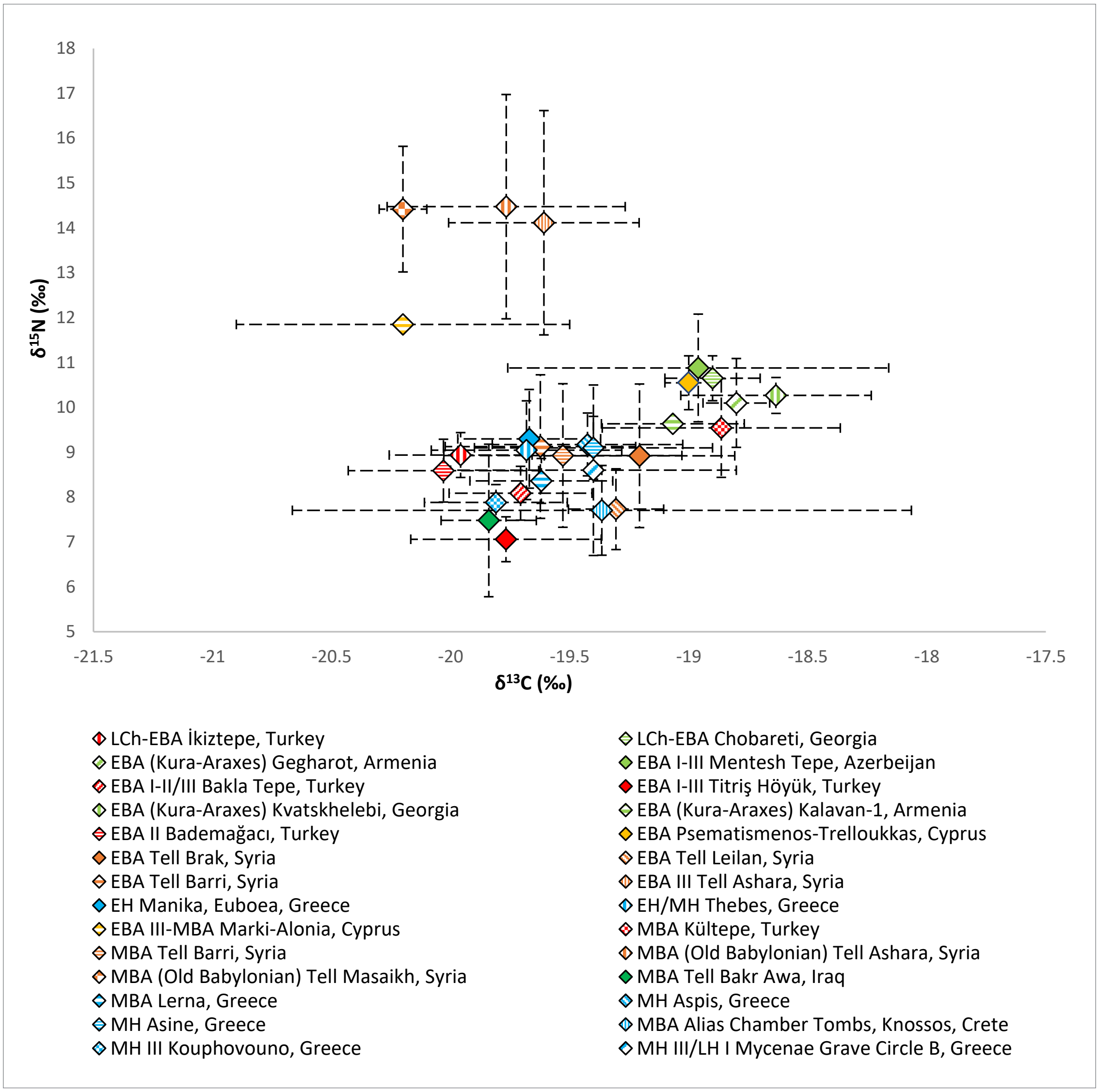


Figure 9. Mean adult human bulk bone collagen $\delta^{13}C$ and $\delta^{15}N$ values and standard deviations for the E-MBA sites examined in this study.

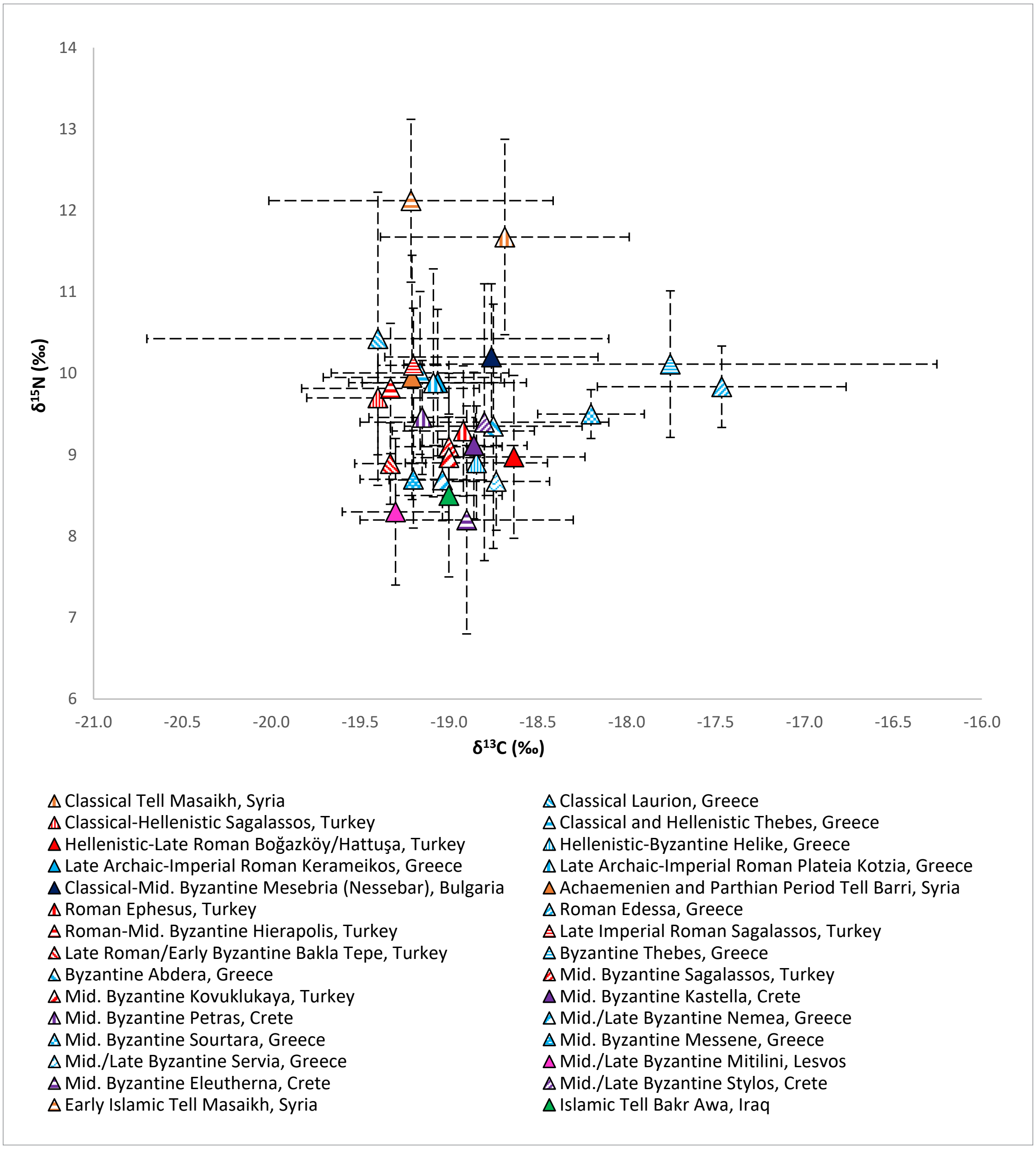


Figure 10. Mean adult human bulk bone collagen $\delta^{13}C$ and $\delta^{15}N$ values and standard deviations for the Classical to Late Byzantine period sites examined in this study.

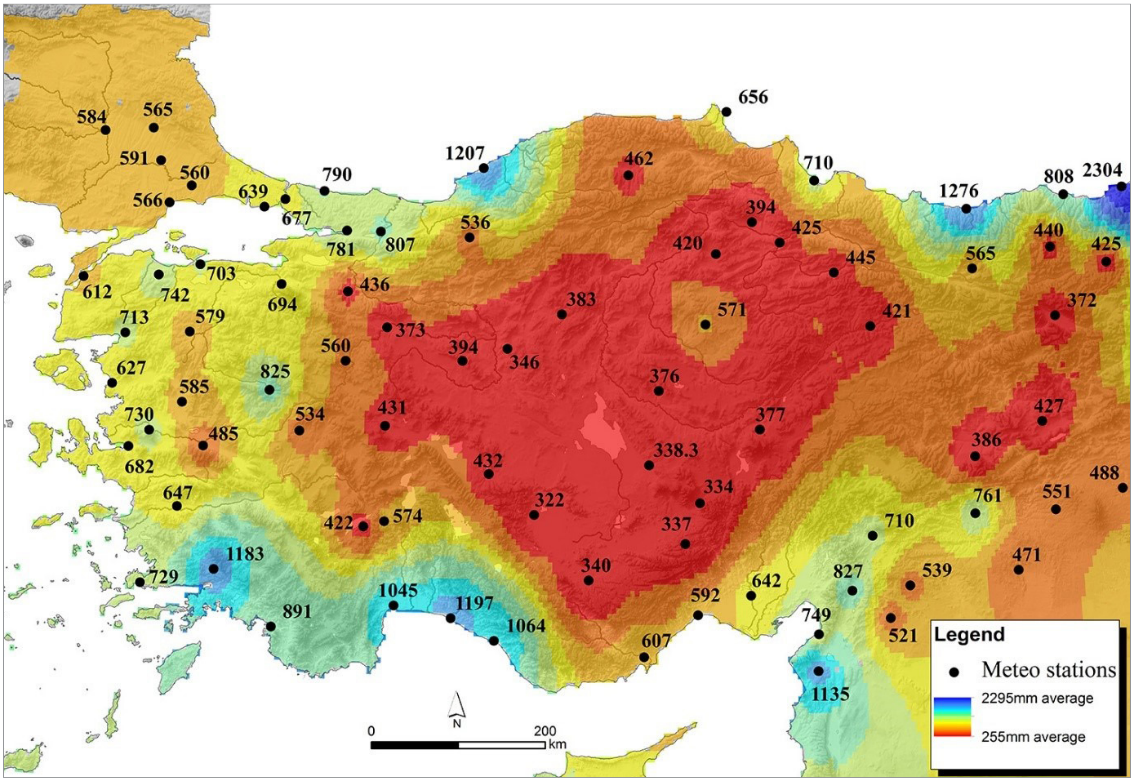
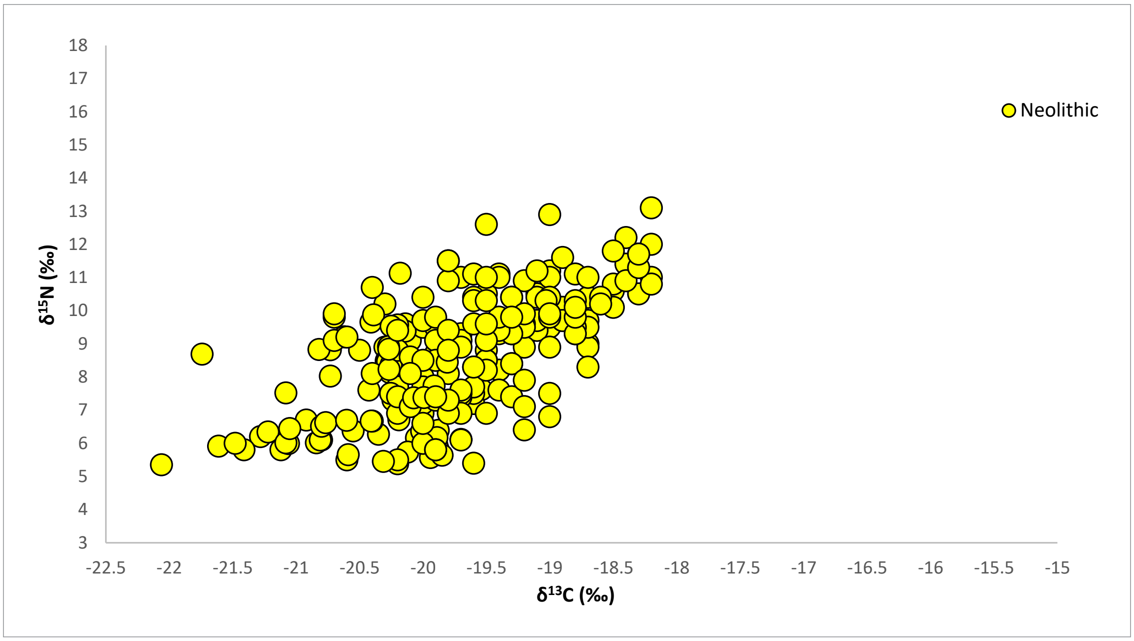
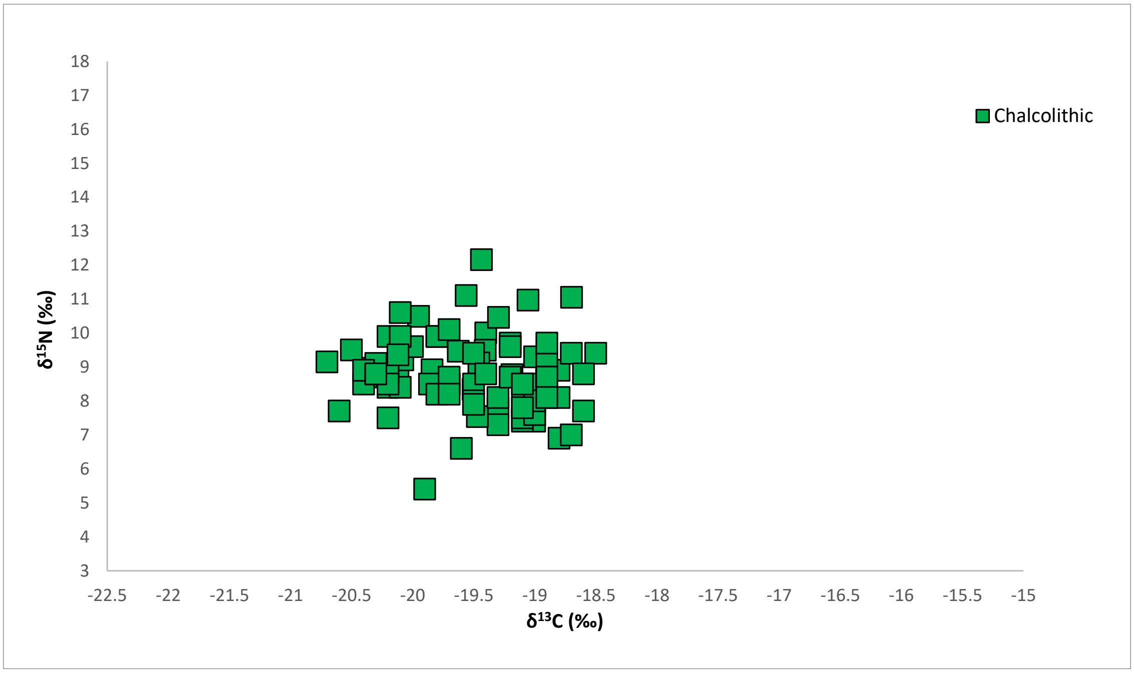


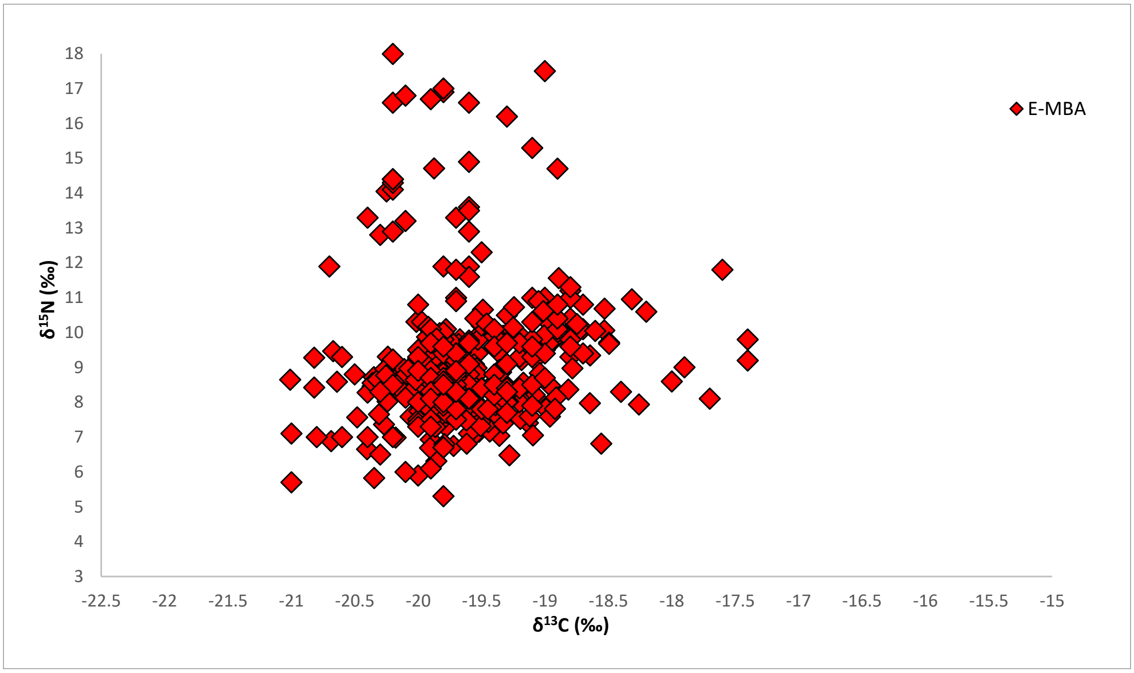
Figure 11. Map showing modern yearly average rainfall (in mm). Courtesy of the Konya Regional Archaeology Survey Project (KRASP) - http://www.krasp.net/en/results/modifying-landscapes/



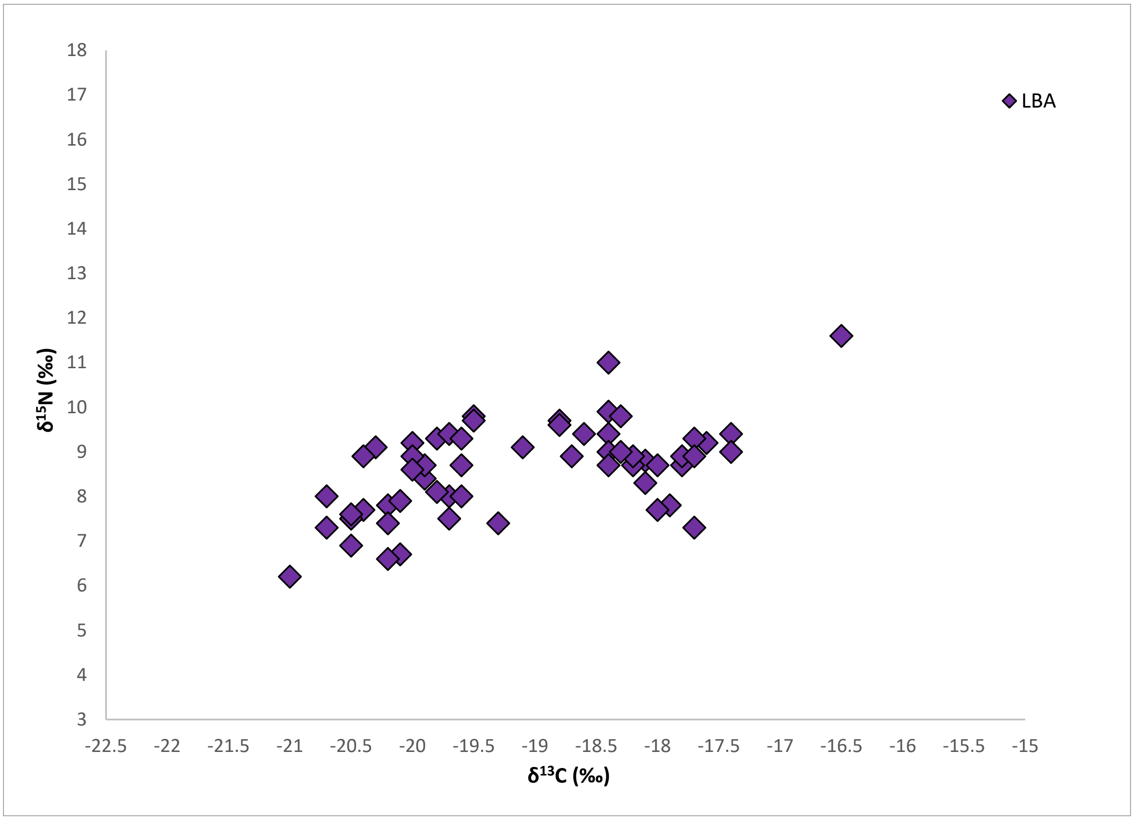
SI Figure 1. Adult human bulk bone collagen $\delta^{13}C$ and $\delta^{15}N$ values for the Neolithic period.



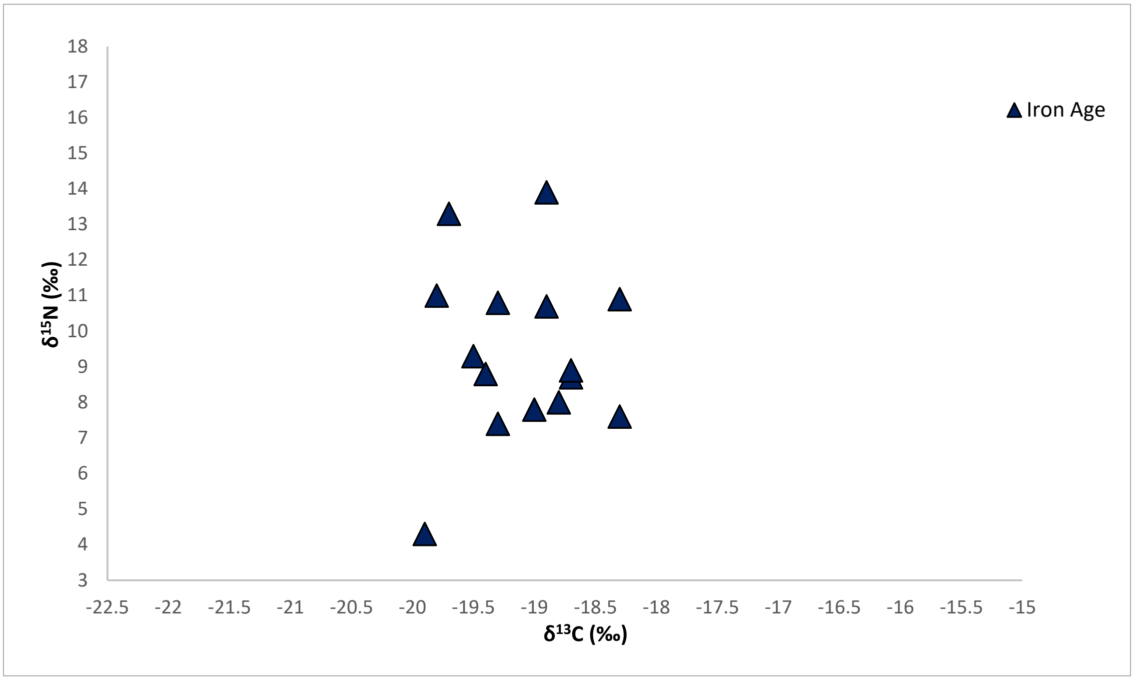
SI Figure 2. Adult human bulk bone collagen $\delta^{13}C$ and $\delta^{15}N$ values for the Chalcolithic period.



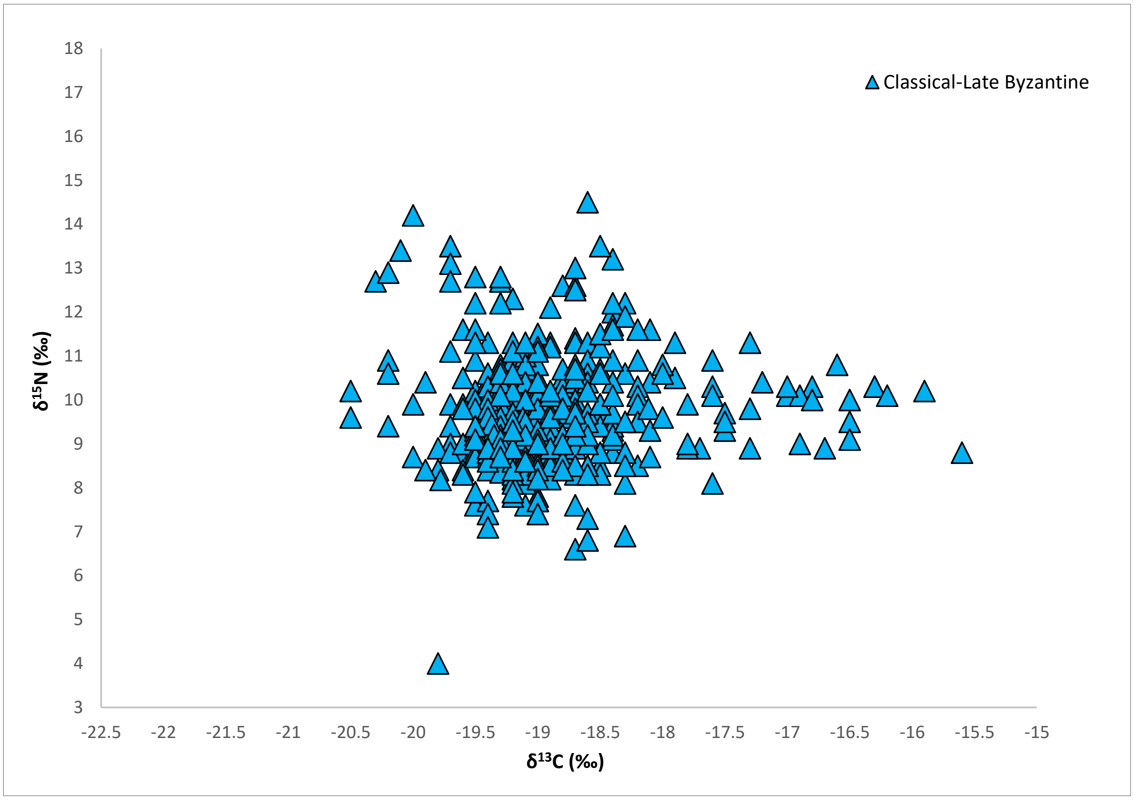
SI Figure 3. Adult human bulk bone collagen $\delta^{13}C$ and $\delta^{15}N$ values for the Early-Middle Bronze Age period.



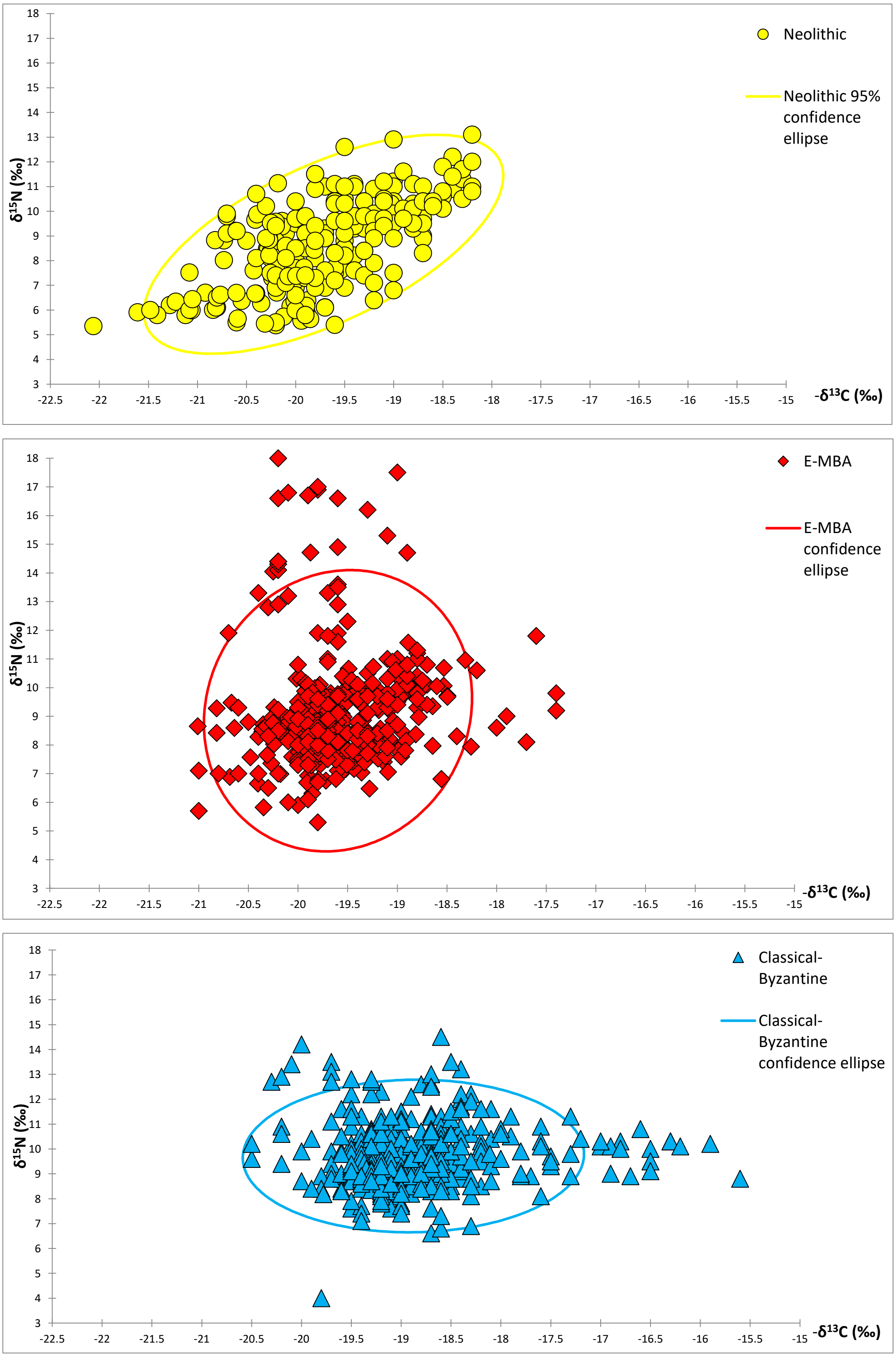
SI Figure 4. Adult human bulk bone collagen $\delta^{13}C$ and $\delta^{15}N$ values for the Late Bronze Age period.



SI Figure 5. Adult human bulk bone collagen $\delta^{13}C$ and $\delta^{15}N$ values for the Iron Age period.



SI Figure 6. Adult human bulk bone collagen $\delta^{13}C$ and $\delta^{15}N$ values for the Classical-Late Byzantine period.



SI Figure 7. Adult human bulk bone collagen $\delta^{13}C$ and $\delta^{15}N$ values for the grouped Neolithic, E-MBA, and Classical-Late Byzantine datasets with 95% confidence ellipses.

Boğazköy (Hattuša) İskelet Örneklemlerinde Biyolojik Stresin Etkilerinin Araştırılmasında Porotic Hyperostosis ve Sağkalım Analizinin Kullanılması

Handan Üstündağ[a]

Özet

Arkeolojik insan kalıntıları bağlamında biyolojik stres göstergeleri (BSG), yetersiz beslenme ve enfeksiyonlar gibi nedenlerle oluşabilen iskelet lezyonlarını kapsar. Heterojen dayanıksızlık ve seçici mortalite gibi faktörler nedeniyle bu lezyonların görülme sıklığını doğru bir şekilde yorumlamak kolay değildir. Bu zorluğu aşmak için lezyonların demografik dağılımını inceleyebilir ve lezyonlu bireylerin sağkalım sürelerini değerlendirebiliriz. Bu çalışmanın amacı, farklı örneklemlerin stresten etkilenme düzeylerini karşılaştırmak için BSG ile Kaplan-Meier sağkalım analizlerini nasıl birlikte kullanabileceğimizi göstermektir. Bunun için, Boğazköy (Hattuša)'dan dört ayrı iskelet örnekleminde, BSG'den biri olan *porotic hyperostosis* (PH)'nin demografik dağılımı ve sağkalımla ilişkisi karşılaştırmalı olarak incelenmiştir. Örneklemler, iskelet kalıntılarının bulunduğu mezarların özelliklerine göre şöyle sınıflandırılmıştır: 1) Helenistik-Roma dönemlerine ait taş sanduka mezarlardan gelen iskeletler, 2) Helenistik-Roma dönemlerine ait basit toprak mezarlardan gelen iskeletler, 3) MS 2-4. yüzyıla ait kiremitlerle örtülü toprak mezarlardan gelen iskeletler, 4) MS 18-19. yüzyıla ait basit toprak mezarlardan gelen iskeletler. Çalışmanın sonuçları, ilk üç örneklemin stres düzeylerinin benzer olduğunu, ancak dördüncü örneklemin stresten daha ciddi biçimde etkilendiğini göstermiştir. Bu bulgu, Geç Osmanlı Dönemi'nde bölgede yaşanan kıtlıklar bağlamında tartışılmıştır.

Anahtar Kelimeler: Biyoarkeoloji, stres, *porotic hyperostosis*, osteolojik paradoks, sağkalım

a Handan Üstündağ, Prof. Dr., Anadolu Üniversitesi, Arkeoloji Bölümü, Eskişehir.
hustunda@anadolu.edu.tr ; https://orcid.org/0000-0003-0861-0156

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Abstract

In the context of archaeological human remains, Biological Stress Indicators (BSI) can include skeletal lesions caused by malnutrition and infections. It is, it is not easy to accurately interpret the incidence of these lesions due to factors such as heterogeneous frailty and selective mortality. To offset this problem, we can examine the demographic distribution of the lesions and evaluate the survival time of individuals exhibiting lesions. This study aims to show how BSI and Kaplan-Meier survival analysis can be used together to compare the stress levels of different populations. For this purpose, the demographic distribution of porotic hyperostosis (PH), a BSI, and its relationship with survival were comparatively examined in four different skeletal sample populations from Boğazköy (Hattuša). The samples were classified by the features of the burials as follows: 1) Stone cist graves from the Hellenistic-Roman periods, 2) Simple inhumations from the Hellenistic-Roman periods, 3) Inhumations covered with tiles of the 2nd-4th century AD, 4) Simple inhumations of the 18th-19th century AD. The results of the study showed that the stress levels of the first three samples were similar, but the fourth sample was more severely affected by stress. This observation is discussed within the context of the famines experienced in the region during the Late Ottoman Period.

Keywords: Bioarchaeology, stress, porotic hyperostosis, osteological paradox, survival

Giriş

Biyolojik Stres Göstergeleri, Osteolojik Paradoks ve Barker Hipotezi

Biyolojik stres göstergeleri (BSG), malnutrisyon, enfeksiyonlar ve bağırsak parazitleri gibi nedenlere bağlı olarak gelişen bir takım iskelet lezyonları ya da değişimleridir. Bunlar *porotic hyperostosis* (PH), *cribra orbitalia* (CO), diş minesi hipoplazisi ve periostal reaksiyonlar olarak sıralanabilir (Goodman vd. 1988; Ribot ve Roberts 1996; Lewis ve Roberts 1997; Larsen 2015). Bu lezyonlar genellikle çocukluk döneminde gelişirler, ancak iskelette kalıcı izler bıraktıkları için sadece çocuklarda değil erişkinlerde de gözlemlenebilirler. BSG, avcı-toplayıcılıktan tarıma geçiş sürecinde insan topluluklarının beslenme ve sağlık durumlarında ortaya çıkan değişimleri ele alan bir çalışmayla (Cohen ve Armelagos 1984) tanınmaya başlamıştır. Sonraki yıllarda BSG ile ilgili çalışmaların sayısı artmış ve araştırmacılar çeşitli iskelet örneklemlerinde bunların yaygınlığını incelemeye başlamışlardır (örn. Goodman vd. 1988; Goodman ve Armelagos 1988; Goodman ve Rose 1990; Ribot ve Roberts 1996). Ancak, Wood vd. (1992) tarafından yayınlanan ve "Osteolojik Paradoks" olarak bilinen bir makale, BSG ile ilgili değerlendirmelere önemli bir eleştiri getirmiştir. Bu araştırmacılar "heterojen dayanıksızlık" ve "seçici mortalite" gibi faktörlere dikkat çekmiş ve bir tartışma başlatmışlardır[1]. Wood ve arkadaşlarına göre,

1 Heterojen dayanıksızlık, bireylerin dayanıksızlık (*frailty*) bakımından farklılık göstermesidir. Seçici mortalite ise dayanıksız bireylerin stres veya hastalık nedeniyle kısa bir süre içinde ölmesi, fakat dayanıklı bireylerin stresli dönemi veya hastalığı atlatarak hayatta kalmasıdır.

BSG'nin varlığı veya yokluğu aslında strese maruz kalanların oranını değil, dayanıklı ve dayanıksız bireylerin oranını gösterir. İskelet lezyonlarının gelişebilmesi için belli bir süre gerekir. Bu yüzden, strese maruz kaldığı halde lezyonlar ortaya çıkmadan önce ölen dayanıksız bir çocukta lezyon gözlemlenmez. Öte yandan, lezyon geliştirebilecek kadar yaşayabilmiş olan dayanıklı bir çocukta BSG gözlemlenir. Dolayısıyla lezyonların varlığı, stresli dönemi atlatıp hayatta kalmanın yani "dayanıklılığın" göstergesi olarak yorumlanmalıdır.

BSG geliştirebilmiş "dayanıklı" çocukların da ne kadar uzun süre yaşadıklarını değerlendirmek gerekir. David J. P. Barker tarafından geliştirilen ve "Barker hipotezi" adı verilen bir hipoteze göre fetal aşamada maruz kalınan olumsuz etkenler (annenin yetersiz beslenmesi, olumsuz yaşam koşulları gibi) bireyin ileri yaşlardaki sağlığını ve kronik hastalıklara yatkınlığını belirlemektedir (Barker vd. 2002; Barker 2012). Bu hipotez geliştirilerek ve postnatal aşamadaki etkenleri de kapsayarak "sağlık ve hastalığın gelişimsel kökenleri hipotezi" adını almıştır (Gillman 2005). Eğer erişkinlik çağındaki hastalıklara yatkınlığın ve genç ölümlerin çocukluk döneminde maruz kalınan olumsuz etkenlerle (stresle) ilişkisi varsa, bunu iskelet örneklemlerinde saptamak mümkün olabilir. Böyle düşünen bazı biyoarkeologlar bu hipotezi arkeolojik iskelet örneklemlerine uygulamayı denemişlerdir (Armelagos vd. 2009; Gowland 2015). Çocukluk dönemi BSG'den biri olan mine hipoplazisinin erişkinlikte ölüm yaşını öne çektiğini ortaya koyan çeşitli çalışmalar yapılmıştır (Goodman ve Armelagos 1988; Duray 1996; Boldsen 2007; Armelagos vd. 2009). Ayrıca CO'nun (McFadden ve Oxenham 2020; Godde ve Hens 2021) ve birden çok stres göstergesinin (Watts 2013) erişkinlik ömür süresini kısalttığını gösteren araştırmalar da vardır. Steckel (2005) Batı Yarıküre'de 6000 yıllık bir süreçte yaşamış olan 3000 bireye ait verileri değerlendirmiş ve mine hipoplazisi, PH ve CO lezyonlarına sahip bireylerin daha kısa ömürlü olduklarını saptamıştır.

Lezyonlu bireylerin ne kadar süre yaşayabildiğini sağkalım (*survival*) analizi ile hesaplayabiliriz. Sağkalım analizi, belli bir olaydan (hastalık, tedavi vb.) sonra popülasyondaki bireylerin ortalama olarak ne kadar süre sağ kaldığının istatistiksel hesaplamasıdır. Biyoarkeolojide BSG ve sağkalım analizlerini birlikte uygulayarak çocukluk dönemi stresinin ömür süresine etkisini inceleyen örnek çalışmalar bulunmaktadır (DeWitte 2014a, b; Redfern vd. 2015, Betsinger ve DeWitte 2017; McFadden ve Oxenham 2020).

Porotic Hyperostosis

Bu çalışma kapsamında malnutrisyona bağlı BSG'den biri olan PH'nin mortaliteyle ilişkisi incelenmiştir. PH, kafatası kemiklerinin üzerindeki gözenekli oluşumlar olarak tanımlanabilir (Şekil 1). Genel olarak, PH'nin çocukluk dönemindeki anemi nedeniyle ortaya çıktığı kabul edilmektedir. Çocuklarda anemi, kemik iliği genişlemesine ve kafa kemiklerinde gözenekli bir görüntüye yol açmaktadır (Stuart-Macadam 1985, 1992; Blom vd. 2005; Walker vd. 2009;

Brickley 2018). Ancak kemik iliği genişlemesine yol açan anemi türünün ne olduğu tartışmalıdır. Araştırmacılar uzun süre bu gözenekli lezyonların sebebinin demir eksikliği anemisi olduğunu savunmuşlardır (Mensforth vd. 1978; Stuart-Macadam 1985, 1992). Fakat bugün birçok araştırmacı PH'nin sebebinin Walker vd. (2009) tarafından önerildiği gibi B12 vitamini ve folat eksikliğine dayalı megaloblastik anemi olduğunu kabul etmektedir. Aslında, demir veya B12/folat eksikliğinin sebepleri aşağı yukarı aynıdır ve anne kaynaklı anemi, beslenmede hayvansal proteinin yetersizliği, bağırsak parazitleri veya enfeksiyonları olarak sıralanabilir (Walker vd. 2009).[2]

Bu çalışma kapsamında, Boğazköy (Hattuša)'daki aynı mezarlık alanına ait ancak bulundukları mezarların tipi ve dönemsel özellikleri bakımından birtakım farklılıklar gösteren iskelet örneklemlerinde, PH'nin görülme sıklığı, demografik dağılımı ve sağkalım süresine etkisi karşılaştırmalı olarak incelenmiştir. Amaç, BSG ve sağkalım analizlerinin örneklemler arası stres düzeyi karşılaştırmalarında nasıl birlikte kullanılabileceğini göstermektir.

Materyal ve Metot

Boğazköy (Hattuša) ve Helenistik-Roma Dönemi Mezarlığı

Boğazköy, Çorum iline bağlı bir ilçe olan Boğazkale'nin eski adıdır (Şekil 2). Hitit İmparatorluğu'nun başkenti Hattuša burada yer almaktadır. Ancak Boğazköy'ün Hitit Dönemi öncesine ve sonrasına uzanan uzun bir iskan tarihi vardır. Bu sebeple "Boğazköy", Hattuša kentinin bulunduğu arkeolojik alanın, Hitit öncesi ve sonrası dönemleri için kullanılan bir isim olarak yerleşmiştir. Burada kurulan Tunç Çağı yerleşimi, MÖ 17. yüzyılın ortalarında Hattuša ismini alarak Hitit devletinin başkenti haline gelmiştir. Hitit Dönemi'nden sonra Boğazköy'de bir Demir Çağı yerleşimi olduğunu ve MÖ 3. yüzyılda yani Helenistik Dönem'de Galatların buraya gelip yerleştiğini gösteren kanıtlar vardır (Schachner 2011). Boğazköy'deki bu yerleşim, Roma İmparatorluk Dönemi'nde ve Bizans Dönemi'nde de varlığını sürdürmüştür (Schachner 2011, 346). Kazılarda Roma Dönemi'ne ait anıtsal bir yapı, bir sur duvarı, büyük bir mezarlık alanı ve olasılıkla yakındaki Roma yolunu korumak amacıyla kurulmuş olan bir askeri kamp bulunmuştur (Schachner 2015). Boğazköy'de Yukarı Şehir'de Orta Bizans Dönemi'ne (9-11. yüzyıllar) tarihlenen bir kilise ve mezarlık alanının varlığı, kilisenin inşasında 6-8. yüzyıllara ait devşirme taşların kullanılmış olması Erken ve Orta Bizans Dönemi'nde burada süregelen bir yerleşimin olduğuna, ancak sonrasında terkedildiğine işaret etmektedir. 16. yüzyılın ortasında Dulkadiroğulları Beyliği'nin bir kolu, Boğazköy'ün yakınında yer alan Yekbaş (bugünkü Evren) Köyü'ne yerleşmişlerdir. Bu yerleşim 17. yüzyılda muhtemelen Celali ayaklanmalarıyla ilişkili

2 Çalışmamızın odak noktası PH'nin etiyolojisiyle ilgili tartışmalar olmadığı için bu konu detaylandırılmamıştır. PH'nin etiyolojisiyle ilgili detaylı bir tartışma için bkz. Üstündağ 2011.

nedenlerle daha güvenli bir konumdaki Boğazköy'e taşınmıştır. Bu köy yerleşimi bugüne kadar varlığını sürdürmüştür (Schachner 2011, 334-340).

Adı geçen Helenistik-Roma mezarlığı, Aşağı Şehir'deki Hitit Dönemi'ne ait Büyük Tapınak'ın üzerinde ve etrafında konumlanmaktadır. Bu mezarlıkta ilk sistemli kazılar 1967 ve 1977 yılları arasında gerçekleştirilmiştir (Kühne 1969; Kühn 2014). Bu kazılarda 63 mezara ait iskelet kalıntıları açığa çıkartılmış ancak osteolojik bir inceleme yapılmadan kalıntılar depoya kaldırılmışlardır. 1999 yılında Büyükkale'nin kuzeybatı terasında altı mezar daha bulunmuştur. 2009 ve 2010 yılları arasında mezarlığın güney uzantısında 14 mezar açığa çıkartılmıştır (Schachner 2010, 2011). 2015 ve 2019 yılları arasında da mezarlığın kuzey uzantısında yapılan kazılarda 63 mezara ulaşılmıştır (Schachner 2016, 2018, 2019). 2009 yılından bu yana Boğazköy projesinin[3] insan osteolojisi çalışmaları tarafımdan yürütülmektedir. Kazı başkanı Prof. Dr. A. Schachner'in önerisiyle kazı evi deposunda bulunan eski kazı dönemlerine ait iskeletler de bu çalışmalar kapsamında incelenmiştir.

Mezarlarda bulunan sikkeler ve seramikler, ayrıca iskeletlerden alınan örneklerde yapılan C14 tarihlendirmeleri mezarlığın MÖ 3. yüzyıldan MS 4.yüzyılın ikinci yarısına kadar kullanıldığını göstermektedir (Schachner 2010, 2018; Kühn 2014). Mezarlıkta birkaç farklı mezar tipi tespit edilmiştir. En yaygın olan basit toprak mezarlardır. Bunlar hem Helenistik hem de Roma Dönemi'nde kullanılmıştır. Diğerleri taş sanduka mezarlar (bunların bazıları taşlarla da çevrelenmiştir), üzeri çatı kiremitleriyle örtülmüş toprak mezarlar, az sayıda *pithos* mezar ve bir *terracotta* lahittir. Taşlarla çevrili taş sanduka mezarlar ve *pithos* mezarlar Helenistik Dönem'e tarihlendirilmiştir. Taşlarla çevrili olmayan taş sandukalar ise hem Helenistik hem de Roma Dönemi'nde kullanılmıştır. Üzeri kiremitlerle örtülü toprak mezarlar da Geç Roma Dönemi'ne aittir (C14 tarihlemesine göre MS 2-4. yüzyıl arası). Helenistik Dönem'e ait mezarlarda Galat tipi seramikler ve metal eşyalar bulunmuştur. Roma Dönemi mezarlarında ise *unguentarium*lar, küçük cam şişeler ve kaplar bulunmuştur. Birçok mezarda ise hiç buluntuya rastlanmamıştır (Kühne 1969; Kühn 2014; Schachner 2010, 2016, 2018). Helenistik ve Roma dönemleri boyunca Boğazköy'deki taş sanduka, *pithos* ve basit toprak mezarların en yaygın konumlanışı doğu-batı yönündedir (Kühne 1969, Kühn 2014). Üzeri kiremit kapaklarla örtülü mezarların büyük kısmı ise batı-doğu yönündedir. Başın batıda yer aldığı ve yüzün doğuya doğru baktığı bu yönlendirme Hristiyan inancına özgü olduğu için bu mezarların Geç Roma Dönemi'ndeki Hristiyanlara ait olma ihtimali vardır.

1968-69 yıllarında Büyük Tapınak'ın üzerindeki güney alanda yapılan kazılarda açığa çıkartılan 22 toprak mezar diğerlerinden farklı özelliklere sahip olması bakımından dikkat çekicidir.

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[3] Boğazköy projesi, Alman Arkeoloji Enstitüsü adına Prof. Dr. Andreas Schachner başkanlığında uluslararası bir ekip tarafından yürütülmektedir.

Kühne'ye (1969) göre bu mezarların yüzeye yakınlığı, gevşek bir toprak dolguya sahip olması ve açığa çıkartılan kemiklerin görece yeni görünümlü olması onları diğer toprak mezarlardan ayırmaktadır. O tarihte bu mezarlarda hiç buluntu olmaması nedeniyle bir tarihlendirme yapılamamış ve bunların Ortaçağ'a ait olduğu düşünülmüştür. Yan yana konumlanmış bu mezarların tümü güneybatı-kuzeydoğu (baş güneybatıda) yönündedir (Kühne 1969). Bu mezarlara ait kemik örneklerinde 2020 yılında yapılan C14 tarihlendirmesi, mezarların 18-19. yüzyıla yani Geç Osmanlı Dönemi'ne ait olduğunu ortaya çıkarmıştır. Bu alan, o dönemde Boğazköy'de yaşayan insanlar veya konar-göçer gruplar tarafından mezarlık olarak kullanılmış olmalıdır.

Bu çalışma kapsamında PH'nin incelenebildiği iskeletler, bulundukları mezarların dönemsel ve tipolojik farklılıklarına göre dört ana grupta sınıflandırılmıştır. Bu gruplar birer örneklem olarak kabul edilmiş ve şöyle tanımlanmıştır:

1. Helenistik Dönem ve Roma İmparatorluk Dönemi'ne ait taş sanduka mezarlardan gelen iskeletler (N: 31)
2. Helenistik Dönem ve Roma İmparatorluk Dönemi'ne ait basit toprak mezarlardan gelen iskeletler (N: 54)
3. Geç Roma Dönemi'ne ait (MS 2-4. yüzyıl) kiremitlerle örtülü toprak mezarlardan gelen iskeletler (N: 45)
4. Geç Osmanlı Dönemi'ne ait (MS 18-19. yüzyıl) basit toprak mezarlardan gelen iskeletler (N: 25)

Örneklemlerde Cinsiyet ve Yaş Dağılımı

Erişkin bireylerde cinsiyet, *pelvis* ve kafa kemiklerinin morfolojik farklılıklarına göre belirlenmiştir (Phenice 1969; Acsádi ve Nemeskéri 1970; Buikstra ve Ubelaker 1994). Ölüm yaşı ise *pubic symphysis* (Brooks ve Suchey 1990), *auricular* yüzey (Lovejoy vd. 1985), kaburgaların *sternal* uçlarındaki (Iscan vd. 1984, 1985) ve diş aşınmasındaki (Brothwell 1981) yaşa bağlı değişimlere göre tahmin edilmiştir. Erişkin olmayan bireylerde ise ölüm yaşı, epifizlerin birleşme (Brothwell 1981), dişlerin gelişme ve sürme (Ubelaker 1989) aşamaları ve uzun kemiklerin uzunlukları (Stloukal ve Hanáková 1978; Scheuer ve Black 2000) esas alınarak belirlenmiştir.

Bu çalışma kapsamında toplam 155 bireye ait iskelet kalıntıları incelenmiştir. Birey sayılarının örneklemlere ve cinsiyet/yaş gruplarına göre dağılımı Tablo 1'de yer almaktadır. Örneklemlerin büyüklüğü 25 ila 54 birey sayısı arasında değişmektedir. Tablo 1'de bireyler, erişkin olmayanlar (20 yaşın altındaki bebek, çocuk ve ergenler), genç erişkinler (20 ila 39 yaş arasındakiler) ve ileri erişkinler (40 yaş ve üzerindekiler) olmak üzere üç yaş grubuna ayrılmıştır. Daha sonra da cinsiyeti belirlenebilen genç erişkinler ve ileri erişkinler, kadınlar ve erkekler olarak ikiye ayrılmıştır. Tabloda görülebileceği üzere erişkin yaşın altındakilerin oranı Örneklem 3 ve 4'te oldukça yüksektir. İleri erişkinlerin oranı ise Örneklem 1'de diğerlerine göre yüksektir. Buna karşın Örneklem 4'te ileri erişkinlerin oranı belirgin bir şekilde düşüktür. Cinsiyet dağılımında en dikkat çekici farklılaşma Örneklem 4'teki genç kadın oranının çok yüksek (%83) olmasıdır. İlk üç örneklemde ileri erişkinler grubunda erkeklerin sayısal olarak ağırlıkta olduğu görülmektedir. Örneklem 4'te ise bu yaş grubunda sadece bir kadın ve bir erkek bulunmaktadır.

Tablo 1. Örneklemlerde cinsiyet ve yaş gruplarının dağılımı.

	Örneklemler							
	1		2		3		4	
	N	%	N	%	N	%	N	%
Tüm bireyler	31		54		45		25	
Erişkin olmayanlar (<20 yaş)	9	32,1	14	25,9	30	66,7	14	56
Genç erişkinler (20-39 yaş)	10	35,7	22	40,7	6	13,3	7	28
İleri erişkinler (40+ yaş)	9	32,3	10	18,5	8	17,8	2	8
Genç erişkin kadınlar	4	50	11	57,9	3	50	5	83,3
Genç erişkin erkekler	4	50	8	42,1	3	50	1	16,7
İleri erişkin kadınlar	3	33,3	2	22,2	2	28,6	1	50
İleri erişkin erkekler	6	66,7	7	77,8	5	71,4	1	50

Gözlem ve Analiz Yöntemleri

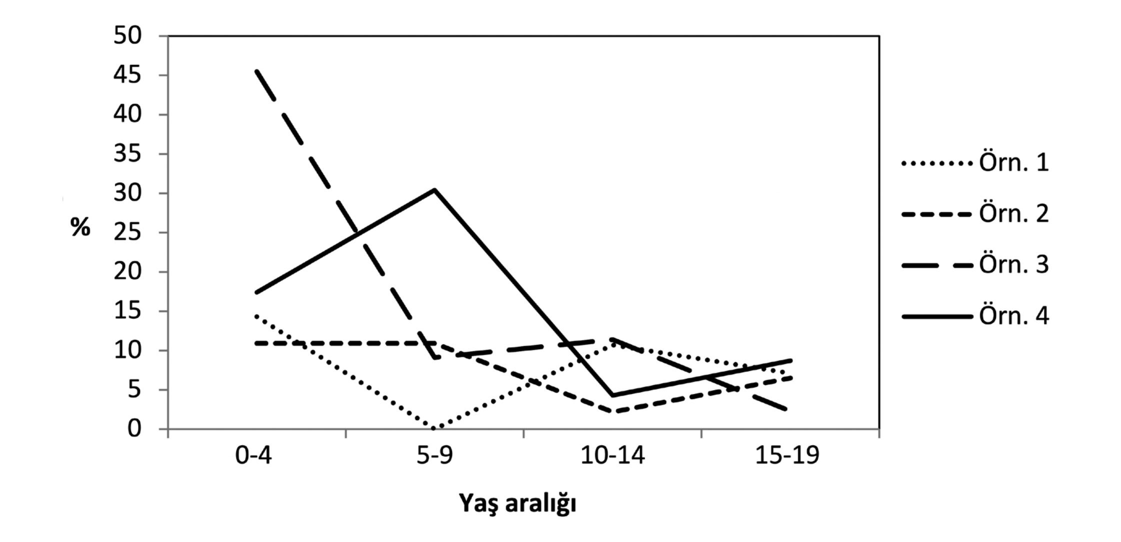
Bu çalışmada çocukluk dönemi stresine maruz kalıp hayatta kalabilen bireyler PH lezyonlarının varlığına göre ayırt edilmiştir. Erişkin olmayanlar ve erişkinlerin hepsinde PH'nin varlığı/yokluğu makroskopik olarak incelenmiştir. PH, sadece kafatasının en az üçte ikisi mevcut olan bireylerde kaydedilmiştir. Lezyonların şiddeti Stuart-Macadam'ın (1985) sınıflandırması esas alınarak dört seviyede kaydedilmiş ancak istatistiksel olarak yeterli sayıya ulaşabilmek için var/yok ikili kategorisinde hepsi birleştirilmiştir. Ayrıca lezyonlar Mensforth vd. (1978) tarafından tanımlandığı şekilde aktif ve iyileşmiş olarak kaydedilmiştir. Aktif lezyonlar süzgeç şeklinde bir görüntüye sahipken iyileşmiş lezyonlarda gözeneklerin içi kemik dokuyla tıkanmış şekildedir.

Lezyonların prevalansı her örneklem için erişkin olmayanlar/erişkinler, kadın/erkek ve toplam kategorilerinde ayrı ayrı belirlenmiştir. Bunların arasındaki farkların anlamlılığı ki-kare testi ile ölçülmüş ve p değerinin 0.05'ten küçük olması istatistiksel olarak anlamlı kabul edilmiştir. Bir kategoride örnek sayısının beşten az olduğu durumlarda Fisher testi uygulanmıştır.

Lezyonlu bireylerin sağkalım sürelerini belirlemek için parametrik olmayan Kaplan-Meier sağkalım analizi kullanılmıştır. Sağkalım sürelerinin örneklemler arasında bir fark gösterip göstermediğini belirleyebilmek amacıyla da log-rank testi (Mantel-Cox) kullanılmıştır. Söz konusu tüm istatistiksel analizler SPSS veri analiz programında yapılmıştır.

Bulgular

Erişkin olmayanlarda beşerli yaş gruplarındaki ölüm oranlarını gösteren Grafik 1'de dört ayrı örneklemde ölümlerin hangi yaş aralıklarında yoğunlaştığı görülebilir. Örneklem 3'te 0-5 yaş arası çocuk ölümleri belirgin bir şekilde fazladır. Örneklem 4'te ise 5-10 yaş arası çocuk ölüm oranları yüksektir. Örneklem 4'teki bu dikkat çekici durumun olası nedenleri tartışma bölümünde ele alınacaktır.



Grafik 1. Örneklemlerde erişkin olmayanlara ait ölüm eğrileri.

Her örneklem için erişkin olmayanlar/erişkinler ve cinsiyet gruplarında PH prevalansının dağılımı Tablo 2'de görülebilir. Örneklemlerin hepsinde ağırlıklı olarak hafif ve daha az oranda da orta derecede PH gözlemlenmiş (Stuart-Macadam'ın sınıflandırmasına göre birinci ve ikinci derece) ancak istatistiksel nedenlerle hepsi tek kategoride birleştirilmiştir. Tüm gruplarda en yüksek PH prevalansı Örneklem 4'te saptanmıştır. Bu örneklemde yedi yaşın üzerindeki tüm bireylerde PH gözlemlenmiştir. PH prevalansı bakımından, Örneklem 4 ile Örneklem 1 (erişkinler ve toplam kategorilerinde) ve Örneklem 2 (erişkinler, kadınlar ve toplam kategorilerinde) arasındaki fark istatistiksel olarak da anlamlıdır. Ancak Örneklem 3 ile Örneklem 4 arasında istatistiksel olarak anlamlı bir fark bulunmamıştır. Her ne kadar Örneklem 3, Örneklem 1 ve 2'den daha yüksek PH prevalansına sahip olsa da aralarındaki fark anlamlı değildir.

PH, tüm örneklemlerde erişkinler grubunda daha fazla gözlemlenmiştir. Bu, PH'li çocukların çoğunun erişkinliğe ulaşmış olduğunu göstermektedir. Ancak erişkin yaşın altındakilerde en fazla PH gözlemlenen Örneklem 4'te (%43) çok sayıda PH'li çocuğun erişkinliğe ulaşamadan öldüğü anlaşılmaktadır. Örneklem 4'teki dokuz yaşında bir çocukta aktif ve iyileşmiş lezyonlar birlikte gözlemlenmiştir. Onun dışında her örneklem için tüm yaş gruplarında gözlemlenen PH lezyonları iyileşmiş aşamadadır (Şekil 1).

Tablo 2. Örneklemlerde cinsiyet ve yaş gruplarında PH prevalansı.

Örneklem No	Toplam		Erişkin olmayan		Erişkin			Erkek		Kadın		
	n/N	%	n/N	%	n/N	%	p^1	n/N	%	n/N	%	p^2
1	9/25	36.0	0/7	0.0	9/18	50.0	0.027*	3/11	27.3	6/7	85.7	0.050
2	11/39	28.2	1/12	8.3	10/27	37	0.122	5/12	41.7	4/12	33.3	1.000
3	11/25	44.0	2/12	16.7	9/13	69.2	0.015*	6/7	85.7	3/5	60.0	0.523
4	11/15	73.3	3/7	42.9	8/8	100	0.026*	2/2	100	5/5	100	-
p^3 (1-2)	0.585		1.000		0.539			0.667		0.057		
p^3 (1-3)	0.773		0.509		0.462			0.050		0.523		
p^3 (1-4)	0.048*		0.192		0.023*			0.128		1.000		
p^3 (2-3)	0.281		1.000		0.091			0.147		0.593		
p^3 (2-4)	0.005*		0.117		0.003*			0.462		0.029*		
p^3 (3-4)	0.104		0.305		0.131			1.000		0.444		

Erişkin olmayanlar (<20 yaş), erişkinler (≥20 yaş), N: Gözlemlenen tüm bireyler, n: PH'li bireyler, p^1: Erişkin olmayanlar ile erişkinler arası fark, p^2: Erkekler ve kadınlar arası fark, p^3: Örneklemler arası fark (parantez içi: örneklem no), *istatistiksel olarak anlamlı fark.

Örneklem 4'te kadınlar ve erkeklerde eşit oranda PH'ye rastlanmıştır. Örneklem 2 ve 3'te erkeklerde, Örneklem 1'de ise kadınlarda daha fazla PH'ye rastlanmakla birlikte bu farklar istatistiksel olarak anlamlı bulunmamıştır. Kadın ve erkek gruplarında genç ve ileri erişkinler arasındaki PH sıklığı farklarını incelemek örnek sayısı çok az olduğu için tercih edilmemiştir.

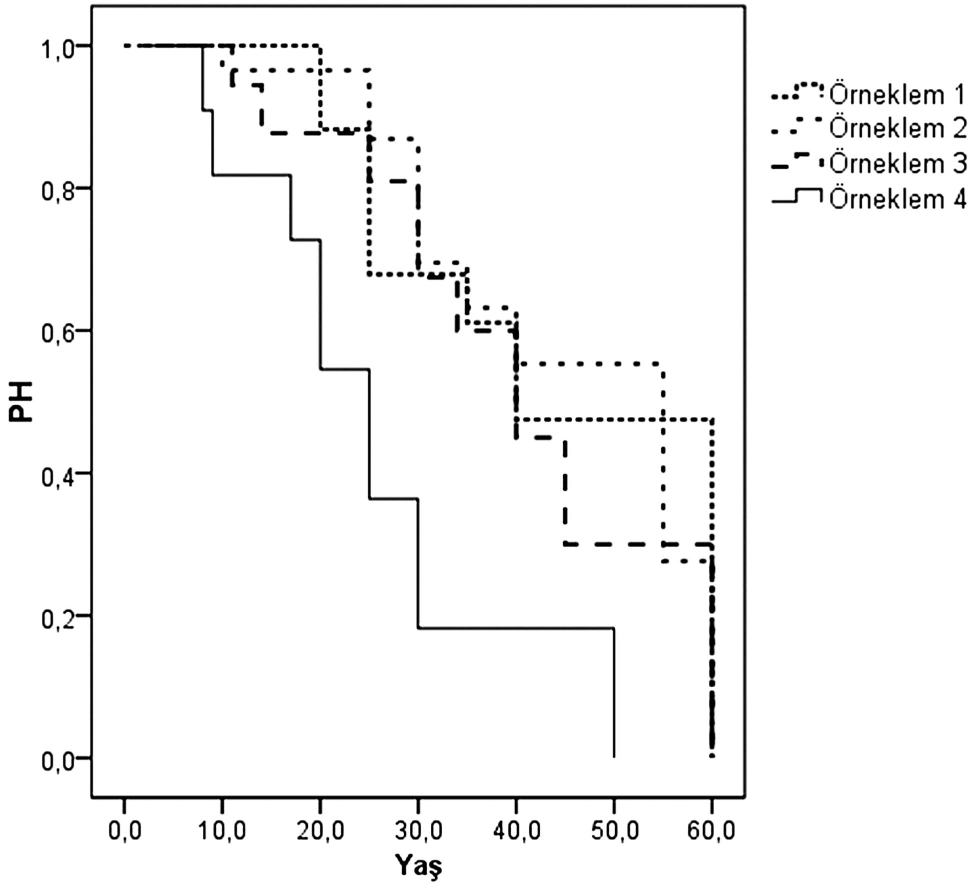
Örneklemlerde PH'li bireylerin ortalama sağkalım süreleri ve örneklemler arası istatistiksel farklar Tablo 3'de sunulmuştur. Kaplan-Meier analizine göre PH'li bireylerin ortalama sağkalım süreleri Örneklem 1, 2 ve 3'de birbirine oldukça yakındır (42 ile 45 yıl arasında değişmektedir). Ancak Örneklem 4'de PH'li bireylerin ortalama sağkalım süresi 25,8 yıldır ki bu değer, ilk üç

Tablo 3. PH gözlemlenen bireylerin sağkalım tablosu.

Örneklemler	Ortalama Sağkalım Süresi	95% GA	Mantel-Cox x^2	p	df
1	43,756	35,015-52,497	16,106	0.001	3
2	45,140	37,850-52,431			
3	42,069	32,637-51,501			
4	25,818	17,562-34,074			
1-2			0.079	0.778	1
1-3			0.179	0.672	1
1-4			8.505	0.004*	1
2-3			0.277	0.599	1
2-4			14.514	0.000*	1
3-4			4.885	0.027*	1

GA: Güven aralığı, *istatistiksel olarak anlamlı fark.

örnekleme göre belirgin biçimde düşüktür. Ortalama sağ kalım süresi bakımından Örneklem 4 ile diğer örneklemler arasındaki farklar istatistiksel olarak anlamlıdır. Sağkalım fonksiyonu da Örneklem 4'teki PH'li bireylerin sağkalım eğrisinin diğer örneklemlerle bariz farkını göstermektedir (Grafik 2).



Grafik 2. Örneklemlerde PH gözlemlenen bireylerin sağkalım eğrileri.

Tartışma

Bir iskelet örneklemindeki ölüm oranlarını yorumlarken, her şeyden önce o örneklemin gerçek topluluğu ne kadar temsil ettiğini sorgulamalıyız. Bunun için kazılan alan kadar kazı tekniklerini de göz önünde bulundurmamız gerekir. Örneklem 3 ve 4'te erişkin olmayanların oranının diğer örneklemlere göre daha yüksek olduğunu belirtmiştik. Ancak bu iki örneklem arasında önemli bir fark bulunmaktadır. Örneklem 3'te 0-5 yaş arası bebek/çocukların ölüm oranı çok yüksekken Örneklem 4'te 5-10 yaş arası çocukların ölüm oranı yüksektir (Grafik 1). İskelet örneklemlerinde genellikle 0-5 yaş grubundaki çocuk ölüm oranlarının daha fazla olması beklenir çünkü bu yaş aralığındaki ölüm riski yüksektir. Dolayısıyla Örneklem 4'teki durumun sıra dışı olduğunu söyleyebiliriz. Bu örneklemde 5-10 yaş arası çocuk ölüm oranının daha yüksek olmasının nedeni, 0-5 yaş grubuna ait iskeletlerin hepsinin bulunmamış olması olabilir. Örneklem 4'ü oluşturan iskeletler 1968 yılında yapılan kazılarda açığa çıkartılmıştır. Her ne kadar o zamanki kazıların durumunu tam olarak bilemesek de bazı bebek iskeletlerinin gözden kaçmış veya toplanmamış olması olasılık dahilindedir. Buna karşılık Örneklem 3'ü oluşturan iskeletlerin büyük bölümü yakın zamanda yapılan kazılarda açığa çıkartılmıştır. Yeni kazılarda iskelet kalıntılarına gösterilen azami dikkat sayesinde tüm bebek iskeletleri toplanmıştır. Eğer durum tahmin ettiğimiz gibiyse, Örneklem 4'teki bebek ve küçük çocuk ölüm oranı çok daha yüksek olabilir.

Örneklem 4'te her yaş ve cinsiyet grubunda diğer örneklemlerden daha fazla PH tespit edilmiştir. Her ne kadar PH'nin şiddeti diğer örneklemlerden daha fazla olmasa da 7 yaşın üzerindeki tüm bireylerde PH gözlenmesi, toplulukta herkesin çocukluk anemisi geçirdiğini göstermektedir. Bu ciddi bir beslenme yetersizliğinin işaretidir. Ayrıca, erişkin olmayanlardaki yüksek PH prevalansı nedeniyle çocukluk anemisi geçiren çocukların büyük çoğunluğunun erken yaşta öldüğünü söyleyebiliriz. Sağkalım analizi, bu örneklemde erişkinliğe ulaşabilenlerin de çok uzun yaşayamadığını ortaya koymuştur. Örneklem 4'te PH'li bireylerin ortalama sağkalım süresi diğer üç örneklemden belirgin biçimde kısadır. Bu grupta PH'li bireylerin yani çocukluk anemisi geçirenlerin büyük kısmı ya hiç erişkinliğe ulaşamamış ya da erişkinliğe ulaşsa da erken yaşta ölmüştür. Bu bulgular, bu örneklemdeki bireylerin diğer örneklemlerdekilere göre daha yetersiz beslendiklerine ve daha dayanıksız olduklarına işaret etmektedir.

Örneklem 3'te erişkin olmayanların oranı oldukça yüksek olsa da PH'nin az görülmesi, küçük çocukların çoğunun lezyon geliştiremeden önce öldüklerini göstermektedir. Erişkinlerde ise erişkin olmayanlara göre anlamlı ölçüde fazla PH gözlemlenmesi, stresli ve riskli dönemi atlatabilen dayanıklı çocukların uzun süre yaşadığını ortaya koymaktadır. Ayrıca bu örneklemde PH'li bireylerin ortalama sağkalım yaşı da yüksektir. Örneklem 3'teki bu durum, heterojen dayanıksızlık ve seçici mortaliteye iyi bir örnek oluşturmaktadır. Dayanıksız çocuklar lezyon geliştiremeden önce ölmüş, dayanıklı olanlarsa lezyon geliştirmiş ve uzun yaşamışlardır. Bu bakımdan Örneklem 3, Örneklem 4'ten farklıdır.

Örneklem 4 adını verdiğimiz MS 18-19. yüzyıla ait iskelet topluluğunun malnutrisyon işaretleri gösteren, yeterli hayvansal proteine ulaşamamış, olasılıkla açlık ve kıtlık sorunuyla karşı karşıya kalmış bir topluluğa ait olduğu anlaşılmaktadır. 19. yüzyılda Orta Anadolu'da büyük kuraklık dönemleri yaşandığı ve bunları ciddi kıtlıkların izlediği Osmanlı arşiv belgelerinden bilinmektedir. İç Anadolu'da Ankara başta olmak üzere Çorum, Kırşehir, Kayseri, Yozgat ve Konya bu kıtlıklardan ciddi biçimde etkilenmiştir (Aybar 2017). Bu kıtlıklar, açlığa bağlı ölümlere, çocukların ailesiz kalmasına, insanların kıtlıktan daha az etkilenebilecekleri yerlere göç etmesine, su sıkıntısı nedeniyle hijyen sorununun ortaya çıkmasına ve enfeksiyon hastalıklarının yayılmasına, ayrıca çok sayıda hayvanın ölümüne yol açmıştır (Tekemen Altındaş

2018). Kıtlık öncelikle kırsal yerleşimleri etkilemiş ve insanlar köylerden büyük şehirlere göç etmişlerdir (Aybar 2017). Yozgat bölgesinde birçok köyün terk edildiği bilinmektedir (Oğuz 2016). Bu kıtlık dönemlerinde on binlerce insanın öldüğü belirtilmiştir (Tekemen Altındaş 2018). Kıtlıktan yaşlıların ve çocukların daha fazla etkilendiği de bazı yazışma belgelerinden anlaşılmaktadır (Aybar 2017). Kuraklık dışında çekirge istilasının da kıtlığı tetikleyen önemli bir etken olduğundan bahsedilmektedir. 1881 yılında yaşanan çekirge istilasında Ankara, Kırşehir, Yozgat ve Çorum bölgesinde binlerce ton arpa ve buğday yok olmuştur (Tekemen Altındaş 2018). Bunlar dışında hayvancılığı ve dolayısıyla besin kıtlığını etkileyen bir faktör de hayvanlardaki salgın hastalıklardır. Arşiv belgelerinde veba-i bakarî olarak geçen sığır vebası salgınlarının, Anadolu'da büyük çaplı hayvan ölümlerine yol açtığı anlaşılmaktadır. 19. yüzyıl sonundaki sığır vebası salgınında sadece Yozgat'ta 30.000 hayvanın öldüğü bildirilmiştir (Ak 2016). Bu dönemde çok sayıda büyükbaş hayvanın ölmesi nedeniyle tarla sürecek hayvanın kalmadığı ve bunun tarımsal üretimi de olumsuz etkilediği belirtilmiştir (Ak 2016). Ayrıca bölgenin Osmanlı Devleti'nin çöküşüne paralel olarak iç siyasetteki karışıklıktan ve ekonomik sıkıntılardan da etkilendiği ve kıtlığın bu sorunlarla da ilişkisi olduğu ifade edilmiştir (Oğuz 2016). 18-19. yüzyılda Boğazköy'deki kırsal yerleşimde yaşayan insanlar ve konar-göçer gruplar, bölgede kuraklık, çekirge istilası, sığır vebası salgını ve ekonomik sıkıntılar gibi faktörlerin etkisiyle ortaya çıkan kıtlıklardan etkilenmiş olmalıdırlar. Örneklem 4'de görülen yaygın aneminin ve erken yaşta ölümlerin nedeni bu olabilir. Bu örneklemdeki bireyler doğrudan kıtlığın olduğu yıllara denk gelmemiş olsalar da kıtlık gibi felaketlerin sonraki nesillerin sağlığını etkileyebildiği bilinmektedir (maternal etki) (Barker 2012; Gowland 2015).

Boğazköy'de Helenistik-Roma dönemlerindeki yaşamsal koşullar hakkında ayrıntılı bilgiye sahip olmamakla birlikte Örneklem 1, 2 ve 3'ü oluşturan iskeletlerin, "İklimsel Roma Dönemi Optimumu" adı verilen ılıman bir döneme ait olduklarını söyleyebiliriz. McCormick vd. (2012) iklimsel koşulların, Roma İmparatorluğu'nun yayıldığı alanlarda MÖ 100 ile MS 200 tarihleri arasında elverişli ve son derece istikrarlı olduğunu belirtmiştir. Bu iklimsel koşullar tarımsal üretim için ideal bir ortam yaratmış olmalıdır. Anadolu'da kuraklık ve kıtlıkların MS 300'lerde başladığı bilinmektedir (Izdebski vd. 2016). Ayrıca Schachner (2016) Boğazköy'deki Roma Dönemi yerleşiminin kırsal özellikli bir yer olmakla birlikte gerek konumu (Galatya eyaletinin başkenti Tavium'a yakınlığı, yakınından geçen ve Tavium'a ulaşan bir Roma yolunun olması) gerekse askeri işlevi (Roma yolunu korumak) bakımından özel öneme sahip olabileceğini ifade etmiştir. Dolayısıyla Boğazköy'de Helenistik-Roma dönemlerinde yaşamış topluluk olasılıkla 18-19. yüzyıllardaki topluluğa göre daha iyi çevresel ve ekonomik koşullara sahipti.

Sonuç

Biyoarkeoloji, iskelet kalıntılarını incelemek yoluyla, insan topluluklarının çevresel değişimlere adaptasyonunu anlamaya çalışan bir disiplindir. Bu nedenle çevresel değişimler her zaman biyoarkeolojinin ilgi odağındaki konular arasındadır. Doğal veya kültürel çevrede ortaya çıkan değişimlerin etkileri, insanların beslenmelerinde, günlük yaptıkları işlerde ve hijyen koşullarında yansımasını bulur. Bunların bedensel etkileri de iskelet kalıntıları üzerinde gözlemlenebilir. Örneğin, kuraklık gibi doğal afetlerin veya savaş gibi olayların sonucunda genellikle kıtlıklar ortaya çıkar. Kıtlık malnutrisyona yol açar, bundan dolayı insanların bağışıklığı zayıflar, enfeksiyon hastalıkları yayılır ve ölümler olur. Dolayısıyla, bir iskelet örnekleminde mortalite örüntülerini ve iskeletlerdeki malnutrisyon/hastalık izlerini inceleyerek kıtlıkla ilgili çıkarsamalar yapmak mümkün olabilir[4].

Bu çalışmada MS 18.-19. yüzyıla yani Geç Osmanlı Dönemi'ne ait olan iskeletlerden oluşan Örneklem 4'ün biyolojik stres ve sağkalım bakımından Helenistik-Roma ve Geç Roma dönemlerine ait olan üç örneklemden daha kötü durumda olduğu anlaşılmıştır. Bu bize Geç Osmanlı döneminde Boğazköy'de yaşamış olan insan topluluğunun adı geçen erken dönemlerde yaşamış olanlara göre çok daha yetersiz beslenmiş ve dayanıksız olduğunu göstermiştir. Bunun, 18-19. yüzyılda bu bölgede yaşanmış olan kıtlıklarla ilişkili bir durum olması mümkün görünmektedir. Öte yandan bu bulgulara dayanarak, İklimsel Roma Dönemi Optimumu adı verilen ılıman ve istikrarlı iklim dönemine denk gelen Örneklem 1, 2 ve 3'ün temsil ettiği toplulukların görece daha olumlu koşullarda yaşadıklarını söyleyebiliriz.

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[4] İskelet örneklemlerinde kıtlığın etkileri konusunda detaylı tartışma için bkz. Morgan 2013; Geber 2014; Yaussy vd. 2016

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Şekil 1. *Porotic hyperostosis* (hafif derecede ve iyileşmiş).

Şekil 2. Boğazköy (Hattuša)'nın konumu.

Archaeology for Landscape Management and Planning: Historic Landscape Characterization of Urla (İzmir)

Elif Koparal[a], Volkan Demirciler[b], Sam Turner[c]

Abstract

Historic Landscape Characterization (HLC) is a Geographic Information Systems (GIS) based approach useful for the management of landscapes. It is a detailed landscape analysis that makes use of spatial data including maps, remote sensing including aerial images and information for defining historic landscapes within the context of their deep history, dynamism and vulnerability. It was initially developed in Cornwall (UK) in the 1990s. Since then the method has been disseminated across Europe, and used in various regions of the Mediterranean to identify the deep history and dynamic nature of landscapes. In this article we share the preliminary results and our approach for HLC analysis executed for Urla region. Urla in İzmir district is a complex place with deep history where the pace of urbanization is high, with consequent negative impacts on the historic landscape. HLC analysis provides a spatial and diachronic method to define knowledge about the landscape and to generate strategies for its management and future planning.

Keywords: Historic Landscape Characterization (HLC), landscape archaeology, cultural landscapes, ancient terraces, Urla-İzmir

Özet

Tarihsel Peyzaj Karakterizasyonu (HLC) Coğrafi Bilgi Sistemleri (CBS) tabanlı bir uygulama olup tarihi dokuya sahip alanlarda yönetim ve planlamada stratejilerin üretilmesine hizmet eden bir yaklaşım içerir. Kapsamlı bir peyzaj analizi olan HLC uygulamasında çeşitli harita,

a Elif Koparal, Assoc. Prof. Mimar Sinan Fine Arts University, Department of Archaeology, İstanbul. Senior Fellow 2021-2022 Koç University, Research Center for Anatolian Civilizations, İstanbul. elif.koparal@msgsu.edu.tr ; ekoparal21@ku.edu.tr ; https://orcid.org/0000-0002-6850-8834

b Volkan Demirciler, Assist. Prof. Çanakkale Onsekiz Mart University, Department of Archaeology, Çanakkale. volkandemirciler@comu.edu.tr ; https://orcid.org/0000-0002-3469-208X

c Sam Turner, Prof. Dr. Newcastle University, McCord Centre for Landscape, Newcastle University, UK. Sam.turner@newcastle.ac.uk ; https://orcid.org/0000-0002-3257-0070

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uydu görüntüsü, hava fotoğrafı ve bilgi kullanılarak hedeflenen alanın derin tarihi, değişim ve dönüşümü ve değişimi kaldırma kapasitesi tanımlanır. HLC ilk kez İngiltere'de Institute of Historic England (Tarihi İngiltere Enstitüsü) tarafından Cornwall'da uygulanmış ve daha sonra uygulamanın yaygınlaştırılması hedeflenmiştir. Akdeniz'de derin ve karmaşık bir yapıya sahip alanlarda ileriye dönük yönetim ve planlama stratejilerinin oluşturulmasında HLC analizleri önemli bir altlık sağlamaktadır. Burada, yine derin bir tarihe sahip olan, uzun vadeli ve giderek hızı artan kentleşmenin tarihi peyzaj üzerinde tahribat riski oluşturduğu Urla bölgesi için uyguladığımız HLC analizlerinin başlangıç aşamasındaki sonuçları ve çalışmanın belkemiğini oluşturan yaklaşımımız paylaşılmaktadır. HLC analizleri Urla ve benzeri karmaşık, dinamik ve tarihsel açıdan zengin bölgelerde yönetim ve planlamaya dönük doğru stratejilerin belirlenmesinde önem taşıyan bir potansiyele sahiptir.

Anahtar Kelimeler: Tarihsel Peyzaj Karakterizasyonu, peyzaj arkeolojisi, kültürel çevre, antik teraslar, Urla-İzmir

Current approaches emphasize the constantly transforming and changing nature of landscapes (Turner and Crow 2010, 216). Historic Landscape Characterization (HLC) provides a novel approach for measuring and defining change in the historic landscape in all its aspects. Landscape is a complex and multidimensional concept, created through the entanglement of culture, materiality, nature, and experience (Ingold 2004; Forbes 2007, 18-49), explored through a wide range of disciplines including architecture, sociology, history, anthropology, ecology, and archaeology. Landscape studies in archaeology have a transdisciplinary nature which is also reflected by the methodologies applied. HLC is an innovative method that is borne out of theoretical approaches that regard landscape as a product of inseparable relationships between perception, society, and environment.

As a major research focus, landscape is still subject to debate in archaeology (Thomas and David 2010). The post-processual criticism of cartesian understanding of landscape infused the approaches with cultural, biographic, and experiential perspectives, which emphasize the subjective perception of landscape (Johnson 2007, 119-161). Together with intensive pedestrian survey (Cherry 1983), remote sensing and GIS-based modeling are key to the rapid systematic recording of historic landscapes and have great potential to respond to complex problems (Conolly 2010). Although the use of remote sensing technologies has sometimes been criticized for neglecting human aspects that requires a "slower" archaeology, the effectiveness and efficiency of using non-invasive technologies for recording is indisputable (Caraher 2016). Today a great percentage of the world's landscape is impacted by human activities of late capitalism, and the rate of change is increasing in pace. Current understanding of landscape management and planning takes "change" as the basic quality of the landscapes and focuses on understanding the long-term evolution that is vital for a better future for landscapes. In many regions, the impacts of global processes like climate change, population growth, urbanization, and industrial development mean the vulnerability of landscapes is a significant issue (Jansen et al. 2009). For this reason, HLC is a useful tool for mapping and modeling the evolution of landscapes and for simulating future scenarios. Archaeologists are responsible for designing research that records the remains of the past and the present (Ingold 2000, 208), but the engagement of archaeology with current and future ecological, social and political issues is central to contemporary archaeological approaches (Harrison 2016). Furthermore, maintaining a record of loss to underpin collective knowledge about the destructive impact of the incipient Anthropocene epoch is crucial to ethically-aware approaches in archaeology.

Landscape characterization techniques were originally developed in the UK during the 1990s for the management and conservation of historic rural and urban landscapes (Fairclough et al. 1999; 2018). The method emphasizes the importance of knowledge about past landscapes for shaping future landscapes for the better (Fairclough et al. 2008). It is a GIS-based technique which makes use of cartographic and remote sensing data (e.g., aerial images) as well as historical and archaeological information as the basis for good management and planning. The method has been widely disseminated to underpin conservation of cultural landscapes over the last decade across the UK and parts of Europe. It is conducted in line with the spirit of the European Landscape Convention (ELC), which has been signed and ratified by 40 countries to date, including Turkey.

HLC has great potential in areas with archaeological heritage, deep histories, and dynamic landscapes where good management is urgent and necessary (Turner 2006). Recent landscape archaeology projects have explored the potential of HLC in the Mediterranean lately (e.g., Turner and Crow 2010, 219; Bolós et al. 2016). HLC studies from Silivri (Turner and Crow 2010), Boğsak (Varinlioğlu 2017) and Kaz Dağları (Şengür and Nurlu 2021) are pioneering cases in Turkey. The application of HLC on the Urla-Çeşme peninsula as part of KLASP (Klazomenai Survey Project) was initiated in collaboration with the McCord Centre for Landscape at Newcastle University (UK) sponsored by the British Council's Newton Fund from 2016 to 2018.

HLC underpins the management and conservation of historic landscapes by providing an interpretation of all sorts of historic features, processes and uses. The most basic objective of HLC is to classify the entire landscape with all its components across extensive areas (Rippon 2004; Turner and Crow 2010, 219). It provides a framework for measuring recent and past changes in landscape character in an extensive area. HLC is a subjective process of interpretation whose landscape "types" and "characteristics" may be based on particular archaeological case studies which have unpicked the entangled landscape patterns created by historic processes and biographies in specific places. A step beyond conventional inventories and databases, HLC does not solely include site information and spatial data in form of 'Points of Interest'but seeks to represent the historic character of features that are grouped together and mapped in the form of polygons.

Our major motivation in using HLC in the Urla region is based upon our opinion that it is crucial to focus on the management and protection of all natural, historical and cultural aspects of landscapes in our archaeological research projects. Making use of technologies and innovative methods in remote sensing and GIS helps us to understand the complexity of landscapes and to measure the pace of change in particular areas and how those particular areas may tolerate that change. As a party to the European Landscape Convention, Turkey has committed to determining the characteristics of landscapes, analyzing the dynamics that transform them, and to formulating and implementing international policies that include the protection, management, and planning of landscapes (Council of Europe 2000). The convention is important as the first international treaty that deals with landscapes with all their aspects, including natural, rural, urban, sub-urban areas, lands, wetlands, and both inland waters and seas. It covers landscapes that stand out with their specific features as well as ordinary or degraded landscapes. Unfortunately, however, policies and strategies in line with this convention have not yet been developed in Turkey on a national scale.

One of the most conflicting developments that took place was the separation of conservation boards for cultural and natural heritage in 2011 by the statutory decree 648. Significant changes have also been made to the law no 2863, the law on the conservation of cultural and natural property that was published in July 1983. By this decree the management and preservation of natural heritage sites weas entrusted to the Ministry of Environment and Urban Planning instead of the Ministry of Tourism and Culture. Following this, the boards of preservation were divided into two as "cultural" and "natural" heritage. This decision has been legitimized on the basis that board members were not knowledgeable about the natural environment but resulted in the questions over who would make the decisions for areas that include both natural and cultural heritage. The solution has been another statuary decree (no.644 article 13A) that entitled the the Ministry of Environment and Urban planning to the final decision about the protection of those "hybrid" places.

These law changes seriously conflict with the definition of landscape in the European Landscape Convention, which regards landscape it as a complex entity comprising all sorts of natural and cultural features. These changes also tend to facilitate neoliberal development activities that have resulted in significant negative impacts on the landscapes such as urbanization, quarrying, wind turbines, motorways, etc. By dividing the boards, their authority and agency in relation to the preservation of landscape dramatically decreased. Thus, sustainable and efficient conservation of landscapes by the government has become an issue of concern to civil stakeholders, for whom recording and defending such places has become as important as experiencing and understanding them.

The aim of this article is to outline the scope of the HLC analysis executed for the Urla region situated at the western tip of Anatolia, on the coast of İzmir. HLC work initiated in 2017 is part of a regional landscape survey project conducted in the Urla-Çeşme peninsula since 2006 (Figure1). This complex research area covers 1600 km2 of land and is subject to high levels of land speculation, population growth and urbanization (Mosler 2009). Under these conditions, the preservation of historic landscapes is a difficult task that requires immediate solutions. Systematic archaeological surveys carried out in the peninsula since 2006 have recorded around 500 archaeological sites, and other types of landscape features such as tumuli, pavements, rock inscriptions, etc. dated from Late Neolithic period to Ottoman era (Koparal et al. 2017). The three districts of Urla, Çeşme, and Seferihisar on the peninsula are popular coastal touristic towns linked to İzmir. The peninsula is also a setting for four ancient Ionian poleis, namely Erythrai, Klazomenai, Teos, and Lebedos, which are significant in regard to the cultural and historical identity of the region. Long-term archaeological surveys (www.klasp.net) focus on recording the diachronic settlement history of the peninsula.

Fifteen years of work combining pedestrian surveys with geoarchaeological research, geophysics, remote sensing, and public activities have provided new insights into the deep genealogies of the peninsula. Engagement with the peninsula's landscape through long-term fieldwork has enabled us to appreciate it as a living entity which encompasses aspects of the past and provides the framework for the future. Keeping a record of our own experiences of the transformation of the landscape including aspects of destruction, loss, change, and local responses to them, has enabled us to compile a particular biography of the landscape. HLC also provides an efficient apparatus for presenting that biography. Over the last decade, the peninsula has been a theatre for the kind of familiar conflict of late capitalism where the government-sponsored expansion of urban activities is pitted against communities who often include newcomers who have settled in villages seeking a sustainable rural life (and who, in the context of gentrification, may be regarded as a potential problem). Although these communities of "new villagers" defend the rural character of the peninsula, it is a fact that this place has always been characterized by continuous urbanization with an increasing pace at least since the Archaic period, if not earlier.

However, urbanization has never previously been accompanied by such vigorous destruction of rural landscapes. The urban expansion is overpowering the 'palimpsest' of the past and diminishing its visibility which has a strong impact on the perception of the landscape. Whilst the remains of past landscapes and their legacy have the potential to provide significant economic benefits to the region through sustainable tourism, their conservation - particularly in the case of the rural heritage - is not being managed effectively. The ancient urban cores Erythrai, Klazomenai, Teos, and Lebedos are regarded as places of great value for demonstrating the ancient legacy of the region with their monuments and architectural remains. However, these were not unique, isolated spots on the peninsula, but rather they were enmeshed in networks of villages, hamlets, forts, tumuli, farming areas, terraces, and rural shrines over the long term (Figure 2). Urban development is not a newly introduced process for Urla-Çeşme Peninsula. Fieldwork has recorded large quarries from antiquity which served to the building of monuments of urban cores, the poleis. Transporting large blocks for the construction of towns required newly paved roads; bridges and aqueducts were built over the frequently-changing watercourses to bring drinking water to newly founded settlements. One of the most relevant historical accounts suggests that Alexander the Great had the intention to open a big channel at the narrowest part of the peninsula to separate the area of Mimas (Plin.Nat.5.31; Paus. 2.1.5; Thuc. 8.34; Liotsakis 2017), which is reminiscent of contemporary projects that are hot topics of debate in Turkey. State-operated building activities, land division, population management, and even mega projects have been a major part of its landscape biography in Urla-Çeşme peninsula. Embracing the highly dynamic nature of the landscape in the region gives a deeper perspective on the vulnerability, fragility, and resilience of cultural landscapes of the past.

From this point of view, we are developing an HLC database for the whole peninsula. Taking a holistic approach to the management of the peninsula's historic landscape is crucial for protecting the natural resources and cultural legacies. A survey of archaeological sites from the Late Neolithic to Ottoman periods of the region are included in the GIS with the HLC alongside digital maps and aerial photographs (Figure 3). An integrated database such as this has the potential to provide benefits for the landscape management and planning, by, for example, by providing a basis for conservation master planning in the region, that could involve all stakeholders in discussion of recent changes or losses in landscape character.

In practice, HLC analysis presents specific characterizations of present landscapes providing interpretations of the temporal processes and landscape assemblages across the whole area. These interpretations are based largely on morphological characteristics such as the form of boundaries, the pattern of land divisions, or the character of terraces. In the Urla region, an understanding of landscape transformations from the remote past to the present is possible through HLC analysis. Since the remains of individual archaeological sites and do not fully reflect the historic characteristics at the landscape scale, the HLC approach makes an interpretation of the total area. Each polygon in the GIS dataset covers a discrete area (so polygons do not overlap geographically).

The initial steps in the HLC process consisted of five main stages:

1. Collection and analysis of spatial, historical, and archaeological data

For the Urla region, topographic maps at scales of 1/100.000 and 1/25.000, cadastral maps at 1/5000, vertical aerial photographs of 1957, 1976, and 1995 and recent digital orthophotos provided the basic dataset, alongside the GIS database representing surface finds logged during archaeological surveys.

2. Identification of historic patterns / periodization

Periodization is a challenging step in designing the HLC database. For Urla we used archaeological survey data to help inform the interpretation of historic patterns. In the study area such data extends back to as early as the Late Neolithic period. From that time onwards, major periods were chosen to represent characteristic episodes of the region's landscape history. This approach aimed to represent aspects of the whole chronology of the region (though in practice, it is often only possible to attempt a characterization for more recent times).

3. Determination of historic landscape character types

HLC types are defined in advance of mapping using knowledge from archaeological and historical research to match recognizable patterns in the landscape to the historical processes and periods through which they were created and subsequently shaped. For the Urla region, eight broad HLC types were determined, each of which also includes subtypes (Figure 4) for a detailed characterization of the landscape.

4. Characterization

Characteristic patterns of landscape morphology and land-use were interpreted to map patterns of HLC types (e.g., patterns of field and terrace boundaries, (including stone walls, vegetation – trees or scrubs–, hedges, fences, ditches, and earthworks); the distribution of specific types of vegetation; and elements of the transport network). Around 2.000 polygons were mapped using ESRI ArcGIS 10.3.1 software. The minimum size of each polygon was fixed at 1 hectare before the start of characterization; areas smaller than this were incorporated into a neighboring polygon.

5. Designing and linking Access database

Data relating to each polygon including the landscape character types and other attributes, were recorded in an MS Access database.

An example of a characteristic landscape type (and one which we have particularly focused on) is "Terrace." Terraces are remarkable components of the landscape in Urla but have been neglected in the archaeological context. In many ways, they appear to epitomize complex political and economic past of the Aegean. In the Urla region and other coasts of Aegean, Anatolia, terraces are important features of the recent political history. In many places, terraces were abandoned after the 1920s and only a very low percentage of them have been used since then (Milioris 1965). Terraces are seen as linked to the Greek past and wine production, which was largely abandoned in the twentieth century after the population exchange of Anatolian Greeks and Greek Turks that took place in 1923 (Baykara 1980). In the last twenty years, however, terrace agriculture and wine production have become an extensive endeavor in a gentrified context. The Urla vineyard route, a wide network of wineries with newly-built vineyards, has become an important aspect of the contemporary landscape. Current orthophotos reveal newly built stepped terraces alongside the old and ancient ones. As one of the defining landscape character types in Urla, terraces have been crucial to our archaeological survey project from the beginning. For example, an estimation of land use and agricultural potential from the Archaic period suggested that terrace agriculture had a significant share in the rural economy (Koparal 2014).

Most of the steep hillsides on the peninsula are covered with terraces that are no longer in use. The types of terraces in Aegean have already been classified into six main types (Rackham and Moody 1996; Grove and Rackham 2001; Turner and Crow 2010) and four of those are adapted for our Urla HLC: Braided, Contour, False, and Step (Figure 5). Terraces might have a longer history of use in the Aegean than it was previously anticipated, and they may have been a significant component of the rural economy from prehistory to the twentieth century (Betancourt and Hope Simpson 1992; Forbes 2007). Recent work showed that agricultural terraces remain poorly investigated from and archaeological point of view due to the problems involved in dating them, which has significantly limited our understanding of past agricultural practices (Turner et al. 2020a). The application of Opticaly-Stimulated Luminescence profiling and dating (OSL-PD) applied to agricultural terraces across the Mediterranean from several different projects has clearly revealed that many terrace systems were in use during the Middle Ages (AD 1100-1600). So far, OSL-PD has focused on three areas at Urla where well preserved stone-faced terraces were found in proximity to ancient villages and farmsteads recorded by the pedestrian surveys, as well as villages abandoned in the last century (Turner et al. 2020b, 597-598).

HLC creates a flexible dataset for measuring and defining the changes in specific areas, including transformations, losses, and gains across various temporalities. Our Urla HLC project aims to cover the entire peninsula in order to facilitate inter-regional comparative work, make use of archaeological data for defining long-term changes by expanding the time-depth of the analysis, and provide a basis for the management and planning of the landscape. The dataset will be shared with local institutions and relevant NGOs in order to contribute to landscape conservation. So far, the work is largely focused on the impact of modern urbanization in the cultural landscapes of the Urla region (Figure 6); it is hoped that it will help to envisage how the current urban sprawl may transform the cultural landscape and diminish the visibility and representation of past landscapes. Archaeological and historical remains of the past provide significant landscape values in this area, which is fast being absorbed by the developing urban pattern. Historic Landscape Characterization analysis gives us a perspective for improving our approaches and methods for a better approach to conservation, management, and planning across the peninsula.

HLC analysis for Urla region shows that the most rapid and dramatic shift in characters took place in the most recent several decades. As it may be followed in the maps presented here (Figure 6), the modern settlement areas expanded, particularly on the coastlines and wetlands. Wetlands where field systems have been known to exist since the antiquity on the basis of archaeological surveys are becoming a setting for modern exurbs. Industrial is a broad type which included factory, quarry, power plant, fish farm, commercial and organized industrial zone subtypes, and is the other character which expanded dramatically in the region. Finally, the terraces also increased, but this signifies the expansion of false terraces used either for recent modern landscaping or new wineries. Urla is one of the places where landscape characters continue to change in at a rapid pace, with the loss of some of them. HLC analysis gives us a perspective on the changing characters of Urla with a combination of various issues about the past, now, and future; it also gives us a medium to generate new methods and approaches to safekeep historic and natural landscapes that are valuable to the region and to characterize it. HLC analysis provides scope to understand how different types of historic landscapes have been sustained or diminished in long-term perspective and thus may help us explain the general trajectories of change in various contexts. For the case of Urla, the HLC database has the potential to answer questions about a landscape that is changing with increasing speed, the drivers that stimulate those changes, and to identify the key issues for the degradation of landscapes. (Figure 7) It is a useful tool for all stakeholders interested in issues related to environmental problems, cultural heritage, and the management of urban development.

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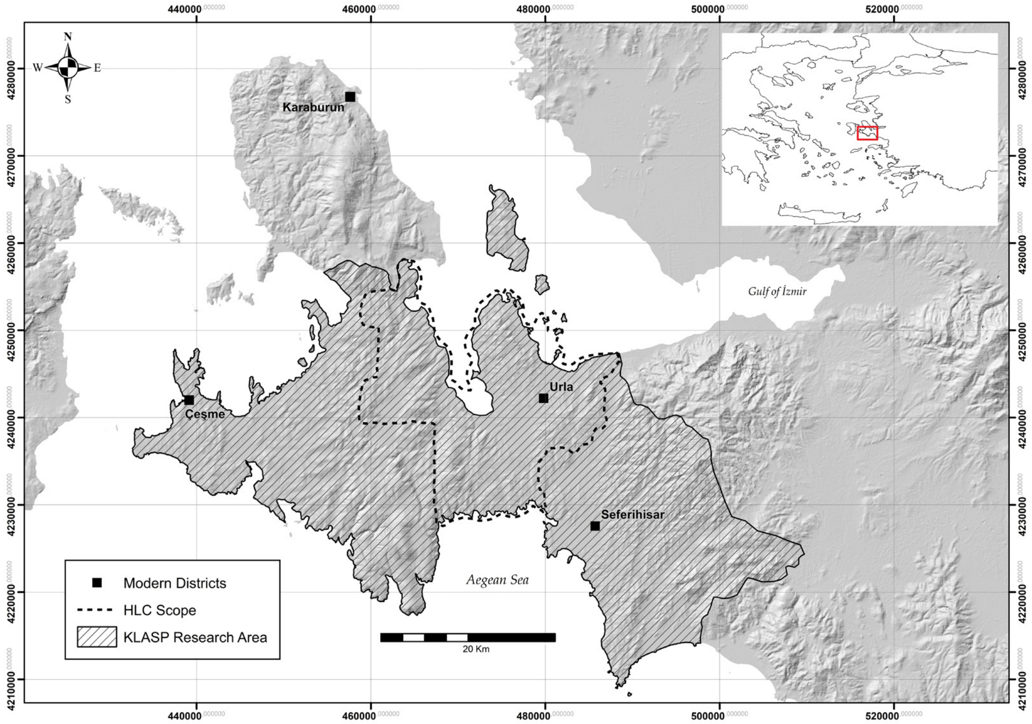

Figure 1. Map showing the research area on the peninsula where Çeşme, Urla and Seferihisar districts are located, HLC analysis discussed in this article only covers Urla region.

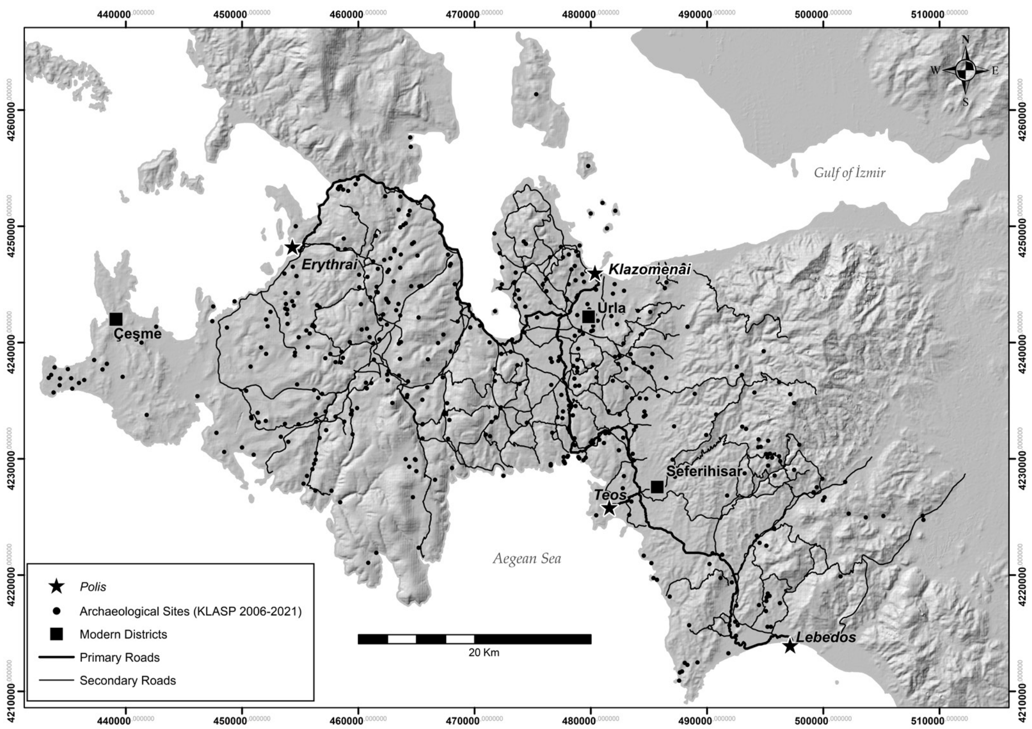

Figure 2. Map showing the points of interest (archaeological sites) and possible ancient routes network suggested on the basis of cost-path analysis executed in GIS environment (ESRI ArcGIS 10.3.1).

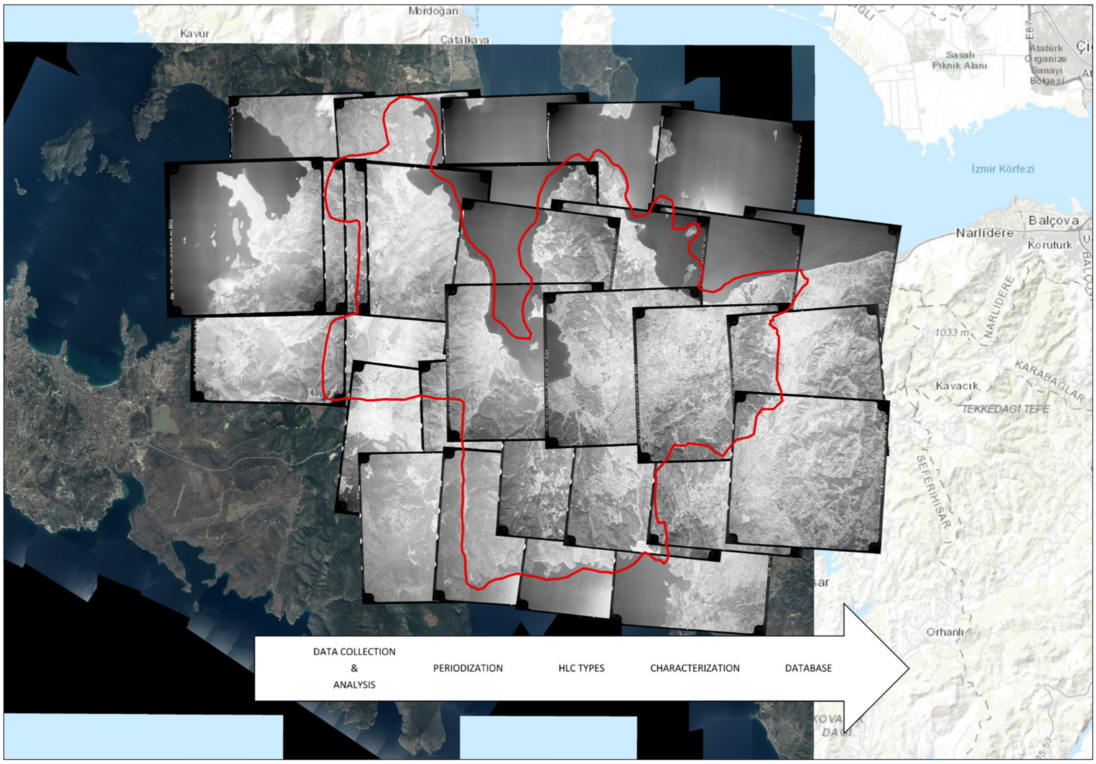

Figure 3. Main steps of HLC analysis for Urla region: Three sets of aerial images from 1957,1976,1995 purchased from General Command of Cartography in Turkey. Aerial images are rectified to create the GIS layers to be used together with layers of orto-photo, topographic maps, archaeological survey data.

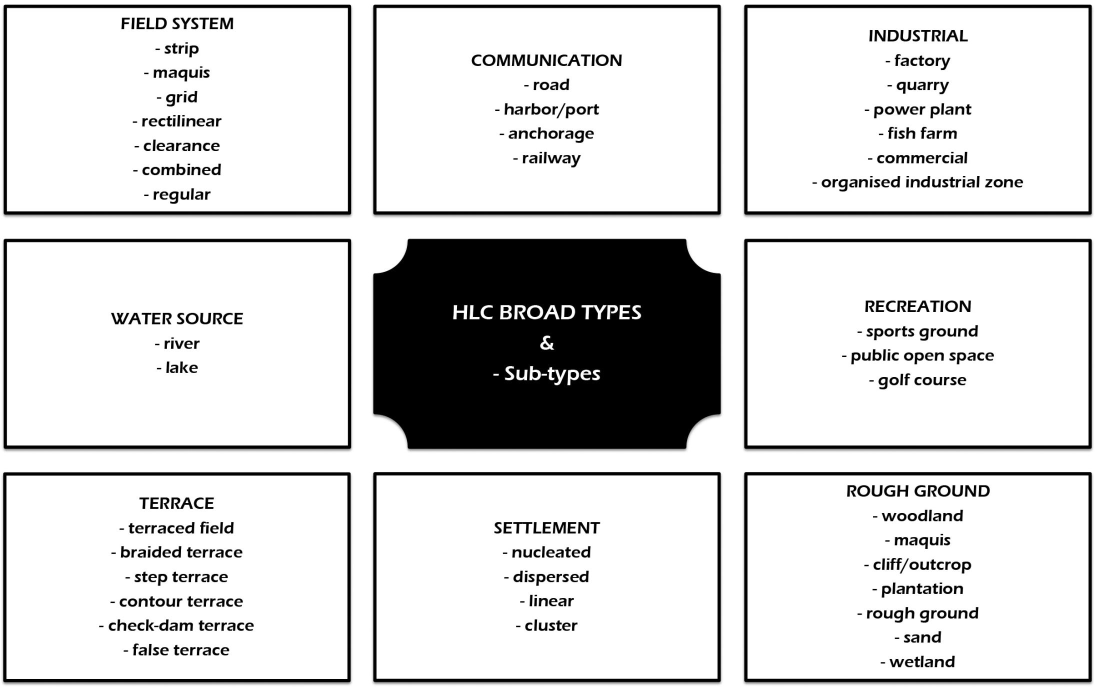

Figure 4. Eight broad types (Field Systems, Water Source, Terrace, Communication, Settlement, Industrial, Recreation, Rough Ground) defined for Urla region with sub-types used for HLC analysis of the region.

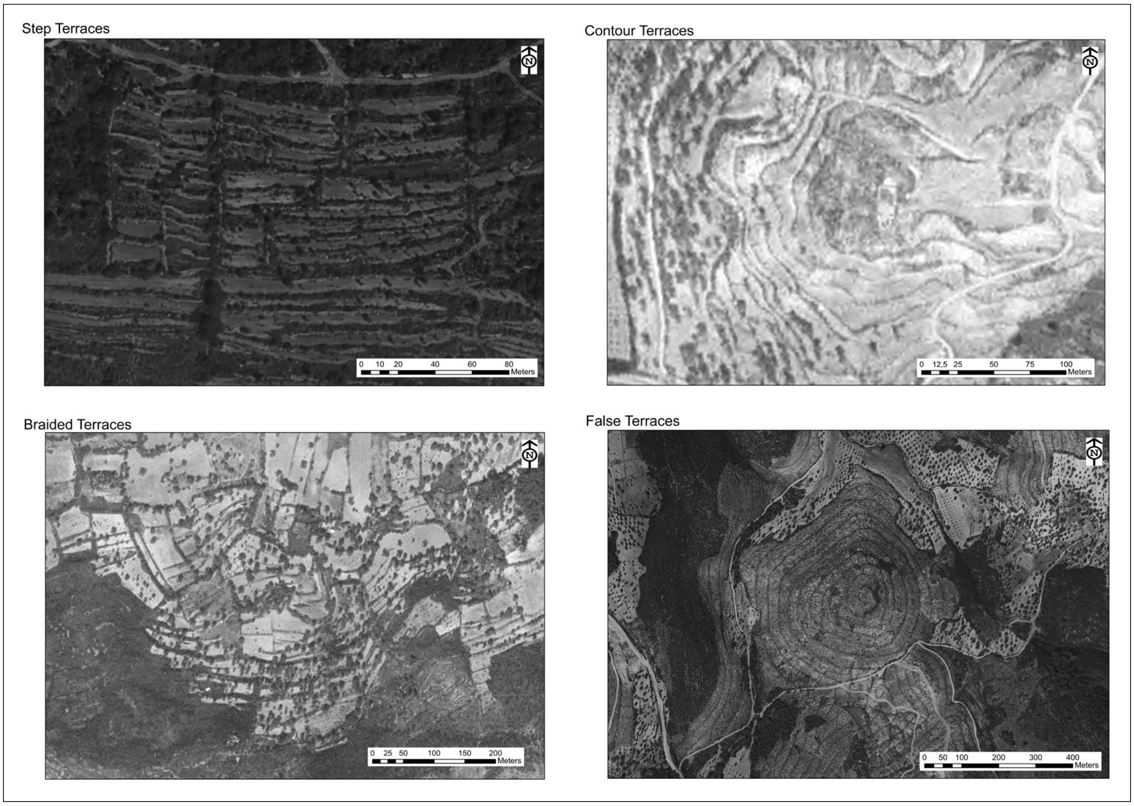

Figure 5. Examples of main terrace types used for HLC analysis in Urla region (Step Terrace 1976; Braided Terrace 1995; Contour Terrace 1957; False Terrace 1995).

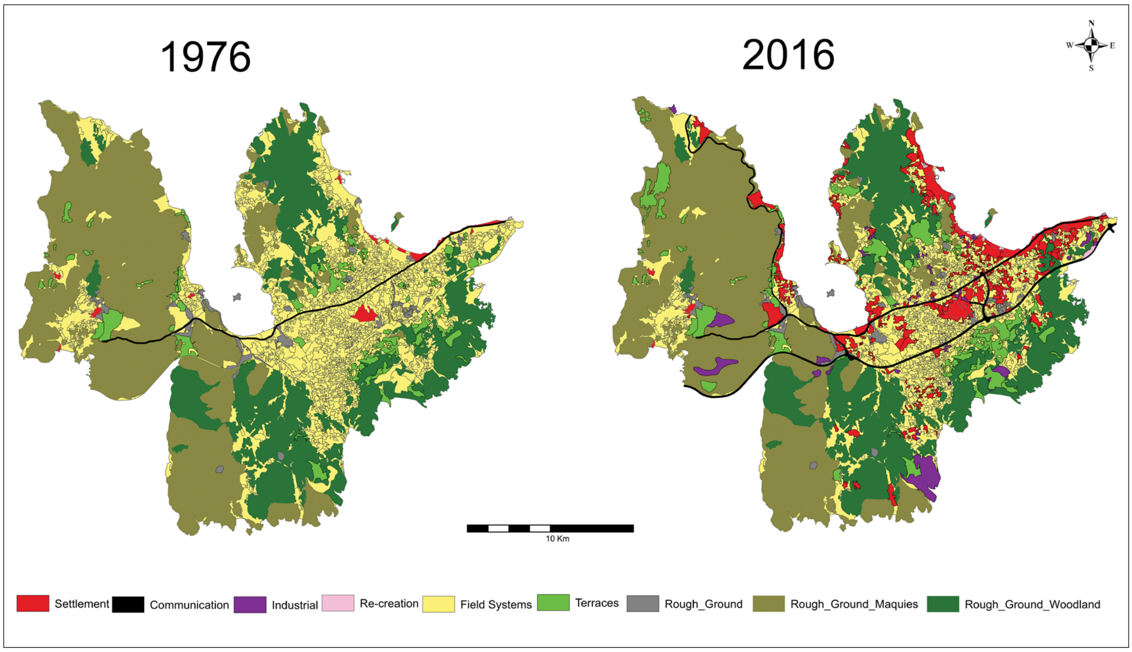

Figure 6. HLC maps of Urla region showing the change from 1976 to 2016 in Urla region which defines the most rapid change in its long history.

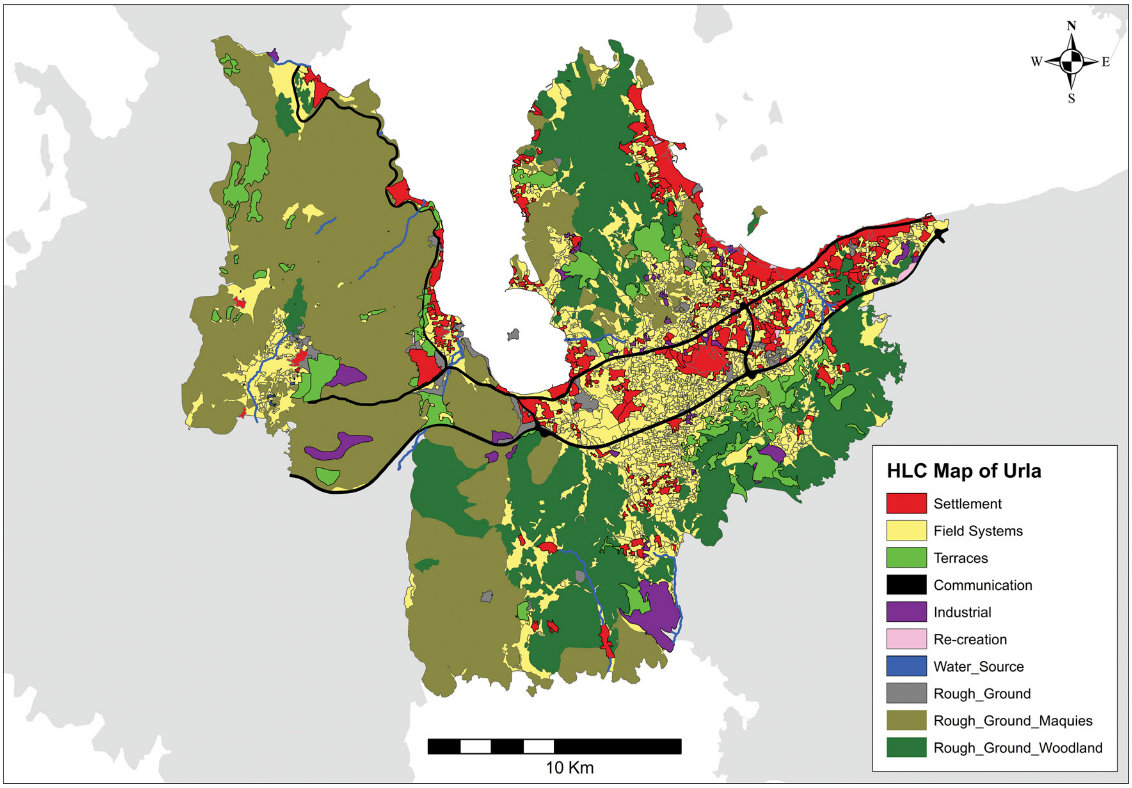

Figure 7. Historic Landscape Character Types Map of Urla region showing the current characters.

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Kitap:

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İlk yazarın soyadı, "vd." ve yayın yılı (Özbal vd. 2004).

Dergi makalesi:

Özbal, R., Gerritsen, F., Diebold, B., Healey, E., Aydın, N., Loyet, M., Nardulli, F., Reese, D., Ekstrom, H., Sholts, S., Mekel-Bobrov, N., Lahn, B. 2004. Tell Kurdu Excavations 2001. *Anatolica* 30, 37-107.

Kitap içi bölüm:

Pearson, J., Meskell, L., Nakamura, C., Larsen, C. S. 2015. Reconciling the Body: Signifying Flesh, Maturity, and Age at Çatalhöyük. I. Hodder, A. Marciniak (Eds.), *Assembling Çatalhöyük*, Leeds: Maney Publishing, 75-86.

Editörlü kitaplar

Metin içerisinde:

Yazar(lar)ın soyadı ve yayın yılı (Akkermans ve Schwartz 2003).

Akkermans, P. M. M. G., Schwartz, G. M. 2003. (Eds.) *The Archaeology of Syria. From Complex Hunter-Gatherers to Early Urban Societies (c. 16.000-300 BC)*. Cambridge: Cambridge University Press.

Web kaynağı:

Soyad, Ad. Web Sayfasının Başlığı. Web Sitesinin Adı. Yayınlayan kurum (varsa), yayın tarihi. Erişim tarihi. URL.

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DERGİSİ
TURKISH JOURNAL OF
ARCHAEOLOGICAL SCIENCES

Submission and Style Guideline

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The content of the manuscripts should meet the aims and scope of the Turkish Journal of Archaeological Sciences (cf. Aims and Scope).

Manuscripts may be written in Turkish or English. The translation of articles into English is the responsibility of the author(s). If the author(s) are not fluent in the language in which the article is written, they must ensure that the text is reviewed, ideally by a native speaker, prior to submission.

Each manuscript should include a Turkish and an English abstract of up to 200 words and five keywords in both Turkish and English. Citations should not be included in the abstract.

If the author(s) are not fluent in the language of the manuscript, a translation of the abstract and the keywords may be provided by the editorial board.

Manuscripts, figures, and other files should be sent via wetransfer or e-mail to **archaeologicalsciences@gmail.com**

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Each article must contain the following:

- Authors (please provide the name-last name and contact details of each author under the main title of the manuscript)
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- E-mail address
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The manuscript should contain:

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Style Guide

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- Manuscripts should be written in Times New Roman 12-point font, justified and single-spaced. Please submit the manuscript as a word document.
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References

Cf.: In-Text Citations and References

- In-text citations should appear inside parenthesis (Author year, page number).
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Figures and Tables

- Please provide a caption list for figures and tables following the references. Provide credits where applicable. Each figure and table should be referenced in the text (Figure 1, or Table 1), but please do not include figures in the text document.
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Dates and Numbers

- Please use BCE/CE and please avoid using dots without dots (i.e., BCE instead of BC or B.C.).
- Please use a dot for numbers and dates with 5 or more digits (i.e., 10.500 BCE).
- Please avoid using dots for numbers and dates with 4 or less digits (i.e., 8700 BCE).
- Please spell out whole numbers from 0 to 10 (e.g., “the floor was renewed eight times” instead of “the floor was renewed 8 times”).

Punctuation

- Please prefer em dashes (—) for parenthetical sentences: “Children were buried with various items, the adolescents—individuals between the ages of 12-19—had the most variety in terms of grave goods.”
- Please prefer an en dash (-) between page numbers, years, and places: 1989-2006; İstanbul-Kütahya.

Abbreviations

- Commonly used abbreviations:

Approximately:	approx.	Figure:	Fig.
Confer:	cf.	*Id est:*	i.e.,
Circa:	ca.	*Exempli gratia:*	e.g.,
Calibrated:	cal.		

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- Each article should contain a list of references in a section titled "References" at the end of the text. Please ensure that all papers cited in the text are listed in the bibliography.
- Citations in the text may be made directly, e.g., 'as shown by Esin (1995) ...' or in parenthesis, e.g., 'research suggests ... (Esin 1995)'.
- References within the same parenthesis should be arranged chronologically and separated with a ";", e.g., '... (Dinçol and Kantman 1969; Esin 1995; Özbal et al. 2004).'
- In references to the studies by the same author from different years, please use the last name of the author once, followed by the years of the cited studies, each separated by a ",", e.g., '... (Peterson 2002, 2010).
- More than one reference from the same author(s) in the same year must be identified by the letters 'a', 'b', 'c' placed after the year of publication.
- When dealing with multiple papers from the same author, single authored ones should be written before the studies with multiple authors.
- When dealing with papers where the first author is the same, followed by different second (or third, and so on) authors, the papers should be listed alphabetically based on the last name of the second author.
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- Please provide the doi numbers of journal articles.

Below, you may find examples for in-text citations and references.

Single-authored journal articles, book chapters, and books

In-text:

Last name and publication year (Esin 1995).

If the page number is indicated:

Last name and publication year, page number (Esin 1995, 140).

Journal article:

Bickle, P. 2020. Thinking Gender Differently: New Approaches to Identity Difference in the Central European Neolithic. *Cambridge Archaeological Journal* 30(2), 201-218. https://doi.org/10.1017/S0959774319000453

Book chapter:

Esin, U. 1995. Aşıklı Höyük ve Radyo-Aktif Karbon Ölçümleri. A. Erkanal, H. Erkanal, H. Hüryılmaz, A. T. Ökse (Eds.), *İ. Metin Akyurt - Bahattin Devam Anı Kitabı. Eski Yakın Doğu Kültürleri Üzerine İncelemeler*, İstanbul: Arkeoloji ve Sanat Yayınları, 135-146.

Book:

Peterson, J. 2002. Sexual Revolutions: *Gender and Labor at the Dawn of Agriculture*. Walnut Creek, CA: AltaMira Press.

Journal articles, book chapters, and books with two authors

In-text:

Last names of both authors and publication year (Dinçol and Kantman 1969, 56).

Journal article:

Pearson, J., Meskell, L. 2015. Isotopes and Images: Fleshing out Bodies at Çatalhöyük. *Journal of Archaeological Method and Theory* 22, 461-482.
https://doi.org/10.1007/s10816-013-9184-5

Book chapter:

Özkaya, V., San, O. 2007. Körtik Tepe: Bulgular Işığında Kültürel Doku Üzerine İlk Gözlemler. M. Özdoğan, N. Başgelen (Ed.), *Türkiye'de Neolitik Dönem. Yeni Kazılar, Yeni Bulgular*, İstanbul: Arkeoloji ve Sanat Yayınları, 21-36.

Book:

Dinçol, A. M., Kantman, S. 1969. *Analitik Arkeoloji, Denemeler*. Anadolu Araştırmaları III, Özel sayı, İstanbul: Edebiyat Fakültesi Basımevi.

Journal articles and book chapters with three or more authors

In-text:

Last name of the first author followed by "et al." and the publication year (Özbal et al. 2004).

Journal article:

Özbal, R., Gerritsen, F., Diebold, B., Healey, E., Aydın, N., Loyet, M., Nardulli, F., Reese, D., Ekstrom, H., Sholts, S., Mekel-Bobrov, N., Lahn, B. 2004. Tell Kurdu Excavations 2001. *Anatolica* 30, 37-107.

Book chapter:

Pearson, J., Meskell, L., Nakamura, C., Larsen, C. S. 2015. Reconciling the Body: Signifying Flesh, Maturity, and Age at Çatalhöyük. I. Hodder, A. Marciniak (Eds.), *Assembling Çatalhöyük*, Leeds: Maney Publishing, 75-86.

Edited books

In-text:

Last name(s) of the author(s) and publication year (Akkermans and Schwartz 2003).

Akkermans, P. M. M. G., Schwartz, G. M. 2003. (Eds.) *The Archaeology of Syria. From Complex Hunter-Gatherers to Early Urban Societies (c. 16.000-300 BC)*. Cambridge: Cambridge University Press.

Web source:

Last name, Initial of the first name. Title of the web page. Title of the website. Institution (where applicable), publication date. Access date. URL.